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FINAL REPORT

Signal Maintenance Symposium

14–15–16 APRIL 1959

Sponsored By:
United States Army
Signal Corps

U. S. ARMY SIGNAL EQUIPMENT SUPPORT AGENCY
Fort Monmouth, New Jersey

HEADQUARTERS
UNITED STATES ARMY SIGNAL EQUIPMENT SUPPORT AGENCY
FORT MONMOUTH, NEW JERSEY

This final report of the Third Signal Maintenance Symposium, held in Myer Hall, Fort Monmouth, N. J., 14-15-16 April 1959, is published for the information and guidance of all concerned. Comments are invited by the host agency, United States Army Signal Equipment Support Agency. A limited number of additional copies are available from the host agency, Attn: SIGFM/ES-M.

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Special

FOREWORD

1. This final report of the Third Signal Maintenance Symposium, held at Myer Hall, Fort Monmouth, New Jersey, during the period 14-16 April 1959, contains all papers presented and a transcript of the discussion that followed each presentation.

2. More than 700 registered conferees from world-wide commands and industry attended the Symposium. During their three-day visit these conferees participated in discussions involving new maintenance concepts and their effect on the Signal Maintenance Program. Problems in maintenance arising from the development and introduction of new equipments and systems, the need for maintaining balance between maintenance requirements and design for performance in these new items, the challenge to develop meaningful parameters for maintainablility, and other vital subjects were presented by authoritative speakers.

3. The Chief Signal Officer feels that your keen interest in the presentations and your active participation in the discussions will be most rewarding to you and that the Defense Program will be strengthened measurably as a result of the Third Signal Maintenance Symposium.

HOWARD E. PRICE
Colonel, Signal Corps
Commanding

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OPENING REMARKS

COL ALLEN T. STANWIX-HAY, DEPUTY CHIEF, P&D DIVISION, OCSIGO: This is the Third Annual Maintenance Symposium of the Chief Signal Officer held here at Fort Monmouth. It is my pleasure to serve as your stagehand, if you will. They have in the program some very distinguished titles. However, if you will just let me be the stagehand I'll be satisfied. At this particular time in opening this Symposium, I would like to express my appreciation and those of us from the Chief's Office to Colonel Price, the Commanding Officer of the U. S. Army Signal Equipment Support Agency, to the committee which has been formed from many organizations in the Signal Corps and has worked so diligently and so hard to put on this Symposium. I would like also to express our appreciation to Colonel Meyer, the Commanding Officer of the U. S. Army Signal School who has made the facilities available to us here at the school. And finally and with great appreciation to General Cassevant, The Commanding General of Fort Monmouth who has again allowed us to use the Post in order to hold this Maintenance Symposium. In order to open the Symposium, and we have been extremely fortunate in our past two in always being able to strike at a time when the Commanding General was present, it is my present pleasure at this moment, Ladies and Gentlemen, to present to you Brigadier General A. F. Cassevant, the Commanding General of Fort Monmouth: General Cassevant.

WELCOMING ADDRESS

Brig. Gen. A. F. Cassevant

Commanding General, Fort Monmouth

I think Col. Stanwix-Hay should be in the diplomatic corps. I don't think he missed anyone he should have mentioned here. I want to thank him very much for his kind words.

The Post personnel and the personnel at the Equipment Support Agency have worked very hard to make this a successful program. The success that comes from it, however, is depended entirely upon how much you people participate. The background and the facilities are here for you and it's now up to you to make the symposium as useful as possible.

I want to welcome you the the Post, and that's my primary reason for being here, but while I'm at it, I want to make a few comments for those of you who have maintenance responsibilities out in the field and with our units particularly. We train a large number of personnel here in maintenance of Signal Corps equipment. We try to inspire them with the importance of their work and we send them out from here as well-trained as we can in the time that we have them. We think we are turning our a pretty well-trained product that needs perhaps some polishing and a little experience, but having the basic knowledge.

I want to point out to you that unless you people in the field assure yourselves that the graduates are, in fact, being put to work where their talents are needed, we are wasting our efforts here and you are complicating your job out in the field. I want to recite two or three examples which have come to us -- one quite recently and I might say unfortunately, from one of our own installations.

The number two man we had here in one of our classes -- we had him pretty well inspired and believing that he had a mission to do -- sent us a very pathetic letter. Where do you suppose he was working? In the Commissary -- and not on maintenance work I might add! Now this is a waste of talent. When we have these complaints from outside of the Signal Corps its bad enough, but when we do it in our own family, it is inexcusable. We've had some malassignments and we've tried to correct them.

We had two, in rapid order, out at Fort Riley. In one instance, the man who was assigned there was the top man in his class -- in carrier equipment. He wrote to tell us of his trouble, and I contacted the Signal Office at Fifth Army, Col. Kurncomp at the time, who promptly went to work on it. The man was transferred to Chicago, Fifth Army Headquarters, where they really needed him, and this one turned out all right.

In another instance, still at Riley, we had a man assigned who was a Radar repairman. The TO called for radar repairman. Unfortunately, the division at Riley was not equipped with the AN/MPQ-10's or other mortor locators which they were supposed to have and would normally have. The man wrote in and said that he was on a yard-bird detail. What was he doing? Pounding nails out of boards in the Signal Repair Shop.

Well, I cite these few examples to point these things out to you so that you gentlemen in the field will seek out these malassignments and do something about them. It is rather discouraging for the faculty of the school here to train these people, fire them with the importance of their work, and then have them go out with assignments that have nothing to do with what they've been trained to do. So my message is directed to you people in the field who have these responsibilities.

Without any further ado, I'm going to turn this back to the Equipment Support people, P&D, and let the working members of this party get to work. It's a real pleasure to be with you. I don't see my P&D friends as often as I'd like to. It's a real pleasure to have you here and be with you a little bit. It's a pleasure to see General Scofield and have him here with us.

KEYNOTE ADDRESS
Maj. Gen. H. L. Scofield
Chief, P&D Division, OCSigO

With the surroundings that you find yourself in this morning and the extreme pleasantness of the day, that you find outside, it's awfully easy to be lulled into a false sense of security.

And under those conditions, one can be sold a bill of goods rather easily. And this brings back to my memory one of my favorite hunting stories.

I was born and raised in Michigan, and among other things we had some fairly good duck hunting up there. And this story is told about this old timer who had a very good retriever and the dog was just part of the family. And he thought the world of it; in fact his day began and ended in this dog. And the day before duck-hunting season opened, a most unfortunate accident happened. The dog was hit by an automobile. And the old timer was broken because he lost what he thought was his best friend. But he also was practical and realized that duck season was going to open next morning bright and early at the crack of dawn and he just had to have a dog. So he headed for the nearest place that he could find a dog and bought one sight unseen. And started out next morning bright and early to his favorite duck-hunting spot with his new dog.

When the first flock of ducks came over, the old timer up with his trusted gun blazed away at the flock, and down came his first duck. And he spoke to the dog, and the dog jumped out of the blind and walked on top of the water, retrieved the duck and, still walking on the water, brought it back and at a word from the Old Timer, dropped it at his feet.

The Old Timer looked at the dog and he looked at the duck and he reached in his pocket and pulled out that bottle of snake-bite medicine that he took along for emergencies and wondered if he had gotten the wrong brand. And he repeated the process several times, and the dog reacted just as favorably under every condition that he could think of. And he could stand it no longer and he had to go back to the house.

And he called up his good friend Tom and he said, "Tom normally we go hunting together on the second day of duck season and I'm looking forward to seeing you tomorrow morning." And Tom said, "I'll be along."

So the next morning, he took Tom out and went through the same process and the dog again reacted just as favorably as he had the first morning. But Tom didn't say a word about the Old Timer's new dog. And this bothered the Old Timer and of course, under those circumstances, it was no time at all before they had their limit of ducks and went back to the house. And they got to the point where they were going to part ways and the Old Timer said, "Tom, you haven't said a word about my new dog." And Tom said to the Old Timer "I wasn't going to mention it but since you brought it up," he said "I am going to have to express my honest opinion. Some son-of-a-gun sold you a dog that couldn't swim." So be careful how you may be lulled, during this symposium, into a false security and find yourself with a dog that can't swim.

When I look at this audience and when I look in back of it as to some of the Agencies and commands and industries that are represented here I stand on this platform with considerable trepidation. I certainly would like to express appreciation for and to sincerely welcome the representatives that are here from the major commands throughout the world and those who are here from other Agencies of the Department of the Army. The Continental Air Defense Command, ASA, DCSLOG, the National Guard Bureau, and many others. But I particularly want to welcome the members of industry who have seen fit to accept the invitation and spend their good time, their important and almost priceless time in sitting down around the table to discuss primarily maintenance. Therefore, this symposium with this cross section of industry and the military present affords an excellent medium for the exchange of information concerning maintenance. And I therefore hold great hope for the success of this Third Annual Maintenance Symposium.

I should like, in the few moments available to me to, if possible, build a framework within which I would hope your discussions, your deliberations might be retained and explored, and thought about. We are here, of course, because we're interested primarily in electronic communications equipment and all of those things which go on to make the application of this equipment possible. And I would like to explore briefly three principal areas that I believe the primary efforts of this Symposium are directed. They are reliability in the equipment itself, maintainability of that equipment, and thirdly the training of those men and women who are primarily concerned with the maintenance of this equipment. I believe within these three major areas most of your deliberations properly should be directed.

Speaking of the first one, reliability -- and these are not necessarily in the order of priority -- it is in this area that industry has the great depth of know-how of basic knowledge and experience that permits them basically to build into the equipment that we use today; the reliability that we need in order to reduce the amount of maintenance we are confronted with.

In my visits to industry within the last few months, I have found an increasing effort on the part of industry to do a better job in assuring themselves that the components that they use in the end equipment which they build are of the highest order of quality. This evidence is extremely strong and for this I feel much better, generally speaking, about the whole matter of reliability. I have seen evidence of even double quality assurance tests -- life tests -- being accomplished by industry, in many instances on its own, in order to insure themselves that the components they are planning in these end equipments meet the requirements of either their own specifications or the Military specifications when there are Military specifications. This trend to me is significant. It emphasizes, however from the point of view of the military, a greater need for more Military specifications in order to standardize, and indicates the required quality necessary in these components. And this is an area that is extremely difficult for us the Military to get resources that will permit us to do the amount of work we would like to do. It nevertheless is an extremely important area for us to direct our attention to. And I would like for one to Command industry wherever they are showing a prime interest in this particular aspect: the components business. I would like to commend them for the efforts they are making -- for the progress they are making -- and the efforts they are expending in this regard.

In this connection and by reason of what it means, I am reminded of a comment that was made by Col. Howard Price last evening, at the dinner table, that to me brings a very significant picture when you let your mind wander a bit. He told me of a cartoon that he saw in which in the foreground of a picture was this Indian with his blanket and his fire and he was sending smoke signals. And in back of the Indian, in the background of the picture, was this electronic equipment obviously of the latest type, extremely complex -- antennas sticking out from every direction. And the caption at the bottom of the picture was "Yes and tell 'em to send a couple of fuses, too."

It doesn't take much imagination, ladies and gentlemen, for one to visualize the true meaning of such a cartoon as that.

Moving on into the second area, that I would like to speak briefly of, namely maintainability. I believe that in the past and even today to a great extent we are tying out maintenance efforts to antiquated concepts. And looking too much

PROBLEMS IN MAINTENANCE OF COMMUNICATIONS SECURITY EQUIPMENT

James R. Sink

U. S. Army Signal Communications Security Agency

It is a pleasure to represent the U. S. Army Signal Communications Security Agency at this symposium. Of course, being in the communications security business, our agency is in the business of taking plain language and making it impossible to understand. I shall try to keep that under control today. My subject today is "Problems in Maintenance of Communications Security Equipment". For the sake of security, the subject will be presented by making reference to portions of actual equipment maintained in the communications security effort rather than by referring to complete equipment. I hope that I have a point of contact with every participant in this symposium. Our agency has no problems, really: -- Nothing that money, more people, and more time cannot solve. This is an unclassified presentation.

I will introduce our agency to you. After the introduction I will discuss some of the problems that confront us and some of the ways we go about solving them. For convenience, throughout my presentation, the Signal Communications Security Agency will be called "SCSA". The subject of Communications Security will be referred to as "COMSEC" for this discussion. The terms "COMSEC" and "Cryptographic" are synonomous as I use them.

During World War II and up to about 1946, Cryptographic Logistics was the responsibility of the Chief Signal Officer. The activity was handled by the Signal Intelligence Service. From 1946 to 1955 the Army Security Agency was assigned responsibility for crypto logistics. In November 1955, this responsibility was again returned to the Chief Signal Officer. Army Regulation 10-128 now places this responsibility with the U. S. Army Signal Communications Security Agency. The SCSA is a class II activity under staff supervision of the U. S. Army Communications Service Division of OCSigO.

I will now describe organization and show you the relationship of the SCSA with the national organization (Figure 1).

Comsec Development

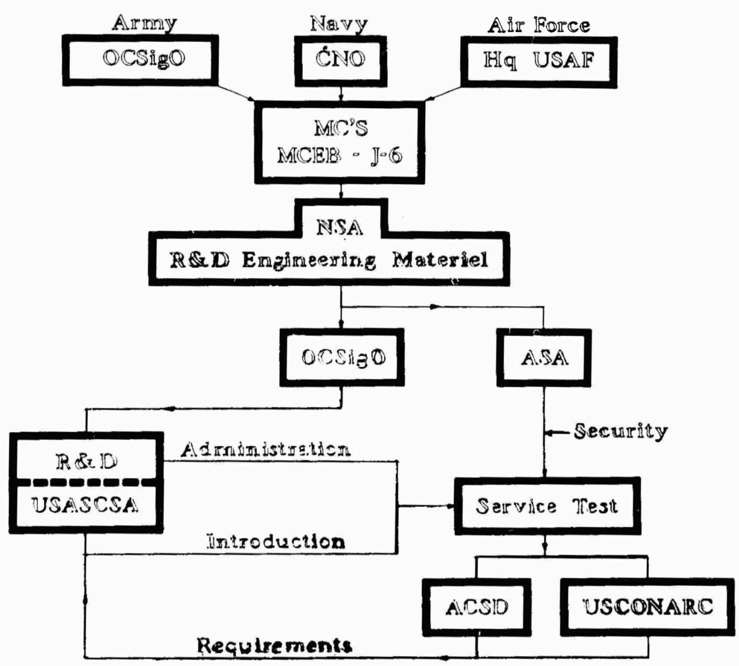


Figure 1.

Figure 1 shows the basic relationships of COMSEC activities as they apply to equipment development, introduction and support. The National Security Agency (NSA) is responsible for development and/or approval of service developed cryptographic principles. A Signal Procurement Office, similar in function to the Laboratory Procurement Office of USASESA, is permanently assigned to administer, as Contracting Officer, development and production contracts for NSA. Military characteristics for COMSEC are approved by the Military Communications Electronics Board (MCEB) of the Joint Chiefs of Staff element J-6.

The R/D Division of OCSigO serves as the Army co-ordinator during equipment development and administers the service tests conducted by Army. The SCSA provides introduction and technical services to the Army Communications Service Division (ACSD) and to the Test Boards of the Continental Army Command (CONARC). The ACSD makes the strategic evaluation and the CONARC makes the tactical evaluation. The U. S. Army Security Agency (USASA) determines the security aspects and issues pertinent security regulations. After Service Test, OCSigO R/D presents the equipment to the Signal Corps Technical Committee for standardization. Requirements for the equipments are computed by SCSA. Production costs such as tooling and the cost of supporting cryptographic materials are funded by the NSA. The SCSA provides funds for the end items of equipment and repair parts, ancillary devices and/or test equipments unique to COMSEC (Figure 2).

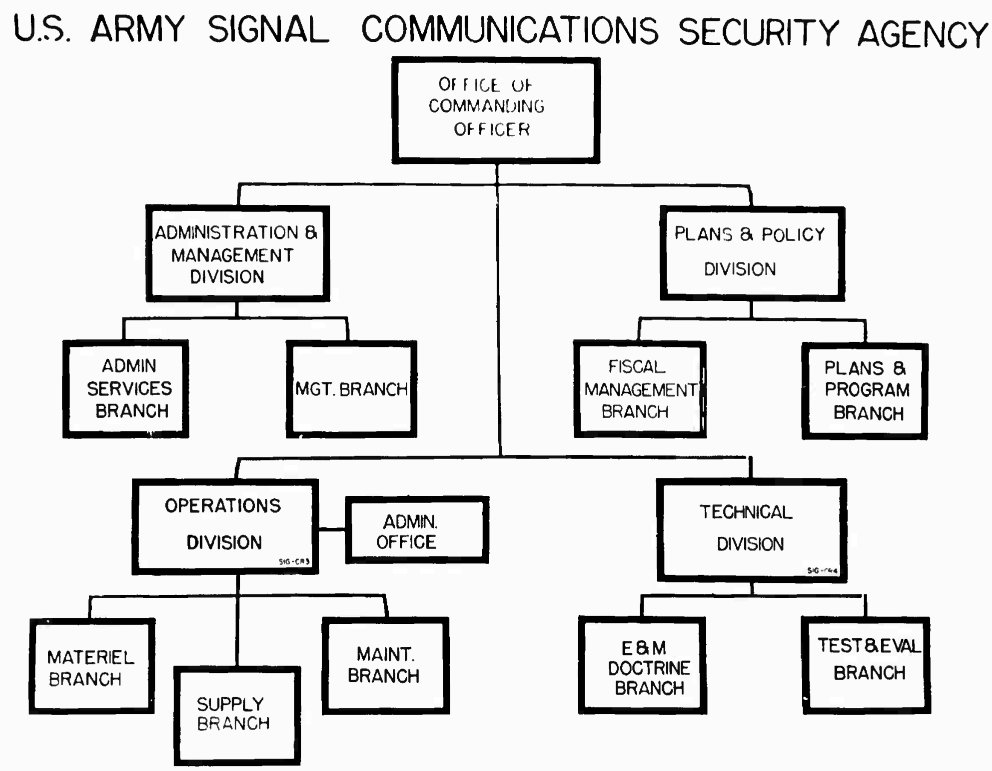


Figure 2.

At SCSA, under direction of the Commanding Officer, are four divisions. The functions of Administrative Division are purely administrative. The functions of Plans and Policy Division are outlined briefly on figure 3.

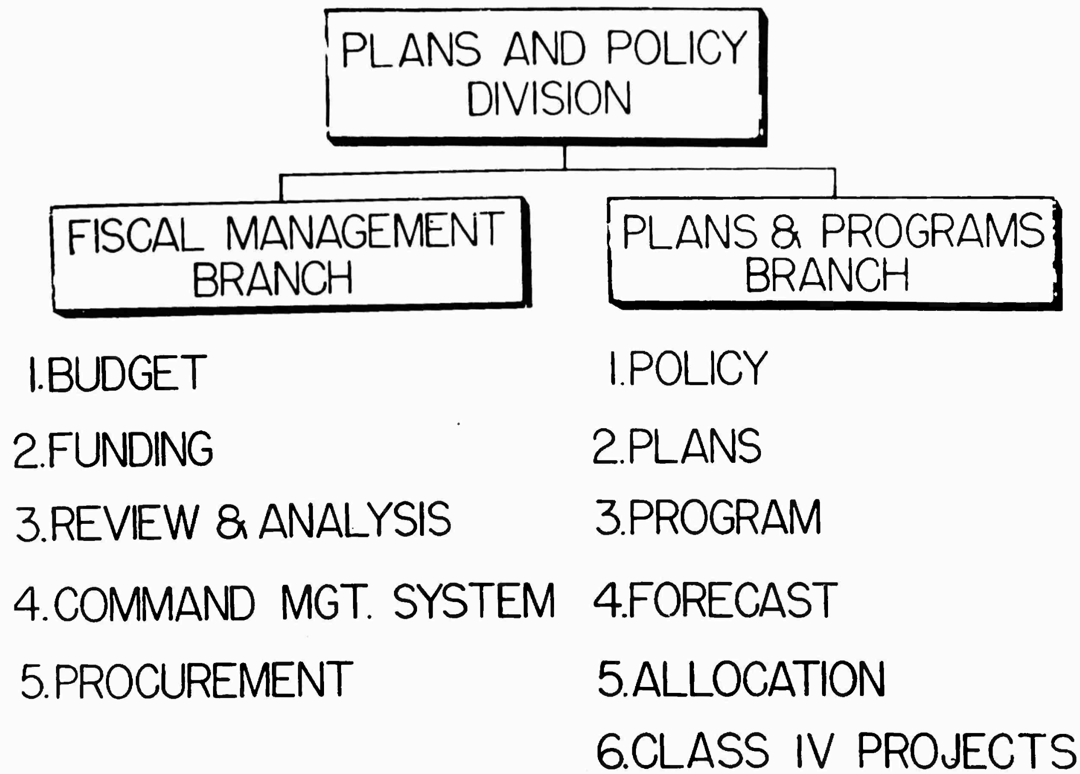


Figure 3.

Operations Division is the division that provides materiel support and depot maintenance. Operations Division functions are outlined on figure 4.

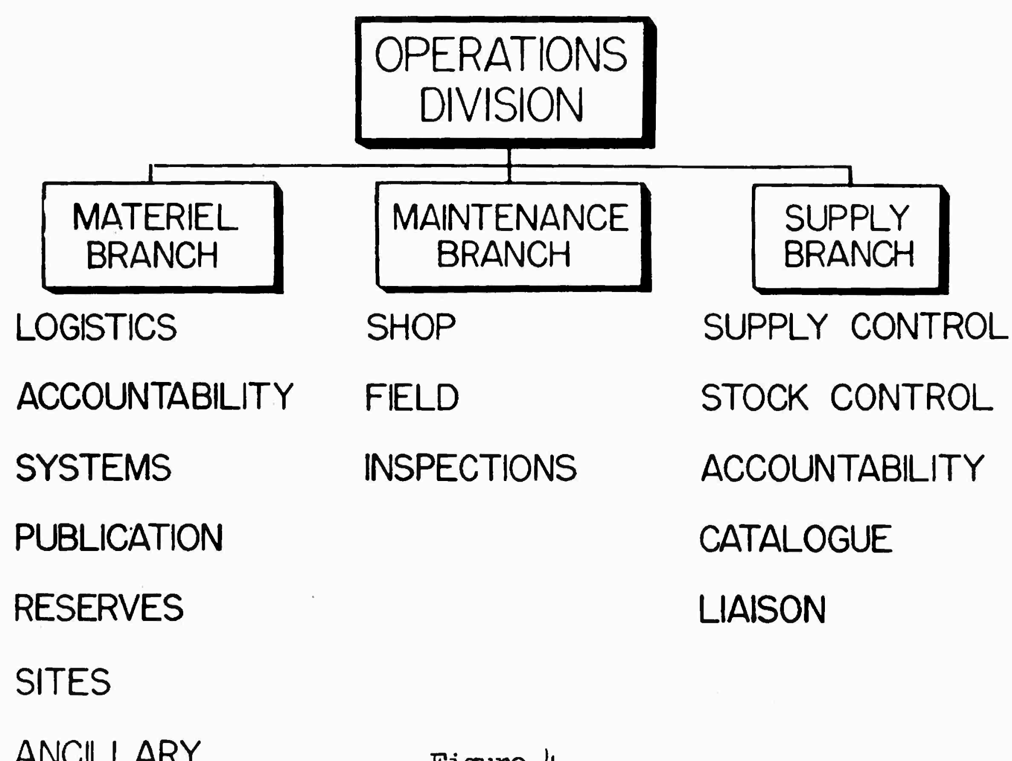


Figure 4.

Technical Division in general provides applications engineering functions which are outlined on the chart (figure 5).

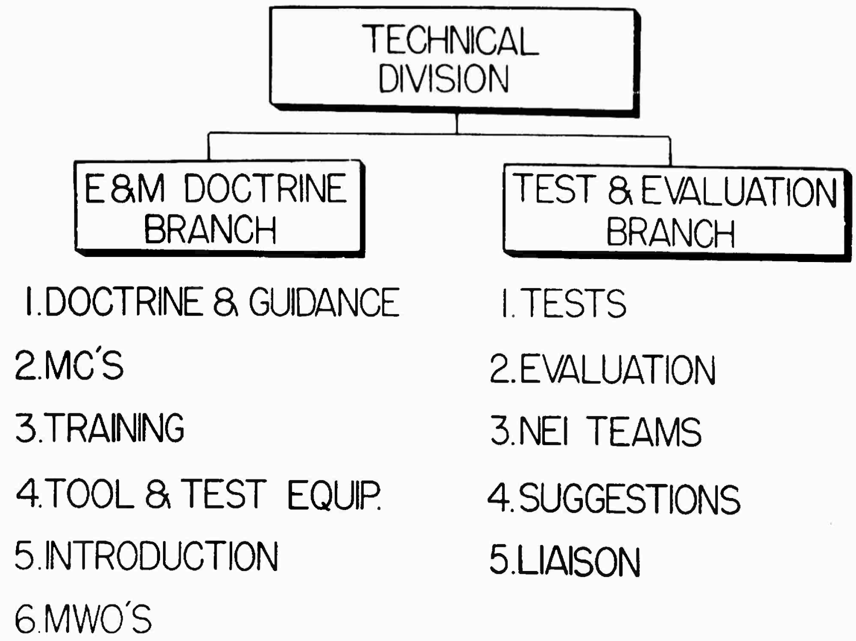


Figure 5.

COMSEC equipment in general is not too different from other communications equipment signal field maintenance. The function of our hardware is to encrypt and decrypt. Different kinds of hardware are required for different forms of communication. I like to think of the process as that means by which communications are changed to deny intelligence to those who do not have the need to know but do have the will to find out. The present trend in design of COMSEC equipment is to keep the classification of the hardware as low as possible, preferably unclassified, while the security of the system is vested in the associated keying material. The trend is for security devices to become more a part of the terminal equipment rather than separate black boxes. Ultimately, the objective is for them to be a part of the communications equipment. The operation of COMSEC equipment is being simplified in new developments which is a needed step in the right direction. The long range objective is to have communications security that is automatic in operation without the communicator knowing that the device is in the system. However, this automation adds to the complexity of the equipment and aggravates the maintenance problems.

Relative to the subject of this presentation, we do have problems. I will place them in six descriptive categories:

1. Increase in the quantity and complexity of COMSEC equipment.
2. Availability of test equipment.
3. Training of personnel.

4. Information to the field.
5. Standardization of operating and maintenance facilities.
6. Lack of stockage guides and allowances.

To show what I mean by the statement that the phasing of new equipment has been such that we are maintaining old type equipment along with new, I have selected some components from the equipment to show to you today (figure 6).

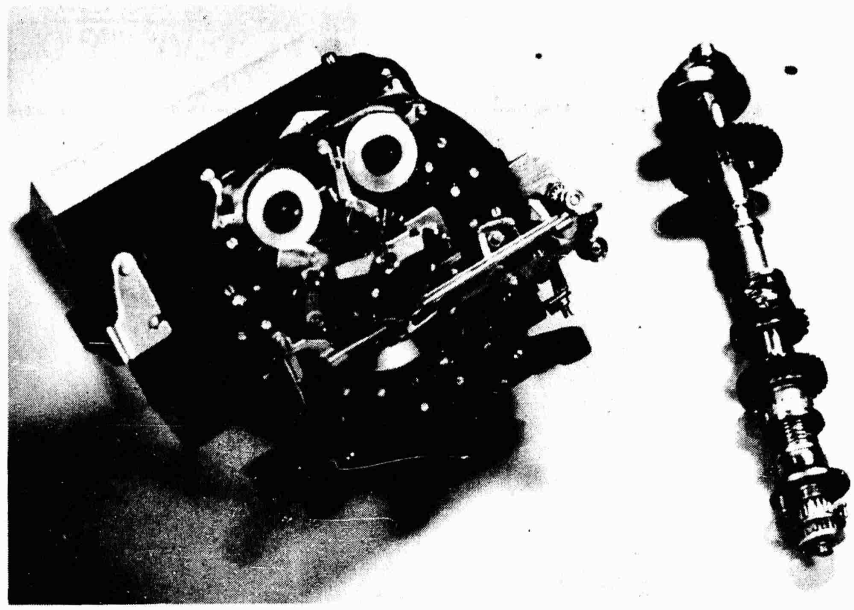


Figure 6.

This component from an electro-mechanical equipment has been in the system since World War II. Maintenance consists of replacement of individual parts. In itself, this type of equipment does not create a maintenance problem because the maintenance man is familiar with it and the system is geared to this type of maintenance.

New complex electronic equipments are being introduced. This introduces a new and foreign problem to our maintenance men. To illustrate, here is one of the less complex components, called a sliding contact board (figure 7).

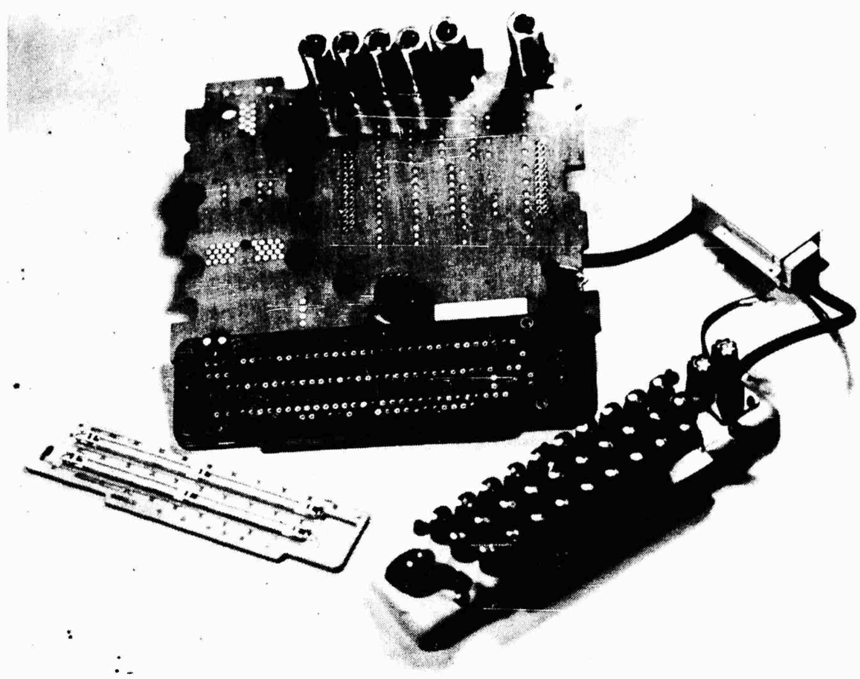


Figure 7.

This component switches the circuits of a keyboard operated device. The board is made up of nickel-silver contacts set in phenolic. The flat contacts of the board mate with plunger contacts on the keyboard or the base panel. Organizational maintenance performed at first or second echelon consists of simple disassembly, buffing, wiping, and lubricating. If organization maintenance is neglected, the failure rate of this component is prohibitive. That's all -- but it is vital. Repair of the components of the machine, of which this component is a part, is performed at fourth echelon. By maintaining a maintenance float at fourth and fifth echelon, our system is able to handle this device rather well but an automatic way of repairing components would be helpful (figure 8).

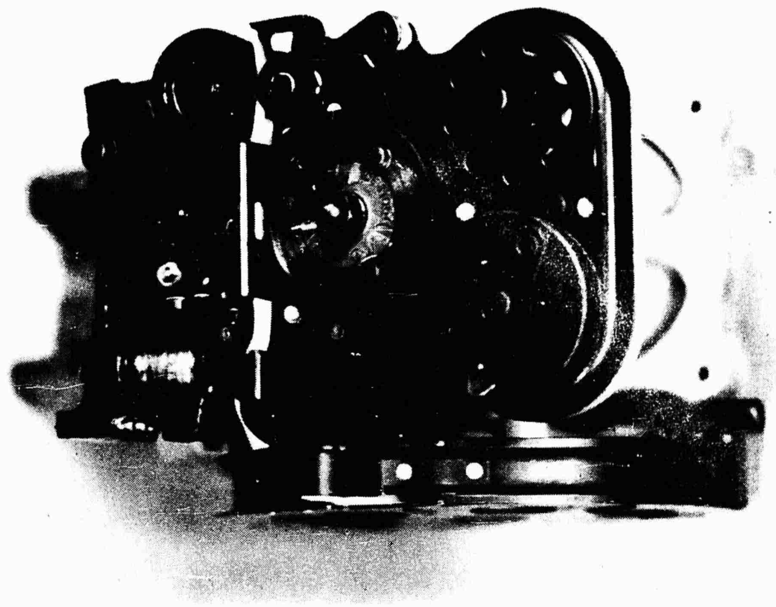


Figure 8.

The component now shown, a motor and pulse generator, has a compact arrangement of coils surrounding a permanent magnet which is rotated by the motor at about 2,300 rpm. A print wheel is attached to the front of the motor shaft. The angular relationship of the position of the energized coil, coupled with the timing of print pulses to the print actuator, determines the printed character.

Replacement of motor bearings, coils, and adjustment of the print wheel is critical (figure 9).

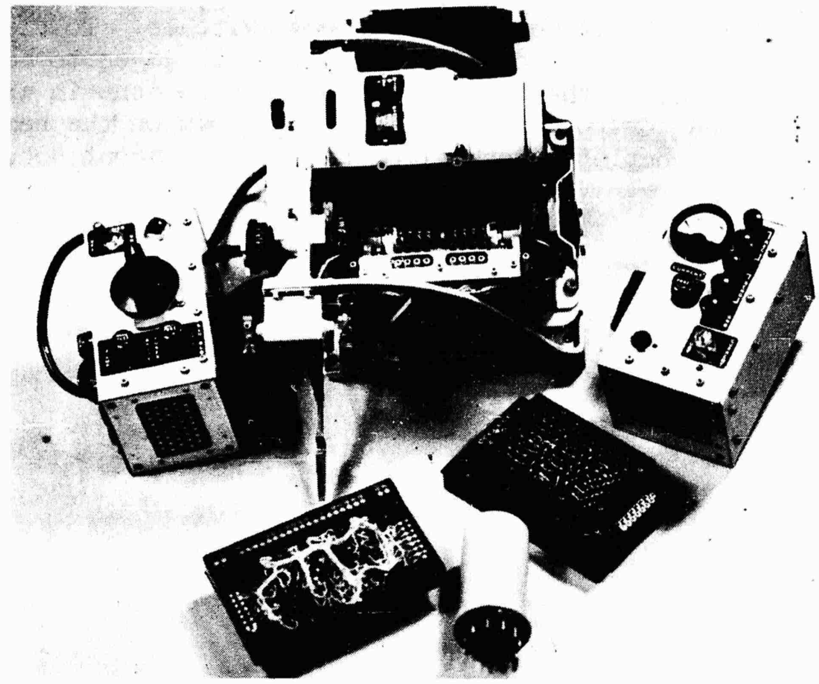


Figure 9.

This group of components is representative of those formed into a teletypewriter security machine used for direct on-the-line application.

Let me single out two of this group of components for further discussion (figures 10 and 12).

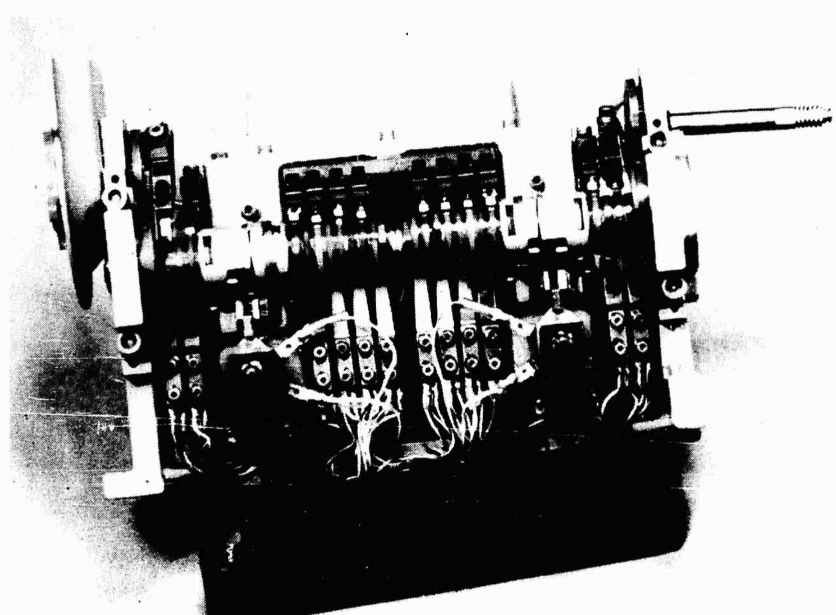


Figure 10.

The heart of the unit, the controller assembly, contains many single pole double throw and single pole single throw switches. To clean, adjust and time the unit is a fairly complicated job. With gages to adjust, and an oscilloscope to observe the timing, the job can be done in about 12 hours, but use of the controller timer test set shown on the next slide (figure 11), permits complete overhaul of the unit in about 4 hours.

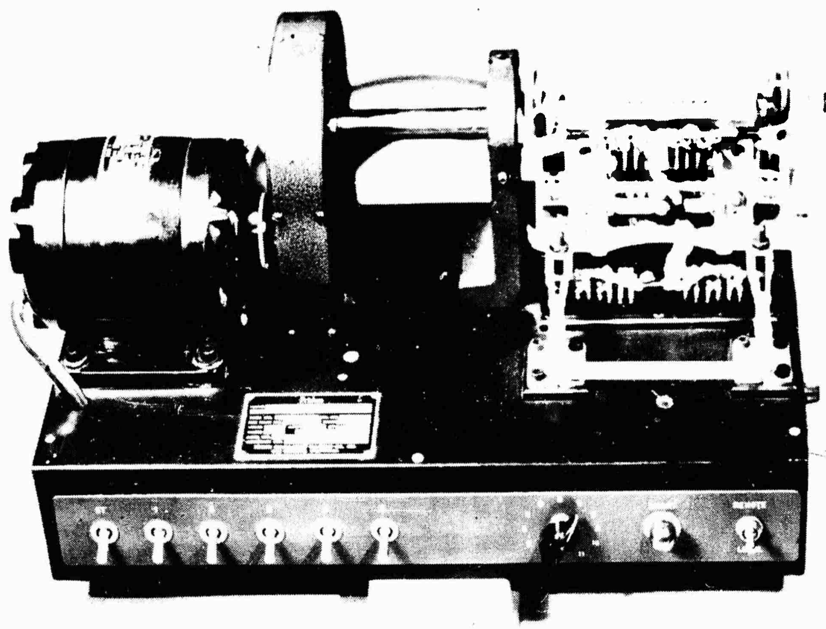


Figure 11.

It is a third echelon operation to analyze the trouble and to replace the faulty component. Routine adjustment, cleaning, and adjusting can be done in a matter of minutes at fourth echelon where the test set will be used.

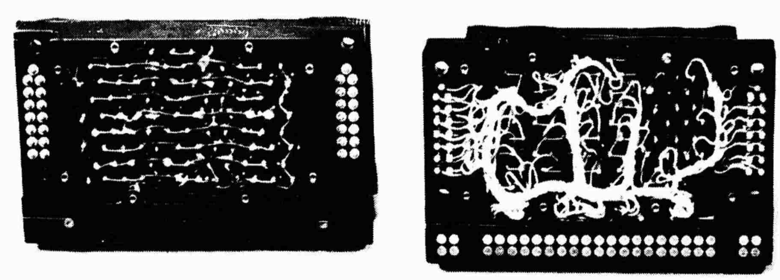


Figure 12.

This component, a translator block subassembly, contains 96 germanium diodes. The diodes are set in the apertures which are arranged like a honeycomb. Considering that the diodes will have a normal failure rate of about 3 per cent when first placed in operation, this component could be a real problem. Finding faulty diodes in this matrix arrangement with an ohmmeter is almost impossible but can be done in about 14 hours. With the use of the translator test set (figure 13), the faulty diode can be located and the assembly can be repaired quite rapidly.

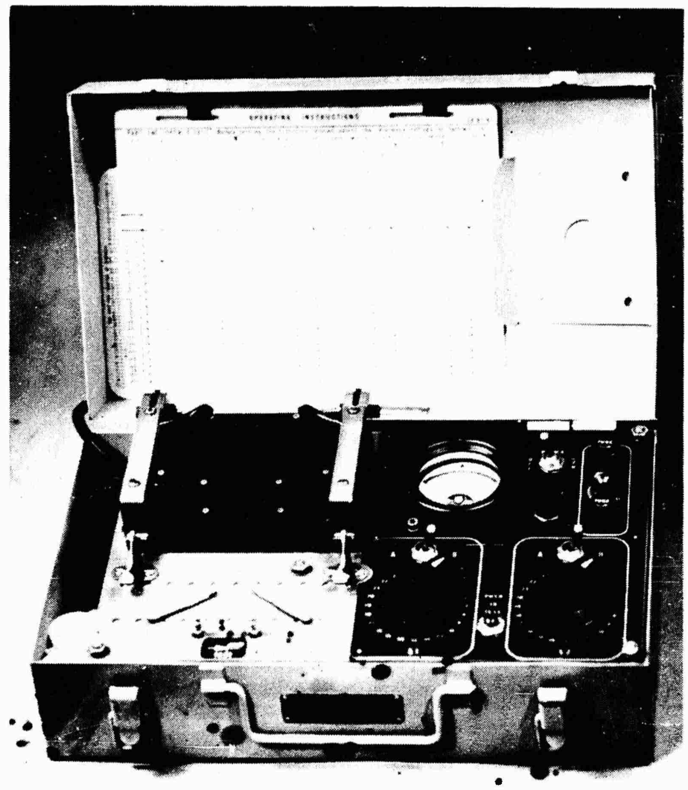


Figure 13.

A specialist trained in soldering the replacement diodes is required at fourth echelon.

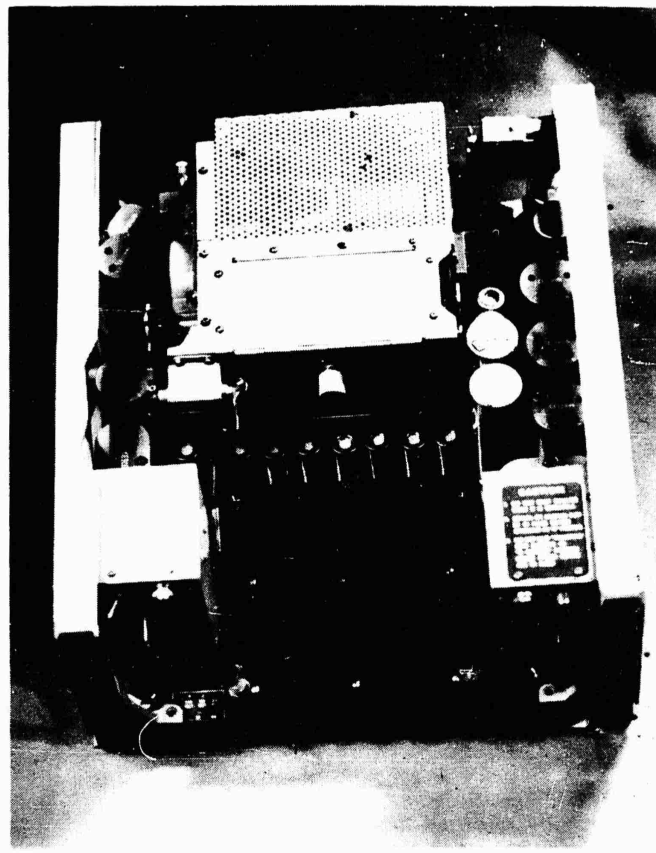


Figure 14.

This picture shows the complete equipment from which the two components were taken. In place of the classified portion of the equipment, I have placed another of the special test sets designed for the machine. Basically, the machine is a two way regenerative repeater with a cipher unit between the stages of regeneration. To determine which component of the machine is malfunctioning, the repairman observes and compares indicators on storage units and indicators on the test set. Use of the range adapter test set also permits the regenerator to be oriented to the signal line.

The component replacement type components shown are from equipments used in both tactical and strategic applications. In the case of the teletypewriter device, I have shown some maintenance techniques that are a step toward automation in maintenance. The maintenance system is now being geared to component replacement on the more complex equipment (figure 15).

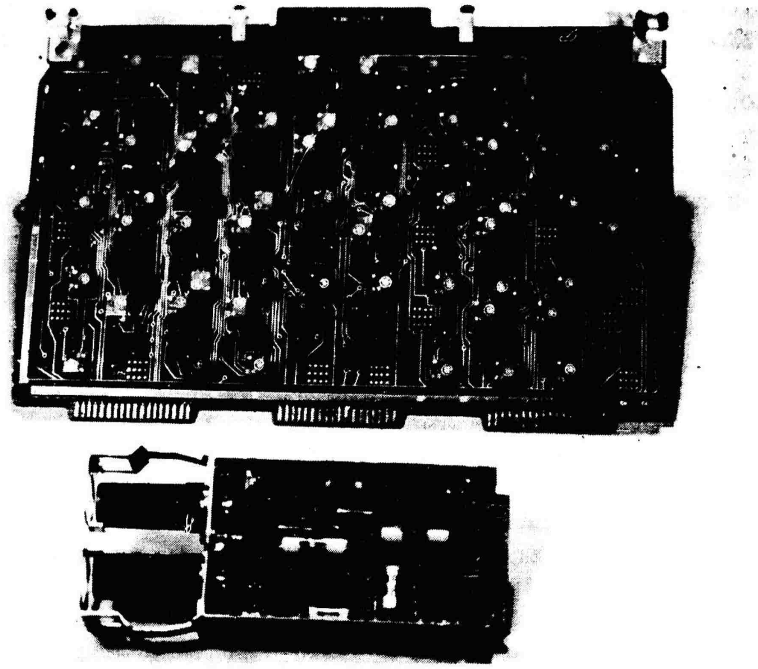


Figure 15.

The component on the bottom of the figure is a component replacement package for a device of more advanced electronic design. At the top is a printed circuit board containing bistable magnetic cores. The equipment is one of the most advanced in our system. Our maintenance experience on the equipment is very limited. Analyzing and repairing the printed boards is a problem. Construction of the core package is such that replacement of an individual component is difficult. Even with the aid of special tools, extreme care must be taken if a core package is to be removed and replaced on one of the boards. Our maintenance skill level is not yet geared to maintain this type of equipment.

The components shown to you in the picture are from an equipment requiring an oscilloscope having features that we have not found in the oscilloscopes listed in the Signal Test Equipment catalog. However, the AN/USM-81 is now entering the signal system and is expected to be available soon. It will suffice for this requirement when available. However, to properly introduce this type of COMSEC equipment to the field, we have, of necessity, purchased nonstandard oscilloscopes. This is an example that supports my statement that availability of test equipment is not current with the needs.

Now here is a real problem. Everyone has personnel training problems, but in our case it seems to be double trouble. Training of maintenance personnel for COMSEC maintenance presents problems which are more complicated than usual because of clearance requirements. Obtaining a clearance up to TOP SECRET cryptographic may take from 3 to 18 months or more. I do not mean to say that the clearance requirements are this high on all equipments. In fact, one of the design criteria for the newer devices is to reduce the classification so far as maintenance is concerned. To illustrate the need for reducing clearance criteria, assume that a clearance is started when a trainee is in basic training. If he is a draftee, it is a gamble whether he will be cleared in time to complete school and acquire proficiency in the field before he completes his active military duty obligation. One solution that is being exploited is to select individuals in the regular army category for cryptographic maintenance. Proficiency examinations are being given to permit the repairmen to receive proficiency pay rates which may help to keep these people on the job in this critical category. A category has been developed for Warrant Officers in the field of cryptographic repair which will provide leadership at the working level and incentive for promotion. Training provided by the Signal Schools is considered good, but must be geared up to the more modern COMSEC equipment requirements. The school courses could be improved by teaching more about the actual application of the equipment. I am thinking particularly about transmission characteristics such as bias and distortion as they may affect interoperations of the communication and the COMSEC system. This may be difficult at this time because training must still be provided for the old equipment as well as the new; however, this point should be considered in future training programs.

Maintenance of component replacement equipment has called our attention to a requirement for a split in the level of skill for our repairmen. At the third echelon where the failures are analyzed and the components are exchanged, the individual should have superior knowledge of the theory of the machine, but he does not have to be as good a mechanic as the man who does the component repairs at fourth echelon. At the SCSA we are writing Technical Bulletins to specify the echelons of maintenance and the tasks to be performed at each echelon. We think that we will be successful in carrying out maintenance by component replacement as soon as the older equipments are removed from service. It is anticipated that it will be difficult to limit the degree of maintenance at the specific echelon. To overcome this, we hope to control the degree of maintenance performed at each echelon by controlling the distribution of components and spare parts. The components and spare parts will be regulated by supply authorization. Maintenance float will be provided so that an exchange of components can be made between echelons.

When the experienced maintenance man is confronted with a new equipment, how does he become familiar with it? As I see it, there are three recognized ways: First, by formal schooling, second, by training received from a New Equipment Introductory (NEI) team, third, by on the job training provided by contract employees acting as regional maintenance representatives. If the man is already assigned and experienced in one of the older equipments, he has two strikes against him when it comes to being selected for formal training in new equipment. Per diem and travel funds are required. His absence throws additional workloads on those remaining. No alternate is available to relieve the candidate for school. At SCSA we have plans to provide regional maintenance representatives but this service is not yet available. New Equipment Introductory teams are available and are working in the field. In future contracts for equipment, we plan to include an arrangement whereby manufacturer's representatives will be available to assist in introducing the equipment.

We do not condone maintenance of COMSEC equipment by persons not fully qualified. We cannot condone it. There can be no guesswork with our equipment. Qualified maintenance personnel are: Personnel receiving formal training at Signal Schools and certified upon completing the courses. Persons trained by NEI teams and certified by the SCSA. Persons trained on-the-job and certified by successfully completing examination.

The information to the field on COMSEC equipment has been insufficient and we know it. To overcome this, we have been publishing New Equipment Introduction Letters which furnish information about the equipment and the application of it. Planning Guides are in process and will be distributed in the near future. The feedback from the field needs to be improved too.

Informal reports received from the field often indicate that our equipment is not performing satisfactorily. These informal complaints are not supported by a return of Unsatisfactory Equipment Reports. In many cases the UER's that are received are vague or indicate that components have failed because preventive maintenance has been neglected, or that the components are from equipments that should have been overhauled. In some instances the reports show that the equipment has been used for the wrong function and that a sufficient trial has not been given. Guidance has been issued to COMSEC users as to which equipment should be reported. We are seriously considering limiting UER's to the equipments during the initial introductory period. I am wondering what the symposium feels about this subject and what the feelings are about screening the reports at Signal field maintenance shops prior to forwarding them to the collecting agency. It appears that a screening would eleminate delay and could weed out vague reports. Faulty maintenance practices could be spotted by such a review and the faults could then be corrected locally.

The supply system for COMSEC equipment is unique. There are two channels by which parts are obtained. Parts that are manufactured under control of NSA are provided by the SCSA. Parts that are obtained through normal Signal Supply channels are considered common and are not provided through COMSEC supply channels.

We realize that the lack of adequate supply publications such as SIG 7 and 8 or the new "P" series manuals has created many problems for those engaged in maintenance. Although the COMSEC parts requirements in Signal Supply represent only a very small percentage of the total supply, a problem is created because proper authorizations for stockage, requisition or issue have not been established. What we are doing now is to develop interim supply manuals patterned after SIG 7 and 8 publications. This interim step is necessary to allow sufficient time for the Signal Equipment Support Agency to prepare "P" series manuals which will serve as authorization for issue for both types of parts. As in the case of obtaining clearances for maintenance personnel, the preparation of the supply manuals at USASESA has been delayed considerably because personnel and laboratory spaces were not adequately cleared.

I hope you now have some insight into the activities of the United States Army Signal Communications Security Agency. I have described and given examples of some of our problems and our approach to their solution. To provide better maintenance support, the support structure in COMSEC must be revised. One approach might be to establish a COMSEC maintenance mission within certain of the Signal field maintenance shops.

Taking the long view, the difficulties we are experiencing are merely those of transition. The challenge of maintaining communications security today is infinitely more complex than ever before. We need your help in meeting this challenge.

On behalf of the Commanding Officer of SCSA, I invite all Army personnel to come to us with COMSEC requirements and COMSEC problems. If the opportunity to join our effort presents itself, I can guarantee that you will find it interesting. We will do our best to assist you with your problems.

MR. HOWARD AYERS - CHIEF COMMUNICATION SECURITY ENGINEER, NATIONAL SECURITY AGENCY: I am going to take just a few minutes to engage in a discussion by example. My purpose is to spotlight one particular area, the need for a change in maintenance training emphasis because of the increasing complexity of the communications security equipment that is reaching the field and is under development. For our purposes, we have divided the maintenance training levels into four categories: mechanical, electromechanical, the basic electronic, and the complex electronic. The mechanical requires training and experience in the operation, repair, and adjustment of mechanical equipment of the complexity of teletypewriter printers. The electromechanical category requires training and trouble-shooting experience on teletypewriter systems including associated mixing and keying equipments. The basic electronic training requires training and experience in servicing electronic power supplies, amplifiers, multivibrators, and oscillators. The complex electronic requires training in advanced electronic theory, and experience in trouble shooting electronic equipment employing complex time relationships, and pulse techniques requiring a knowledge of pulse techniques equivalent to that required to service radar and time division multiplex equipment. Now, to give you an indication as to the trend in maintenance requirements, I have summarized here from a National Security Publication IAG 4, Communications Security Equipment Status Report, dated October 58, the number of equipments in service that require these four categories of maintenance, the number of equipments under development, and a total of the two. We now have two mechanical equipments in service and four under development. We now have 13 electromechanical equipments in service and 4 under development. We now have 3 basic electronic equipments in service and 3 under development. We now have 7 complex communications security equipments in service and 20 under development. This is the problem. In going from mechanical and electromechanical to basic electronic and complex electronic is somewhat like changing from streetcars to buses. All motormen in streetcars do not have the aptitude to become bus drivers. In any event, even if they have the aptitude, they must be retrained; so in the area of communications security equipment we have about the same problem. I have summarized here the training that is conducted by the Army, Navy, and the Air Force in this particular area. The Army MOS is 342; the Navy number is 8450; and the Air Force AFSC is 363X0. Now, in the first place, to do electromechanical maintenance work requires an aptitude, so tests are given to determine whether or not the individual has this aptitude. If he does, then he is given teletypewriter training, basic electricity, and electronics and then he's trained on communications security equipment. This may be 6 to 8 equipments. In the Army, this has been taking 38 weeks, in the Navy 28 weeks, and in the Air Force 37 weeks. In the electronic area, again you have to select the men with the aptitude, and the MOS here for the Army is 345, the number for the Navy is 8201, and the AFSC is 306X0. In this area, we have training in basic electricity and electronics, electronic circuits, and then communications security equipment. In one case, we usually train on 6 or 8 communications security equipments. In another case it is usually 1 equipment.

The total time required for the electronic training is 24 weeks for the Army, 38 weeks for the Navy, and 27 weeks for the Air Force. I would like to offer for your consideration a comparison between the time spent by the Army and the Navy for the electromechanical -- 38 weeks and 28 weeks respectively; and for the electronic -- 24 weeks by the Army and 38 weeks by the Navy. We think the Navy has a stronger maintenance training effort with 38 weeks than the Army has with 24. Maybe we ought to borrow some of these and put them down there. The National Security Agency in performing its functions of research and development, test evaluation, and production of communications security equipment is in a unique position to recognize the shadows of coming events. We want to point out particularly the tremendous increase in complex electronic equipments that are going to be available for operational use either at the present or in the near future. This is going to require special attention in the training area, and you are the people in the services who must meet this responsibility. The National Security Agency conducts training of a very minor nature, a very limited nature, a one-time-one-shop job. We train the maintenance people so that they can maintain the equipment during service test, and we train the instructors from the parent user organization so he can go back and establish his own training course in the parent organization for repetitive training of maintenance people. So the responsibility for getting ready and conducting the training to maintain these complex electronic equipments rests with the user organization. It's a challenge and it's yours. Thank you.

LT COL H. MARGOLIES - U. S. ARMY MAINTENANCE BOARD: Can you outline the plans for support of communications security equipment?

MR. SINK: Colonel, there has been a study made. There have been several attempts to reach a conclusion as to exactly what the support structure will be. I am going to call on Colonel Storey and ask him to give you the latest, because I have been vacationing in Fort Shafter for the last 25 days.

LT COL JAMES STOREY, U. S. ARMY SIGNAL COMMUNICATIONS SECURITY AGENCY: To answer that question, a plan is now under study for the actual maintenance concept for equipment within the Army. It is well realized that the quality and number of equipments that will be sent to the field army are going to be so vast it is going to take a new structure, one that is unlike anything we have at this time. I will then endeavor to get you different information on this question and give it to you at a later time. Thank you.

MR. BERNARD PEAR - SIGNAL CORPS LOGISTICS EVALUATION GROUP: I am from the Signal Corps Logistics Evaluation Group. If you haven't heard of the group before, you'll hear about it before the end of the conference. Now, Mr. Sink, in the beginning of your talk, I became quite perturbed. You see, there is nothing that annoys anyone that has had experience with supply, maintenance, and allied problems as the introduction of a unique system. You see, I handled personally one of the first unique systems. That was radar at the beginning of World War II and it was only a question of time before I had to get out from under, because I found that I was simply marching along the sidelines while everybody else was marching up the main highway. And that's what happens to every unique system. Now you allayed my fears to a considerable extent, toward the end of your talk, when you talked about your coordination with the Equipment Support Agency. That is, of course, the thing to do. You've got to integrate the support of your equipment along with the support of all other Signal Corps equipments because certainly under conditions such as in any future warfare, it will be hard enough to support any one maintenance organization and if we enter it with a log of maintenance organizations, with each one handling a unique system, we won't get off the ground at all. Now, there is one question I would like to ask you and I know it will make me even less popular than I am right now. You showed us the trend of equipment design and, of course, you showed that you are going to increase the very type of equipment which creates the problem of the maintenance technician. Everybody agrees that our big problem is that we can't train enough technicians and maintenance people, and we will probably be able to train fewer in the future. Yet you come along and say you are developing 20 super complex equipments which will require many more maintenance technicians. Now, the question I would like to ask: What effort, if any, has been exerted to avoid the development of supercomplex equipment?

MR. SINK: Thank you for your very well-put question. As I pointed out in the presentation, Signal has inherited several systems all of which were unique. It is our aim to take everything we can away from the unique system and make it part of the Signal Corps. The trend is going that way. I think that it will go more that way in the future. The effort that we are making to become something other than unique is great. It's too late; I will admit that. We hope, in the future, our design aims will take us out of the black box stage and put us so that we are only another component in the communications system. There are developments in that area today but, as I say, they are not with us. We have to live through the transition period.

ORGANIZATIONAL AND FIELD MAINTENANCE IN THE ARMY NATIONAL GUARD

Maj. Elmer L. McGuire
National Guard Bureau

1. Introduction

I will present to you a brief history of the National Guard, the general organization of the National Guard Bureau, the organization for maintenance of all equipment in the Army National Guard, and finally, a maintenance problem.

2. History of the National Guard

This presentation will portray briefly the historical position of the National Guard and the successive steps that resulted in its emergence today as a full-scale partner of the Army and Air Force.

The National Guard is organized under the "militia clause" of the constitution, which reads in part:

"The congress shall have power to *** provide organizing, arming, and disciplining, the Militia and for governing such Part of Them as may be employed in the service of the United States, reserving to the States respectively, the appointment of the Officers, and the authority of training the Militia according to the discipline prescribed by Congress ***."

EVOLUTION OF MILITIA SYSTEM

Our militia system, though uniquely American in concept, actually stems from earliest Anglo-Saxon days and has evolved through Colonial times up to present based on our military experience in the Colonial wars and in the Wars of the Republic.

The stockades that protected the early Colonial settlements were garrisoned by the local Militia Company composed of all able-bodied males in ages 16 to 60 years.

As mobile forces were needed for expeditions to harass the Indian and attack him in his strongholds, each local Militia Company was called upon to furnish its proportionate share of young and unencumbered men who would remain in the field for extended periods of time and who were formed into Ranger-type companies called "Trained Bands." These quotas were generally filled by volunteers, but any shortages were supplied from men who were drafted or impressed. This selective draft was not the invention of the Colonists — they were simply using the same device employed by the Saxon King Alfred to provide men for his expeditions against Danish raiders of his day.

These Ranger Companies were grouped into battalions for expeditions against the French and Spanish, just as later was the case with Washington's Continentals of Revolutionary fame.

The distinction of being the oldest National Guard units in the United States with unbroken lineages is shared by the 101st Engineer Battalion and the 182d Infantry Regiment, Massachusetts National Guard. The units trace their history back to October 7, 1636, when the General Court at Boston ordered that all military men in the area were to be formed into militia regiments. Two of these regiments, the North Regiment and the East Regiment, both of which fought in the Revolutionary War, later became the 182d Infantry and 101st Engineers.

The basic and advanced individual training of these frontiersmen was rugged, on the job in nature, and self-assessing. Indian fighting quickly divided them into either the quick or the dead. Though unwilling generally to submit to rigid discipline, Major Robert Rogers demonstrated with his Rangers what capable leadership and effective training could do with this splendid material when enlisted for long service. Lt. Colonel George Washington's "Virginia Regiment," which he trained on the western frontier (presently the 176th Infantry, Virginia National Guard), saved Braddock's veteran red-coated regulars from complete destruction. Note here the magic formula: "Capable leadership and effective training made possible by long service."

The Companies of English yeomen who destroyed the French knights at Crecy with their longbows were ancestor units of those "Trained Bands." Likewise, the New England Militia Companies, which stood up to the British Regulars at Bunker Hill, were worthy descendants, as were Smallwood's 5th Maryland that saved Washington's Army at the Battle of Brooklyn, Andrew Jackson's Tennessee riflemen at New Orleans, and Jefferson Davis' Mississippi Rifles at Buena Vista.

Frederick Funston's Kansas Volunteers in the Philippines; New York's 14th and Brooklyn's 23d, the 118th Palmetto Regiment of South Carolina and the 60th Brigade of North Carolina that smashed the Hindenberg Line in World War I; Virginia's 116th Infantry (The Stonewall Bridge), assaulting Omaha Beach in Normandy; Oklahoma's "Thunderbirds" and California's 40th "Grizzly" Division in Korea. All were successor units to those "Trained Bands," and they portray dramatically the march of George Washington's "Well regulated militia" through the pages of this Nation's history. These were long service militia units, uniformly organized, armed, and equipped, capably led and adequately trained. President Washington described in his "Sentiments on a Peace Establishment:"

> "The Militia of this country must be considered as the palladium of our security, and the first effectual resort in case of hostility;
>
> "It is essential, therefore, that the same system should pervade the whole: That the formation and discipline of the militia of the continent should be absolutely uniform."

The soundness of his thinking is attested by the rapid development of the National Guard since 1916 and by the combat divisions and other units in the National Guard placed in the field in two World Wars and in the Korean Emergency.

In the interval between 1792 and 1900, the Militia received little support, financial or otherwise, from the Federal Government.

As late as the War between the States, Federal support of the Militia was limited to $250,000 annually -- approximately the cost of a single M-48 medium tank!

The National Defense Act of 1916 established the National Guard of the several States, the Organized Militia as it was then termed, for the first time as a component of the Army when in the active military service of the United States.

Section 60 of the National Defense Act of 1916 required that the organization of the National Guard be the same as that prescribed for the Regular Army.

From this Act flowed that uniformity of organization, adequate equipment, effective training, and Federal supervision which Washington and his Generals said were essential to "a well regulated Militia."

FULL PARTNERSHIP WITH ACTIVE FORCES

The worth of the National Guard contribution to our fighting strength in World War I is evidenced by the fact that 17 Divisions served overseas, and that of the eight American Divisions rated Excellent or Superior by the German Supreme Command, six were National Guard Divisions.

In World War II, the National Guard mobilized 18 Divisions and other units with an aggregate strength of 302,000. Of the 280,000 enlisted men, approximately 82,000 or 29% were appointed to commissioned rank. Of all the officers inducted for World War II, nearly 70% were serving in Field Grade at the close of the war.

The late Robert P. Patterson, then Secretary of War, had this to say of the National Guard at the end of World War II:

> "The National Guard took to the field 18 Infantry Divisions-- 300,000 men. Those State troops doubled the strength of the Army at once, and their presence in the field gave the country a sense that it had passed the lowest ebb of its weakness.
>
> "Nine of these Divisions crossed the Atlantic to Europe and Africa, and nine went to the far reaches of the Pacific.
>
> "The soldiers of the Guard fought in every action in which the Army participated from Bataan to Okinawa. They made a brilliant record on every fighting front. They proved once more the value of the trained citizen-soldier."

THE NATIONAL GUARD TODAY

The past World War II National Guard was organized under the provisions of the "Approved War Department Policies of 13 October 1945."

Two missions were assigned:

THE NATIONAL GUARD OF THE UNITED STATES

To provide units of the Reserve Components for the Army, adequately organized, trained and equipped, available for mobilization in the event of national emergency or war, in accordance with the deployment schedule, and capable of participating in combat operations in support of the Army's war plans. This mission may include the defense of critical areas of the United States against attack.

THE NATIONAL GUARD OF THE SEVERAL STATES

To provide sufficient organizations in each State, so trained and equipped as to enable them to function efficiently at existing strength in protections of life and property and preservation of peace, order, and public safety, under competent orders of the State authorities.

National Guard units were allotted to the States under the troop basis established by the Department of the Army to meet War Plan requirements.

Recognition of the present established position of the National Guard in our National defense structure is best appreciated by reading that language which has been repeatedly enacted into law by the Congress.

The following is quoted from current military legislation:

> "The congress further declares, in accordance with our traditional military policy as expressed in the National Defense Act of 1916, as amended, that it is essential that the strength and organization of the National Guard and Air National Guard, as integral parts of the first line of defense of this National be, at all times maintained and assured."

It has consistently and constantly fought for the right to be among the first to fight, which right also has been repeatedly enacted into law by the Congress and I quote:

> "It is the intent of Congress that whenever Congress shall determine that units and organizations are needed for the National Security in excess of those of the regular components of the ground forces and the air forces, the National Guard of the United States, or such parts thereof as may be necessary for a balanced force, shall be ordered into the active military service of the United States and continued therein so long as such necessity exists."

In 1956 the National Guard, Army and Air, attained the greatest strength in its long history (over 1/2 million officers and men), a strength which exceeded the combined active drilling strength of all other reserves of the Armed Forces. National Guard strength is limited from year to year to that number that can be supported by the monies annually appropriated by the Congress.

3. National Guard Bureau (Figure 1)

The keystone in the arch of the National Guard system is the National Guard Bureau, a Special Staff Agency of the Department of the Army and the

Department of the Air Force, specifically created by law to meet the special needs of the National Guard and to foster its development.

It is the duty of the Chief, National Guard Bureau, to advise the Chief of Staff of the Army and the Chief of Staff of the Air Force with respect to the Army National Guard and the Air National Guard.

The National Guard Bureau has evolved from the National Militia Board established in 1908 and the Militia Division, War Department, created in 1916, renamed the Militia Bureau in 1920, and finally redesignated the National Guard Bureau in 1933.

The law has provided since 1921 that a General Officer of the National Guard head the Bureau, and it has further provided since 1950 that 40% of the officers on duty in the National Guard Bureau, below General Officer rank, be National Guard Officers.

The National Guard Bureau consists of a Bureau Overhead, an Army Division, and an Air Force Division. It is unique among staff agencies at the seat of government in that it is a joint agency. As a Bureau of the Department of Army and an Agency of the Department of Air Force, the National Guard Bureau operates in close relationship with the several States, United States Continental Army Command, Continental Armies, and Continental Air Command and its numbered Air Forces on affairs of the Army and Air National Guard. Its mission is to participate in the formulation of and the administration of a program for the development and maintenance of the Army National Guard and the Air National Guard in the several States with the objective of providing trained and equipped units capable of immediate expansion to war strength and available for service in time of war or national emergency.

The major functions of the Bureau in accomplishing its mission apply to both the Army and Air National Guard. Briefly, they are:

Administering and promulgating policies, directives, regulations, and agreements.

Making recommendations.

Initiating proposals for changes in existing laws, policies, plans, regulations, and programs.

Preparing and defending estimates of necessary Federal funds and administering approved budgets.

Preparing and distributing regulations, circulars, and other administrative instructions.

Extending and withdrawing Federal recognition of officers and Warrant Officers.

Assisting the several States in preparation of plans affecting the Organization and location of units.

Extending and withdrawing Federal recognition of units.

Performing administrative functions pertaining to the procurement, supply, maintenance, and accountability of Federal Property.

Being the channel of communications between the Army and Air Force and the several States.

Being the office of record for the Army and Air National Guard not in Federal service.

The National Guard Bureau, Army and Air Force Divisions, are organized along parallel lines, each division having five branches with similar functions. In addition to the Army and Air Force Divisions, there are organized directly under the Chief, National Guard Bureau, four separate offices:

The Legal Advisor, the Information Office, the Administrative Office, and the Policy and Liaison Office.

4. Army Division

The Army Division has five branches--Comptroller, Installations, Logistics, Organization and Training, and Personnel.

5. The Logistics Branch

Actually the Logistics Branch of the Army Division performs the same function for the Army National Guard as do the CONUS Army G-4 and Technical Service sections for the Active Army units.

In the National Guard, the United States Property and Fiscal Officer of each State is the counterpart, in the chain of supply, of the Installations Commander in the Active Army. This officer is on active duty for as long as he holds the position. He is furnished a full-time staff, paid from Federal funds, with which to accomplish his mission.

The Logistics Branch is a functional organization, composed of three sections, namely: Supply, Services, and Maintenance. To enable the several States to accomplish organizational and field maintenance of all technical service equipment--approximately 1 billion, 454 million dollars worth--there are now established 724 Battalion Organizational Maintenance Shops, 59 Combined Field Maintenance Shops, 51 Aviation Maintenance Shops, and 5 Field Training Equipment Concentration Sites.

These shops are manned by Army National Guard Technicians paid from Federal funds. At the time this presentation was prepared, we had 2,573 Organizational Maintenance Technicians, 3,896 Field Maintenance Technicians, and 490 Army Aviation Maintenance Technicians.

The Maintenance Section, National Guard Bureau, with 2 officers and 3 civilians (this includes two clerks), is responsible for an over-all maintenance program, which include some of the following functions:

Development and yearly revision of the Maintenance Technician Criteria, grade structure, and workload factors.

Development of Maintenance Shop Criteria for construction.

Continuous review of maintenance tool and equipment requirements.

Performance of administrative functions pertaining to the maintenance of all Federal property issued to the Army National Guard.

6. Office, The State Maintenance Officer

One of the technicians I previously spoke of is a State Maintenance Officer, one authorized each State. He is a commissioned officer of the Army National Guard occupying a position on the Staff of the State Adjutant General and is technically responsible for the establishment and operation of a State-wide maintenance program (Figure 2).

The State Maintenance Officer is responsible for the efficient operation of: The Combined Field Maintenance Shop or Shops - A Field Maintenance Facility, staffed with Army National Guard technicians and equipped with tools, test, and shop equipment for repair and servicing of all technical service equipment, except Army aircraft, assigned to the Army National Guard.

The Army Aviation Maintenance Shop or Shops - A facility staffed with Army National Guard technicians and equipped with tools, test, and shop equipment for the repair and servicing of Army aircraft assigned to the Army National Guard. The repair and servicing referred to here encompasses Organizational Maintenance, 3d Echelon, and some 4th Echelon.

Field Training Equipment Concentration Sites, if applicable--A facility located at a field training site for the purpose of receiving, maintaining (Organizational and Field), storing, and issuing heavy items of equipment, with related OVM, utilized by the Army National Guard of one or more States during annual Active Duty for training Periods.

The State Maintenance Officer is responsible for giving technical assistance and guidance to the organizational commanders.

7. Combined Field Maintenance Shops (Figure 3)

The organization of our field maintenance shops is simple; it includes:

THE SHOP OFFICE - Serves as the nerve center or headquarters for the entire Combined Field Maintenance Shop operation.

THE AUTOMOTIVE SECTION - Contains those skills necessary to repair all equipment of a type such as Ordnance automotive, Engineer tractors and graders, Signal Corps generators, Transportation Corps boats, Chemical smoke generators, and Quartermaster bath and laundry units, to mention only a few.

THE ARMAMENT SECTION - Parallels any Ordnance Armament Section (that is, Artillery, Small Arms, and Instrument repair).

THE ELECTRONICS SECTION - Is a combination Signal Corps repair shop and an Ordnance Corps electronics repair shop.

THE SERVICES SECTION - Contains those skills and equipment necessary in the Allied Trades to support the Automotive, Armament, and Electronics Section.

8. The Field Training Equipment Concentration Site is organized the same as the Combined Field Maintenance Shop with additional support such as storekeepers.

9. The Army Aviation Shops consist of a shop office and the aircraft and engine repair section. This shop is headed up by a maintenance supervisor and is on the same organizational level as the Combined Field Maintenance Shop superintendent.

The repair of avionics equipment is performed by the electronics section of the Combined Field Maintenance Shop; the density of equipment to be supported in each State will not currently justify a full time avionics technician or the duplication of test equipment at the aviation shop. We are considering the feasibility of maintenance floats in those Aviation Maintenance Shops separated by "X" distances from the Combined Field Maintenance Shops.

10. Maintenance Technicians

The establishment of criteria for maintenance technicians that will satisfy the requirements for the entire United States and Territories is very difficult, considering climates, distances to be traveled by contact teams, facilities, types and densities of equipment, and usage. We are, however, completing a revision of our current criteria through the use of equipment equivalents assigned each major item requiring repair. The definition of an equipment equivalent as extracted from SR 310-30-15 is:

> "One item of equipment within the *** equipment field which is found in the greatest density has been selected as unity. Other items of *** equipment have been assigned a relative fraction or multiple of unity based on the relative man-hours required to repair the average item received as compared to the item assigned unity."

By applying the formula:

$$\frac{\text{Productive Hours Per Man-Month}}{\begin{array}{l}\text{Man-Hours Required}\\ \text{To Repair One}\\ \text{Equipment Equivalent}\end{array} \times \begin{array}{l}\text{Percentage of Equipment}\\ \text{Equivalents Supported that}\\ \text{are Repaired Each Month}\end{array}} = \begin{array}{l}\text{Equipment Equivalents}\\ \text{Supported Per Month}\end{array}$$

We determine the number of equipment equivalents that can be supported per man. With this approach to the manning criteria, we feel that it can be administered in the Bureau with a minimum of effort, can be easily defended, and can be altered to fit any foreseen changes.

11. Problems

Problems--Maintenance Problems? -- Yes!!! We have them.

Actually our problems are no different from those in the Active Army. It is my firm conviction that our primary problem is nothing more or less than organizational maintenance, the heart and soul of any workable maintenance system; if it is effective, equipment will be operationally serviceable and combat ready. If it is deficient, the Army loses part of its ability to move, shoot, and communicate.

Preventive maintenance is not a modern invention. Commanders have always been charged with insuring that both manpower and material are ready and able to accomplish an assigned task. This can be done in only one way--by everlasting interest of every member of the chain of command--in short, by recognizing that maintenance is not the job of the technician, important as he may be, but the job of the Commander.

Junior officers and NCO's are usually willing, yes, even anxious, to do a creditable job if they only know what is wanted and how to achieve it. When faced with the supervision of maintenance, these young commanders too frequently hide their ignorance by pleading that maintenance is technical, requiring trained supervisors. Nothing could be further from the truth. Preventive maintenance is simply hard work--hard work in cleaning and lubrication, hard work in tightening and simple adjustment, and hard work in replacement of minor accessories and assemblies.

Involved technical skills are not required of a commander. Sanitary engineers are not required to supervise and inspect a latrine, nor is a chef necessary to supervise a mess. But in both cases, as is the case with all maintenance activities, the immediate commander must know what is desired and how to inspect for it.

Command at all levels must recognize that maintenance ranks in importance with training and operations. Training, morale, and sound operational plans are worth nothing if weapons and equipment fail in the hour of critical need.

The commander must demand and assure himself that he is getting effective preventive maintenance through active and aggressive command supervision during scheduled maintenance periods. Training and operations must not be emphasized to the detriment of required maintenance.

Now allow us to quickly, mentally review some of our current maintenance regulations and directives. Ah! Yes! Through the flourishing of plenty of paper the commander is led to believe that his equipment is superior. He cannot perform his assigned mission, when in fact the only truck that will move ammunition or the only radio that can go on the air is unsatisfactory, while, only because of properly executed and authenticated sheaves of paper, his other equipment is superior but won't move, shoot, or communicate.

It would, therefore, appear that first we, as technical service representatives, have work to do.

We have to review, discard, and rewrite some of our very old, outdated regulations and directives. The directives for care of today's equipment have been governed largely by past experience with outmoded materiel, e.g., THE WAGON.

It is our job to teach the commanders how to inspect. They will become enthusiastic when they gain confidence.

The U. S. Army Maintenance Board has made tremendous strides forward in those areas just mentioned. I wonder, however, what we can do to help them with this ever-growing problem.

By modernizing our thinking and with the subsequent realistic revision of our directives, I feel we have every right then to insist that a fair share of time be allotted for preventive maintenance, to appear specifically as such on the training schedule and to be properly supervised. I would not be hesitant to recommend it be executed by the numbers.

We must recreate an atmosphere which will encourage the utmost in the performance of maintenance. Above all, the command approach must be realistic.

NATIONAL GUARD BUREAU

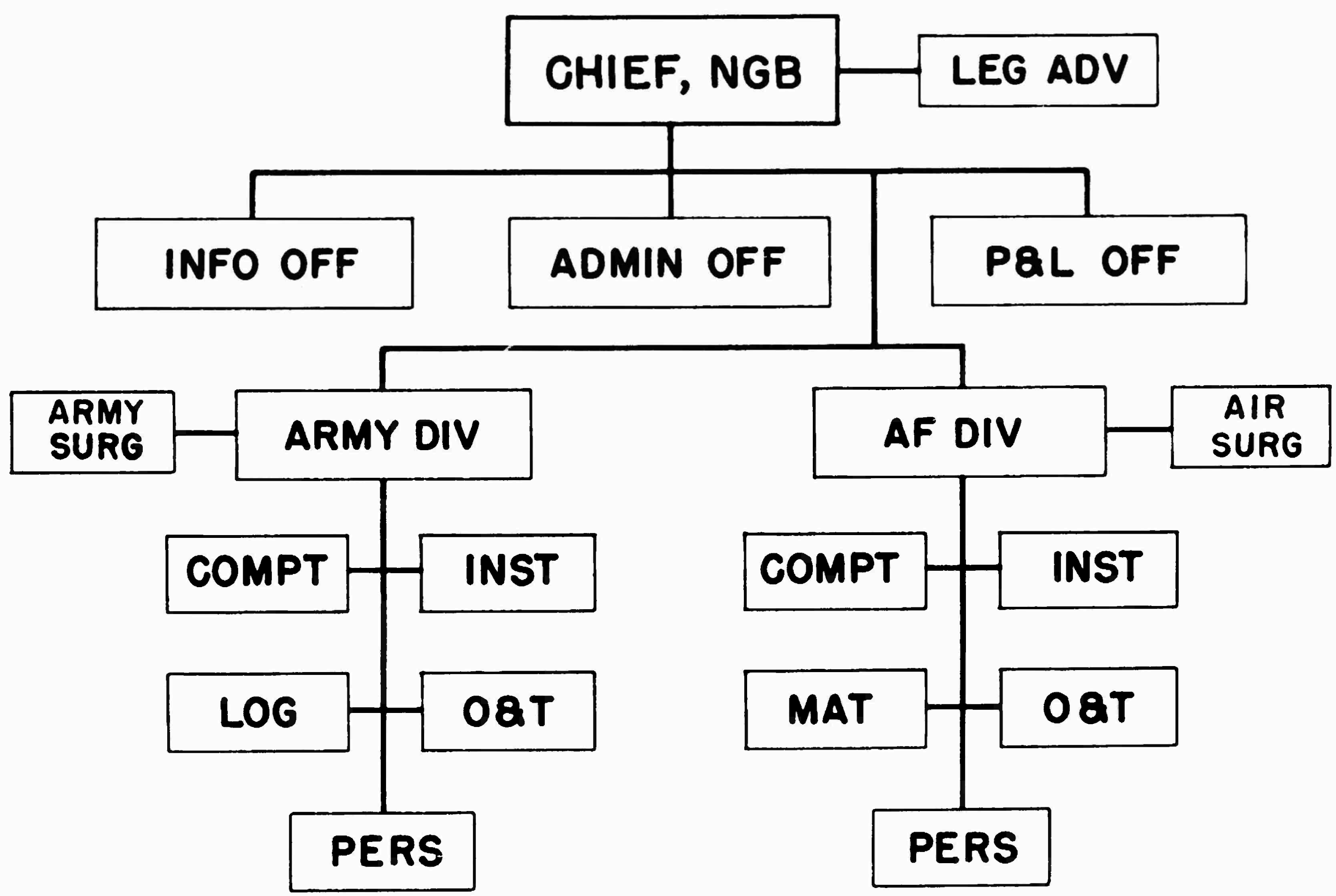


Figure 1

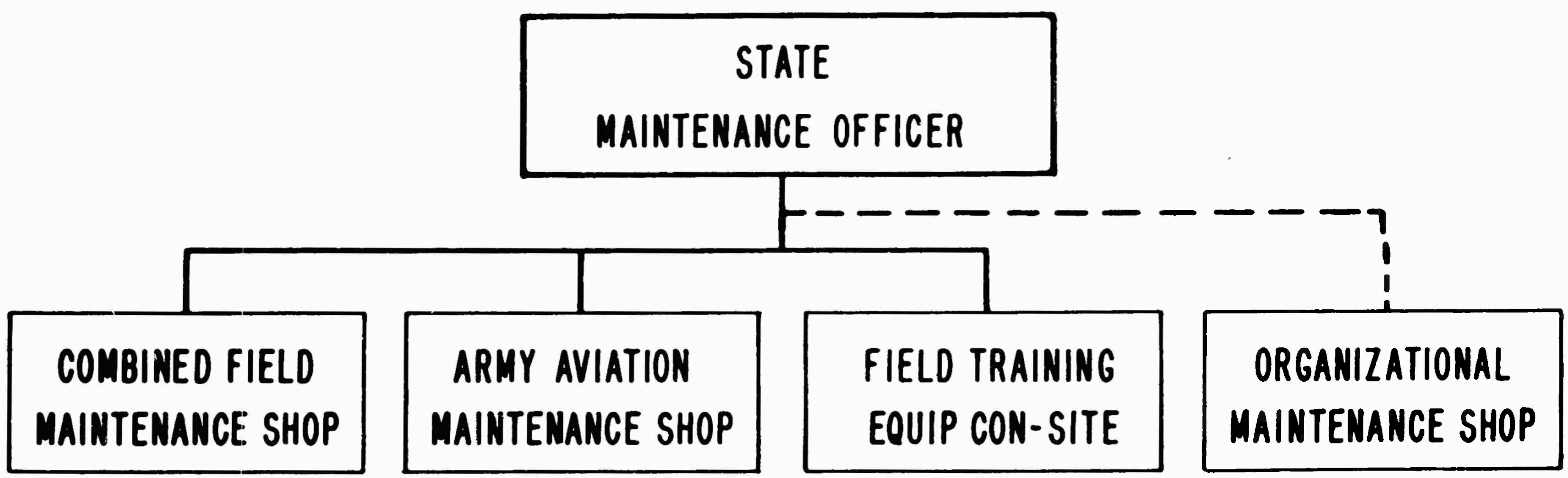

STATE
MAINTENANCE OFFICER
COMBINED FIELD
MAINTENANCE SHOP
ARMY AVIATION
MAINTENANCE SHOP
FIELD TRAINING
EQUIP CON-SITE
ORGANIZATIONAL
MAINTENANCE SHOP

Figure 2

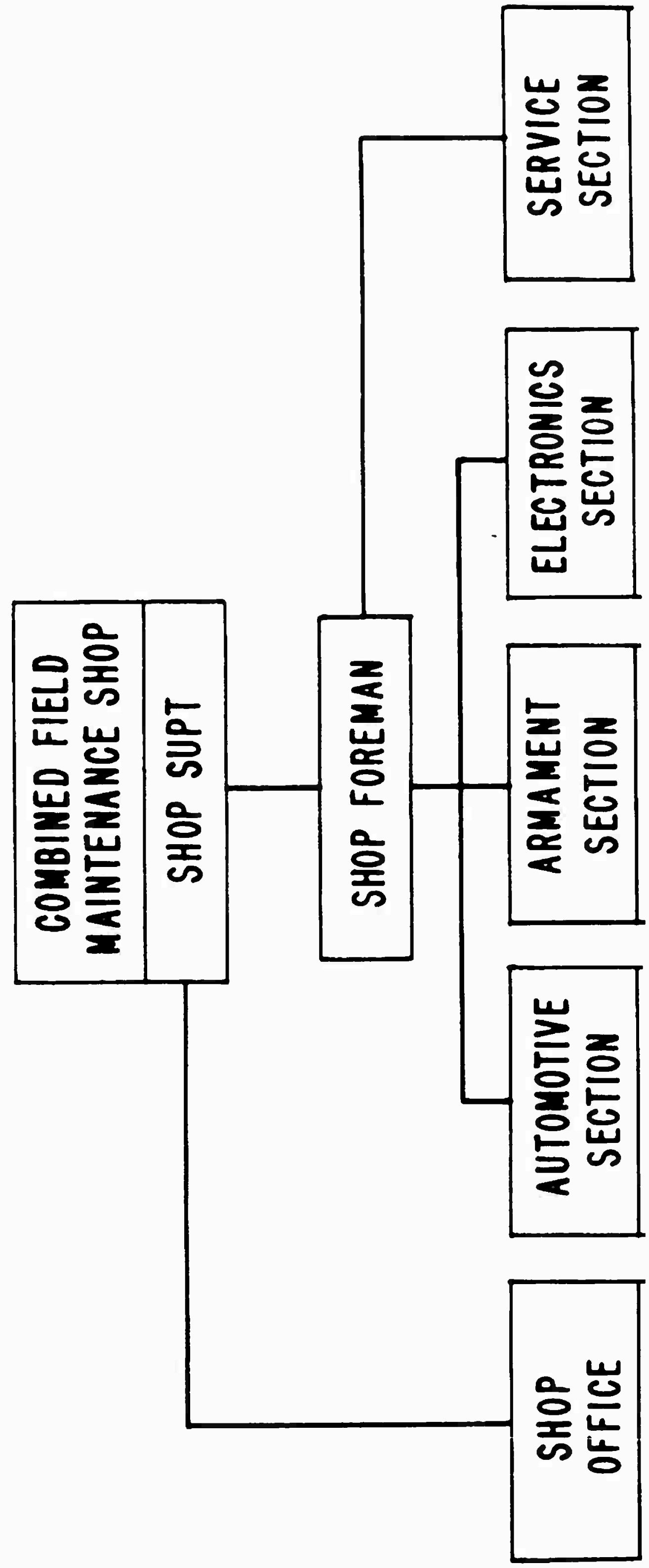

COMBINED FIELD MAINTENANCE SHOP
SHOP SUPT
SHOP FOREMAN
SHOP OFFICE
AUTOMOTIVE SECTION
ARMAMENT SECTION
ELECTRONICS SECTION
SERVICE SECTION

Figure 3

MR. R. MANLY - RAMO-WOOLRIDGE: Major McGuire, do you have available a tabulation of the man-hours required to maintain each equipment? And, how could I get a copy of it?

MAJOR MCGUIRE: Yes, I do have, in some sort of a form. Whereabouts are you located? If you will see me after, I can give you some information on that.

MR. JACOBS - SYLVANIC ELECTRIC: I am curious to know the extent of the equipment equivalents. This seems to be a relatively good measure of the system's complexity, and I was wondering how much success you've had with it. Is there any way in which contractors can evaluate their own equipment for complexity in concerning themselves with reliability measures and maintainability measures?

MAJOR MCGUIRE: As I said in the presentation, we are just now revising our criteria and using this equipment approval approach to the overall development of the criteria. There was in the regulation, or in the special regulation which I referred to, a table of equipments covering some equipment, mostly ordnance. We asked the Signal Corps to give us some assist on equipment equivalents. They were working on it at one time. I have never seen anything, or any change to the regulation which would give us some assist. We brought in some people from the field and maintenance officers and sat down around a table and finally came up with an equivalent for each type of equipment based on what weight that equipment should have. I am sure that it will have to be revised as we get into this program or into this approach of developing our technician criteria. So far as we're concerned it is very very new, and we do not have the criteria in the field as yet.

MAINTENANCE OF ELECTRONIC EQUIPMENT IN COMMERCIAL AIRCRAFT

Morten S. Beyer
Director of Operations and Maintenance Planning
Capital Airlines

Commercial aviation is entering the electronics age -- although certainly it is behind the Military Services, with their guided missiles, early warning devices, and scores of vastly complex weapons depending upon electronics for their control and operation.

The jet aircraft which are being delivered to the airlines today depend to a high degree on electronic control of their engines and flight systems, on Radar, and on radio devices for their navigation. Electronics control the heating, the highly critical pressurization, the fuel flow and mixture, the operation of propellers or variations in jet compressor settings. Electronics are to an increasing degree replacing the manual or hydraulic controls of earlier aircraft due to the need for swift, precise,and complex operations.

Airline Maintenance Departments have moved forward with the technology of the electronics age. Old concepts and procedures required change. Personnel acquired new skills. It is the job of airline maintenance to provide safe, dependable air transportation at a reasonable cost. There can be no compromise with safety -- for as Andre Priester, late Vice President and Chief Engineer of Pan American often said: "Aviation is not inherently dangerous, but like the sea is terribly unforgiving of any carelessness or neglect."

The maintenance department is the largest single department within the airlines, in the case of Capital comprising 2,600 of the company's 7,500 employees. The Department is headed by an Assistant Vice President, reporting to the Vice President of Operations and Maintenance, in whom responsibility for the "production" function of the airline is vested. This organization is desirable in order that both the pilots who use the planes and the men who maintain them are both within the same major department, assuring the maximum responsiveness of each to the needs of the other.

The Maintenance organization is broken down into two major functions: line Maintenance, responsible for the aircraft in their normal daily operation, and Base Maintenance, responsible for major inspections and overhauls. Mechanics and spare parts are stationed at every "overnight" terminal on the airline and at the principal intermediate cities. The Washington base maintenance organization consists of three major departments: Electronics, Engine, and Aircraft Overhaul. Each of these departments is broken down in turn into shops -- such as in the case of the Electronics Department, the Radio, Instrument and Electric Shops, and Radio and Instrument line service. An independent Inspection Department, reporting directly to the Assistant Vice President of Maintenance provides quality control surveillance of the various maintenance activities. Approximately 12% of base maintenance employees are engaged directly with electronics.

There are two major types of maintenance: corrective and developmental. Corrective maintenance is designed to find and rectify malfunctions which occur in service, such as changing a faulty relay. Developmental maintenance seeks to determine the reason the relay malfunctioned and build in a permanent "fix."

The maintenance process depends heavily upon manualization and procedures. When a new electronic device, such as the Collins Integrated Flight System, is installed on our aircraft, the manufacturers' maintenance and overhaul manual is incorporated into our procedures. As experience is gained with the system, changes are made by our personnel. We have generally found manufacturer's procedures to be unduly complex and time-consuming and have, therefore, developed short-cuts which enable us to get the job done quicker and better.

Maintenance of the aircraft and its systems in the field is accomplished in accordance with the Company's maintenance manuals, again setting forth trouble shooting procedures, specifying tolerance in performance, and prescribing action to be taken in event of malfunction. More and more, aircraft are going to the "Black box" concept, where the field mechanic simply changes the unit and sends it back to the main base for overhaul. Naturally, there are still adjustments in setting made in the field, checks of wiring, and so forth, but the trend is toward quick change of entire units. This has the definite advantage of reducing the time spent in line maintenance and, therefore, minimizing flight delays.

The Job Card is the basic unit of management control of maintenance. A job card is issued to each mechanic every time he performs a maintenance operation -- changing a fuel control unit, or overhauling it. These cards indicate the work done, the time required to perform it, and are signed off by the mechanic and inspector indicating the airworthiness of the completed job. From these cards, the entire structure of management control is built. The job cards are processed to determine manhours worked in each shop and work center, labor costs of work performed, comparisons with standards, production counts, budget compliance, and average manhours required to perform the various operations. The cards are used by production control for assignment of personnel and for maintenance of records of work accomplished and are compiled to ascertain progress on major jobs, such as aircraft overhauls.

Capital Airlines operates a fleet of 100 aircraft: 58 jet-props and 42 piston aircraft, flying a quarter of a million hours a year. We spend four million manhours of labor maintaining this fleet, and advance production planning is obviously essential. A one-year master plan of all major maintenance operations is developed, and this is refined down through the individual shops and work centers in terms of the specific number of governors, master controls, Radar's, VORs, etc., which will be required each week to support the master maintenance plan. These requirements are in turn translated into purchase orders for anticipated repair materials, and into manpower quotas. As more experience is gained with aircraft, maintenance requirements change. As engine life on the Viscount was extended from 1,000 hours to 1,900 hours, engine shop requirements were cut almost in half, while on the other hand, the aging of the aircraft brought on additional metal and electrical work.

Production controls are established to insure that, in each week, the specific shops actually turn out the units which are required to meet schedules. Priorities are set and production quotas varied to meet unforseen needs. A Kardex rack is established for each work center, and production control insures that each man has a full quota of work assigned to him.

Each unit overhaul and maintenance job has a manhour and material standard. Largely based on experience, these standards are set on the normal material and manhour requirement. Production of each shop is then measured weekly against standard. Manpower standards are expressed in terms of "earned hours", and the hours that a shop earns each week based on its production are compared with the actual manpower expenditure. A similar comparison is made for material useage. Deviations in production below standard are followed up by top supervision to determine corrective measures required.

In addition to these techniques, management employs the tools of work simplification and work measurement. Skilled maintenance men observe the operations of mechanics in performing repetitive jobs and devise methods of cutting out unnecessary steps and operations. Over a period of time, improvements of from 25% to 50% can be expected in routine operations.

Quality control in aircraft maintenance is vital. An independent inspection department is provided to oversee the line maintenance and aircraft overhaul function, including the electronic features of this work. In line maintenance, wide use is made of "electronic test jeeps", which can be plugged into the aircraft's systems and provide a functional check of radio, instruments, emergency circuits, and other components while the aircraft is in the hangar. In the overhaul shops, quality control is vested in the individual mechanic, utilizing manualized overhaul procedures and bench checks to determine airworthiness.

A basic feature of quality control is the analysis of failures to determine weak spots and develop fixes. The Electronics Section of the company's Engineering Department works closely with Maintenance and the manufacturers. Units which continue to give unsatisfactory service are discarded and those of better manufacture substituted. Due to the high utilization of commercial aircraft (averaging over 3,000 hours per year) weaknesses of units are quickly apparent, and improvements can be proved out in a short time. Emphasis is placed on rapid accomplishment of required fixes, and it is not uncommon that an entire fleet will be "campaigned" in a matter of days to correct an unsatisfactory situation.

A final quality control measure is time control. Each unit on the aircraft has a time limitation ranging from 1,000 to 10,000 or more hours, after which it must be removed and sent to the overhaul shop. Time limits are extended based on the performance of the unit in service. If failure rates are within control limits, time extensions are granted.

Qualified personnel are essential to quality maintenance and reasonable costs. In the words of Eddie Rickenbacker, founder of Eastern Airlines, "Aviation is not so much a business of machines as of men." The swift advance of electronics has placed a burden on aviation to upgrade the skills of existing employees and procure qualified new personnel. In this regard, the airlines can be grateful to the armed services who today provide the vast bulk of new skilled employees. Others come from trade schools and other branches of industry.

Even the most qualified technician requires constant training to keep up-to-date. The company operates a training department and keeps skilled instructors on duty in the hangars and on roving assignment to the field stations. When new units are introduced, the supervisors and mechanics who will be responsible for them are sent to the manufacturer's facility for thorough instruction in all phases of their operation and maintenance.

Increasing complexity has led to greater specialization. Gone is the "jack of all trades" mechanic. In the shops, one or two men are assigned to overhaul each unit and instrument. In line maintenance, the "black box" concept has tended to ease, rather than increase the skill problem, since only responsibility for removal, installation, and necessary adjustment remain there.

According to an old farmer, "the finest fertilizer in the world is the footprints of the boss." The line supervisor, bossing a shop or work center, is the key man in the management system on whose shoulders rests the burden of actually implementing the planning, procedures, and cost controls of the organization. Among the airlines, the vast bulk of supervisors are drawn directly from the ranks of the mechanics. Training programs in supervisory techniques are of relatively recent origin but are developing rapidly, and one of management's major tasks has been to provide the line supervisor with the technical, planning, personnel relations, and other support which is essential to the performance of his job.

The employees of the airlines -- like almost everyone else these days -- are represented by organized labor. And the supervisors are the first line of management in dealing with the unions. Firmness, fairness, and strict adherence to the union contract are essential. A matter of concern to management is the growth of the "made work" and hardening of the arteries of initiative represented by abuses of the seniority system. Electronic maintenance requires the best brains and special talents that are not necessarily found at the top of a seniority list. With the swift-moving technology of electronics, management must reach out to find and reward the abilities that electronics demands.

The forecasting of future material requirements is one of the thorniest problems faced in aviation. One airline supply man remarked that one year after delivery of a new plane, half of his inventory was obsolete, and the other half out of stock. Several specific steps have been taken by Capital Airlines to minimize this problem:

1. Use of material standards and application of these to the maintenance manual master plan.

2. Insistance that manufacturers establish parts warehouses, and carry the inventory of replacement parts themselves for over-the-counter supply when needed.

3. Establishment of tight specifications for new aircraft and their components, insuring the use of the most proven and dependable systems --

thereby reducing the unforecastable unknowns.

4. Requirement that manufacturers provide warranties on their products and therefore absorb the principal burden of unsatisfactory service.

There has been considerable discussion in our industry, and I imagine among you too, as to the concept of "expendability" or "throw-away" vs overhaul. Each item in the airline inventory is classified either as a "repairable" or "expendable," and we have generally found that there are very few items outside of nuts, bolts, gaskets, wires, and washers which are not "repairable." With the increasing sophistication of electronic units in particular, it is hard to conceive of a device which cannot be repaired more economically than replaced. By the time the engineering and manufacturing skills have brought a unit to the level of perfection required for airline use, a great deal has been invested in it, and the unit is generally too valuable to throw out.

Electronics maintenance has posed a major challenge to management, one which is to a large degree being met satisfactorily. There is increasing concern lest electronics become over-complex. We have seen recently where the highly complex Vanguard missile failed repeatedly, while the less sophisticated but workable Army Redstone succeeded. It is far better in our business to have a simple device which works than a much finer one which does not -- in short, the only thing that counts is the end result.

And this applies to management in general where the test of good management is concrete results expressed in terms of safety, production, cost control, and profit. The importance of maintenance in the over-all management job cannot be under-emphasized, for in both the airlines and the armed services, poor maintenance can immobilize expensive equipment and endanger lives.

As the airlines go forward into the electronics age, they will more and more depend upon you of the Signal Corps and the other branches of the Armed Services who are today doing the pioneering, developing, and de-bugging of the devices which we will use tomorrow. We know and appreciate that your pioneering is paying off in better defense for the people of America today and better air transportation tomorrow.

MR. A. J. FINOCCHI - ITT LABORATORIES: You indicated that you've got about 3000 or 3500 flight hours out of aircraft. Could you estimate what you've done with the craft the other approximately 5000 hours of its yearly use?

MR. BEYER: These 3000 to 3500 hours represent time that the aircraft is actually in the air. We spend at least an equal amount of time getting ready to get into the air. In other words, taking the airplane, putting it on the line, loading the people into it, taxiing out to the end of the runway and that process all through the day, and we spend approximately 1/4 of the airplane's time either in maintenance or getting ready to go into maintenance. In other words, we assign that much time to the maintenance function. We fly approximately 90% of our fleet every day.

COL DRAKE - U. S. ARMY GENERAL DEPOT, PIRMASENS: I would like to know when Capital is going to start meeting connections with Ozark in Chicago?

MR. BEYER: I think that's a loaded question. In that regard, our schedules are based on the average elapsed time that the aircraft is required to perform. We do have problems, and all the other airlines have problems, in meeting connections which are set too tight and under conditions of air traffic control. One of our big problems in one of the areas that electronics is working on but has not yet solved is this problem of permitting aircraft to fly in instrument weather with the same facility that they fly in contact weather, permitting them to come in one after the other without any delay or holding or stacking overhead. We're working toward this goal and making progress, but I wish it were more and I hope it comes a lot faster than it has in the past. I hope that in the future we will always make our connections with Ozark.

QUESTION (UNIDENTIFIED): The bulk of your maintenance is done in the Washington area. I assume that would be comparable to what we call depot maintenance or base maintenance in our system. To what extent do you perform maintenance in the other areas? Is it mainly as far as replacement of little black boxes, or what? And, secondly, along with that, as far as the parts that would be needed for any type of repairs or maintenance in these other areas, is it, again, confined mostly to replacement of components, or how do you work that out with your manufacturers to provide a part for you--a part off the shelf proposition?

MR. BEYER: Regarding the first part of that question, Washington is our depot and it is there that we perform the vast bulk of our maintenance. Our field maintenance is confined solely to parts changing, and we provide the field stations with what experience indicates to be necessary in terms of rotable spare units: starters, generators, tires, wheels, brakes, instruments, radio units, and so forth. The mechanic in the field operates almost entirely as a parts changer, and very often our procedure, when we have a discrepancy or problem, is, if it is at all possible, to fly the airplane to Washington. In event of engine difficulties, for example, all our four-engine aircraft, we ferry them on three engines to Washington in preference to changing that engine in the field, because we can do a better and quicker job and it minimizes the amount of stock that must be maintained. The stock in the field is on our account. We have to buy that from the manufacturer and maintain it. We have similarly in our depot a stock of rotable spare items that are in the shop process. We have to own those.

MR. SAM KIRSCHNER - U. S. ARMY SIGNAL EQUIPMENT SUPPORT AGENCY: What sort of preventive maintenance program do you people have on your electronic equipment?

MR. BEYER: I think you know certainly my feeling that preventive maintenance in electronic equipment is very different. When an engine begins to give you trouble, it tends toward failure with many many signs that this is going to happen. Most electronic units either work or don't work. Our preventive maintenance efforts in electronic units are confined almost entirely to the use of the test jeeps checked out on the system. Of course, we change them if they don't work. But primarily the effort is to analyze each and every failure, each and every premature removal to try and find out what weakness caused the failure and to build in the fix either by strengthening, beefing up, modifying the unit, or if it gives consistent trouble getting a new unit that will provide dependable service.

MR. RAPPAPORT - DCS LOG: You indicated after 24,000 hours of flying time, your maintenance cost equals the initial procurement cost of your aircraft. Can you define what you consider to be your maintenance cost in arriving at that figure?

MR. BEYER: Technically, that's the direct maintenance cost which is labor and materials invested in the maintenance, overhaul, and changing of components on that aircraft in accordance with the Civil Aeronautics Boards accounting system.

LT COL GEORGE BROOKS - SACRAMENTO SIGNAL DEPOT: To what extent does Capital employ interchangeability of parts from one model plane to the other to the next?

MR. BEYER: That's a good question. We do it to the maximum degree practicable in the minds of our engineering department. For example, a lot of our galley equipment, almost all of our radio equipment, and many of our instruments are standardized between aircraft types, and wherever it is possible to standardize, we definitely do so. Of course, where the model of the aircraft changes many of the dimensions change. It's not possible to get all of the standardization. For example, wheels and tires. Every airplane takes a different size, although we'd save a great deal of money if we had all of them use the same size. But, in the electronic area, especially, it has been possible to do a good deal of standardization when we make modifications. We modify our Viscounts to put in much the same material that we have in the constellations and DC-4s, and subsequently we have gone the other way and made changes in the 4s and constellations to utilize some of the similar equipments used in the Viscount. It saves a great deal in money, time, trouble, maintenance familiarity, and so forth.

MR. W. KRAMER - U. S. ARMY SIGNAL SUPPLY AGENCY: Would you explain -- in repairing the black boxes, which are returned for repair, do you maintain an inventory of parts to perform this maintenance? Do you have an arrangement with the equipment supplier to maintain an inventory for you, or do you have some method of contract overhaul? This is with the electronic-type boxes.

MR. BEYER: We generally maintain a sufficient supply of spare parts within our shops to overhaul the normal flow of units, whether black boxes or otherwise. For the major items, low-use items, unusual items, peak requirements, and so forth, we would look to the manufacturer. In the case of the Viscount, Vickers warehouse stocks not only the aircraft parts, but also the parts for most of the components that are on the aircraft. We do not, nor do I think the majority of commercial airlines, utilize contract services. We do as much of it ourselves as we can. This is because we are primarily in the business of flying airplanes and maintaining them as part of that process, and certainly would not necessarily be comparable with the military activity. There are cases however, when we have an aircraft which is of an unusual type -- we only have a couple of them. We've considered, for example, for the C46s, and DC6Bs contracting the maintenance out rather than maintaining the spare parts stock and going through all the maintenance training and proficiency and tooling that would be required to build up, to maintain the aircraft. We judge the question of whether to contract or not to contract basically on the needs of our service and capabilities.

SIGNAL MAINTENANCE IN SUAREUR

CWO-W4 Roy L. Albright
U. S. Army Communications Zone, Europe

1. Signal Maintenance in USAREUR, General.

a. Although the title of this presentation is "Signal Maintenance in USAREUR" and the term USAREUR literally means United States Army, Europe, we shall necessarily include in this discussion Signal maintenance in the European Theatre insofar as the support elements are concerned.

b. Basically, our greatest area of involvement is Seventh Army in Germany, units directly under control of Hq USAREUR, Com Z support units in France, and the US Army Forces in Italy known as SETAF.

c. Seventh Army in Germany is organized for maintenance along conventional lines, utilizing semi-fixed field maintenance shops supported by an Army depot. The Army depot does both "repair and return," and repair for return to Army depot stock.

d. The area commands in Germany are under direct control of USAREUR. These area commands have no tactical function; they are housekeeping type support units, and their fixed field maintenance shops have no Army support mission.

e. Com Z, a support organization, operates fixed field maintenance shops which support Com Z units located in France.

f. Superimposed upon the geographical areas occupied by Seventh Army, area commands and Com Z, we find the 4th Signal Group which operates the long-lines Signal communications systems and provide their own organizational and field maintenance.

g. SETAF is more or less autonomous with respect to organizational and field maintenance, including retrofit of their aircraft at the present time.

h. Technical assistance to Seventh Army, area commands, Com Z and SETAF is provided by our station liaison office in Orleans, with branch offices in Germany.

i. Com Z, with headquarters in Orleans, France, and Supply Control Center at suburban Maison Fort, is charged with logistical responsibility for this rather far-flung area. In order to provide necessary support, Com Z operates three depots: two in France (Saumur and Verdun) and one in Germany (Pirmasens). At the present time, Col. Joseph Bent at USAREUR Headquarters in Heidelberg is the USAREUR Signal Officer's chief of support activities. Col. Arthur L. Baker is Com Z Signal Officer. Col. Charles H. Phipps is Signal Supply Officer with combined responsibility for supply and maintenance. Maj. Richard S. Bush is Maintenance Officer on the staff of the Signal Supply Officer. Col. Joseph Ahern is Chief, Signal Supply Control Agency.

j. In addition to the maintenance organization above, Com Z has the added responsibility of providing maintenance support for EUCOM, SHAPE, and to a limited degree, NATO. An additional workload not common to CONUS depots is direct responsibility for surveillance and repair of Signal equipment in Ordnance Depot stock and in Ordnance vehicles undergoing overhaul.

2. Maintenance Problems Peculiar to the Field Army.

a. Factors which adversely affect Signal maintenance in the field army in Europe might be summarized as:

(1) Extremely wide dispersion of units over the area. This impedes supervision, technical assistance, and delivery and return of equipment, particularly during the long winters common to the area. The high usage rate on maneuvers and field training greatly increases the generation rate of unserviceable equipment.

(2) Another adverse factor has been the frequent re-organizations effected within the last few years. These reorganizations, plus the high usage rate, parts shortages, bad weather, short term enlistments, and other factors, have caused an average of 2-1/2 million dollars worth of unserviceable stock to be returned to Com Z depots each quarter of the year.

b. Technical ability is a factor. Recently, Signal equipment has been rapidly increasing in complexity. This, plus the wide variety of equipment entering field shops, requires a high degree of technical knowledge by warrant officers and senior NCO's in charge of the shops. Many of these people have not been given advanced technical training such as is available from RCA, Philco, CREI, and similar institutions. Consideration should be given to providing this type training prior to their overseas assignment.

3. Composite Direct Support Maintenance.

a. The next portion of our discussion deals with Signal maintenance under the "Composite Direct Support Unit" concept.

b. In preparation of this paper, we encountered the terms ROTAD, ROCID and ROCAD. These abbreviations were found to have the following definitions:

ROTAD - Reorganization of the Airborne Division

ROCAD - Reorganization of the Current Armored Division

ROCID - Reorganization of the Current Infantry Division

c. The foregoing three types of reorganized fighting units have been involved in the presumption that organization must fit the type of warfare to be encountered. Thus the pentomic division, as we know it today, must be a highly mobile, fast moving striking force capable of operation over extremely broad areas. This latter factor has tremendously increased communications requirements and communications equipment problems.

d. In order to support properly this fast-moving type of warfare one of the prime problems is a Signal Corps responsibility: that is, development of dependable, light-weight communications equipment which requires little or no maintenance in the forward areas. Such equipment is now under development. Unfortunately, the newest types of items now reaching the theatre require more, rather than less, maintenance in both forward and rear areas.

e. In planning the streamlined striking force, it was recognized that there are two distinct groups of individuals within the division, those who fight and those who support the fighting.

f. The ROCID unit we will discuss was organized with two basic tenets in mind:

(1) That the communications equipment to be used under this type organization will be ruggedized with maintenance primarily by replacing plug-in units.

(2) The supporting personnel will be grouped into a single organization.

g. Within USAREUR, the 24th Infantry Division was given the mission to conduct a test of "Composite Direct Support Concept" using organic personnel and equipment. This division has its headquarters, three battle groups, and all service troops organized under the ROCID concept. The remaining two battle groups were organized under ROTAD, thus giving the division an airborne capacility. This capability has been recently assigned to another division.

h. The mission and basic thought behind the proposed operational plan was directed to the following areas:

(1) Relieve tactical commanders of all possible logistical responsibilities.

(2) Centralize control of supply and maintenance and thus provide staff and commanders one agency with which to deal.

(3) Maximum use of available transportation.

(4) Efficient use of supply and maintenance personnel and equipment.

i. Significant changes have been effected within the organizational structure of the ROCID division in order to facilitate the operation of the Consolidated Direct Support Unit. The second echelon maintenance responsibilities for Ordnance, Signal, and Engineer equipment in the battle groups, the composite artillery battalion, and engineer battalion have been transferred to the company commander of the forward support company of the Ordnance battalion. This shift in responsibility has been accomplished by transferring the maintenance personnel and equipment of these units to the control of the Forward Support company platoon leader, giving Ordnance platoon leaders capability and responsibility for performance of organizational maintenance on Ordnance and Signal equipment as well as field maintenance of Ordnance material. Other units in the division, to include the tank battalion, the Transportation battalion, light artillery, division trains and the armored cavalry battalion, have retained their organic Signal maintenance capability as prescribed by TO/E. Signal field maintenance responsibility as well as personnel and equipment have been transferred from the division Signal Battalion to the Division Maintenance Office.

j. To implement the test, Division Trains was organized as follows:

(1) The role of the Trains commander includes the functions of the Support Group Commander in the ROTAD division. In the ROTAD division he is the logistical operator rather than a tactical commander. In the present organization, the Trains commander is a tactical commander and is responsible for all logistical support for the division. The division G-4 is the planner, policy maker, and coordinator. The relationship of the Trains commander with G-4 should be similar to that of a battle group commander and the G-3.

(2) A division Logistical Operations Center, commanded by a lieutenant colonel, has been organized to coordinate and control at a central location all supplies and maintenance.

(3) The division Maintenance Officer is responsible for field maintenance of Ordnance, Signal, and Engineer equipment, as well as supply of spare parts for all technical services except Quartermaster. He is also responsible for the second echelon maintenance of Ordnance, Signal, and Engineer equipment for the battle groups, engineer battalion, the Signal battalion, and the composite artillery battalion and all major items, including division maintenance float.

(4) Unit commanders retain first echelon maintenance responsibility.

(5) The division supply officer is responsible for division technical service supply and maintenance activities.

k. There are nine mobile Signal Corps repair shop vans M-185 authorized the division which are to be employed as follows:

(1) One with each battle group, totaling five.

(2) The remainder are to be based near the division headquarters complex. Their assignments are:

(a) radar and radio

(b) radio, radio relay, carrier

(c) radio, avionic and photo

(d) general maintenance, plus teletype and crypto.

l. With reference to organization for supply, the division operates through a single DSU. This is, in fact, five separate stock control units since it was found necessary, early in the test, to segregate stock cards by technical service. Approximately 700 line items are currently stocked at the DSU. The Army Signal Officer has advised that the number of line items stocked compares favorably with other divisions but notes that the proportion of end items stocked in this division is higher than in the others. It also appears that a larger maintenance float will be required to support this type organization.

m. It is emphasized that tests of the new maintenance concept have not been completed; therefore a qualitative analysis will not be attempted at this time. It was observed that a number of factors exist which will render qualitative analysis difficult. These are:

(1) The division is operating in garrison rather than under actual or simulated atomic warfare conditions.

(2) The division is not equipped with the authorized M-185 shop vans which are essential to this type maintenance.

(3) Because of funding limitations it was necessary in the early winter, to suspend ordering all repair parts except for deadlined items.

(4) The types of equipment now in hands of the troops require a tremendous amount of maintenance in both forward and rear areas. Furthermore, in some cases, this equipment is over ten years old.

n. No doubt a number of questions will arise which will have to be resolved prior to adoption of this or any changed method of operation. One of the questions which seems pertinent to this observer is how the Ordnance Officer who may have little or no technical training in electronics will evaluate the degree of proficiency of the repair personnel, particularly the platoon leaders in the forward areas, since these people are trained by Signal. This is particularly pertinent since the Division Signal Officer has no maintenance responsibility under this operational concept.

4. Radiac Instrument Calibration.

a. This is a relatively new enterprise for signal maintenance. We have approached the problems and solutions with a great deal of caution and, I might add, little know-how. We anticipate that before the end of FY-60 we shall have upwards of 10,000 radiac instruments in the theatre scattered over Germany, France, and Italy.

b. Excluding dosimeters, the adopted types of instruments with which we are concerned are the AN/PDR-27, AN/PDR-39, and the IM-108. All of these are gamma ray indicating instruments. In order to provide an alpha detecting capability, we have received a quantity of commercial type instruments known as JUNO. Also an interim CONUS-supplied gamma instrument in the theatre is the CVD-720. We also will use a German-manufactured gamma meter known as the "6109". The latter three types will be used in limited quantities only.

c. The big problem facing Signal is calibration. Since we require radio-active material for calibration, numerous safety precautions must be applied. AEC and the Surgeon General are constantly increasing their surveillance over radio-active materials to insure that no hazard exists.

d. In order to establish our calibration facilities, we have recently employed a physicist with extensive experience in calibration of these instruments. He will supervise our radiac calibration program which will be controlled from the new depot at Saumur. Interim calibration is to be effected by a bank of Chemical Corps M-3 sources. We have recently learned that our application for license for an AN/UDM-1 has been approved by the AEC. This will be our major calibration source. Full use of the AN/UDM-1 will be hampered for a time by lack of a suitable building in which to house the source. We expect to overcome this difficulty.

e. The problem of on-site, go/no-go field calibration of radiac instruments is expected to be solved by the modified TS-784. It is understood a contract for this modification has been awarded to a CONUS firm with delivery expected about 1 July 1959. The problem of licensing and control over this instrument has not been finally resolved. The subject is sensitive, as the TS-784 employs Strontium 90 as the radio-active element.

5. <u>Signal Retrofit of Army Aircraft During FY-60.</u>

a. The Signal retrofit of Army aircraft during FY-60 envisions an increase in the total number of aircraft requiring retrofit, with little change to the basic configuration developed over the past two years. The sporadic increases and decreases are to be leveled off with standardized installations based upon a firm program that has taken into consideration the availability of equipment and the capability of facilities.

b. The lack of equipment which characterized deficiencies of the past has been rectified in most instances.

c. From the standpoint of essential VHF communication in Army aircraft in the European Theatre, probably the outstanding item in FY-59 was completion of retrofit with the ARC type 12 VHF communications. In a similar manner, completion of the FM transceiver AN/ARC-44 retrofit in the L-19 was a noteworthy accomplishment.

d. In the second general type of systems retrofit, the air navigation equipments have been less uniformly installed than is the case with VHF. Fixed wing types L-20, L-23, and U-1A are now equipped with either the AN/ARN-12 or -32 type marker beacon receiver. The same is true of the AN/ARN-30A omni-range receiver.

e. The FY-60 program now being firmed differs from that of FY-59 by these exceptions:

(1) Deletion of the L-19 from any planned retrofit action in FY-60.

(2) Inclusion of the AN/ARC-44 in all models of the L-20, which was not so in FY-59.

(3) Inclusion of the AN/ARN-32 Marker Beacon Receiver in the FY-52 and -54 models of the H-19.

(4) Materially reducing the Type U-1A aircraft retrofit and withholding that portion for the second half of FY-60.

(5) Suspension of any further retrofit action on aircraft type H-13 for FY-60.

(6) Complete elimination of aircraft type H-34A from any retrofit schedule in FY-60.

f. Progress in planning of the equipment needs of the FY-60 program is noted in that definite planning began early at USAREUR Hq as did preparation for implementation at the Com Z level. A very large scope was given to the original plan as given to Com Z in December, 1958. But, some active spear-heading toward solution of equipment and publications problems has obtained concrete results. Coordination of these efforts and steps toward implementation of a program was recently accomplished by a conference in the Signal Division of Hq, Com Z.

g. A shortage of personnel in MOS 824 presents the most serious threat to the program. Since the retrofit mission has been concentrated at the Avionics Center, US Army General Depot, Pirmasens, Germany, the theatre requirements have been programmed and processed through this facility. Even though USAREUR's originally extensive retrofit program for FY-60 is firming into a smaller one, it is still substantial. Use of more than one Army facility, at least to a limited extent, in the ensuing schedules appears feasible, if not even essential, to the assured completion of the fiscal year's retrofit program.

h. The recent progress made in developing a firm program for FY-60 is encouraging. Success will be measured in increased output per dollar invested and a more satisfied customer.

6. Depot Repair of Spiral Four Cable.

a. Spiral-4 cable CX-1065/G now in hands of troops does not lend itself to splicing by vulcanizing methods because of the type of insulation used. Since no approved splice had been developed, we accumulated over 21,000 reels of this cable in USAREUR. The average rate of accumulation in the theatre is about 800 reels per month.

b. Two major problems existed. One was the splice. The other was replacement of the connector at the cable ends. The depot splice finally approved is shown in C1 of TM 11-381. A replacement field-replaceable connector has been developed and is being used.

c. Approximately 60% of the cable on hand was found to be uneconomical to repair and is being eliminated from the system.

d. In order to provide a capability for repair of spiral-4 at the recurring rate of generation, we established repair facilities at the Verdun General Depot.

e. Repair is an expensive operation. We employ 36 people on the actual repair plus additional personnel for handling, screening, and repair of the reels. It is too early to determine true repair cost as training of personnel, development of line techniques, and other factors have distorted the cost picture until the first of February. Experience has shown that replacement of an average of 1.1 connectors per reel is required. First procurement cost for the connectors was $24.00. Subsequent large-scale procurements may be expected to be lower. The final average repair cost per reel, including replacement of connectors, is expected to be about $50-$55.

7. Maintenance Support for New R&D Type Items in The Theatre.

a. A relatively large number of new R&D type items are being introduced into the theatre in this and the next fiscal years.

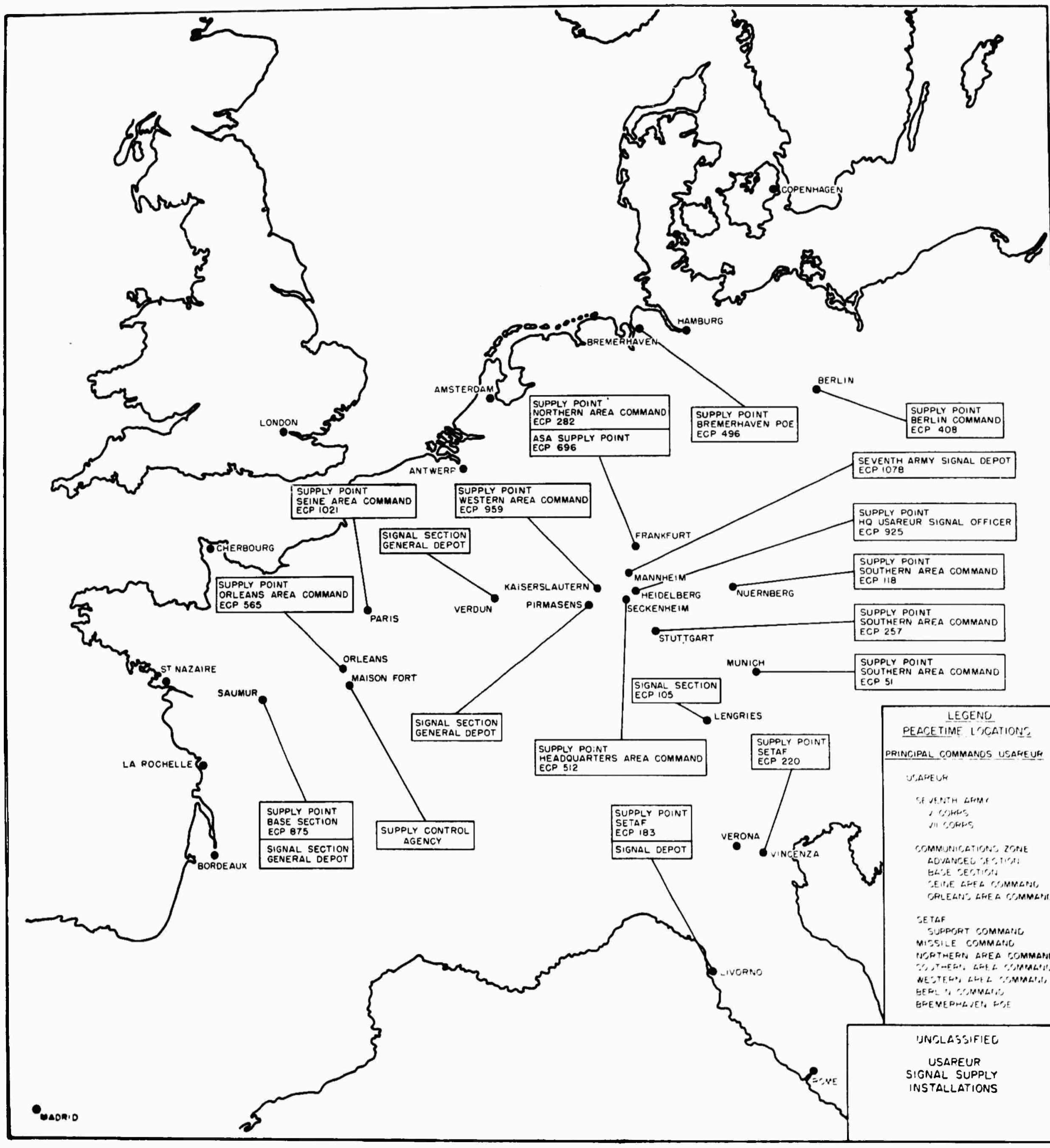
b. These items are relatively complex in nature and have been type-numbered but not standardized. Supply and maintenance support presents a problem.

c. The basic concept of maintenance for these items is that manufacturers representatives will accompany the equipment and perform maintenance on a contract basis for one year or possibly 18 months. After that period of item, if the items are still in the theatre, it is expected that maintenance will become a theatre responsibility. During this interim period, stock numbering and provisioning of parts should be accomplished and usage experience recorded.

d. In order to support this operation, we have established a special ECP account at the Pirmasens Signal Depot.

e. Initially, parts requests will be forwarded through transceivers, bypassing the Com Z Supply Control Agency, to OSANY, thence direct to the designated CONUS supporting depot, who will extract NSN items on the manufacturer of the equipment. The manufacturer will ship direct to the ECP supporting the project.

f. Training of military personnel to support these items is a responsibility of CONUS except for long-range depot maintenance planning. Initiation of training requirements for depot personnel will be a responsibility of Com Z.


COPENHAGEN
HAMBURG
BREMERHAVEN
BERLIN
AMSTERDAM
LONDON
ANTWERP
SUPPLY POINT
NORTHERN AREA COMMAND
ECP 282
ASA SUPPLY POINT
ECP 696
SUPPLY POINT
BREMERHAVEN POE
ECP 496
SUPPLY POINT
BERLIN COMMAND
ECP 408
SEVENTH ARMY SIGNAL DEPOT
ECP 1078
SUPPLY POINT
SEINE AREA COMMAND
ECP 1021
SUPPLY POINT
WESTERN AREA COMMAND
ECP 959
SUPPLY POINT
HQ USAREUR SIGNAL OFFICER
ECP 925
SIGNAL SECTION
GENERAL DEPOT
FRANKFURT
CHERBOURG
SUPPLY POINT
SOUTHERN AREA COMMAND
ECP 118
MANNHEIM
HEIDELBERG
SECKENHEIM
KAISERSLAUTERN
PIRMASENS
VERDUN
NUERNBERG
SUPPLY POINT
ORLEANS AREA COMMAND
ECP 565
PARIS
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MAISON FORT
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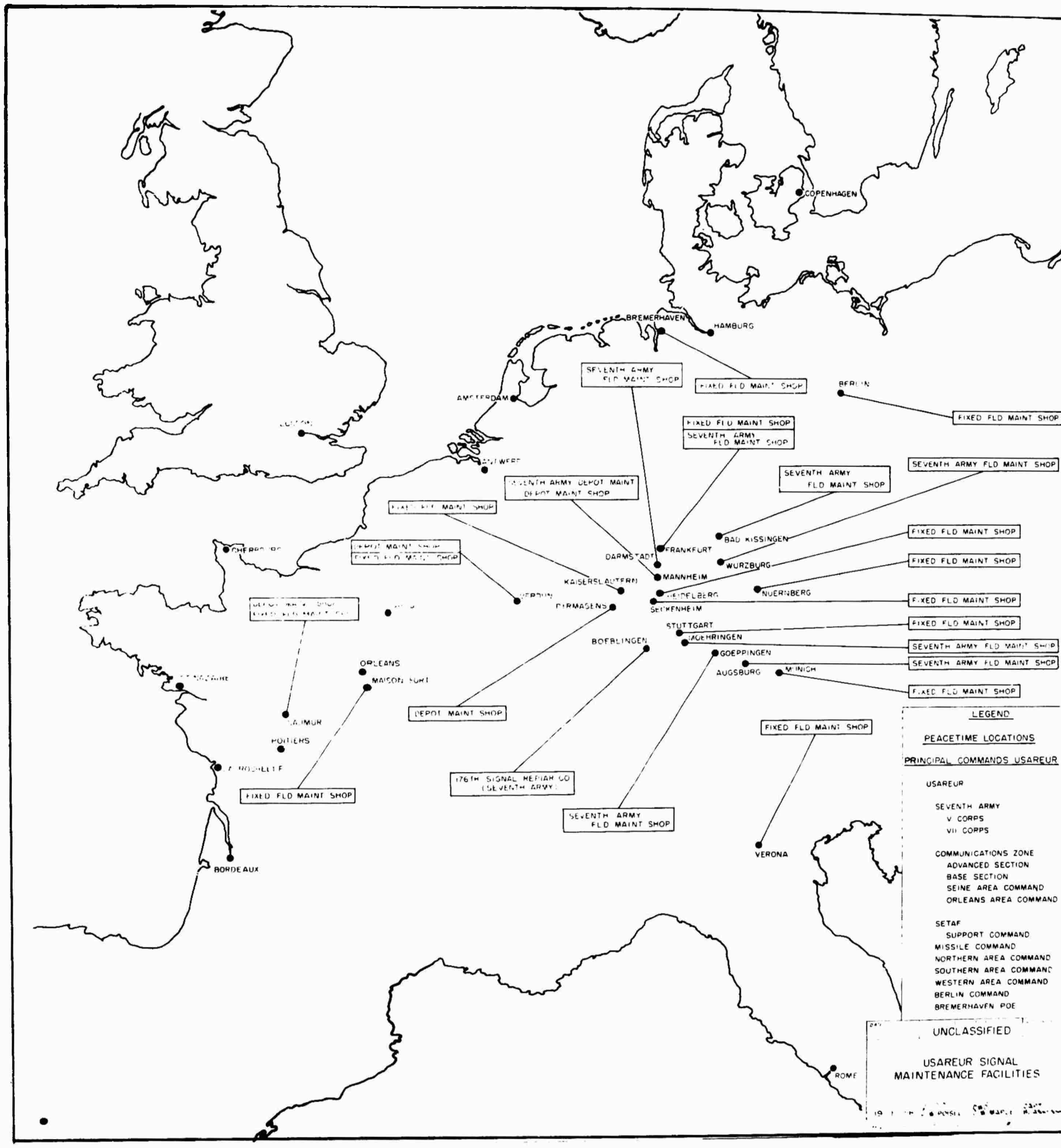
ECP 51
SAUMUR
SIGNAL SECTION
ECP 105
LENGRIES
SIGNAL SECTION
GENERAL DEPOT
SUPPLY POINT
HEADQUARTERS AREA COMMAND
ECP 512
SUPPLY POINT
SETAF
ECP 220
LA ROCHELLE
SUPPLY POINT
BASE SECTION
ECP 875
SIGNAL SECTION
GENERAL DEPOT
SUPPLY CONTROL
AGENCY
SUPPLY POINT
SETAF
ECP 183
SIGNAL DEPOT
VERONA
VINCENZA
BORDEAUX
LIVORNO
ROME
MADRID
LEGEND
PEACETIME LOCATIONS
PRINCIPAL COMMANDS USAREUR
USAREUR
SEVENTH ARMY
V CORPS
VII CORPS
COMMUNICATIONS ZONE
ADVANCED SECTION
BASE SECTION
SEINE AREA COMMAND
ORLEANS AREA COMMAND
SETAF
SUPPORT COMMAND
MISSILE COMMAND
NORTHERN AREA COMMAND
SOUTHERN AREA COMMAND
WESTERN AREA COMMAND
BERLIN COMMAND
BREMERHAVEN POE
UNCLASSIFIED
USAREUR
SIGNAL SUPPLY
INSTALLATIONS



COPENHAGEN
BREMERHAVEN
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SEVENTH ARMY FLD MAINT SHOP
FIXED FLD MAINT SHOP
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DEPOT MAINT SHOP
FIXED FLD MAINT SHOP
FRANKFURT
BAD KISSINGEN
DARMSTADT
MANNHEIM
WURZBURG
KAISERSLAUTERN
NUERNBERG
PIRMASENS
STUTTGART
BOEBLINGEN
GOEPPINGEN
AUGSBURG
ORLEANS
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BASE SECTION
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ORLEANS AREA COMMAND
SETAF
SUPPORT COMMAND
MISSILE COMMAND
NORTHERN AREA COMMAND
WESTERN AREA COMMAND
BERLIN COMMAND
BREMERHAVEN POE
UNCLASSIFIED
USAREUR SIGNAL MAINTENANCE FACILITIES


CABLE END
SEAL NUT
SPRING
COUPLER ASSEMBLY
LOCKWASHER
JACKET
SLEEVES
RETAINING RING
CABLE GRIP
LOCATING WASHER
GASKET
HOUSING
GROUND DISC
CONTACT ASSEMBLY
LOCKWASHER
RING GUIDE
END CAP

MR. A. J. FINOCCHI - ITT LABORATORIES: You estimate that you have 2-1/2-million dollars per quarter of electronic gear returned for repair. Could you possibly estimate what percentage of the outstanding gear in use this represents?

CWO ALBRIGHT: I would prefer not to make an estimate. However, I can state that the anticipated field returns are running approximately 10%. Up until mid-FY 59, we were using a figure of 20% but we found that to be high. It was revised and our present estimate on field returns is 10%. Please keep in mind that all of these field returns are not immediately rescheduled for repair. Some may go to excess, some may prove uneconomical to repair, and for some of them we simply may have no requirement.

CARL SOHLGREN - BENDIX PACIFIC: I have a question of Mr. Albright. What is the major cause of the spiral-4 cable failures?

CWO ALBRIGHT: The major specific cause that I have observed was spiral-4 becoming unserviceable because the users of the spiral-4 kick it off the back end of the truck. Spiral-4 cable is rugged, but unless the connectors on the end of the cable are properly inserted into the cavity on the DR-15 before the reel is removed from the vehicle, the connector will be damaged and, again, the big problem is a matter of supervision, because sprial-4 in its normal use will not become unserviceable for a long period of time. We have the problem, of course, of supervision to prevent the boys from kicking the reel off the back of the truck where it strikes hard and sharp obstacles and obstructions and the reel does become unserviceable. Incidentally, I should like to mention that we have relatively few short circuits in spiral-4. That's a surprising factor to me. When we have trouble, it is one of two things normally: it is a minor breakage of the cable insulation, or it is a complete breakage of all four-wires. We rarely have a case of a short circuit or a single conductor problem.

MR. BERNARD PEAR - SIGNAL CORPS LOGISTICS EVALUATION GROUP: This is intended for Mr. Albright. I was very much interested in your statement that your customer liaison operation is now under COMZ. Now, I recall that approximately 2 years ago it was first started from Pirmasens and, at that time, there was considerable expectation as to its effectiveness because of its being out of the depots. Does that constitute a change? Are you now running it directly from Orleans?

CWO ALBRIGHT: The whole technical existence with the exception of station liaison in France is now supervised and run from the Supply Control Agency at Masonforte.

MR. PEAR: Does that include evaluation of its effectiveness with reference to deadline equipment in 7th Army?

CWO ALBRIGHT: Generally speaking, yes. We do utilize the facilities of the depot engineering divisions for those cases which require engineering assistance or specialized test equipment which is not available to the technical assistant personnel otherwise. When I stated that we were running the program from Masonforte, I did not mean to imply that we had equipped Masonforte with lab equipment or anything of that sort. The boys still utilize the very close cooperation given us by all three of the depots when they have need of engineering and test equipment resources.

MR. PEAR: May I ask another question in this vein? Is there any effort to evaluate the deadlined equipment with reference to its essentiality -- in other words, are all failures to supply considered in the same category or is any effort made, for instance, from Orleans to determine what percentage of supply failures affect what essential equipment? -- What degree of essentiality?

CWO ALBRIGHT: There is an evaluation made which in the past has been based upon the information contained on the periodic field maintenance report. That evaluation has been attempted within our office. We have not had at our disposal all of the information that we have needed. The new field maintenance report described in the new AR 750-15 will provide us with more feeder information from which we can base our exhaustive determination of the specific problems involved. That is a matter, Mr. Pear, which has been given considerable consideration at the COMZ maintenance level within the past several months.

CARL SOHLGREN - BENDIX PACIFIC: Question for Mr. Albright concerning spiral-4. You mentioned that there was a new spiral-4 connector available, and I would like to know if this connector is also available for contractor use now?

CWO ALBRIGHT: The sprial-4 connector to which I made reference was purchased on a single one-time contract. It is a new item in the system. We got most of those connectors in the European Theater since we were the only depot who were doing spiral-4 repair. The initial contract actually called for a larger quantity of the connectors than were actually delivered. I believe the company which was producing these connectors ran into some trouble and my understanding is that a new contract will be necessary to supply the system with the required number of connectors.

COL STANWIX-HAY: In answer to your question, sir. If you would desire to have information on the contractual affairs of the connectors, we would be glad to talk to you at any time, sir.

ENVIRONMENTAL MAINTENANCE PROBLEMS IN USARAL

CWO Howard L. Mayberry
Headquarters, United States Army, Alaska

1. INTRODUCTION:

On behalf of the United States Army, Alaska, I would like to express our appreciation for the opportunity to participate in this symposium. I am certain that our contribution of environmental maintenance problems will afford matter for discussion.

The majority of our maintenance problems are not new. Many of you gentlemen, I am sure, have been confronted with the adverse effects of temperature extremes. The fact that we wear a polar bear patch does not give us a franchise on exclusive cold weather know-how, as there are regions in the Continental United States that experience cold spells more intense for short durations than those prevailing in some areas of Alaska. The environment of USARAL does present various maintenance problems. Some of these we must tolerate, while others we hope to eliminate.

Before proceeding, I should like to familiarize you with some geographical aspects of USARAL (Figure 1). Our operations are staged primarily in two main regions. Here in the Pacific Coast Region, the "banana belt" of Alaska, in the vicinity of Anchorage is located Fort Richardson and Headquarters, USARAL. Also, the U. S. Army Supply and Maintenance Center, Alaska, furnishing logistical support to the command including Yukon Command, Fort Richardson, Fort Greely, Port of Whittier, Wildwood Station, and Shemya. Moving north to the Interior Region, where incidentally, we experience the major portion of our Signal maintenance problems, there is a much more rigorous climate. Here at Ladd Air Force Base is the home of Yukon Command, and one hundred miles southeast from Ladd is located Fort Greely, housing the Army Arctic Test Board and Cold Weather and Mountain Training School. Temperatures in this area vary from 100 degrees Fahrenheit in midsummer to 65 degrees below in winter.

We can expect a higher than normal incidence of failure when equipment is operated under conditions of extreme cold (Figure 2). To limit troubles, all equipment is winterized each year before the advent of cold weather. Winterization is not an involved procedure although failure to follow through in certain simple procedures can cause serious difficulties. Performed at the second and third echelon level, these procedures include inspection of frost shields and gaskets, removal of excessive lubricants and change-over to low temperature lubricants. Hand in hand with maintenance must go adequate training and indoctrination of troops. Without proper usage the winterization program is ineffective and there remains that proverbial ten percent who don't get the word, don't have the time, or just think it isn't necessary. Failures as a result of such omission fall into the category of problems we are prepared to deal with. Technical Assistance, Spot Check, and Command Maintenance Inspections are some tools employed by us to assure a maximum level of winter preparedness.

Condensation, crystallization of amorphic materials, frost, fine blowing snow, and ice fog all contribute to our environmental maintenance problems. To illustrate some of these problem areas, I will discuss some of our difficulties. During the recent exercise "Caribou Creek" whenever equipment exposed to low ambient temperatures was evacuated for field maintenance to the mobile Signal Maintenance Support Team, condensation would develop when such equipment was placed inside the heated shop truck. It was necessary to be sure the equipment was completely dry when it left the shop, or it would freeze up and become damaged when returned to users.

During operations in cold weather a frost shield for the microphone element of Handset H-33/PT is available as a standard item of issue. This shield when properly installed aids in preventing the freezing of microphone elements. We constantly stress to the troops the importance of this frost shield, but every so often an individual will come up with an inoperative handset, simply because he failed to replace a punctured shield. Operators should carry extra shields or improvise by cutting shields from the plastic material used in wrapping dry batteries.

The maintenance of the Interphone AN/VIA-1 installed in Tank M-41 poses another problem (Figures 3 and 4). During fording operations, Cable Reel RL-149 becomes wet and on occasion freezes. Infantry troops desiring communication with the tank commander reach for the handset and start pulling. If the reel is frozen they will exert undue pressure, and the reel unit or the handset may be damaged. Here again troop training is highly important. Coordination between Ordnance, Tank Companies, and Signal Field Maintenance Shops has been effected to inspect, repair, and replace waterproof gaskets and plug drainage holes in the Interphone housing.

The maintenance of Radio Set AN/GRC-26A installed in Armored Personnel Carrier M-59 has presented us with a definite challenge (Figures 5 and 6). At low ambient temperatures, the metal skin of this vehicle becomes cold soaked and the interior looks like the inside of a refrigerator long overdue for a defrosting. Several hours may be required to heat the interior sufficiently to sustain operations. Teletypewriters will either operate erratically or be inoperative until sufficient heat has been generated to cause lubricants stiffened by the cold to loosen bearing surfaces and shafts. Once the inside of the vehicle warms, condensation will form, and care must be taken to prevent freezing of rotating parts when equipment is turned off and the vehicle cools. Shock mounts stiffen in extreme temperatures and subject components to severe mechanical shock during movement over rough terrain. The limited space available within the Armored Personnel Carrier and low ambient temperatures impose a definite hardship on operator and maintenance personnel. Our future plans are for limited replacement of this radio equipment with Radio Set AN/GRC-46. Since the latter is physically smaller, we anticipate at least better maintenance conditions as a result of easier access to components.

A winterization procedure often overlooked is lubricating the magneto of Power Unit PE-75. The fly wheel of this power unit must be removed to gain access to the magneto assembly. Operational failures have resulted because maintenance personnel lacked the information or the initiative to take such action.

Some other areas are: Frozen generators on Telephone EE-8 have been reported. The incidence of this type of failure is very low and is generally traceable to an omission in the unit's winterization program.

Coaxial cables become rigid when wxposed to sub-zero weather and will crack easily (Figures 7 and 8). At such temperatures, insulation is brittle and sudden twists will cause it to snap. This cable must be handled carefully, especially when coiling. Warming also helps. Tape should also be warmed, as it will not adhere properly when frozen.

Cracking of the rubber insulation on Mast Base MP-65 and the problem of the pen heater in Recorder AN/TMQ-5 are problems we have not eliminated. In operation of Radio Set AN/GRC-9 during movement, the weight of the antenna and the stiffness of the mast base result in cracking of the insulation. The pen heater dilemma is a condition almost humorous. When activated for some time the solvent in the ink solution evaporates and the flow of ink ceases. When not activated the ink solution freezes. Here a solution is the solution.

USARAL utilizes both normal and low temperature type of dry batteries. At very low ambient temperatures the capacity of such batteries is materially decreased. Several types of vest type battery packs have been developed, fabricated and tested. Just recently we used one which had been designed by one of our eager young lieutenants. A vest battery pack for Radio Set AN/PRC-10 and Radio Set AN/PRC-6 which is carried under the operator's outer clothing (Figures 9a and b and 10a and b). These vests provide us with longer periods of service before battery replacement becomes necessary. Winter type batteries for Radio Set AN/PRC-10 have recently increased in price from $9.50 to $28.90. This severe price increase has really shaken up the units, as it takes a big bite out of their consumer funds, which are limited. We hope the vest idea will be instrumental in saving many taxpayers' dollars. We are also toying with the idea of using only summer type batteries with the vest. This would result in a savings of $25.03 per battery. There are 175 AN/PRC-10 and 167 AN/PRC-6 radio sets throughout USARAL. Dollar savings over a one year period would be terrific.

PREVENTIVE MAINTENANCE:

Preventive Maintenance, as always, is essential, especially in USARAL where evacuation or repair of disabled equipment is often difficult. One of the obstacles to effective preventive maintenance during sub-zero weather is the absence of suitable facilities. It is indeed difficult to accomplish F-I-T-C-A-L with mittened hands or cold, numb fingers. Under these conditions maintenance is not performed properly and may not be performed at all.

FIELD MAINTENANCE SUPPORT:

As the command is organized into two major areas, Signal Fixed Field Maintenance Shops are established at Fort Richardson and Yukon Command, Fairbanks. Responsibilities in each area are determined by the number of units supported and type of equipment in use. In addition to the tactical equipment support provided, the Signal Field Maintenance Shop at Fort Richardson is also responsible for support of marine electronic equipment installed at Port of Whittier and Port of Anchorage, which includes support of Army Transportation vessels visiting these installations. This shop also serves as a back-up for the Signal Fixed Field Maintenance Shop, Yukon Command. Each Field Maintenance Shop also has the responsibility for issuing Category 200 items to units.

Mobile support is restricted to hard-surfaced roads. Muskeg, streams, and other terrain features present driving hazards and limited support. Normal third and fourth echelon stocks, fast-moving second echelon items, test equipment, and direct exchange components are carried to afford a maximum maintenance capability to field units.

COMMAND GUIDANCE:

The Signal Office, USARAL, exercises command guidance of maintenance activities by means of close and continuous support to field maintenance shops and assigned units. Means employed to insure an effective guidance program are Command Maintenance Inspections, Technical Assistance, Visits to units, and use of a Technical Information Bulletin published to disseminate maintenance and related technical information to all users of Signal equipment.

CONCLUSION:

As I have outlined in the past few moments, most of our environmental maintenance problems are encountered during operations in sub-zero weather. These problems have been solved only by aggressive and determined action to train personnel in proper utilization and preventive maintenance of equipment. We are constantly working to maintain and increase the operational effectiveness of tactical units. Constant command supervision of maintenance activities at all levels is being exercises and has materially contributed to solving some of our problems.

UNITED STATES ARMY, ALASKA

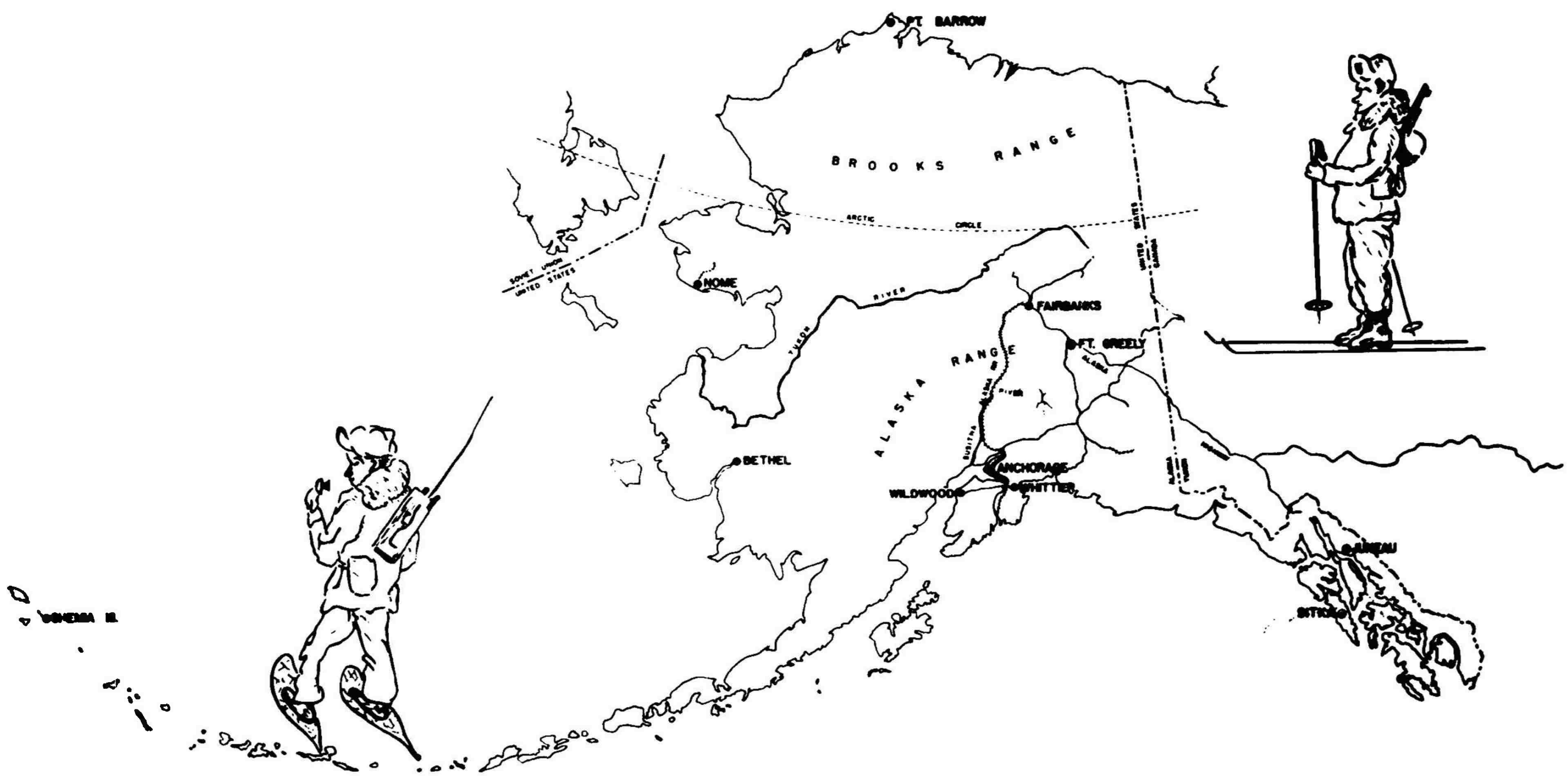

Figure 1

Figure 2

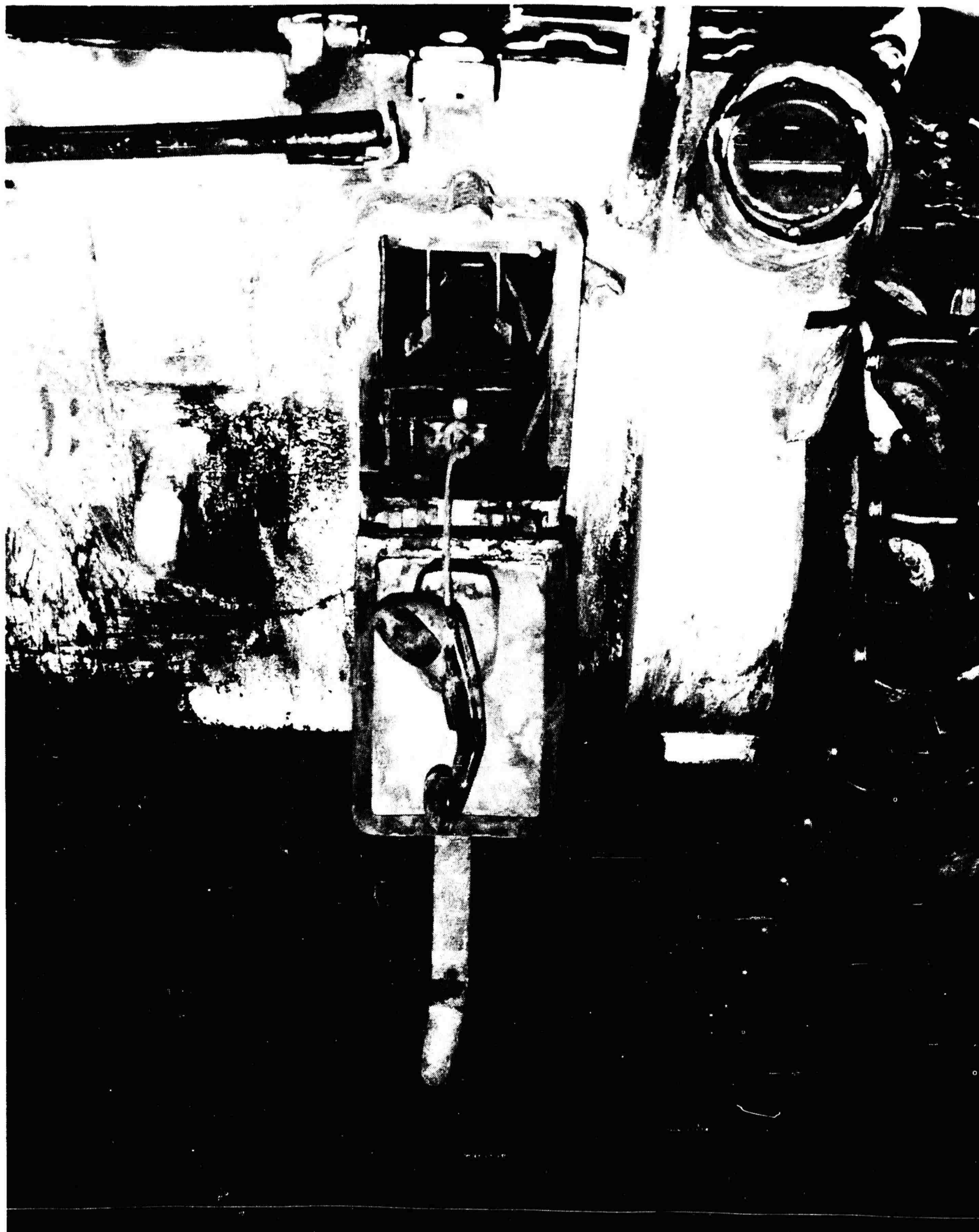

Figure 3

Figure 4

Figure 5

Figure 6

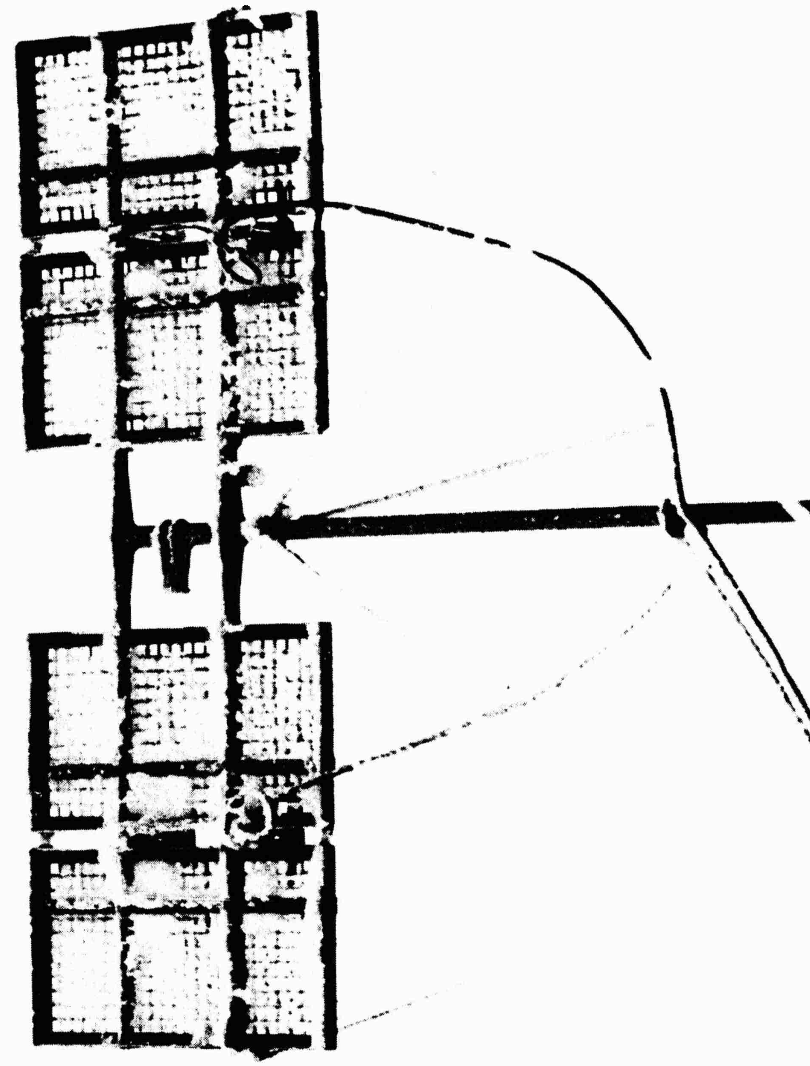

Figure 7

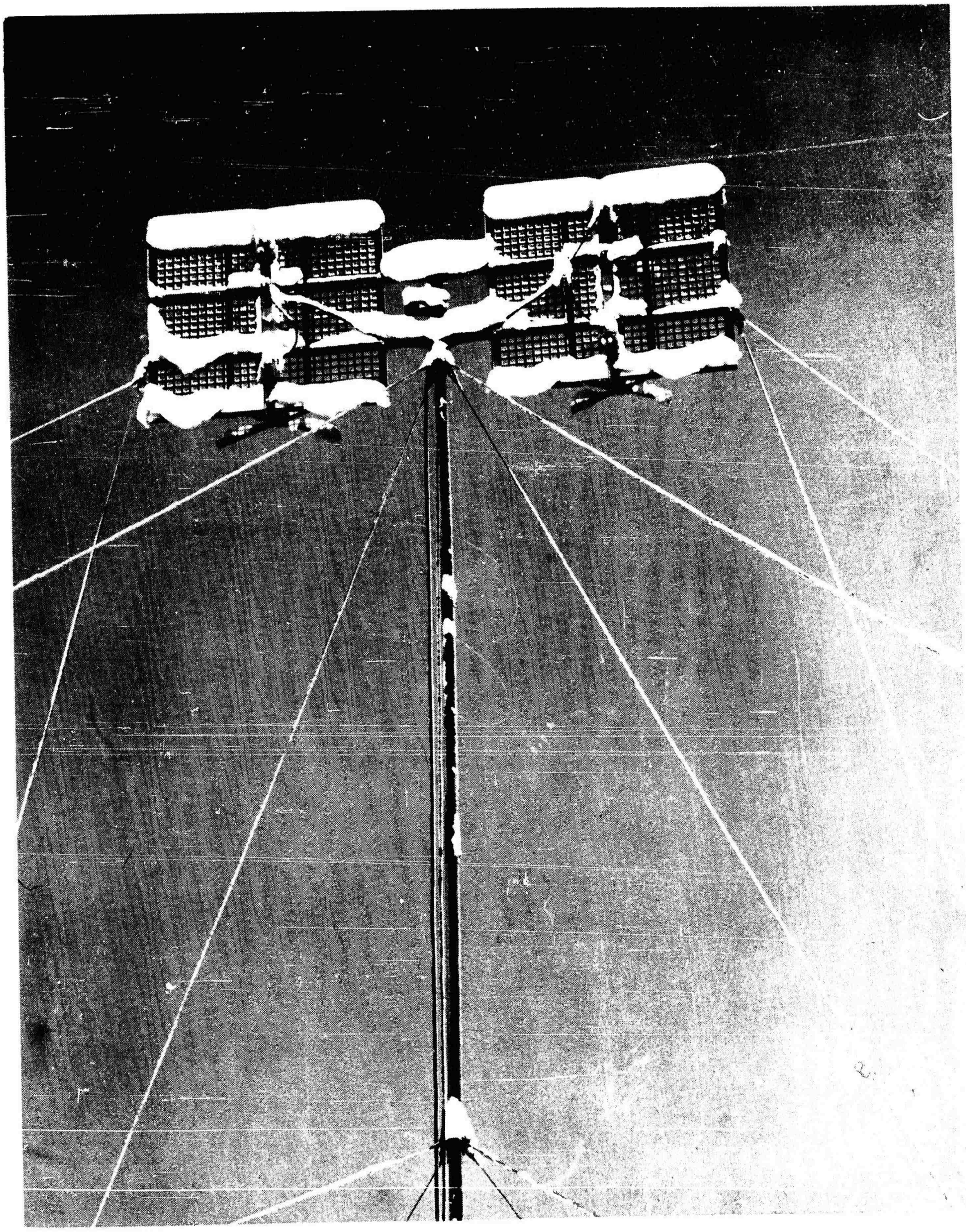

Figure 8

Figure 9a

Figure 9b

Figure 10a

Figure 10b

MR. A. J. FINOCCHI: I have a question for Mr. Mayberry also. Do you notice any tendency for your greases under these temperatures to separate out into oils and soaps?

CWO MAYBERRY: Not too readily, no. Our greases are winter lubs. Once in awhile they do ball up, but I don't know whether that's what you mean by soaps or not.

MR. A. J. FINOCCHI: What I meant was, in opening a new can or a new lub, do you notice that the grease does not appear to be soapy but appears to be separated into an oil and a fat?

CWO MAYBERRY: We have had no problems with that. None has been reported to me. I have not noticed any myself either.

MR. FRANK A. HARTSHORNE - RCA: Have you compiled data or would you hazard to estimate the relative numbers of outages or failures of the equipment during the winter months as contrasted to the summer?

CWO MAYBERRY: Well, the winter months are 7 months of the year and it's hard to estimate. I'd say that we probably get 75% more outages in winter or cold weather months.

MR. HARTSHORNE: I was thinking of this on a normalized basis. In other words -- per month -- do you find you have twice as many failures during these winter months as contrast to a typical summer month?

CWO MAYBERRY: No, it will probably increase for a period of 30 days; we will probably get an increase of 50% of the normal summer-type outages.

MR. HARTSHORNE: If I understood that correctly, you're saying you find about half again as many failures during the typical winter month as during a summer month?

CWO MAYBERRY: That's right. This can be attribited to equipment which is operated outside, like power units; cameras become sluggish, and the PIO people get out to try to take a picture and damage something on the camera. We do have a few more, 50% more, outages during the cold weather months than we do in the summer.

MR. D. IBSON - GE: A question for Mr. Mayberry. There's an increasing tendency to utilize connectors both for cables and replaceable modules having a large number of very small pins. Physical laws of capillary traction would indicate that those could perhaps fill up with water more than larger connectors. Have you worked with such connectors and have you found them to freeze up more than standard ones?

CWO MAYBERRY: We have had no problems with our connectors as such up there. The only problem we have with connectors is on this RF cable. The rubber shrinks away and it pulls the shielding with it from the connector. That's the only connector trouble we've had. I don't believe I've worked with the type which you have mentioned.

SIGNAL MAINTENANCE IN USARCARIB

William C. Kongable
Signal Section
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After attending the Symposium last year and remembering the fine hospitality I received and the information derived from the discussions on world-wide maintenance problems, it is a pleasure to attend again this year.

First, I would like to deliver a message of Greetings and Best Wishes from my Boss-man, Captain Henry G. Smart, known to many of you as "Joe". He regrets that he cannot be here with you and greet all his friends personally. Incidently, Captain Smart, who has been Signal Supply Officer, USARCARIB, and Chief, Signal Supply and Maintenance Division, since August 1956, has just extended his tour with us until June 1960.

The subject of this paper is: Signal maintenance problems in the USARCARIB within a large geographical area, involving many allied nations and widely dispersed facilities.

To help you understand our problems, the numerous and varied missions will be discussed that we, as a Signal Field Maintenance Shop, must support.

It will be seen that the capabilities and skills of our personnel and the facilities of our shops must be more than those normally found in Stateside Post Field Maintenance Shops.

The Missions assigned to the Signal Officer, USARCARIB, include many not found in other Army areas and must be supported by our Field Maintenance Shops. Beside supporting the primary mission of defending the Panama Canal, serving seven Army Posts in the Canal Zone and two training areas in the Republic of Panama, operating facilities for ACAN, command networks and Vanguard, there are other missions of vital importance to the defense and solidarity of the Western Hemisphere.

One is the USARCARIB School in Ft. Gulick, where since 1949, 7,922 students from practically every country in Central and South America and 8,030 United States citizens from Puerto Rico have graduated in some course necessary in the operation of a modern Army, even to cooking and baking.

The Signal Section of the school trains students in the operations, maintenance and repair of all types of Signal equipment used by the armies of the respective countries and of the United States.

To repair the unserviceable equipment generated by the school during an average year requires approximately 3500 man hours in our Signal Field Maintenance Shops. While the school is in progress there is a steady flow into the shops of unserviceable equipment which require immediate repair for the continued operation of the class. However, after the school term is over, in order to be ready for the next group of students, all unserviceable equipment is evacuated to the shops at one time.

Needless to say, the instructors and translators have problems in translating TM's and supply manuals into languages each student can understand.

One of our biggest headaches in maintenance is the tape recorder RD-87/U. Under daily classroom use, by different instructors, this type equipment will not remain serviceable for any length of time, and is constantly being returned to the shops for adjustment of the mechanical mechanism or sound system. It's rather embarrassing to an instructor in a class to have the recorder go out of order in the middle of an important discussion on a technical problem. The need for a sturdier and better-designed piece of equipment is evident by the complaints from other users who must depend on this equipment daily to complete their mission.

The Jungle Warfare Training Center is another mission. Here a company of the 1st Battle Group, trained and skilled in Jungle tactics, indoctrinate newcomers and groups from other branches of the service in the art of jungle warfare and survival under battle conditions. The terrain used in the exercises are typical of the tropics: dense jungle, hills, rivers, cliffs and various wild animals new to most trainees.

Here students are trained to live in and off the jungle, to recognize dangerous or harmless snakes, animals and birds, which ones are edible, and how to prepare them for eating (figure 1). They are taught how to recognize edible or poisonous plants, roots and fruits, and to protect themselves from the elements by building shelters from available materials. During the rainy season everything gets wet and remains wet day and night as does the Signal equipment used in the training.

In the dry season the trade winds blow salt spray over the jungle. The trees retain most of their foliage but all other vegetation dies and brush fires are prevalent. The dense foliage and dampness increase the difficulty of communications during the wet season and during the dry season the salt encrusted foliage also has an effect upon reliable communications.

The Signal equipment used during these training courses soon show their defects and weak points. Leather and canvas articles become soggy and covered with mold in the 99% humidity, fungus collects on plastic and glass objects and ruins many binocular and camera lenses if they are not removed and cleaned regularly. The AN/FRC-10 Radio Sets are always getting damp and the battery cases are always losing their legs. The H-33/PT Handsets lose their usefulness after a few falls down a hillside or into a river, while antennas are soon whipped to pieces by the underbrush. The equipment returned to our shops for repair generally require a complete overhaul and refinishing job after a training course is completed. Speaking of H-33/PT Handsets, the average cost of repairing sets in our shops is above the procurement cost of $8.96. Wouldn't it be more economical to design a better handset that will stand the rough use it must take in the field, or procure more for replacement issue, rather than repair them at above procurement costs?

Our Aviation Electronic shop is located at Howard Air Field, fifteen miles from the main shop, where the facilities are shared by Army and Air Force aircraft. Transportation Corp Aircraft Maintenance Shops are located in the same hangar, which enables us to repair the electronic equipment while the aircraft are being repaired or serviced. The 937th Engineer Co.

(Aviation Section) Operation Center is based in the next hangar.

The 937th was activated in 1952 to provide air support for the Inter-American Geodetic Survey which has been operating in Central and South American countries since April 1946. This unit is engaged in the unique mission of providing aerial support for a collaborative mapping program embracing an area of some eight million square miles, including Mexico and sixteen republics of Central and South America and the Caribbean Archipelago. Helicopter and fixed wing aircraft fly daily throughout Latin America, transporting survey crews, supplies and equipment to remote and otherwise inaccessible mapping areas. Limited landing fields are available in some areas of operation, one is illustrated in figure 2.

This type of flying requires considerable skill and courage. Most of the 937th personnel are graduates of the Army Aviation School at Ft. Rucker, Ala. One can realize that the pilot must have the most dependable and proper type of electronic equipment on these flights.

Of the 42 planes of various types assigned to the 937th, 29 are stationed at eleven Project Headquarters outside of the Canal Zone from Torreon, Mexico, on the north, to Lima, Peru, on the south, and the Dominican Republic on the east in the Caribbean (figure 3).

At the termination of each black line is an IAGS Project Headquarters where all business is transacted and information from mapping stations in that country is received and transmitted to the Canal Zone Headquarters.

A fixed radio station is located at each of these points, usually a BC-610 Transmitter, R-290/URR Receiver and associated equipment.

Each station is in contact with its own mapping stations, who use the AN/GRC-9 radio sets for this purpose and the AN/PRC-10 radio sets for communicating between their line camps.

Aircraft supporting these projects must be able to contact the project headquarters and the mapping stations when delivering supplies and equipment.

The 3500 miles distance between Torreon, Mexico, and Lima, Peru, indicate the scope of our maintenance problem in servicing and inspecting Signal Equipment installed in these aircraft. (Imagine a mechanic being sent from a Kansas City Field Maintenance shop to repair a plane in Los Angeles or Boston.) The aircraft at most of these stations are too far from the Canal Zone to be returned for maintenance at regular intervals. Local facilities and trained personnel or parts are not available to repair the aircraft or radios at these stations.

Each plane is scheduled for SCAMP at the end of three years, and must be returned to the Canal Zone and flown to San Jose, Costa Rica, where rebuild is performed by a civilian contractor. Our electronic equipment is removed and set aside during the rebuild, and then reinstalled and aircraft returned to the Canal Zone for electronic rehabilitation. Facilities are not available in San Jose, Costa Rica, at the present time to overhaul the electronic equipment. A study is being made regarding the maintenance of our radio equipment by the contractor as soon as they move to a newly established airport and qualified electronic repair facilities are made available. As stated before, the 937th supports the IAGS at eleven projects. All communications are in the high frequency range and each project uses the same frequency for reporting to the Canal Zone and a different frequency to receive reports from mapping locations in their respective areas. The aircraft must also operate on those frequencies when stationed with the project or in the Canal Zone. The only 35-watt radio set available to cover this frequency range is a commercial set, manufactured by Sun Air, procured locally and installed under the provisions of AR 750-712. This equipment is operating successfully and maintenance float sets have been made available to replace unserviceable sets at the various project headquarters upon request to our shops. At the present time Army does not have suitable equipment in this frequency for L-19 and H-13 aircraft.

The H-13-H helicopters have just been received equipped with the AN/ARC-44 FM radio which will not net with any station operated by IAGS or on the Canal Zone. The Sun Air Radio is being installed under local command authority in order to support the IAGS.

Five AN/ARC-44 installations have been received for L-19s and are being installed in 20th Infantry and T.C. maintenance float aircraft.

The proposed AN/ARC-39 Radio Set with 10-watt output is not powerful enough for use in the aircraft supporting the IAGS. Because of the mountainous terrain in Central and South America and the distance between radio stations, the aircraft would lose contact with all stations on many flights if using this equipment. While assigned to support the IAGS, the AN/ARC-44 radio sets installed in the 937th aircraft and supporting IAGS are just so much dead weight to carry around.

Four out of ten of the supports for the AN/ARA-31 antenna on the H-13-H helicopters have cracked at the welded clamps. A complete break would allow the broken section to hit the tail propeller with disastrous results. Also on the L-19, there is little hope of the ARA-31 antenna assembly lasting with planes landing on the grass-covered landing strips found in most of the areas supported by the 937th.

The following mock-ups have been received by our shops to date: AN/ARN-6; AN/ARN-12 and AN/ARC-44. Yet to be received are the AN/ARC-21, AN/ARC-30A, AN/ARC-55, AN/ART-34, AN/ASN-13 and J-2 Gyro compass mock-ups.

The sixteen Military Missions located in the capital cities of Latin American countries are an important part of the USARCARIB (figure 4).

Their function is to furnish military advice and assistance in training according to the contract between the United States and the host government. This is provided under "The Military Assistance Program" (MAP) and "Military Assistance Advisory Group" (MAAG). The latter was established for the purpose of determining the allied countries requirements, preparing end-item aid programs, and assisting in training the host government's military forces.

To increase the efficiency of their operations and furnish immediate communications with USARCARIB Headquarters in the event of a local emergency, each Mission has a radio station, installed either in the Mission office building or the home of the Mission Chief, depending on the location in the city, availability of power, and for strategic reasons. Normally they consist of a BC-610 Transmitter, R-390/URR Receiver, locally fabricated Phone Patch facilities, Rotary Beam Antenna and Steel tower if space is available, and an emergency power unit. Each station has its own individual problems of installation, such as power, location of equipment, local regulations, type of buildings, and availability of local labor and supplies. The main problem is power; most of the cities are furnished 220 volts on open transmission lines and with poor voltage regulation; either stepdown auto transformers are needed or an emergency power unit is used.

The installation usually requires two trips by our shop personnel, first to visit the location, draw up plans, check power requirements, materials required, and availability of local labor and supplies. All equipment is then shipped by military mission aircraft as space is made available, and our personnel fly in later to make the installation with the assistance of inexperienced local labor. Each installation presents different technical problems and the installer must be experienced and have the ability to cope with any problem that arises. This is another reason why our maintenance personnel must be more than bench repairmen.

The maintenance of this equipment after installation is a problem not fully solved as yet. To fly a repairman to some of these locations is rather expensive. Usually the personnel assigned to the stations are operators only and do not have the training and experience to perform major repairs on the equipment. Local repairmen are usually not available unless employed by commercial airlines and would work on off-time. One proposal for scheduled maintenance and repair was fifty dollars a month with parts furnished by the mission. This was far above the average maintenance costs on similar equipment in the Canal Zone and was not accepted.

The possibility of combining the maintenance of Military Mission Stations, IAGS Stations and Aircraft electronic equipment under one activity has been studied but a workable plan has not been formed to date.

All other Mission electronic equipment used in the training programs are returned to our shops by air for repair as required, such as projectors, visual aid equipment, cameras, code training sets, and wire and radio communication equipment. One of our reporting problems is that we can never forecast the workload that will be generated by these missions in any one quarter.

Now we are trying to devise a way to collect the density of equipment and quantity of deadlined equipment information required by the proposed revision of AR 750-15. While on the subject of revised AR 750-15, who, in a using organization performing only first and second echelon maintenance, will determine that an item of electronic equipment will require more than four hours to repair in order to classify it as deadlined for reporting purposes?

Another Mission of the Command, coordinated with the Military Missions, is the training of Army personnel of the various Latin American Republics in their own countries in the operation, maintenance, and repair of radar and tactical radio equipment. Teams are sent upon request of the host government for periods of up to ninety days. The problem is to find the persons qualified to instruct in the native language and able to translate all Technical Manuals and supply publications into the simple terms that the average native can understand. The only Spanish publication listed is TM 11-4000 dated 27 September 1946, "Trouble Shooting and Repair of Radio Equipment, " which would not be of much assistance in training on late-type equipment. In order to support this training problem so essential to the defense of the Western Hemisphere, more training aids for bilingual instructors should be made available. Many hours spent in preparation of the lessons by the men assigned to a particular training mission could be saved if they could be furnished lesson plans and TM's in required languages. One of the vital importance is an Operation Manual on proper communication procedures which would enable all the countries to standardize their procedures and eliminate confusion during any future emergency requiring a cooperative action.

These publications must be written in terms and words that would meet the level of education found in the army personnel of the various countries. Many of the military are recruited from rural areas where higher levels of education are not readily available.

We have also had students from the USARCARIB School after graduation sent to our shops for specialized instruction in certain types of tactical equipment. Here again, the need for TM's in their language would help them remember the instructions they received orally after they return home.

The supply of repair parts and delays in procurement of much needed parts for the repair of signal equipment is not a new subject and has been discussed many times in previous meetings. The problem is still with us and becoming larger as new equipment is being added to inventories and new repair parts required to repair them. A supervisor listens to a great many gripes and is asked many questions by his foreman and repairmen. The answers to these questions seem important when production drops and equipment is deadlined due to failure of some simple part not available in the supply system or in local purchase channels.

One question often repeated is: Why do I have to wait hours for a 3¢ to a 15¢ resistor to finish a repair job, fill out a parts request after research in a SIG 7&8, and send it to production control, where a Form 1546 is typed and signed by the supervisor, forwarded to Stock Control to be vouchered, posted to stock record cards and costed, location noted, forwarded to FIA Section for obligation, forwarded to Storage Section for processing and issue from a location within fifty feet of the repairman? All this for a 3¢ to 15¢ item. Seven copies of a requisition are required and nine different persons are involved before an item is issued. How much does that resistor cost before it is finally soldered into place? Why not a stock of commonly used resistors issued in kits similar to hardware kits?

Other questions asked many times. Why are there so many stock numbers, sizes, forms, and tolerances for resistors and capacitors of the same value? Why must there be so many different sizes, threads and finishes of bolts, nuts, and screws used in the assembly of equipment? If a replacement is required, either it must be locally fabricated, a substitute must be used, or we must wait until Ordnance places a requisition on the Z.I. for procurement, since all this type hardware has become their responsibility.

Why must I sign for a TE-113 Tool Set for bench work when I never use two thirds of the tools in the set but must waste time keeping them polished and ready for inspection, which takes plenty of time in this humid climate? Why can't I just draw the tools I need?

Why must we issue, use and repair equipment for which there are no army parts lists or Federal numbers on repair parts? For instance, there is the AN/URC-4, a survival radio set procured by the Air Force and issued by the Army for use in survival kits. Army has a TM; Air Force has a TO Maintenance Parts list, listing manufacturers parts numbers that Air Force Supply cannot identify. The Depot Repair Parts List Index lists a publication #0075 but no publication date. We have forty-six of these sets issued to the Army Aviation units here to maintain. This set must be in every plane at all times, since an aircraft without one crashed in the jungle last October with pilot and crew member only a twenty minute flight from the air base while on a search mission for a missing local plane with five persons aboard. The crashed plane could not be spotted in the dense jungle from the air and the pilot and crew member were not rescued until they made their way to a river three days later and were seen and rescued by a helicopter. No trace has yet been found of the local plane or passengers. So it is very essential that repair parts be available for the AN/URC-4 radio or a radio set be furnished that can be maintained. We also repair many of these radio sets for the Air Force under cross servicing agreement.

When will a SIG 7&8 be available for the AN/ARC-59 Radio Set, (Collins 18S-4A)? There are fifteen of these sets in this command and only a commercial catalog is available for ordering parts at the present time.

Another parts problem here in the USARCARIB is local procurement. In the United States, it is only a matter of picking up a telephone and calling a local store or wholesale agency. Here in Panama and also in every country where we have a Military Mission or IAGS radio station, very few items are available unless common to most commercial receivers or transmitters. At one station, stand off insulators were required. Local dealers did not stock this item, but informed our repairman that Coke bottles were used locally with fine results.

Recently an official interpretation was made of the phrase "local procurement." It has been defined as "off the shelf, in the immediate vicinity." Prices in the Republic of Panama are much higher because of import taxes. The local merchants do not carry a very large inventory of even common items such as 6BE6 electron tube. If the local Procurement Agency makes an attempt to purchase and the dealer is out, the order is cancelled, returned to Signal Supply and must be placed on OSANO. We all know local procurement in CONUS for overseas is slow. It has been found that we can order by air mail from Miami or New Orleans and pay air freight and get the item much cheaper than in Panama and delivery will be made in a matter of days. An exception to the local purchase rules would be ideal for the Canal Zone to permit us to continue to purchase from CONUS sources small items for deadlined equipment.

One problem is the delay between requisitioning time and the final procurement of items listed in SIG 7&8s. For example, five relay SN #5945-540-9353, for the AN/SRC-8AZ were ordered on 8 August 1959. Another was ordered on 13 August 1958, and on 8 December 1958 ten more were ordered. Earliest delivery date promised was 28 February 1959, and the stock number has been changed to 5945-546-9353. During this period, eight out of twelve radio sets installed on T.C. Harbor Craft were inoperative until jury-rig modifications were made by the repairmen.

Last December, the Military Police requested that all AN/VRC-19 radio sets installed in vehicles be realigned. Reception and transmission qualities had become lower and because of the hilly terrain, many more dead spots were encountered while working on different posts. Forty-eight sets were realigned, repaired, and modified with Diode type rectifiers, and operations were returned to normal level. The following parts were found defective and replaced:

108	1AD4 Tubes	2	5840 Tubes
15	2E24 Tubes	4	6AK6 Tubes
6	3B4 Tubes	32	Ballast Tubes
265	5678 Tubes	22	Vibrators
10	5672 Tubes		

During the preceding year repairs and alignment were performed on deadlined equipment only as it was sent to the shops because of shortage of personnel in the shops and operational requirements for all M. P. vehicles.

During the previous twelve months including December the cost of maintaining seventy seven AN/VRC-19 Radio Sets totaled 1,925 manhours and $2,091.00 in parts or an average of 25 manhours and $27.00 parts cost per set. We have no way of comparing these costs with other maintenance shops world-wide. We would be interested in the costs of maintenance of this equipment in other areas.

Two years ago we were told by technicians from USASESA that the new AN/URM-94 Test Set was very essential in aligning and repairing the AN/VRC-19. Special authorization was received from OCSIGO on 30 July 1958. Requisition #DF-636 was placed 12 September 1958. Latest information on delivery is June 1959.

Termites are the scourge of the world, wherever there is wood and a dark place to work. There is a saying in the Tropics that many a building would fall down if the termites quit holding hands or the paint flaked off. They live in trees, in the ground, in houses, in lumber yards, and in anything that has wood products used in manufacture. One type can live in furniture, without moisture, for years, the only indication of their presence being a pile of sawdust on the floor every day, and then one day you discover that the paint is the only thing holding a section of the furniture together. Locally manufactured plywood looks perfect when purchased, but a few months later your homemade piece of furniture is full of pin holes where termites have eaten their way out of the inner layers, even after all the heat and pressure in manufacture.

Even lead covered power or telephone cable makes good chewing for them (figure 5). This high voltage cable exploded after moisture entered through the termite holes. Cable run through ducts or conduit underground or even buried are all subject to the ravages of this pest. Whether it is the insulation under the lead or the lead itself that attracts them is not known, but after eating their way through the lead, they have been found in the insulation. Since paper insulation is used in telephone cable, one theory is that they are after this woodpulp product. Another theory advanced in the case of power cables is that the current passing through the cable sets up a vibration or sound that attracts the termites.

What ever the reason, various methods have been employed to reduce the damage to power cables in ducts and underground. One method is to coat the cable as it is pulled in with creosote compounds, another to sprinkle DDT powder on the compound as it passes into the duct. The ends of the ducts or conduit are sealed with compounds mixed with DDT. Contractors and workmen are warned not to throw any kind of wood into trenches when covering underground cable. It has been found that a cable buried in loose dry shale is more susceptable to attack then one buried in permanently moist earth.

Underground synthetic rubber-covered cable is not impervious to the ravages of the termites (figure 6). No remedy has been found to prevent this except to use other type cable.

Lead coating containing antimony seems to be harder for the termites to penetrate, but it cannot be formed as easily and is more likely to crack and become useless if moved after installation.

The United States Government and the Republic of Panama entered into a treaty in 1955 and one of the provisions of "The Memorandum of Understandings" was that all employees of the United States Government in the Canal Zone be treated equally, regardless of their citizenship.

One point of this memorandum is that every employee will receive the same base pay as every other employee who is doing the same job at the grade and step regardless of citizenship. This applies to every employee in the Canal Zone whether he or she is employed by the Army, Panama Canal Company, Navy, Air Force, or any other United States Government Agency.

This system,called the "Canal Zone Job Evaluation and Pay System," places all "Blue Collar Workers" or craftsmen under a new Manual Category based on the Navy Manual of Definitions of Civilian Ungraded Ratings, NAVEXOS P-1005, and locally developed guides. This category includes ratings and pay levels of M-1 through M-16.

Pay in M-1 through M-10 is based on similar rates of pay for the same level of skill in the Republic of Panama. Pay in the M-11 through M16 is based on the average rates of pay in United States Naval bases for similar levels of skill, plus a 25% overseas differential.

A former journeymen level Radio Installer and Repairer WB-15, pay $3.10 to $3.49, is now rated as a Radio Mechanic M-11 at $2.84 to $3.36 per hour. A former Radio Installer and Repairer WB-17 at $3.20 to $3.60 per hour rates as Electronic Mechanic M 12 at $2.93 to $3.46 per hour. Former WB-18 and WB-19 Radio and Electronic Repairman working on radio, radar, and fixed stations systems are now classified as Electronics Instrument Mechanics M-13 at $3.58 per hour. A citizen of Panama qualified as a journeyman at M-11 would receive $2.04 to $2.39 per hour, which is the U. S. rate of pay less the 25% overseas differential and 10% income tax factor.

A Radio Mechanic (limited) M-8 classified at the locality rate of pay receives 77¢ to 92¢ per hour (a local rate Janitor receives 62¢ per hour).

All Telephone Instrument Repairmen are classified at locality rates of 84¢ to 99¢ per hour.

Teletype Repairer and System Installer WB-17 at $3.20 to $3.60 per hour is classified as Teletype Mechanic at $2.84 to $3.36 per hour.

All positions classified as security positions must be filled by United States citizens and receive United States rates of pay regardless of skill level and pay grade, but below M-11 level very few United States citizens are occupying these jobs at the present time except for security jobs.

In the event of a National Emergency or any trouble with the surrounding country, all of these locality pay scale jobs might be vacated and United States citizen craftsman would not be available to fill these jobs immediately without recruitment from the States. This might be disastrous to National Security.

Due to the complexity of some of the electronic equipment in the Army system it is impossible to hire local citizens as radio mechanics unless it is planned to give them months of training on the equipment that they are required to repair. Their previous training has consisted mainly of correspondence school courses and employment in local commercial radio shops repairing common household Radio Receivers and other equipment no more complicated than a tape recorder.

Some positions of journeymen and journeymen (limited) have been filled by local repairmen for the past four years in our shops as radio repairmen; only one has had the previous training and natural skill and ability to become a journeyman M-11.

Our personnel problems here are similar to those experienced in the United States. We hire an exceptionally good radio repairman, who has the skill, knowledge and ability to perform any job assigned to him, and within a year or two, because he cannot be paid a higher salary, he goes to another government agency where there is a chance for advancement and training.

We recommend from past experiences that applicants for overseas positions should be more carefully screened as to qualifications and that they be informed of all actual living conditions before they are hired. Employees have been sent to us as journeymen who have had no previous experience on Army type of equipment nor worked on any equipment except common receivers or television. Applicants whose only experience has been as operators of radio equipment have had to be returned to the States as unsatisfactory after being hired as station maintenance repairmen.

Performing the many missions assigned to our Signal Shops requires personnel who are skilled in all types of electronic equipment and can be reasonably satisfied with their families living conditions and their own chance of advancement. The missions of our shops require that the repairmen be familiar with every type of old and new Signal Equipment and be able to complete any assigned job without delay. The loss of one step in the pay scale, the family morale factor, and the uncertainty of advancement will have an adverse effect on retaining and recruiting well-trained and experienced technicians in the USARCARIB.

Exercise Banyan Tree was completed on schedule and reported a success in all phases. Thirteen-hundred airborne troops were dropped on schedule (figure 7). Equipment and cargo were dropped or landed successfully in support of the operation. The radio equipment AN/PRC-10s and AN/PRC-6s dropped with the airborne troops were not damaged and operated without trouble during the two-day problem. Their command net equipment also operated perfectly with the exception of an AN/GRC-19, vehicle mounted, because of failure of the generator on the vehicle.

The weather was perfect for the exercise, a high temperature of 92° and a low of 66°. The black globe temperature high was 115° and low was 89°.

The wind speed was 0 mph during the drop and the highest during the two days was 18 mph. However, as this was the dry season in Panama and very little rain had fallen in the past two months, dust was a big problem in the exercise area. Men, vehicles, and equipment were soon coated with the white powdery dust.

Prior to the exercise, our shops installed fourteen AN/VRQ-3 Radio Sets, nine AN/VRC-10 Radios and two AN/GRC-9 Radios in jeeps for the umpires and Staff Section. Also two AN/GRC-10 Radios were installed for the Signal Corps Support Team. Forty-five AN/PRC-10s in station stock were inspected and repaired for issue to the umpires and for maintenance float in the Signal Support Team mobile repair van.

The Signal mobile repair van, with two enlisted radio repairmen were stationed near the Signal Command Post a week before the exercise, repairing equipment for the aggressor and 1st Battle Group.

They were supplied with a maintenance float stock of RT-68 Transceivers PP-112 Power Supplies, AN/PRC-10 and AN/PRC-6 Radio Sets and repair parts necessary to support the above type equipment and components.

During the exercise, direct exchanges were made for defective equipment and repairs were performed in the van. During the two days of the exercise, thirty RT-68 Transceivers, eight PP-112 Power Supplies, four AN/PRC-6 Radios, five AN/PRC-10 Radios and two AN/GRC-9 Radios were repaired by our mobile repair van. This was a very small percentage of the equipment in use under battle conditions.

The RT-68 Transceiver and PP-112 Power Supply in the AN/VRQ-3 Radio Set were exchanged more often than any other items. It is the opinion of those concerned with the problem that voltage loss in the wiring of the mount and controls prevented the keying relays from operating. The AN/VRC 10 Radio Sets operating under the same conditions did not develop any trouble during the entire exercise.

Another trouble experienced with the RT-68 Transceiver was buildup of air pressure in the case during the day while operating in the direct sunlight. To keep the pressure down the TR antenna tuning cover was loosened. This allowed dust to collect in the set, however, and is not considered practical.

No trouble was experienced with the AN/GRC-10 and AN/TRC-24 Radio Sets while operating during the exercise in the field. However, when the air conditioning failed in the Transmitter building in the Canal Zone the AN/TRC-24 there required realignment when the temperature increased rapidly.

Three failures of the heavy duty generators on 3/4-ton trucks, cargo, caused failure of radio communications.

One with AN/GRC-19 Radio Set, unloaded with the airborne troops, failed immediately and the radio was not available during the entire exercise. The second burned up the batteries while an AN/MRC-20 Radio Set was being operated by the Air Force, Air Control Section. The third burned up the batteries while being driven to the Canal Zone. Evidently the voltage regulation is not critical enough to reduce the charging rate when required.

At this date, five days after the exercise, equipment is being received by our shops from the Aggressors and 20th Infantry for repair; final tabulation of repairs generated by the exercise cannot be made, but it has been proven that troops and equipment, dropped after a two thousand-mile, seven-hour airlift and a sudden increase in temperature of 69^{o}, can still perform a successful mission in the defense of our freedom.

Captain Smart has requested that I convey his sincere appreciation to the Procurement and Distribution Division for the excellent support received on Exercise Banyan Tree. Fortunately Signal requirements were made known in sufficient time to requisition from CONUS. Every item requested was received in sufficient time for our shops to make the necessary installations according to schedule and before they were required for the Exercise.

Figure 1

Figure 2

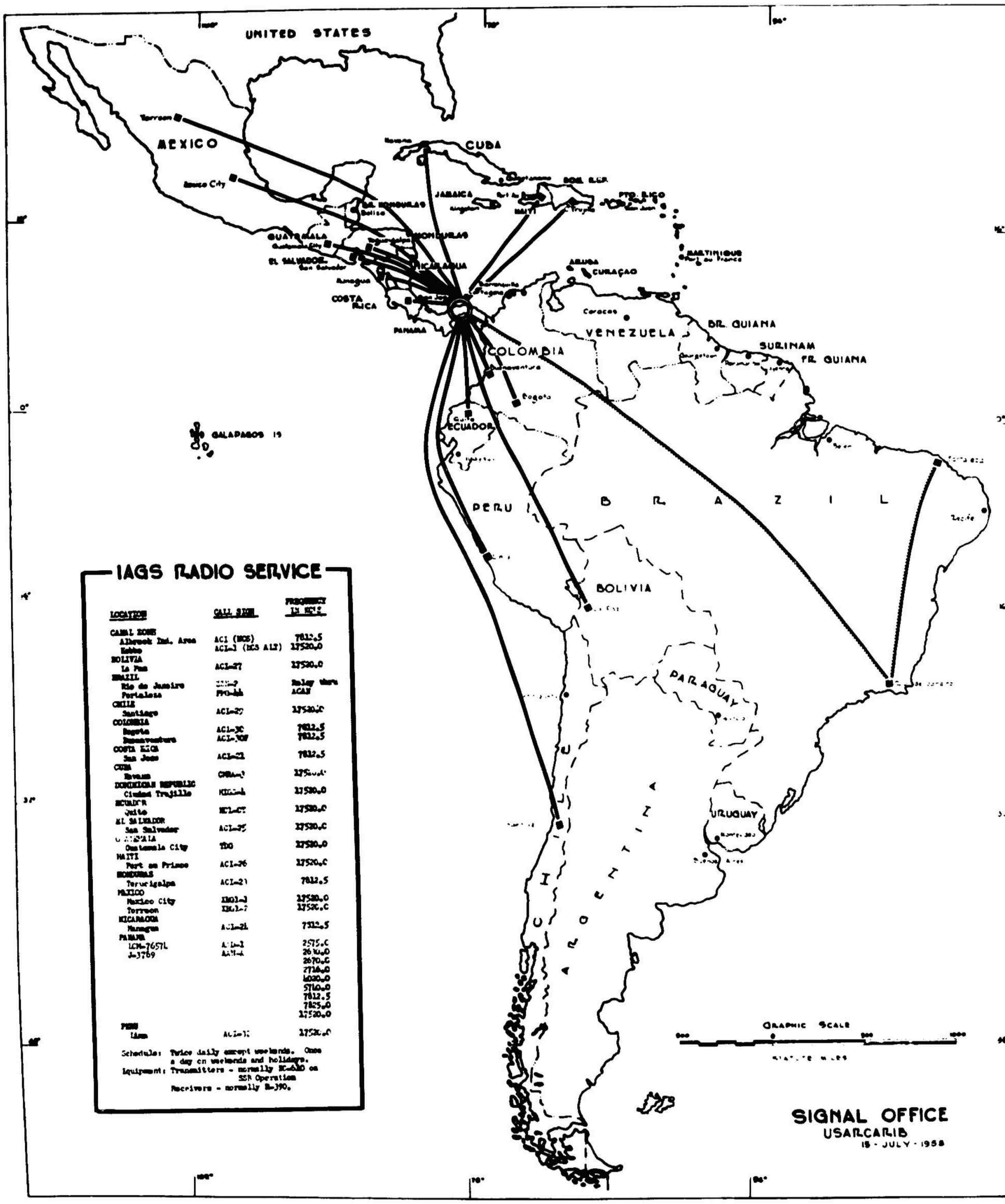
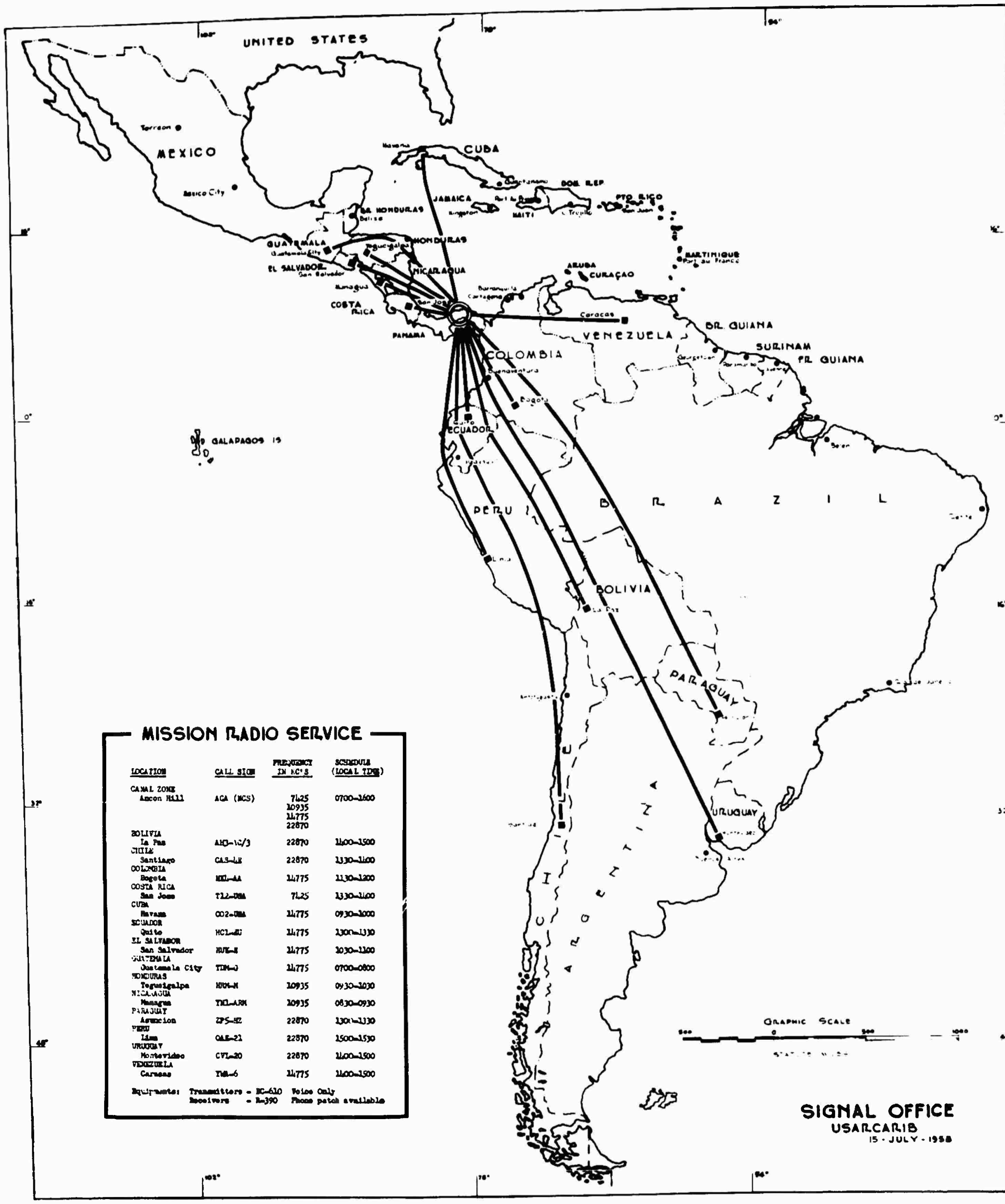

UNITED STATES
MEXICO
Torreon
Mexico City
CUBA
Havana
JAMAICA
BR. HONDURAS
HONDURAS
GUATEMALA
Guatemala City
EL SALVADOR
San Salvador
NICARAGUA
Managua
COSTA RICA
PANAMA
HAITI
DOM. REP.
PTO. RICO
ARUBA
CURAÇAO
MARTINIQUE
VENEZUELA
Caracas
BR. GUIANA
SURINAM
FR. GUIANA
COLOMBIA
Bogota
GALAPAGOS IS
ECUADOR
Quito
PERU
B R A Z I L
BOLIVIA
PARAGUAY
URUGUAY
C H I L E
A R G E N T I N A
GRAPHIC SCALE
STATUTE MILES
IAGS RADIO SERVICE
LOCATION
CALL SIGN
FREQUENCY
CANAL ZONE
Albrook Ind. Area
ACI (NCS)
7812.5
ACI-1 (NCS ALT)
17520.0
BOLIVIA
La Paz
ACI-27
17520.0
BRAZIL
Rio de Janeiro
Fortaleza
CHILE
Santiago
COLOMBIA
Bogota
Buenaventura
ACI-3C
7812.5
7812.5
COSTA RICA
San Jose
7812.5
CUBA
Havana
DOMINICAN REPUBLIC
Ciudad Trujillo
17520.0
ECUADOR
Quito
17520.0
EL SALVADOR
San Salvador
17520.0
GUATEMALA
Guatemala City
TDO
17520.0
HAITI
Port au Prince
ACI-26
17520.0
HONDURAS
Tegucigalpa
7812.5
MEXICO
Mexico City
17520.0
Torreon
17520.0
NICARAGUA
Managua
7812.5
PANAMA
LCM-7657L
J-3769
2575.0
26?0.0
2670.0
2716.0
4020.0
5710.0
7812.5
7825.0
17520.0
PERU
Lima
Schedule: Twice daily except weekends. Once a day on weekends and holidays.
Equipment: Transmitters - normally SSB Operation
Receivers - normally R-390.
SIGNAL OFFICE
USARCARIB
15 - JULY - 1958

Figure 3



MISSION RADIO SERVICE

LOCATION	CALL SIGN	FREQUENCY IN KC'S	SCHEDULE (LOCAL TIME)
CANAL ZONE			
Ancon Hill	ACA (NCS)	7425 10935 14775 22870	0700-1600
BOLIVIA			
La Paz	AHB-1C/3	22870	1400-1500
CHILE			
Santiago	CA3-LE	22870	1330-1400
COLOMBIA			
Bogota	HKL-AA	14775	1130-1200
COSTA RICA			
San Jose	TI2-UMA	7425	1330-1400
CUBA			
Havana	CO2-UMA	14775	0930-1000
ECUADOR			
Quito	HCL-EU	14775	1300-1330
EL SALVADOR			
San Salvador	HUK-E	14775	1030-1100
GUATEMALA			
Guatemala City	TDM-J	14775	0700-0800
HONDURAS			
Tegucigalpa	HRM-N	10935	0930-1030
NICARAGUA			
Managua	YNL-ARM	10935	0830-0930
PARAGUAY			
Asuncion	ZP5-HZ	22870	1300-1330
PERU			
Lima	OAE-21	22870	1500-1530
URUGUAY			
Montevideo	CVL-20	22870	1400-1500
VENEZUELA			
Caracas	YMA-6	14775	1400-1500

Equipments: Transmitters - BC-610 Voice Only
Receivers - R-390 Phone patch available

Figure 4

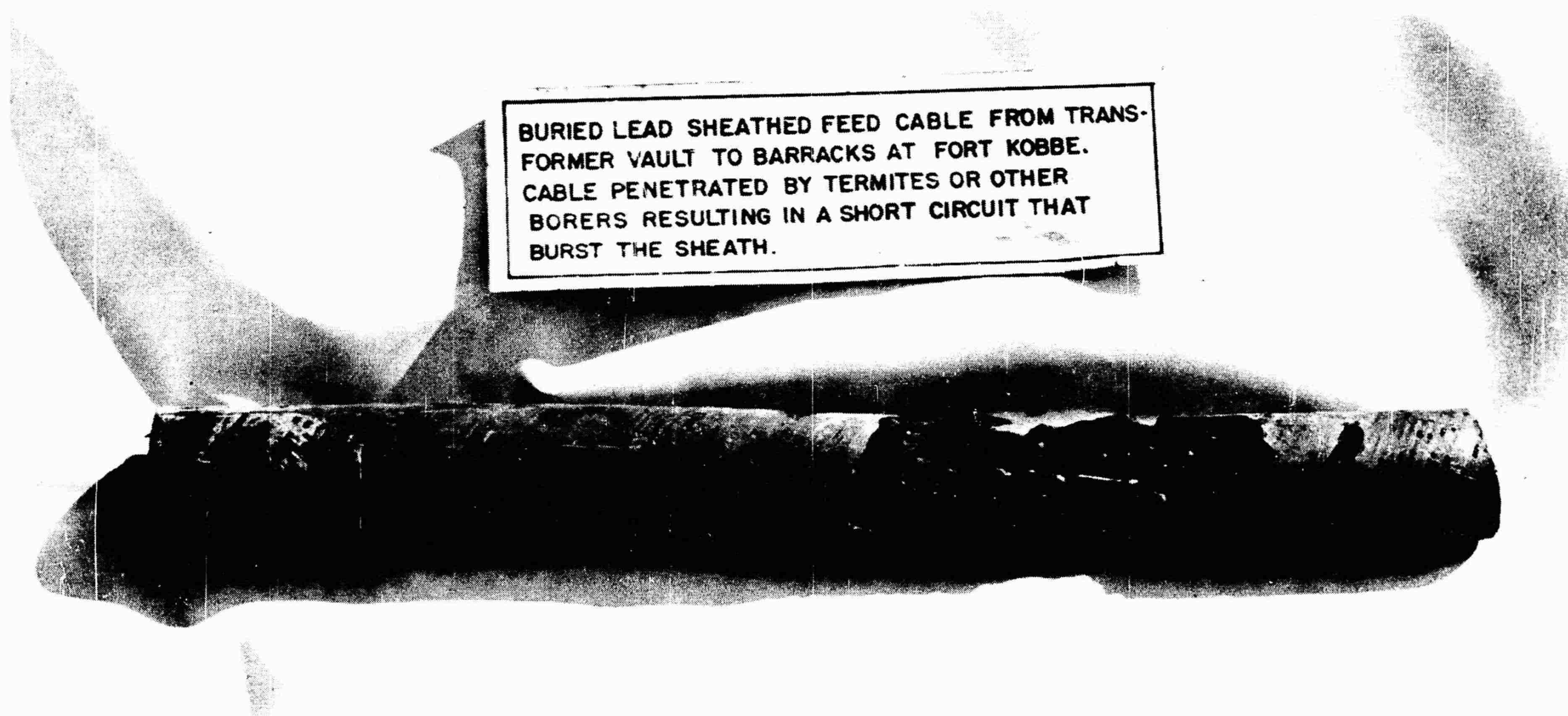

BURIED LEAD SHEATHED FEED CABLE FROM TRANS-
FORMER VAULT TO BARRACKS AT FORT KOBBE.
CABLE PENETRATED BY TERMITES OR OTHER
BORERS RESULTING IN A SHORT CIRCUIT THAT
BURST THE SHEATH.

Figure 5

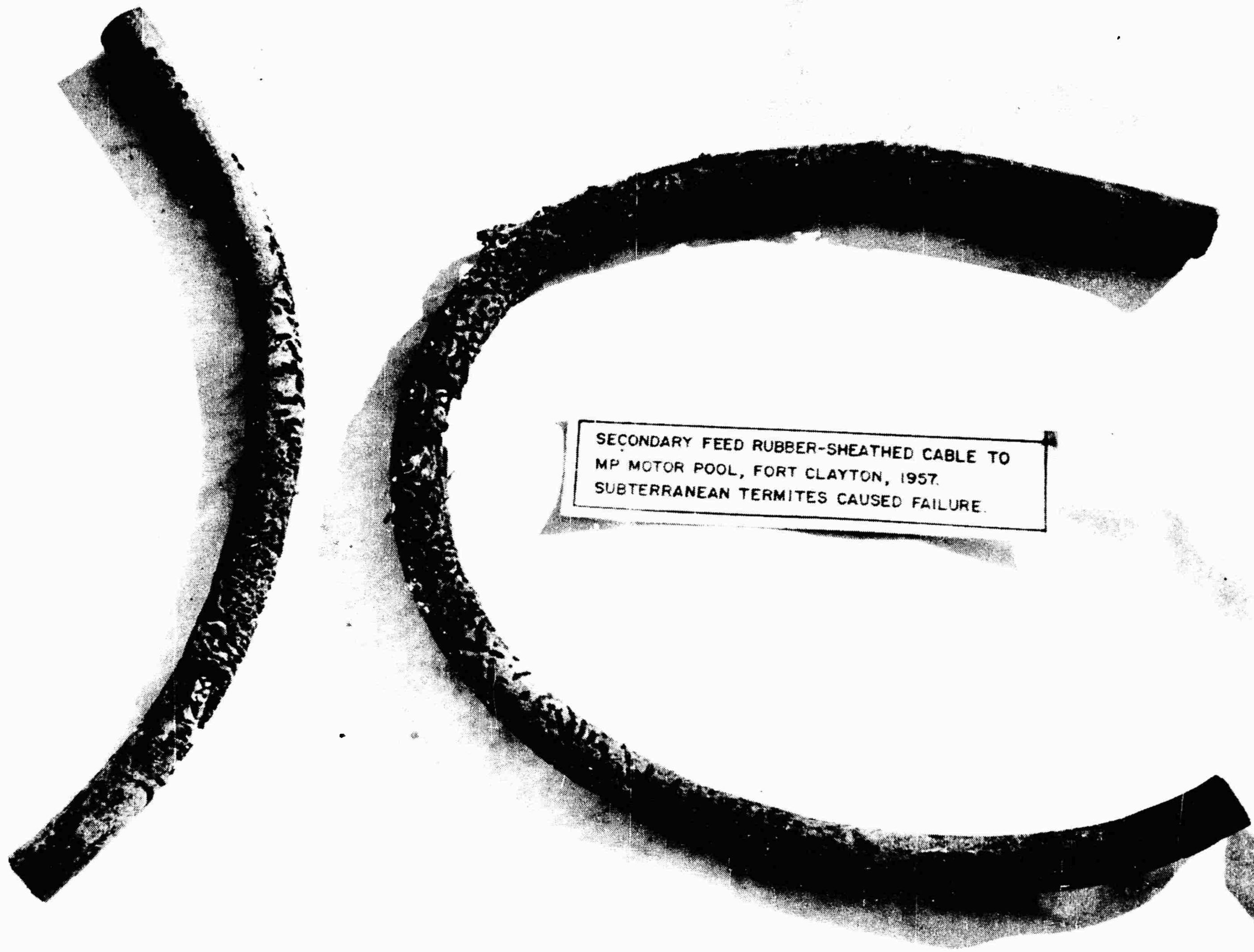

SECONDARY FEED RUBBER-SHEATHED CABLE TO
MP MOTOR POOL, FORT CLAYTON, 1957.
SUBTERRANEAN TERMITES CAUSED FAILURE.

Figure 6

Figure 7

EQUIPMENT SIMPLIFICATION, A VITAL REQUIREMENT TO IMPROVE MAINTAINABILITY

Col. W. B. Latta
Office of Deputy Chief of Staff for Logistics

I was asked to speak on Maintenance Support Planning. I have chosen instead to discuss first things first. As I see it, there is an aspect of Support Planning that we must come to "grips with" if we are to make a really significant advance in maintenance.

In a recent speech Gen. Taylor, The Chief of Staff of the Army said, "that the history of progress of the human race could be measured by our progress in mobility and in communications." If we think back, we can see that progress was exceedingly slow from the time of the Stone Age man to the present century. In the last sixty years, progress has accelerated. In the last fifteen years, the rate of progress has been a dizzy one. This age of scientific break-throughs has seen the introduction of the Jet Age, the Atomic Age, the Space or Missile Age, and the Electronic Age. It has, moreover, witnessed a host of other important inventions that in any other age would have been revolutionary in themselves.

To those of us engaged in maintenance, it has meant that our scientists and engineers have been so busy designing equipments to do things that have never been done before that they have seemingly forgotten about the problems of the people that must keep them working, and so these new equipments have become increasingly complex to maintain. As a friend put it the other day, "we are fast approaching the point where our equipment will require only an idiot to operate the push button, but a genius to maintain it."

This rapid technological advance has also resulted in tremendous demands for logistical support for our complex equipment. Yet on today's atomic battlefield, we need mobility more than ever. The Chief of Staff, General Taylor, has been quoted as saying "Our Army must be able to disperse and hide, and converge and fight. It must be able to shoot, move, and communicate." If we are to attain this concept of mobility, we must reduce our requirements for logistical support. We can no longer afford widespread dumps of parts, heavy stocks of unit spares, and long lines of trunks.

With these thoughts in mind, Lt. General Carter B. Magruder, the Deputy Chief of Staff for Logistics, is personally pushing two policy objectives. These are:

1. To reduce requirements for highly trained technical specialists.

2. To reduce requirements for the numbers of items and logistical tonnages in the Army, particularly in forward combat areas.

We are seeking to attain our first objective, of reducing our need for technical specialists, by simplifying the operation and maintenance of our equipment, and by making our equipment more reliable. The objective of reducing the numbers of items and tonnages in the forward combat area is being sought through technological improvements in our equipment, and through advances in supply and maintenance practices.

The attainment of these two objectives really adds up to improved maintainability in our equipment. The question then is how may the Army attain improved maintainability in a broad program sense rather than individually in specific equipments. In our analysis, we perceived many problems but actually only two principal ones.

First, as we saw it, there has been a lack of balance in the design and development of new equipment, as between performance and maintenance characteristics.

Secondly, there has been an inability to specify what we wanted in maintainability, an inability to specify it in measurable meaningful contractual language. Our inability to measure maintainability has been in part responsible for the lack of balance between performance and maintainability.

As regards the lack of balance, we found that maintenance practice in the past has been to depend on the design engineer to consider ease of maintenance along with a host of performance objectives. Performance was measurable; maintenance was not. The emphasis was on performance. The result was increased performance and generally increased complexity, but not reduced maintenance.

We feel that we have done something about this lack of balance in the past two years. It is imperfect. But it is an important beginning that can be expanded and perfected. It is working better in some technical services than in others. We must inject maintenance influence into design thinking -- to bring maintenance into balance with performance considerations. A formal program has been established for this purpose. The objective is to assure communication between maintenance and design engineers at prescribed intervals during the development of a new equipment. This is called the Specific Review Point Program or Product Review as it is known in the Signal Corps. We realize that formal reviews are not necessarily the most fruitful, but they are a beginning and a necessity. It is hoped that informal continuous contact between reviews will grow from the formal program to be the more general rule.

This Specific Review Point Program is tied to the development cycle of new equipment. I am sure that you are familiar with this cycle, but, for those of you that are not, it may be worth while to briefly review the evolution of new equipment. From new idea to production hardware, a new equipment progresses from a:

Qualitative Materiel Development Objective, to a

Qualitative Materiel Requirement, to

Military Characteristics, to

Technical Characteristics, then through various stages of

Research and Development, to

Service Tests, and into

Production.

Maintenance influence is first brought to bear in the review of a Qualitative Materiel Requirement. This is done by my office to determine whether maintenance objectives are being clearly set forth in the initial broad language describing a new piece of hardware. My office has a second opportunity for review when the military characteristics are drawn. Technical Service Maintenance Personnel have their first crack at a new equipment idea in their review of the proposed Military Characteristics. This review constitutes the first stage of the "Specific Review Point Program." The prescribed points of review in this program are:

1. On receipt of proposed military characteristics from the preparing agency.

2. During preparation of technical characteristics and development of initial design.

3. During prototype design.

4. During engineering tests.

5. During service tests.

Many other matters are included in these required specific reviews not relating to maintenance such as producibility, use of materials, and scheduling.

To further assure balance between performance and maintenance characteristics and lacking specific measurable maintenance criteria, we have set forth in published policy the following broad maintenance objectives for consideration during development and design and during specific reviews:

1. Increased reliability to reduce maintenance.

2. Reduced requirements for technical knowledge and manual skill.

3. Reduced time required to accomplish maintenance.

4. Reduced frequency in cyclic and corrective maintenance.

5. Reduced requirements for repair parts.

6. Improved accessibility for maintenance.

The important point is that specific Army policy has been published to require that maintainability is given maximum practical consideration throughout the evolution of new development items. This policy requires that the proposed new equipment be reviewed at each specific point by maintenance engineers, and that maintenance recommendations be resolved. In other words, these maintenance engineers figuratively look over the shoulders of the design engineers as a new weapon or equipment successively advances from concept, to breadboard, to prototype, and finally through service test to production.

To summarize this phase of our discussion, the Army has a program to assure balance between maintenance and performance in the design and development of new equipment. It is up to you to improve it in concept and to make it work in execution.

You will recall that I stated that our second principal problem in maintainability was our inability to specify it in measurable meaningful contractual language. As most of you know, our maintenance design practice in the past has been to depend on little more than general statements on ease of maintenance in our specifications for new equipment. Some would call them prayers of hope at best; they were certainly not meaningful in any measurable sense. As a matter of fact, over fifty years ago, in the Signal Corps' first contract for the purchase of an airplane, the contract read, "It will be simple to operate and maintain." Yet, even that contract contained three measurable specifics on performance -- none on maintenance. There has been practically no progress on maintenance specifics in the intervening years.

General Magruder's personal interest in maintainability is evidenced by his including, in his fiscal year 1959 "Army Logistics Posture" report to the Military Appropriations Committee, a discussion on the Army's program to improve the maintainability of our complex equipment. In this connection, I will read a brief paragraph from a backup submission to General Magruder's posture statement to The Congress. I quote:

"In developing each new piece of equipment, we have always furnished very definite military characteristics and specifications for improved operational performance. However, neither the military nor industry have been too precise in prescribing the necessary ease of operation and maintenance characteristics. * * * * * * the ability to spell these out has not kept pace with technological advances."

This, we feel, is a statement of our second major problem in maintainability. Our Army equipment is not simple to maintain, in large part, because we have not been specific in what we wanted in ease of maintenance. Until the Army clearly and unmistakably states measurable parameters for maintainability, we cannot expect the contractor to provide it.

As Lord Kelvin, the British physicist, so aptly put it: "When you can measure what you are speaking about and express it in numbers, you know something about it; but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meager and unsatisfactory kind."

Applying this thought to our specifications for maintainability, it is obvious that since we can't effectively measure what we are talking about and express it in numbers, we do not know very much about it. The challenge then that confronts us is to develop meaningful measurable parameters for maintainability. This will not be easy. We are dealing with intangibles.

In this connection I wish to acknowledge the work being done here at the Signal Equipment Support Agency (SESA) under the monitorship of Mr. Walter Grubb and Mr. Robert Redfern. Mr. Redfern will speak to you later in this symposium on "Quantification of Equipment Maintainability," and report on the work being done under a contract with the American Institute for Research. I look forward with interest to the final results of this contract. There is little doubt but that it is only the beginning of a major effort that will be required. The Signal Corps can be justifiably proud to be the first and only technical service to have a contract underway in this important area.

Yet from where I sit in the Pentagon, we still have a long way to go in specifically defining and obtaining ease of maintenance in Army equipment. There are a number of equally fundamental answers we must obtain in order to measure maintainability.

For example we need to know how much it costs to have a repair part in the system. How much does it cost in engineering the part, in keeping the specifications and drawings up to date. How much does it really cost to buy the part and rebuy it, -- to compute requirements, to manage and control the stock of that part, to package it, to ship it, to repackage, to reship and so on until we finally have the cost of disposing of it. What is the cost of providing the thousands of bins to hold that part. There have been only incomplete computations in these cost areas. Yet this cost is essential to measure maintainability.

As another example, we need to know how much it costs to provide a maintenance technician to accomplish the repair. This would also require complete costs including support personnel. We need to know how much this cost is reduced as the equipment is simplified. In connection with both the above examples, we have made a recent study of the total cost of electronic equipment during the first five years of its life in the Army. We found that the original purchase price represented only one-fourth of the total five year cost. The remaining three-fourths of the cost was in maintenance, the majority of which was in people, to repair it, or to handle the parts to repair it.

As another example, we need to know when it is more economical to "throw away" modules rather than repair them. I suspect it would be more economical to throw away a very large number of our present modules. We need criteria on which to base this judgment. One approach might be to require a study of the economics by the manufacturer as a part of each contract just as we require provisioning information. He would need some information from the Army as to type costs in providing parts and repair personnel. Without this other information, rough cut studies could be made even now, that would result in significant throw away decisions.

Finally, we must provide the contracting officer with a meaningful basis on which to accept or reject contractual proposals that would improve maintainability. In fact, we need to provide contractual incentive for maintainability so that the contractor will be impelled to simplify the maintenance of our equipment.

In addition to our programs to assure proper balance between performance and maintainability and to provide measurable criteria, the Army seeks to simplify or improve maintainability by specific contracts for the purpose. For example, the Signal Corps Contract with RCA to develop mass production techniques for micro-miniaturization of equipment. This technique will not only provide equipment of less than 1/10 the size and weight of present equipment, but even more significantly it will provide equipment of greater reliability and with optimum potential for use of throw away modules.

A second example, is the Signal Corps contract with Ramo-Wooldridge to develop a multipurpose, automatic test equipment for use at the field and depot level. The results of this study will be covered in a paper at this Symposium by Mr. Ron Manley of Ramo-Wooldridge.

A third example of maintenance oriented contracts are those with W. L. Maxson, and with Collins Radio to develop transistorized power supplies for radio sets. This is part of the larger objective of replacing vacuum tubes, and components containing mechanical moving parts such as vibrators, relays, switches and the like with militarized solid state electronic devices that will not quickly wear out.

In summary, we have two big problems in improving maintainability. We must keep maintenance in balance with performance in the development of new equipment. And, we must specify maintainability in measurable contractual language. We cannot completely accomplish the first without the second. However, we do have an interim program to bring maintenance into balance. It requires energetic implementation and will significantly improve maintainability. Both of these problem areas pose a challenge. There is much we need to learn about maintainability. The horizon is unlimited in both a technical and management sense. As little as we know, however, there is much that we can do now to simplify the maintenance of our equipment.

MR. C. SCHILDHAUER - BENDIX FIELD ENGINEERING: Colonel, it seems to me that there is a rather grey zone between the maintenance engineering and the design engineering. The companies usually try to get youngsters out of college with engineering degrees. What do you think about having those people, before they really get into design, spend a year in Alaska, as we saw yesterday, a year in the Caribbean area, and perhaps a year in Europe, and then get into design engineering to be qualified as a contractor for that particular type of work.

COL LATTA: This is, I think, a real interesting question. I would like to ask you a couple of questions though before I answer it. Is this at your expense?

MR. SCHILDHAUER: I would say it would be at the company's expense in order to qualify as a contractor.

COL LATTA: Well I would say its a fine idea. I am not sure, frankly, that too many companies would enthusiastically embrace it. I think anything that we can do in this would certainly be most helpful. Anything we can do to give the companies that are our suppliers an opportunity to rub their noses in the problems in the field would be a help. Now actually there are some companies that are doing things along this line. There's a big company in the electronics area, American Bosch Arma, that to my knowledge has trained over 200 of their people in the last couple of years with a program of maintainability. They've made arrangements with the Army and with the Air Force and have sent their people out on such an ambitious program that they've sent them out to view NIKE sites and aircraft operations. They made certain arrangements with the Army, with the Air Force, and with the Navy to try to rub the noses of their people in these problems. They have actually provided special courses in these areas. We think its a wonderful idea and we'd like to help wherever we can. Now we have worked a little bit in this area. We feel we even have a problem here in the army, as a matter of fact, in this. We're using for the most part, in the various tech services, a mixture of military and civilians in this work. As we get problems on our military spaces, we don't keep the military-civilian balance of the people there. We tried to keep military who were young people coming right out of the field in there to bring their viewpoint. We would like to have the civilian engineers frequently go out and spend 6 weeks or 2 months and rub their nose in field problems. I'm talking of Civil Service people. The problems of doing it with a company are special problems, but we ought to try to help. I don't know whether we could do it on such an ambitious scale.

MR. KONRAD B. ZOLL, USACA: I would like to know where we are going to get these maintenance engineers. I think I detected a faltering step in that direction from the last gentlemen, but I'm afraid that we are going to have to do more than rub our noses in this problem. We are going to have to have our hands in it. I'd like to submit that these maintenance engineers have one qualification, that they NOT be graduate engineers. I think that you people and most of us are not completely aware of how much of a problem there really is in maintenance. From where you sit and from where most of us sit, we just can't see the problem. It's a problem that can only be seen from underneath. It can only be completely seen by the men who actually do the maintenance. You can't engineer maintenance from an engineer's standpoint. You've got to engineer maintenance from a maintenance man's standpoint and these things are poles apart. I have seen and talked to many very, very competent engineers from the SigC labs and I have yet to meet the first one who has a really complete understanding of maintenance from the maintenance man's standpoint. But this is the man we've got to satisfy.

COL LATTA: As I see it, you haven't asked a question, but made a statement. I would like to agree with your statement in whole. In one technical service, let me just sketch the program that they have. They try to maintain a balance of about 50% service engineers. For the most part, these people are not graduate engineers. I don't see that this hurts, but there are some fine people that haven't had the education; there are some fine people that have had it and made the most of it, and still gain a great deal of practical experience. They maintain about 50% military personnel -- young officers who have spent time right out on the line doing maintenance, directing maintenance, running maintenance. They keep bringing these people in for about 2 or 3 years, and they try to keep a balance that way with a military-civilian viewpoint. They are strictly maintenance people. They are not development engineers who are told, "Well, now you are doing maintenance engineering; you're not doing development engineering." They do rotate their Civil Service people out. Not as much at one time as I thought they should be. They have been rotating them out more recently. They try to get them out for about 6 weeks or 2 months TDY. They send them to Europe, to the Far East, and even to Alaska. When I say rub your nose, I mean get your hands and get every bit of you into it. I agree with you.

MR. ZOLL: OK. Its awful hard to do though, unless you're actually charged with the responsibility of performing the maintenance and have performed it.

MR. D. D. PIDHAYNY - THOMPSON RAMO-WOOLRIDGE, INC: Colonel, about 15 months ago, there was a symposium held in Los Angeles and one of the comments that was brought up in regard to maintainability was the fact that this costs money. In any R&D program, you have to devote a certain amount of manpower to look into this problem. Now the question I ask is -- What have you people done to see that these funds become available for this activity?

COL LATTA: Well, let me hit that in a couple of ways. Number one, it does cost money; number 2, we lack as I say the means right now. I am asking you to come up with ideas, you Mr. Industry, you Mr. Signal Corps, and you Mr. Army, to come up with ideas on how to measure this return. I know there is a return. The fact that built-in maintainability only costs us 25% of the original cost, and the usual maintenance cost is 3/4 of the cost even in a 5-year life proves how important this is. This is recognized in DCSLOG. We're looking for specific proposals. This isn't satisfactory, and I agree, but as we find a specific proposal that on its merits seems to indicate that it would pay off and be worthwhile either before the fact or after the fact, we turn them over to our engineers. I have a group of engineers, a whole branch as a matter of fact hired from industry on contract to us, whose sole job is really to look for these ideas and if they get stopped somewhere along the line, to bring them around that stop, that bar, bring them up, measure them, take a look at them, see if they look good, and if they'll pay off, to try to grease the way to help the corps involved get the money. As a matter of fact, in several cases we provide the money ourselves for the purpose and, in about the last year, we have been responsible, on our level alone -- that's the general staff level -- for some 20-odd contracts. This is just a small beginning. We've only begun. The horizon is broad and we've hardly touched it. We've hardly scratched the surface. But the biggest thing is, we don't have the means of measuring it today. This is what we need, a means of measuring.

MR. PIDHAYNY: Well, actually when you call out the reliability of the equipment, you define reliability in the overall sense, taking into account the field and its service in the field. Now you have a means of measuring. But to do this is really a very costly operation, and here's where the whole picture breaks down. At least that's the way I see it.

COL LATTA: What's your solution?

MR. PIDHAYNE: Well, I think the solution is here; it's a matter of directing in the contract that certain requirements be met and then paying for it. I see no other alternative. This costs money, and the reason for this is it takes a pretty high level engineering effort to design into the system that which is needed to reach these ends.

COL LATTA: If you have some good ideas at times and don't get a meaningful response to them, come in and tell us about them because we're looking for ideas. We're looking for, as I say, an equipment-by-equipment sense where it will really pay off. Multipurpose universal test equipment is an example. We have a similar case where we've been helping to provide the money in directing, requiring, and making a particular tech service do it in a guided missile area where we found that we have tremendous sets of test equipment for each of a number of guided missiles. We can't afford all of this test equipment. We felt that we'd get a multipurpose one. We could make it automatic; we could reduce technical skills this way and anything we'd have to spend on that would be nickels and dimes compared to how it would pay off. This is under way in the Ordnance area. There is a similar one that I spoke of here in the Signal Corps area. These things have to be done, but we can only do them when we hear about them. Any ideas that we can get on how we could measure this -- This is the big thing that we lack today. We lack it, you lack it, the contracting officer lacks it.

MR. A. J. FINOCCHI, ITT LABORATORIES: I first have a general comment to make, if you will, and that is that every speaker has asked for maintenance help and I think, just from industry's point of view, that you are going to need more maintenance help. In 90 years, we've gone from telegraph key and a wire line to a tropospheric scatter system, the type you put on a jeep out front. You're going to need more maintenance to help it. One of your men, Mr. Albright, pointed out that most of his trouble comes from misuse of equipment by kicking things off the back of the truck. You're going to have to get men who are dedicated to maintenance, who are going to make a career of it within your system -- not a rotation every 3 years to a brand new set of men who are going to learn how to handle very complex equipment. If you can handle this problem I think you'll have a good 50% of your maintenance problem licked.

COL LATTA: Thank you, that's what makes a horse race. Just from a practical point of view, I'd say that it takes two opinions, or many, to make a horse race. I think this is a very fine idea, but I don't think it's practical, frankly. We're living in a democracy. Our mothers are not going to let us keep people in for more than a period of 2 or 3 years. We're doing well to keep them for that time now. Congress is not going to pay enough money to hold people for an indefinite period. We have some practical problems on how many people can be trained and to how high a level. We have to tackle the problem. We can't take the point of view of the development engineer that equipment can become infinitely complex. We have to get practical, we have to get balance, and we have to understand the job of the man in the field and simplify the equipment. It's just gone out of reason, going at a dizzy accelerating pace. But as I say, these are two different viewpoints and that's what makes a horse race.

THE IMPACT OF MODULAR DESIGN ON PROVISIONING

R. E. Moore and D. K. Morgan
International Business Machines Corporation

All agencies of the Department of Defense and the entire defense industry have a vital interest in the support of systems and subsystems. Since provisioning is an important function of support and much of the equipment for which we are planning support is of modular design, I would like to discuss with you "The Impact of Modular Design on Provisioning."

The impact of modular design on provisioning can best be described as "a challenge." Modular design presents a challenge to all Department of Defense agencies and the entire defense industry to prepare and implement logistic plans that will insure the sequential collection and intelligent use of information and data that is necessary in accomplishing provisioning. There is a further challenge to use the knowledge and devices available to provide better systems, more reliable systems, and more maintainable systems and to provide the means of maintaining those systems at a high degree of operational readiness.

The primary objective of any support program is to maintain systems or subsystems in their prescribed operational status.

The maintenance process is taken to include, among other things, gaining confidence that the operational status of the system is within the range of acceptability, the identification of causes that produce unacceptable effects, and determining the nature of the controlled change or changes which when administered to the faulty system will return that system to a satisfactory operational status.

The controlled change required to restore a system to a satisfactory operational status is not always the replacement of a defective part or unit. However, my discussion today is centered around insuring the availability of parts or units to accomplish this type of repair on systems of modular design and construction.

One of the prime necessities in planning for the support of a system is establishing the identity and estimating the quantity of parts and units required to accomplish anticipated system repairs for a predetermined period. This is usually referred to as provisioning.

Provisioning is only one factor but a very important factor in the support of a system. There are other factors and I would like to explore these for a brief period in order to bring provisioning for modular designed equipment into better focus.

The operational readiness of a system is dependent upon its reliability and maintainability. These features, or lack thereof, are inherent in the design of the system and are not a part of my discussion. However, I would like to observe that with absolute reliability there would be no need for maintainability and with instant maintainability, reliability would be less important. Since neither absolute reliability nor instant maintainability are attainable in the foreseeable future, it is necessary to arrive at a compromise. We can only hope the compromise reached by the designers of a particular system is the right one for that system.

Assuming that a satisfactory compromise will be reached, we have now to face the problem of maintenance.

For the period of this discussion may we assume that maintenance is comprised of three major factors: Parts, Time, and Tools. Placing this in an equation: Maintenance = Parts + Time + Tools.

Let us develop the equation further:

$$\text{Systems Maintenance} = \begin{array}{l}\text{Bits \& Pieces}\\ \text{Assemblies}\\ \text{Subassemblies}\\ \text{Cables}\\ \text{Units}\\ \text{Bulk Items}\\ \text{etc.}\end{array} + \text{Time} + \begin{array}{l}\text{Manpower}\\ \text{Tech Data}\\ \text{Tools}\\ \text{Test Equipment}\end{array}$$

In the equation, Parts includes any replaceable part, component, assembly, subassembly, unit, or bulk item. Time itself is not a variable factor, but available time is variable. Tools include manpower and tech data as well as tools and test equipment.

Again referring to the equation, let us consider manpower. Particularly in the field of electronics we have seen a tremendous change in the operational environment and tactical usage of equipment. Not many years ago electronic equipment had restricted usage in limited fields. The performance of the equipment did not have any great bearing on the success or failure of a mission. It would be more convenient if it worked properly, but no vital problem would be generated if it did not function properly. During this era there was little difficulty in finding sufficient skilled personnel to accomplish maintenance, for the demand for personnel was not large.

Since the success of a mission was not completely dependent on the operational effectiveness of electronic equipment, maintenance personnel had time to de-bug a system and replace defective parts as required. In most cases no critical situation developed if there was some time delay while waiting for replacement parts.

The tremendous increase in the use of electronic equipment in the last decade has spread pretty thin the available supply of trained technicians. An equally important factor to consider is the increased complexity of this equipment. It is logical to assume that a percentage of the technicians considered completely competent on equipment being maintained five years ago could not be trained to be completely competent on present-day equipment.

The usual procedure in the early days of electronic systems was to train maintenance personnel in the operation and maintenance of all the individual components of a system. Such training required considerable time and also required the selection of personnel with the proper prerequisites in education and natural abilities. However, with limited demand, sufficient men with the proper qualifications could be found. Today the supply of skilled manpower is only a little better than it was in the past. So, in our equation, total manpower available changes only a little.

Again referring to the equation, time itself does not change, but available time is a variable factor, continually diminishing. The speed of all communication and travel has had a direct effect on rapid developments in the international military and political situation. Speed of communication has also accelerated scientific and technological development. It is pretty much an accepted philosophy today that any system nearing the production stage is already obsolete. It is also well known, and it is a contributing factor to our deep concern for the safety of our country and our American way of life, that our potential opponent in a shooting war is only hours away, and this time is rapidly diminishing.

Going back to the equation, we find that manpower has changed only a little, but time available has changed drastically. Refinements in tools and test equipment will have a profound effect on the time required to restore a failed system to operational readiness, but in order to get full usage out of advancements in the state of the art, it is required that more efficient use be made of available manpower. Tech Data must be directed to personnel with limited training rather than to the highly trained technician. But even Tech Data, in conjunction with advanced test equipment, will not balance the maintenance equation unless it is made possible for the available maintenance personnel to accomplish their task quickly by having directly available a replacement that can be almost immediately substituted for the failed part or unit.

With our dependence on electronic systems almost absolute, time limitations vastly reduced, skill levels available for each system lower, required skill levels higher, our situation would seem rather bleak.

Referring again to our maintenance equation, we now have it pretty well out of balance. We have a greater number of more complex systems. This alone would cause an imbalance. In addition we have considerably less time for maintenance. This increases the imbalance. We have less skilled manpower available per system. This further increases the imbalance.

Our situation is bleak until we consider the potentials offered in modular design and construction of systems, subsystems and test equipment.

Modular design has been defined in many ways. My personal choice of a definition is that modular design is a system of interconnected functional units or black boxes designed and constructed to facilitate removal and replacement.

Modular design is not entirely new. It has been in use for many generations and has been applied to many products in various forms. However, its importance in the construction of electronic equipment, particularly in the field of defense production, is rapidly increasing.

In order to facilitate removal and replacement, all electrical and mechanical corrections must be readily accessible and capable of manipulation without special tools where possible.

There is no hard and fast rule that dictates the size or weight of a module, although it is generally accepted that the size and weight of a module should be such that it is easily handled by one man.

The type of system and tactical usage of that system will control, to some extent, what one man can handle. What one man can handle easily in a permanent or land-based installation might be very difficult if not impossible in an aircraft, in a moving vehicle, or in a boat.

While the definition as given states that each module will be functional in nature, it is not impossible to visualize the desirability of joining a number of modules together to accomplish a single function. This would seem particularly advisable if one or more of the small parts required to accomplish a particular function had potentially high failure rates. It would then appear desirable to place these parts in a separate module.

To get the most benefit out of modular design, it is necessary to have the right type of tech data and greater development and refinement of test equipment, including built-in test; in addition, provisioning must attain a high degree of sophistication.

In order to attain a high degree of sophistication in provisioning, it is necessary to review and understand all the possible ramifications of this important function. I do not mean to convey to you the possibility that I know all there is to know about provisioning or that I am willing to admit there is any one person possessed of this knowledge. However, I would like to discuss with you provisioning functions and particularly provisioning as it applies to modular designed equipment. Before discussing this subject it might be well to present a definition of the word. However, I doubt that anyone here needs to have the term "provisioning" defined. My personal choice of a definition is: "Provisioning is the act of preparing beforehand a stock of needed materials such as the necessities of life." Certainly you will agree that provisioning as a function in the support of end items of military products does provide the necessities of life for that end item.

Provisioning action normally includes parts and subsequently includes the tools and test equipment required to accomplish repairs to the level reached by parts provisioning action.

With limited time and manpower for the return of a failed system to operational readiness, the major burden of meeting the challenge of supporting today's modular equipment falls in the area of test equipment and parts. Parts is used here as an all-inclusive word; parts, units, assemblies, subassemblies, bulk items. It includes provisioning actions, production, procurement, transportation, storage, allocations, and other actions affecting parts. Modular design cannot be considered as a separate factor in provisioning but must be considered in conjunction with other factors which affect the capability of returning a failed system to operational readiness in time to be effective.

In provisioning for the support of modular equipment, it is necessary to consider not only the unit that may fail and require replacement but the part that has failed in the unit and will be required at higher echelons when the unit is repaired.

Proper provisioning will result in having the right units or parts at the right place at the right time. However, in order to accomplish proper provisioning for any type of system, it is necessary to know, among other things, the number of systems to be maintained, the deployment plan of the systems, the strategic and operational environment in which the system will be used, maintenance and operational personnel descriptions, number of anticipated training and combat missions, estimated hours of operation per mission, the types of repairs to be accomplished at each level of maintenance, detailed information concerning component parts, and general criteria governing the employment of test equipment and other related information.

In the provisioning of modular equipment all of this information has greater importance and other vital pieces of information must be added. Among the required items of information that are additional or now have more importance are:

1. Which units are considered throwaways?

There are those who advocate that all units be designed as throwaways, to be replaced and discarded when known to be defective.

There are those who claim that any unit can and should be repaired.

Somewhere between these extremes lies a balance that is the most satisfactory compromise. My own feeling is that the number of throwaways will increase, but will not in the foreseeable future eliminate the rotable spares.

2. Estimated turn-around time of each unit or black box.

By use of a turn-around factor plus other information, it will be possible to calculate the number of units that will be in the pipe-line and thus reach a figure for provisioning action.

3. A code indicating the maintenance echelon at which a part can be used.

This code, in conjunction with other information, will be used to compute the quantity of each part required at each maintenance echelon and then added to equal total procurement.

4. The procurement time for each part.

From this will be determined the point in time at which parts must be placed on procurement in order to receive the part for concurrent delivery with the first system.

5. Items that should have special consideration because of value or quantity required.

For items of high value, consideration must be given to the advisability of using some form of phased procurement. Under this philosophy a more flexible production and delivery schedule is permitted. There is also a reduction in the initial investment in spares. By having parts available to build a unit or subassembly, it is possible to use them as either parts or assemblies and it is also possible to incorporate any engineering or manufacturing improvements if and when assembly is accomplished.

All provisioning accomplished on any system to be used by any Department of Defense agency must be accomplished with the following basic concept: that the system is to be supported on a high level of operational effectiveness in peace time as economically as is consistent with planning for the possibility of having to support that same system under combat conditions when economy may not be quite so important, but time will be of supreme importance.

May we return now to our out of balance equation. We find it looks a little better if we use all the potentials of modular design. As stated earlier, the full benefit of modular design can only be realized if provisioning procedures and the development of test equipment and test procedures reach a high degree of sophistication.

Let us turn for a few minutes to what could be termed the Evolution of Provisioning.

The Evolution of Provisioning

Planning for the support of a system or subsystem, far too many times, has been haphazard or neglected, has been delayed until a critical need is created or just simply treated as an unimportant, unpleasant task.

With such an attitude toward support it is only natural that provisioning has, in many instances, been treated like an undesired stepchild. However, rapid technological development and the uncertainties of the political and economical atmosphere in which entire systems programs must exist has brought more clearly into focus the importance of provisioning actions and the generation and compilation of the information and data so necessary to accomplish intelligent provisioning.

It has been said that it takes three generations to develop a gentleman. By the same philosophy, intelligent provisioning must begin long before a provisioning conference or the generation of a provisioning list.

At the time a system or subsystem is conceived in the minds of policy-making bodies, planning for the support of that system or subsystem must begin. The tactical usage to be made of a system will determine many things, including the type of personnel that will be available for operation and maintenance, potential operational environment, lines of communication, deployment, and other information essential for preliminary planning. The importance of the mission of the system will indicate potential time limitations for accomplishing maintenance. These considerations will influence the decisions of Research and Development engineers in regard to reliability, maintainability, and the degree to which they feel the system should be broken into modules.

Agreement must then be reached between the contractor and the cognizant Department of Defense agency concerning reparable and non-reparable items, development of second source of vendor items, changes in vendor catalog items, contractor support, etc.

Discussions with the using agency must culminate in a mutual agreement on the general methods of supporting the systems, that is, types of repairs to be made in each echelon, spares and spare parts distribution, throwaway policies, etc.

Information is also required concerning the existing maintenance organizations which might support the equipment as regards existing support equipment, skills and facilities, etc.

The sequential collection of all this information and data should be taking place prior to or concurrent with the development of the system.

As soon as possible after the development of each module of a system is completed, the following information for each part should be made available to provisioners.

Assembly and schematic drawings

Stock numbers (if available)

Item descriptions (if required)

Number in use for each item

Reliability data for each item

Replacement factors for major units

Anticipated hours of operation

Knowledge as to whether an item should be replaced individually or as a part of the next higher assembly

Knowledge of which echelon of repair should perform the operation or the parts and quantities that should be provisioned.

Some of this information would come from existing records, experience with this part in other systems, reliability studies, and the personal experience of the designers, and some would be based on the nature of the part and sound judgment.

With this specific information on each part and other general information as discussed earlier as a background, the participants in a provisioning or source coding conference would be in a position to accomplish their tasks intelligently and economically.

It has been observed many times that the proper equipment for a provisioning conference would be a turban and a crystal ball. I don't agree -- a <u>turban</u> is <u>not</u> required. It is possible that a crystal ball would be useful <u>but it must be</u> polished with all the information and data available -- information and data that has been collected, compiled, and edited from the time the system to be supported was but a gleam in the eye of the designer.

<u>Conclusions</u>

With increased and more efficient usage of modular design principles in the design and construction of electronic equipment, it seems logical to assume that the day will come when major systems will be maintained at a high level of operational readiness by relatively low-skilled personnel. This can be accomplished by the use of easily replaced spares and adequate test equipment and procedures.

Built-in Test, in conjunction with "on board" spares, offers infinite possibilities in the area of first echelon maintenance to restore and maintain the operational effectiveness of a system that has failed during a mission.

Self-healing design techniques offer the potential of having a system conduct a self-test, select an alternate mode of operation if the primary mode is inoperative, and indicate the failed unit in the inoperative mode. This is fantasy, perhaps, but much of what is commonplace today was fantasy a few years ago.

I do not mean to imply that skill levels of maintenance personnel can be reduced or that the demand for high-skilled personnel will be lessened. Rather the skills will be redistributed. Units that are generated reparable will be forwarded to higher maintenance echelons for repair. These higher maintenance echelons will require high-skilled, well-trained personnel. There will be a need for high-skilled personnel at every echelon of maintenance to direct the efforts of less-skilled personnel. However, no matter what skill levels may be available, no echelon of maintenance can be accomplished satisfactorily without adequate and timely provisioning.

If we provide the best test equipment imaginable, superior Tech Data, and infallible test procedures that can be successfully used by any basic trainee to determine the part or unit that has failed in an inoperative system, nothing is accomplished unless a replacement for the failed part is readily available. This replacement part can be anything from a fuse to a complete functional unit. When a system is not operational because of a failed part, the price or size of the failed part does not measure the degree to which a system is not operational. Either it works or it doesn't.

Intelligent provisioning can be accomplished if the task of provisioning is placed in its proper perspective. Provisioning as a function of support is of vital importance and deserves the concentrated efforts of the Department of Defense and the defense industry in devising plans and concepts that will remove much of the mystery that seems to be attached to this function.

As stated at the opening of this discussion, the impact of modular design on provisioning can best be described as "a challenge." Modular design presents a challenge to all Department of Defense agencies and the entire defense industry to prepare and implement logistic plans that will insure the sequential collection and intelligent use of information and data that is necessary in accomplishing provisioning.

There is a challenge to make use of the modular design philosophy in the design and construction of systems, subsystems, and test equipment to provide better, more maintainable systems.

There is a challenge to conceive, design, develop, and produce these systems in less time.

There is a challenge to develop test equipment, including built-in test equipment, to quickly and accurately determine the nature of the failure and the identification of the failed part or unit.

There is a challenge to devise and organize the collection and collation of interrelated provisioning data in such a manner that provisioning will lose its mystery and the provisioners upon completing their task will have some assurance that theirs is a job well done.

There is a challenge to balance the maintenance equation by using all the knowledge at our command to develop and refine test equipment to a point that it can be used effectively and efficiently by available personnel to identify the failed part or unit and then, by full use of the principles of modular design and sophisticated provisioning principles, have immediately available a replacement that can be easily and quickly utilized to restore a failed system to operational readiness.

The rewards for meeting this challenge are many, but the most important reward is the satisfaction to be gained from doing a job well and knowing that by doing so you will help other military projects and make an important contribution to the defense of our nation.

DISCUSSION

MR. BERNARD PEAR, SIGNAL CORPS LOGISTICS EVALUATION GROUP: Mr. Moore, that was a very good philosophical discussion of the problems of of provisioning. You know, in my lifetime, I reversed the usual progress. I was a philosopher when I was young and the older I get the less of a philosopher I become. My mother used to say that for a philosopher I ate too much. Will the modular construction provide us with any better estimates of failure rates which is one of the problems in provisioning? One of the difficulties we've always had in determining how many parts we need, for instance for the initial year, is the fact that we never seem to have really good failure rates. Can the manufacturer of modular type of equipment give us better information as to the probability of failure of the modules? Can he, therefore, commit himself to the dollar value that has to be placed on the contract for the replacement modules? Unless he can do that, provisioning will be no better under modular construction than it is today.

MR. MOORE: I have to agree with your last statement. Unless we can, it will be no better. But one thing we do have with modular design is that we can cut down on time. I think time is important. If we can find the module that has failed and have one available to replace it, I think we have gained a lot. But going back to the original question, as far as being able to come up with failure rates, I think a lot of this is dependent upon the experience you've had. From the experience that we have had coming up with failure rates, we have been able to use certain items we've used in our commercial line. Also we have had reliability type tests and, with the combination of these, we have come up with our failure data. But I do not feel that this gives us any better information than we have had in the past for selecting the right items for provisioning.

MR. A. J. FINOCCHI, ITT LABORATORIES: Do I infer from your comments that you intend to standardize on a particular module? In other words, will you have a standardized amplifier module for all kinds of gear? If so, I can understand your lessening of your provisioning. If not, I can see that provisioning will become more complex.

MR. MOORE: If we have a large item when we provision, we have to have the complete breakdown of all the parts. If our modules are too small, they only comprise one to two parts, and we're not gaining anything. But using the throwaway philosophy, which I did elaborate on today because there is a discussion on throwaway philosophy, we can combine a number of components in a module, simplify provisioning, and have fewer total parts to be concerned with.

MR. FINOCCHI: I'm sorry this hasn't answered the question. My point is that if I have many different kinds of equipment to maintain, will this module be able to be plugged into any of the other gear or must I have these modules for each particular kind of equipment. This may make provisioning more difficult.

MR. MOORE: Would you repeat that again please? -- the last part?

MR. FINOCCHI: The module that fits into one piece of gear, is it your suggestion that this module will also replace say an IF amplifier stage in any other piece of equipment that requires an IF? Would you standardize a module? If not, I must now provision an amplifier module for every kind of IF amplifier that I'm using in any particular location. This might be more difficult in provisioning.

MR. MOORE: I'm not in a position to answer that one.

MR. JOHN H. HERSHEY, BELL TELEPHONE LABORATORIES, WHIPPANY: I would like to make a statement, not ask a question. With respect to the question that was raised earlier, in the area regarding future prediction of failure rates early enough to help people provision their new systems. I think it should be pointed out that this operation or the necessary work to accomplish this has to be a team type of operation of exchanging information on the past history among using services. There needs to be, I believe, a closer feedback of data from the field to the design and development organizations to establish bases that can be used as past history to predict future. I'm not advertising my talk after lunch, but I expect to get into part of this problem today to show what the problem is and an approach that has been taken. I personally believe that it is within the realm of the possible today to predict, within 25% let us say, the parts required as a function of mission time for the first year on a new system. I believe that it is possible to do this.

MR. FRANKLIN, U.S. ARMY R&D LABORATORIES: This is more in the nature of an elaboration rather than a question. Concerning the ability to obtain failure rates, there will be fewer modules than separate parts in our military electronics the way things are planned. This means fewer items to be considered; consequently, there will be more money and time and people available per item to come up with failure rates. Chances are that we will have more information on failure rates in the future regarding the standard modules. With reference to the question on standard modules, there is a trend toward this in our R&D thinking and planning.

APPLICATION OF ADVANCED TECHNIQUES AND AUTOMATIC EQUIPMENT IN THE MAINTENANCE OF SURVEILLANCE DRONE SYSTEMS

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1. Present Drone Maintenance Problems

The mission of a Surveillance Drone System is to provide battle area information for ground combat operations. A war fought in the future would be of such a nature as to require high mobility, a self-supporting capability, a fast reaction time to a changing combat situation, and the ability to function while dispersed from any central headquarters or supply activity. The more advanced systems will be capable of all-weather, day and night operation. These requirements, which are placed on the surveillance system itself, of necessity place certain requirements on the maintenance plan devised to support the system. Thus, while there are similarities between the maintenance program for a typical Surveillance Drone System and other drone systems, there are at the same time differences. There are several different types of drone systems presently in use or under development. These systems may be divided into three major categories:

a. Target Drones, such as the OQ-19, KD2R-5, KD-B, KD4R-1, RP-76, and RP-77.

b. Evaluation Drones, such as the Q-2, Q-4, and Q-5.

c. Tactical Drones, such as the SD-1, SD-2, SD-3, SD-4, and SD-5 Surveillance Drones and Decoy Drones, such as the Goose, etc.

Figure 1 shows, from left to right, the Radioplane OQ-19 Target Drone, the X-Bow Guided Missile, the XQ-4 Evaluation Drone, the RP-77D Target and/or Reconnaissance Drone, and the RP-76 Target Drone.

The maintenance of these types of drones varies drastically, dependent on the amount, type, and complexity of equipment required to carry out the required mission. Equipment profiles of a target drone, tactical drones, and an evaluation drone are shown in figures 2 through 5 to give a picture of the varying degree of drone complexity.

It is noted that the RP-76 target is very simple and the only electronics involved is the passive radar reflector (Luneburg Lens), a guidance package consisting of a simple autopilot and command receiver, and a Tracking Aid Transponder. In contrast, the evaluation drone is loaded with electronics, particularly from a pay load standpoint. There is a greater concentration of electronics in some evaluation drones than in the missiles being evaluated. For example, an evaluation drone presently being developed by Radioplane requires approximately thirty antennas to satisfy requirements for radar and countermeasures simulation, scoring, instrumentation and basic control.

It is also noted from figures 2 through 5 that the surveillance drone has an electronics complexity greater than the target but less than the evaluation drone. This degree of complexity has a great influence on the maintenance requirements of each. Target drones and evaluation drones are normally operated in a peaceful environment. A surveillance drone system, however, has to operate in a battle environment which places restrictions upon the support equipment and procedures used to accomplish the primary maintenance objective of assuring that equipment is in operating condition and to repair that equipment which is not. These restrictions, or operational design objectives, include:

a. Mobility

b. Dispersion

c. Capability of being operated under battlefield conditions of stress, unfavorable terrain, noise, etc.

d. For the more advanced systems, all-weather operation.

e. For a recoverable system, the necessity for rehabilitation.

To successfully operate under these restrictions, the Surveillance Drone Maintenance Program is divided into the following three functional areas of activity:

a. Launch-site activity, including minimum assembly and servicing and a quick pre-flight check prior to launch. A malfunctioning black box is replaced and the defective unit returned to the rear maintenance area.

b. Rear maintenance area, including detailed repair of returned malfunctioning black boxes and the rehabilitation of recovered drones. This area also serves as the central supply source for the forward launch areas. It receives crated drones which would be uncrated and assembled as much as possible prior to being shipped to the launch site. Spare parts to support the level of maintenance performed at the launch site are stocked and forwarded, as required. This area may be located 50 miles or more from the launch area, and should probably service more than one forward unit. Equipment which is beyond the repair capability of this maintenance activity and which is not expendable is returned to a depot.

c. Depot, including overhaul and repair of assemblies beyond the capability of the rear maintenance area. The depot also serves as a central supply source for the rear maintenance areas. It stocks crated drones and spare parts for shipment to the rear maintenance areas, as required. The depot is normally located at a considerable distance from the rear maintenance areas.

It can readily be seen that by dividing the Maintenance Program into three major functional areas, optimum support can be achieved. The forward launch site must move as the battle situation demands. The ground equipment, therefore, must be of a minimum size and provide a high order of physical mobility and rapid (if any) set-up time. It must meet rather rigid human engineering requirements pertaining to such things as space limitations, safety, and environment. The rear maintenance area, while still required to be mobile, does not require as high a degree of mobility or as rapid a set-up time. Also, it is separated by a greater distance from the forward battle area. The depot is separated by even a greater distance from the area of combat and, depending on actual conditions, can be of a permanent or a semi-permanent nature.

2. SD-1 Surveillance Drone System

Now that we have discussed drone maintenance problems in general and have seen the similarities and differences of the surveillance drone system to other drone systems, let us review in detail a surveillance drone system now being developed and produced by Radioplane for the U. S. Army, namely the SD-1 System.

a. Mission

The mission of this system is to be ground launched, climb to altitude (maximum of 15,000 feet above sea level), cruise a maximum range of 50,000 yards, obtain data by means of either conventional camera or secure type television link, return the data and vehicle to the launch area, and recover the vehicle by parachute. Figures 6 through 10 show the SD-1 Vehicle, some of its operating equipment and a normal launch and recovery of the vehicle.

b. Vehicle Configuration

The vehicle is a single engine monoplane with a fuselage length of 160 inches and a wing span of 138 inches (figure 10). The design gross weight is 420 pounds with a fuel load of 35.6 pounds. The specified performance is a top speed of 184 mph, service ceiling 15,000 feet, and an endurance at sea level of 30 minutes. Conventional aileron and elevator controls are used, but no rudder is required.

c. Equipment

The drone equipment consists of the following major assemblies (figure 11):

(1) Camera - (Conventional or closed system T. V.)

(2) Radar Reflector Pods or X-Band Beacon for Tracking Purposes

(3) Wing Tip Light

(4) Aileron Servo

(5) Main "J" Box

(6) Receiver - Autopilot

(7) Vertical Gyro

(8) Elevator Servo

(9) Tail Light

(10) Antenna System

(11) Parachute Release Mechanism and Parachute

(12) Battery

(13) Engine with Propeller

3. SD-1 Handling, Checkout and Maintenance Concept

The SD-1 Surveillance Drone System handling, checkout, and maintenance concept requires three major areas of endeavor. The first area, called the Launch Area, is devoted to fueling, launch handling, pre-flight checkout, launching, command control, and recovery of the drone and is located in the tactical firing area (figure 12). Maintenance in this area is limited to replacement of easily replaceable major assemblies. The second area, called Field Maintenance, is located up to fifty miles away and provides for checkout, troubleshooting, repair, and/or major assembly or component replacement (figure 13). The third and final area may be termed Depot Maintenance where precision major assemblies would be overhauled, tested, and repaired or replaced down to faulty parts such as bearings, gears, gimbals, etc.

4. SD-1 Maintenance Equipment

The launch area equipment is located in the tactical firing area in a safe zone to the rear of the zero-length launcher with the exception of the control vehicle, which is located based on accessibility to communication with launch personnel and also advantageously for controlling drone flight. This location may vary from 50 to 500 yards from the launcher. The launch area equipment consists of a portable, zero-length launcher, adjustable in elevation up to 20 degrees; a drone engine starter consisting of a gasoline engine-driven hydraulic pump and motor mounted on a three-wheel portable cart; a fuel supply assembly mounted in a GFE 1/4-ton trailer; an equipment trailer for transportation and storage of spare parts, checkout equipment, packed parachutes, JATO Units, and an electrical power supply (figure 14); and the pre-flight checkout console for determining flight readiness in conjunction with the ground control station on a go/no-go basis (figure 15).

The field maintenance area is a completely self-contained maintenance facility, equipped to provide all necessary operations to keep the SD-1 drones operational. The primary function of this maintenance area and equipment is to provide for repair and replacement of damaged components of the drone and the ground support equipment. The maintenance equipment is divided into two major areas, the first being that required for electronic maintenance and the second for aircraft and engine maintenance. The electronic maintenance equipment consists of a GFE M 109 shop van, modified by the contractor to incorporate benches, cabinets, instrument racks and commercial or militarized commercial equivalent standard test equipment such as signal generators, tube testers, oscilloscopes, voltmeters, frequency meters, power supplies, etc. (Figures 16 and 17.) Handbooks, drawings, cables, and accessories, and spare parts down to the plug-in assembly or component level are also contained within the van to allow complete bench testing maintenance and troubleshooting of malfunctioning equipment. Precision electromechanical equipment requiring major rework (e.g. gyro repair, servo repair, etc.) would be sent back to the depot maintenance area. The aircraft and engine maintenance area provides for the repair and replacement of damaged components of the air frame, engine, and mechanical handling equipment with any equipment or components requiring extensive repair being replaced. This area, with the exception of the engine flushing tank, the power unit, and the transport vehicle, is inclosed within a GFE squad tent and is located in the immediate vicinity of the electronic maintenance van. The tent has close to 400 square feet of working area and sufficient overhead clearance to allow personnel up to 6 feet 4 inches tall to move around without discomfort. Other major equipment in this area is a portable drone litter for transporting recovered drones after flight, conventional hand tools and equipment for assembly or disassembly of the airframe and engine and for making sheet metal repairs, a parachute packing system, a collapsible handling stand, a mobile dolly, an engine flushing tank for cleaning engines and engine parts, an engine starter, work benches, a GFE power generator trailer assembly, and lastly, a modified GFE M-35 truck, which includes provisions for accommodating six complete wings and three drones less wings.

5. Advanced Techniques and Equipment Developed for Other Military Programs

It may be seen that the SD-1 Surveillance Drone System is fairly simple in concept and equipment, but as the Surveillance Drone family progresses from the SD-2 through the SD-5 and eventually possibly through an SD-10 and so on, each being more advanced and more complex, it will be mandatory to have more advanced techniques developed to cope with increased maintenance problems.

a. Vehicle Equipment Design Techniques

It has become a requirement with the advent of increased complexity and performance of electronic equipment that design techniques be developed to facilitate maintenance.

The first area, which has received wide attention and is beginning to be very commonplace in most military systems, is the concept of easily replaceable major assemblies or modularized construction, including microminiaturization and wafer-type construction. Typical examples of this type of design approach used in drone systems may be readily observed by referring to figures 18 through 20, which show a low-cost hit-miss detector with conventional plug-in modules; an evaluation drone flight control computer with plug-in, subminiature, printed circuit cards; and a low-cost target drone command-control-flight-control package with transistorized plug-in printed circuit modules and plug-in transducer and gyro modules as well. Figure 21 shows the prototype of an active radar-augmenter that utilizes traveling wave tubes. Since this unit only contains the tubes and a power supply, there is little need to modularize, but steps are being taken to package the tubes and power supply in separate assemblies to still further simplify maintenance problems and increase flexibility of installation.

The other design techniques that are essential to reduce the maintenance problem are stressing interchangeability between like assemblies, utilization of as many identical modularized assemblies or component parts as possible, and providing adequate test points to facilitate checkout and fault isolation. These test points where feasible, should provide normalized voltages, say 0 to 5 volts dc, to simplify maintenance equipment if this can be done without penalizing the airborne equipment as to size, weight, and reliability.

A technique that has been applied to a limited extent during the past few years is to build self-test features into the actual airborne equipment with malfunction display information being provided on the equipment itself or brought out on a single test lead. This approach, if applied carefully, will not reduce equipment reliability or increase size and weight and should greatly reduce the amount of maintenance equipment required.

b. Maintenance Equipment Design Techniques

Since the end of World War II, each succeeding year has brought a sizeable increase in complexity of military weapon systems. In addition, technological advances in the military field have given impetus to the new and ever-growing field of automatic industrial control. These two major areas of development have already, in many instances, reached the point where it is not feasible to use manually operated checkout equipment.

The modern military weapon system or drone system is composed of many highly complex interdependent sub-systems, each containing several major assemblies. In order to successfully accomplish the design mission, each element must function precisely.

The interdependence factor also requires a much closer tolerance of each sub-system, which in turn requires more accurate and comprehensive test techniques and equipment. Most accurate test equipment today consists of laboratory type instruments which require highly skilled operators. These technicians must deduce that a malfunction occurs in a particular portion of a system by interpreting test results. This requires a thorough familiarity to assure understanding of both the test equipment and the system being tested.

To provide comprehensive and accurate testing of complex systems in a reasonable amount of time and to reduce maintenance time, it is essential that test equipment conduct a system checkout in a rapid and trustworthy fashion. This equipment must also isolate trouble down to an easily replaceable assembly level without requiring the services of skilled personnel. It must be versatile, accurate, reliable, thorough, and completely self-checking.

It is imperative that there be good correlation of testing methods and equipment among the various levels of field and factory maintenance in order that all levels of test results can be compared directly and suitable corrective action taken when required.

At the present time, the majority of systems are checked out with large installations of commercially available, manually operated, special-purpose test equipment. These installations are in all cases tailored specifically for the systems they are designed to checkout. Thus they rapidly grow obsolescent and require major redesign each time the systems they are testing are modified. Unless the maintenance personnel have a thorough understanding and familiarity with the system they are testing and with the test equipment they are using, a great deal of difficulty is encountered in interpreting the test results and determining whether the system, the test procedure, or the test equipment is good or bad. Furthermore, due to human limitations, a great deal of expensive equipment is often damaged by carelessness, lack of experience, or poor judgment.

Newly developed maintenance and checkout equipment may be divided into five major assemblies:

i. Programming

ii. Stimuli Generation

iii. Measurement

iv. Evaluation

v. Summarization

i. Programming

Automatic programming of electronic equipment has been well established in the field of digital computers and commercial telephony. It is, therefore, reasonable to utilize digital techniques for programming testing of electronic equipment, since what is primarily involved is a series of predetermined discrete commands or instructions in a predetermined time sequence. The programming equipment should establish for each test condition the proper input signal or stimuli scale and function, the output signal tolerance levels, and the input and output connections for the equipment being tested. Several proven reliable methods of providing an automatic instruction source and reader may be utilized, but the four types that appear to possess the flexibility and capacity required are telephone type stepping switches, punched cards, punched tape and magnetic tape -- the latter three with their associated readers. Figure 22 shows different versions of programmers and includes from left to right, a relay, stepping switch, and punched-tape programmer.

ii. Stimuli Generation

In order to verify any electronic equipment's performance, it is necessary to supply an input signal or stimulus to the system. This stimulus may be a power signal, U.H.F. signal, pressure signal, or Infra-Red signal, etc. The stimuli generators normally receive discrete input commands and produce a predetermined output value to the equipment being tested with the input commands being generated in the programming equipment. A great deal of emphasis has been placed on the development of this type of equipment and several varieties of generators for all known types of stimuli are readily available. A few typical generators that are available commercially are the Microgee Products, Inc., Voltage to Displacement Table, the Krohn-Hite Voltage to Frequency Generator, and the Marquardt Voltage to Pressure Generator. (See Reference 7d for a more complete listing.)

iii. Measurement Equipment

This category of equipment may be composed of power meters, frequency counters, voltmeters, ohmmeters, oscilloscopes, etc., but the measured value does not have to be noted by the personnel conducting the test, since the measured value is routed directly or converted by the measurement equipment to information suitable to be supplied to the evaluation equipment. Emphasis in the computer field has led to numerous automatic digital voltmeters and frequency counters, which during the past five years have been proven to be extremely accurate and reliable. Typical manufacturers of such equipment are Beckman Instruments, Computer Measurements, Hewlett Packard, and Kin-Tel (Reference 7d).

iv. Evaluation Equipment

The Evaluation Equipment takes the programmed tolerance values from the Programmer and the measured value from the Measurement Equipment and compares the signals, determining for each test whether the measured value is within or out of tolerance. The comparison of signals to determine whether one signal is higher or lower than another is well known and is commonplace in all types of airborne control equipment. Both analog and digital comparators are available from several sources, typical manufacturers being Stromberg-Carlson, Marquardt, Hoffman Labs, etc. (Reference 7d).

v. Data Summarization

This last category consists of equipment provided to record the measured test results and has again been developed and proven to be extremely reliable in the Digital Computer Field. The most widely used equipment in this area is a printed tape recorder or a punched card recorder receiving input signals directly from the measurement equipment. This permanent record of the test results serves a vital use in that it allows direct comparison between tests made at the factory when the equipment is fabricated and tested and tests made in the field when the equipment is received. Any discrepancies quickly pin down abusive handling in crating, shipping, or uncrating. Furthermore, in the case of recovered equipment or plain preventative maintenance, marginal equipment is readily spotted by comparison with previous test recordings. This information may be fed back through the affected maintenance echelons or to the system contractor to facilitate any corrective action required. IBM, Remington Rand, Clary, Hewlett-Packard, and Computer Measurements are a few of the manufacturers of this type of equipment (Reference 7d).

c. Typical Advanced Maintenance Equipment

Several types of maintenance and checkout equipment of the type previously discussed are now available commercially and in many cases even have military versions. A typical piece of maintenance equipment required for most programs is a harness and electrical test set. Several different varieties of this type of equipment are available (Reference 7d), and a typical example is the DIT-MCO Harness and Electrical Test Set. This equipment is designed to maintain and/or test harness, and electrical equipment is commercially available in a portable ruggedized military version. One of the many models available is shown in figure 23. The test set is a general purpose electrical circuit tester, and it detects continuity errors, shorts between circuits and circuits and ground, and excessive leakage current. The test set features automatic programming utilizing rugged telephone-type relays and stepping switches. Plugboard programming systems for handling different versions of the same equipment are also available to simplify set-up changes, and the entire test set features modular construction for ease of accessibility and maintenance.

Several more automatic system test sets with larger capacity have recently been introduced on the market. Typical manufacturers are Stromberg-Carlson, Sperry-Rand, Robertshaw-Fulton, and the Nortronics Division of Northrop Corporation. For illustration purposes, the Nortronics DATICO (Digital-Automatic Tape Intelligence Checkout) is shown in figure 24. The Federal Catalog Number is 6625-650-7542. The basic portion of DATICO automatically checks out any system for voltage, count, and time measurement, and several auxiliary portions are available to provide R.F., pressure, voltage, and other stimuli signals. The major assemblies of the unit are a punched paper tape programmer, an electro-mechanical communicator that performs the function of selecting input and output leads as well as controlling input stimuli, and an automatic recording digital voltohmmeter and frequency meter, together with a digital comparator. There are various read-out combinations available of the test data, with the standard being a printed paper tape in addition to visual displays. This equipment is extremely well-suited for Depot or field level maintenance, since it has the capacity of automatically pinpointing malfunctions down to the major assembly or even to the part level, such as resistors or condensers, of many different classes of equipment with only a change in the punched tape information supplied to the programmer and the accessory stimuli generators.

What is believed to be a unique and novel development in bench test equipment suitable for field maintenance is the Radioplane Electronic Support Equipment being developed for an evaluation drone system under Air Force contract. This equipment is semi-automatic in operation and features a telephone-type stepping switch programmer. The novel features of this equipment may best be explained by referring to a typical piece of this equipment developed to check out and maintain a rather complex automatic flight control system, which utilizes an analog computer type mechanization with 21 replaceable amplifier assemblies in addition to gyros, transducers, and electro-hydraulic actuators. The test set features a built-in instruction book on the front panel so that a minimum skill level technician with very minor instruction can operate the equipment. A close-up of the front panel is shown in figure 25. In addition to the human engineered front panel operation flow, the isolation of malfunctioning major assemblies is pin-pointed to the technician by means of a low cost display indicator that gives the technician positive instructions on what assembly to replace or adjust. Figure 26 shows a typical visual indication and instruction for a malfunctioning assembly. The test set features an automatic self-test; that is, it checks itself prior to conducting a test on any equipment, again visually indicating what maintenance procedure to follow in the event of a malfunction. Further self-checking is contained in the test program during the actual equipment tests to provide fail-safe operation.

d. Maintenance Concept and Logistic Plan

In order to take full advantage of the previous design techniques for the drone and maintenance equipment, it is also required that a systems approach be applied simultaneously in order to arrive at a thoroughly integrated maintenance concept and logistic plan. The latter must carefully review the relative advantage of replace and throw away vs. replace and repair and establish a spares provisioning philosophy that will fully utilize the design techniques employed in the vehicle and maintenance equipment. If there are no spare modules, and maintenance personnel are required to replace individual component parts, then the entire intent of the new design techniques employed in designing the vehicle and maintenance equipment are wasted.

The essential factor to be stressed in developing such a maintenance concept and logistic plan is to minimize personnel required not only as to number, but also as to skill level and amount of training and at the same time minimize the amount of maintenance equipment needed. Although these desires may seem contradictory, it is obvious that if each maintenance echelon is restricted to replacing only equipments or modules and the maintenance equipment does the thinking and specifies what is wrong and what to do about it, and at the same time adequate spare equipments and modules are available, it is possible to achieve the desired results.

e. Closed-loop Maintenance Information Feedback

In order to augment the successful conclusion of the preceding maintenance concept and logistic plan, it is essential that a closed-loop flow of information be provided. This feedback system should be automatized as much as possible to prevent the system from becoming over-damped or sluggish due to excessive delays. In other words, maintenance personnel in the launch area or field maintenance area, or even depot area, should not have to fill out numerous and complicated forms, since under peace or war conditions these forms are sometimes neglected or filled out incorrectly.

This may readily be handled by providing automatic data and failure recording in the maintenance equipment as discussed previously. This information, when sent back through the maintenance echelons, should receive priority attention so that the logistic plan, the maintenance concept, and the vehicle equipment all are modified simultaneously, if required, in order to correct shortcomings or improve the over-all system performance.

6. Conclusions

In conclusion, if there is to be a significant reduction in maintenance costs and increased over-all system reliability for the Surveillance Drone Systems presently under development or to be developed in the future, it is necessary that several objectives be satisfied.

First, all equipment must be designed to be maintained. Techniques such as modularized construction, interchangeability, adequate test points, self-testing capability, and normalized test signal outputs are available and should be utilized to the fullest extent feasible.

Second, maintenance equipment must be designed to minimize the number, as well as the skill level required, of maintenance personnel both for operation of the equipment and its repairs.

Third, a maintenance concept and a logistic plan must be developed utilizing a systems approach to take full advantage of the two objectives above. Spares provisioning must be adequate to enable replacement of faulty assemblies or modules, or the above maintenance techniques serve no purpose.

Fourth, a closed-loop information feedback system must be employed to keep all maintenance echelons informed of problem situations so that corrective action may be instigated wherever such action is needed. This system must be automatic, since relying on maintenance personnel to fill out numerous complicated and opinionative forms, especially under war conditions, makes communication of this type of data almost worthless. These objectives are already being phased in on a large number of military programs and should be utilized in Surveillance Drone Systems as well, with the degree of inclusion, naturally, being a function of system complexity.

The acceptance of these objectives must be on an evolutionary rather than a revolutionary basis in order to be successful. However, the objectives must be phased in as early as possible in the planning and thinking of all concerned personnel if we are to be successful in maintaining our offensive and defensive military capability.

Acknowledgement:

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7. References

a. Final Report, Signal Maintenance Symposium, 22, 23 and 24 April, 1958 - United States Army Signal Equipment Support Agency, Fort Monmouth, New Jersey.

b. Army Maintenance for Military Electronics, Al Steinburg, Military Electronics, February, 1959.

c. Handbook - Operation and Maintenance Instructions for Surveillance Drone - Model SD-1, Radioplane Division, Northrop Corporation.

d. Automatic Checkout Equipment, L. S. Kilvans, Electronic Industries, Part I, April, 1958; Part 2, May, 1958.

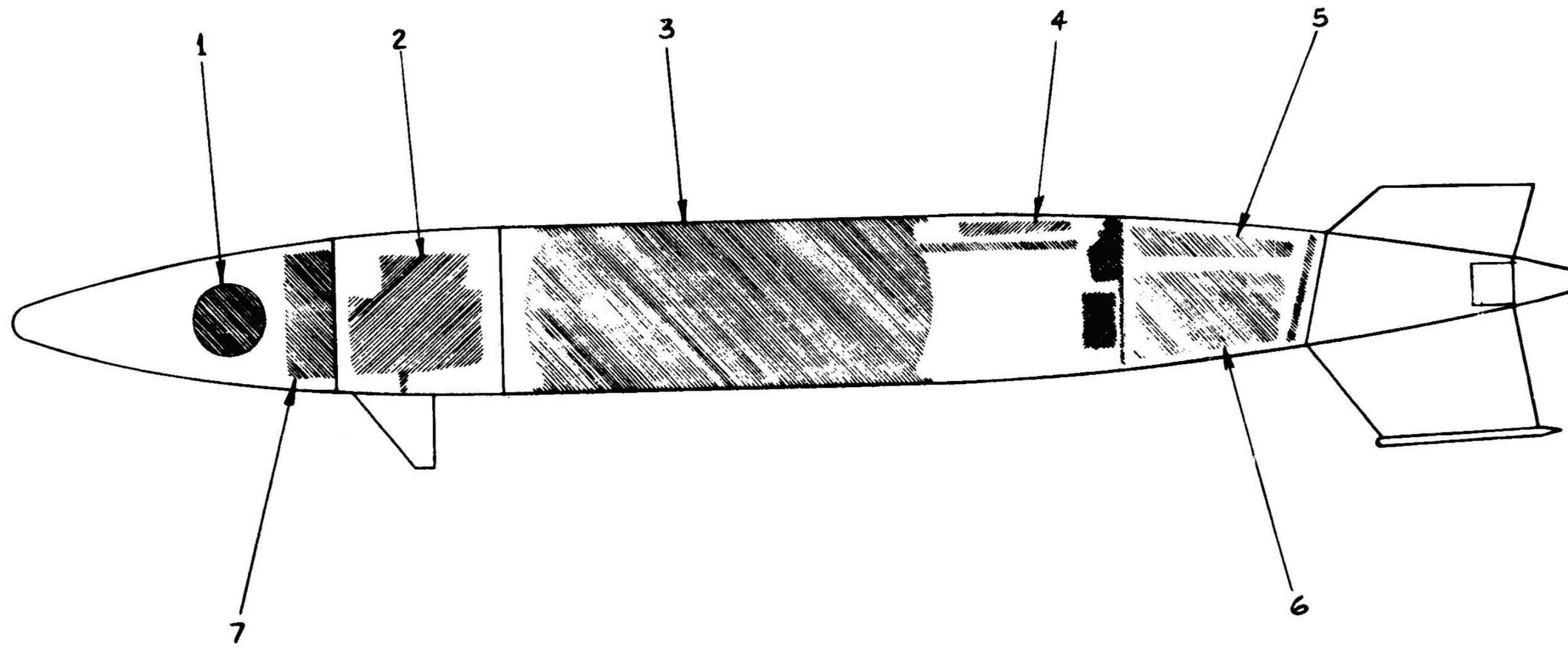
e. Specification for Television System for Drone Reconnaissance, J. R. Mahoney, H. L. Polisky, Radioplane Specification 1825B, 6 October 1958.

f. Model Specification - Surveillance Drone, Model SD-1, F. A. Paul, L. A. Brown, Radioplane Report 1694B, 4 April 1958.

g. Q-4A Operational Employment, Contract AF 33 (600) -35049, J. Dresner, K. L. Butterworth, Radioplane Report 1813A, February, 1959. (Classified Report)

h. Specification for DATICO Catalog Number DAT-001, Nortronics-Systems Support, A Division of Northrop Corporation, 13 March 1958.

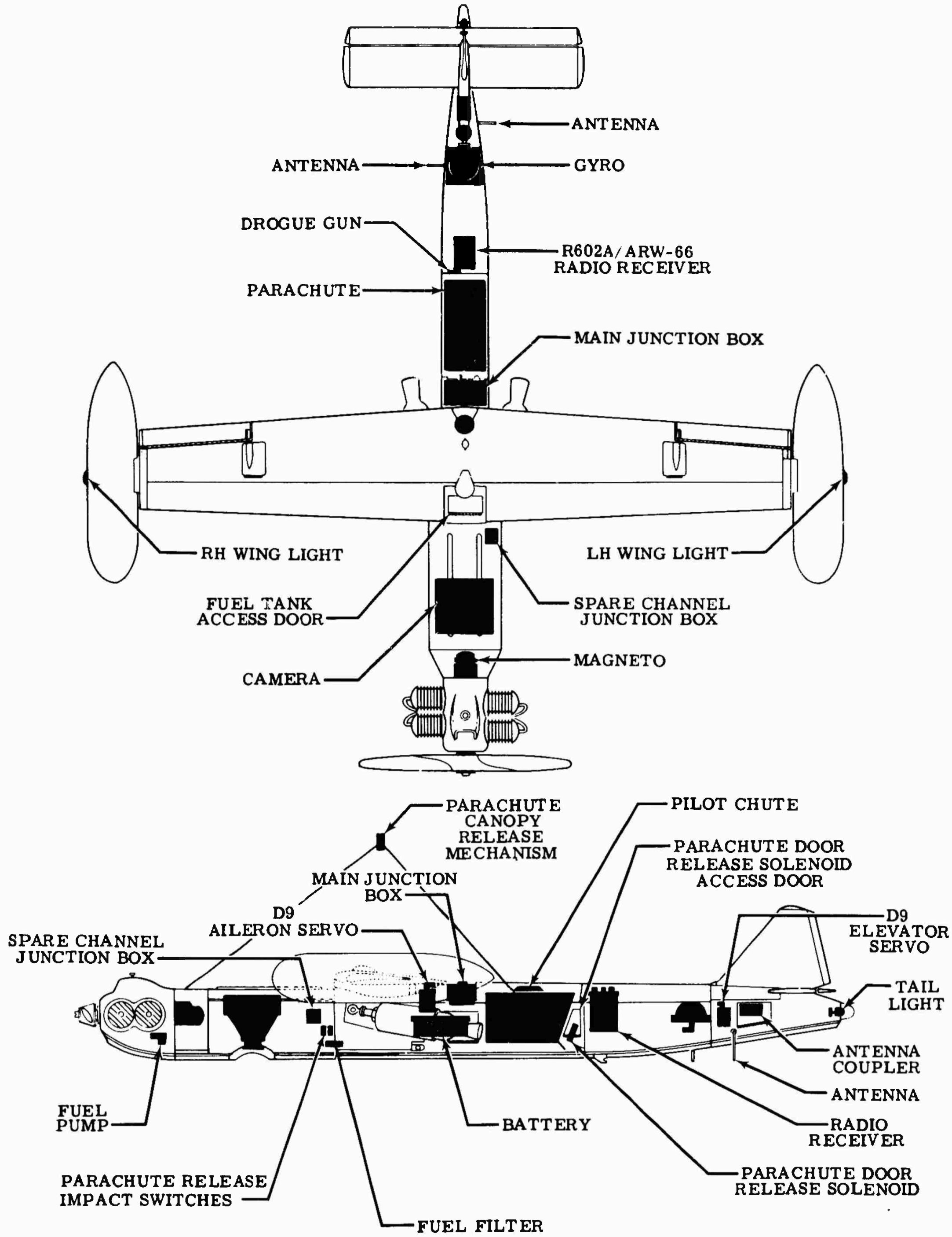
TYPICAL DRONE VEHICLES
(L. to R. - RP-71, X-BOW, XQ-4, RP-77D, RP-76)
FIGURE 1



1. RADAR REFLECTOR (LUNEBURG LENS)
2. GUIDANCE PACKAGE (AUTOPILOT & COMMAND RECEIVER)
3. SOLID PROPELLANT ROCKET ENGINE
4. TRACKING AID AND POWER SUPPLY
5. DRAG CHUTE
6. MAIN CHUTE
7. BATTERIES

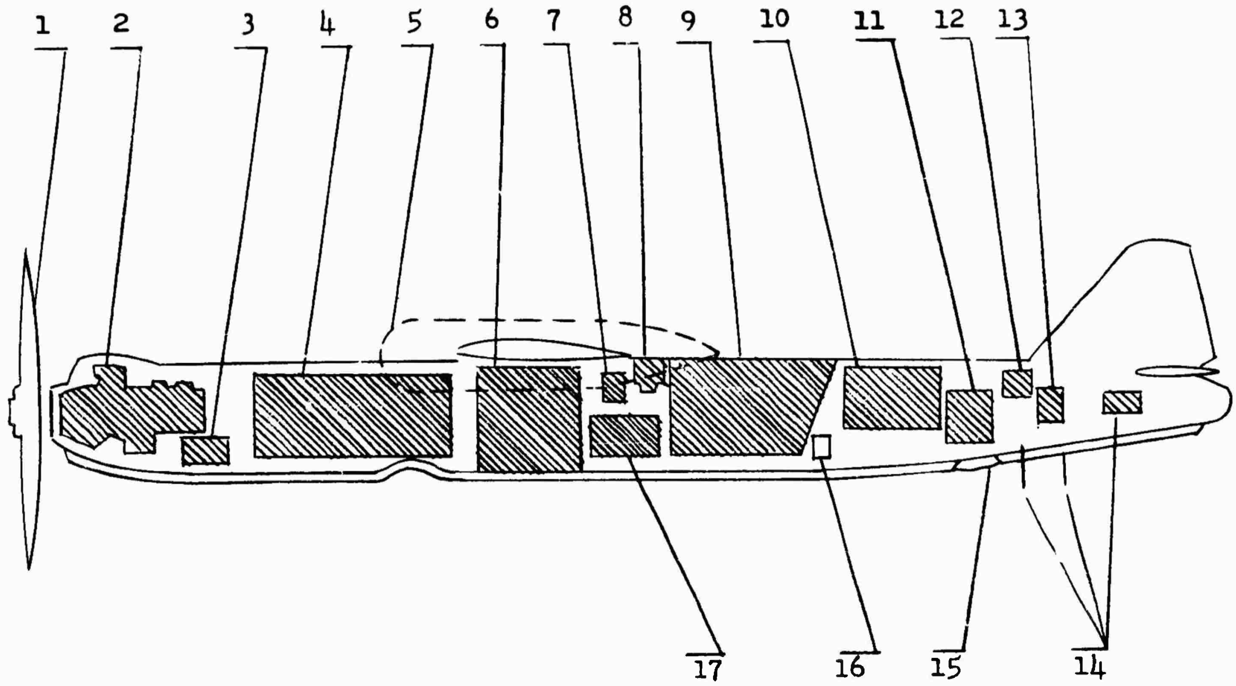
EQUIPMENT PROFILE - RP-76 TARGET DRONE

FIGURE 2



EQUIPMENT PROFILE - SD-1
SURVEILLANCE DRONE WITH CAMERA

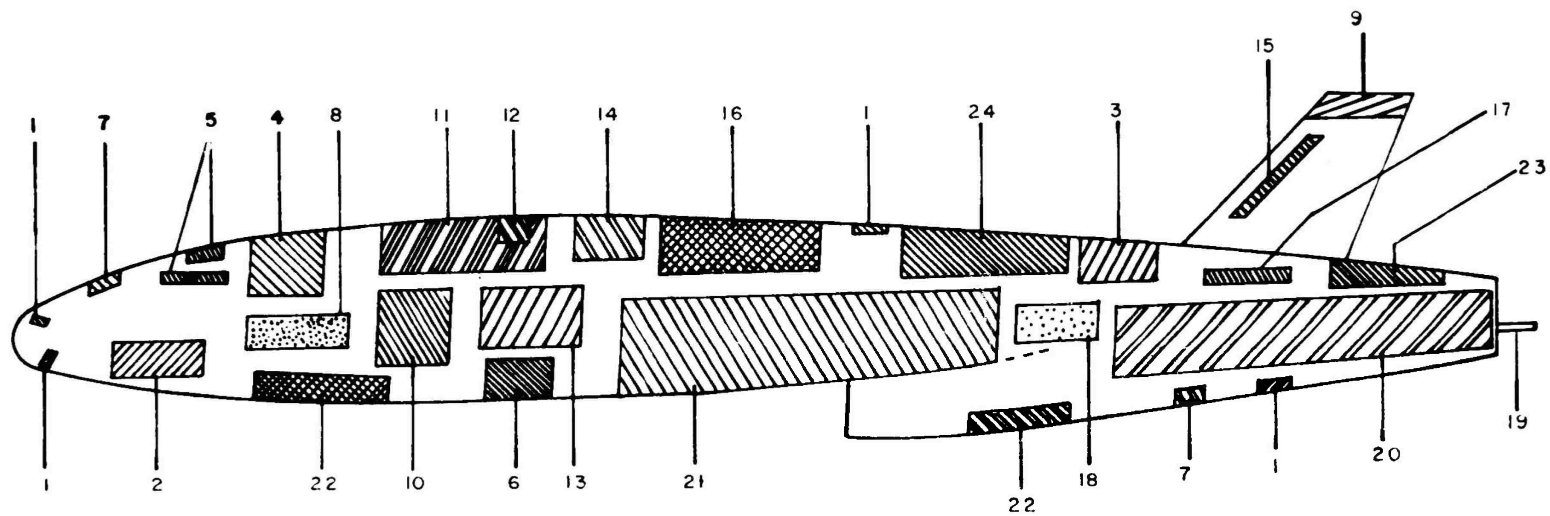
FIGURE 3



1. PROPELLER
2. ENGINE (TYPE 0-100-2)
3. ALTERNATOR (400 CYCLE)
4. CAMERA & SYNC. EQUIPMENT
5. POD ASSY. (NOT SHOWN FOR CLARITY)
6. FUEL TANK
7. AILERON SERVO
8. MAIN JUNCTION BOX
9. PARACHUTE
10. VIDEO TRANSMITTER
11. RECEIVER-AUTOPILOT
12. VERTICAL GYRO
13. ELEVATOR SERVO
14. ANTENNA SYSTEM
15. TV TRANSMITTING ANTENNA
16. PARACHUTE RELEASE MECHANISM

EQUIPMENT PROFILE SD-1 SURVEILLANCE DRONE (T.V. VERSION)

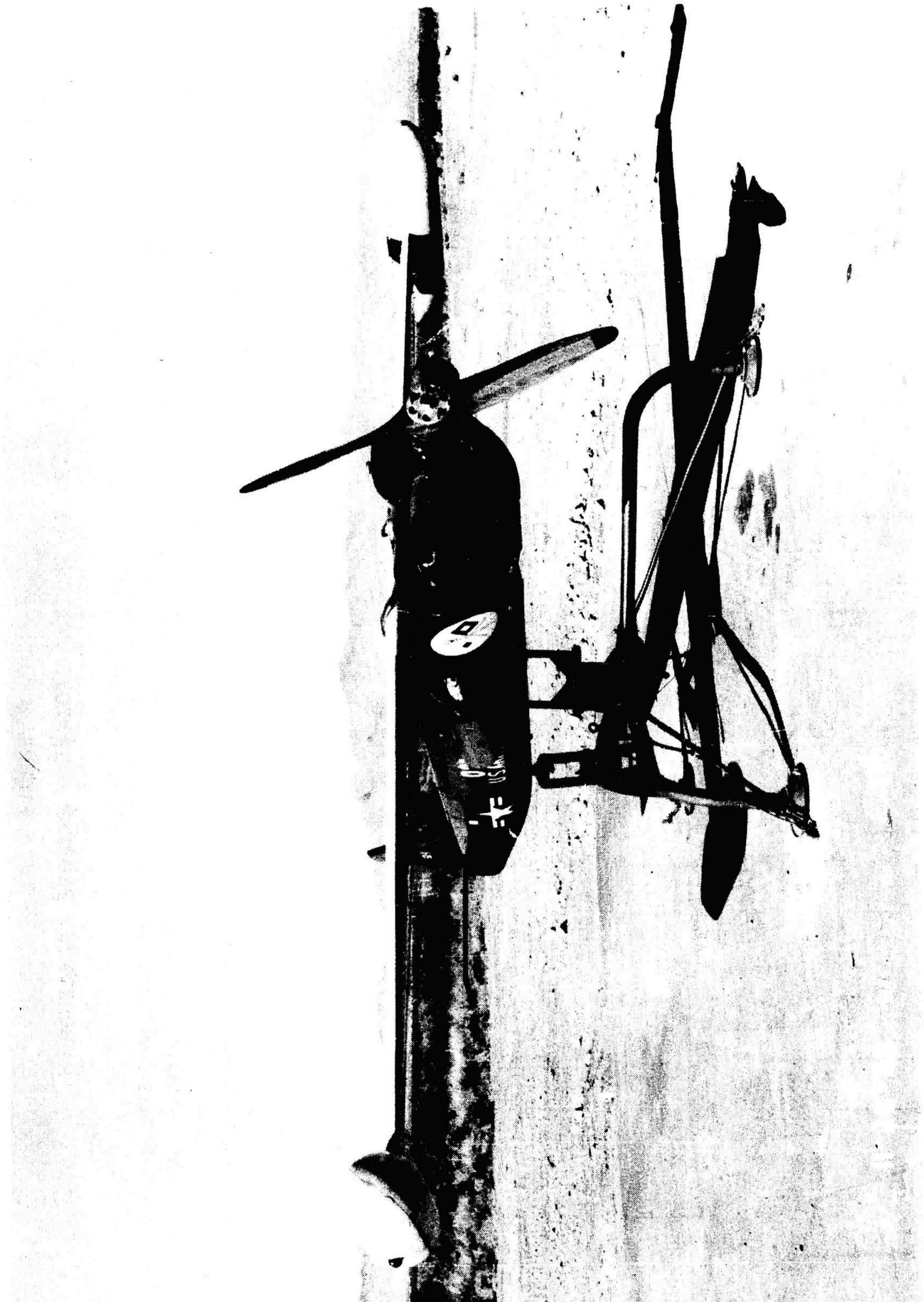
FIGURE 4



1 RADAR AUGMENTATION ANTENNAS
2. RADAR AUGMENTER
3. CHAFF DISPENSER
4. ELECTRONIC COUNTER MEASURES (ECM)
5. ECM ANTENNAS
6. ELECTRONIC SCORING
7. SCORING ANTENNAS
8. INSTRUMENTATION
9. INSTRUMENTATION ANTENNA
10 ELECTRONIC DISTRIBUTION BOX
11 RECOVERY BEACON
12 RECOVERY BEACON ANTENNA
13 POWER SUPPLY
14 COMMAND RECEIVER
15 COMMAND RECEIVING ANTENNA
16. FLIGHT CONTROL COMPUTER AND SENSORS
17. FLIGHT CONTROL ACTUATORS
18 AC GENERATOR AND HYDRAULIC POWER GENERATORS
19. INFRA RED AUGMENTATION
20. ENGINE
21. ENGINE FUEL TANKS
22. LANDING BAGS
23. FIRST STAGE PARACHUTE
24. MAIN PARACHUTE

EQUIPMENT PROFILE - TYPICAL EVALUATION DRONE

FIGURE 5

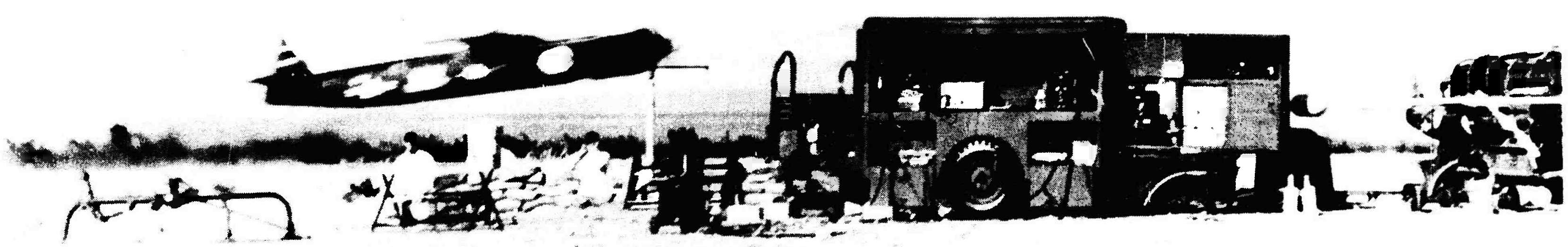


SD-1 SURVEILLANCE DRONE

FIGURE 6

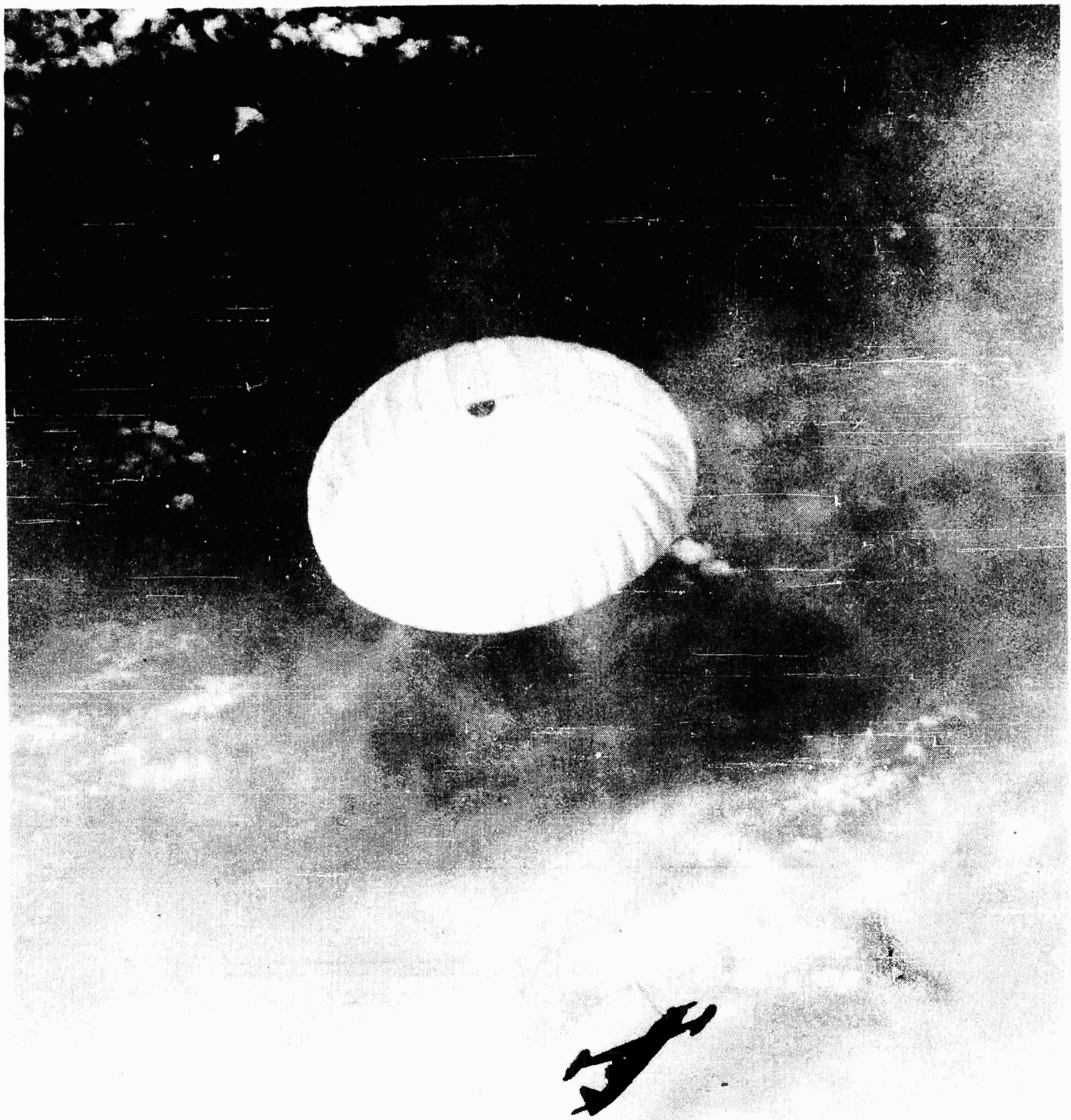
SD-1 SURVEILLANCE DRONE
WITH STARTER AND LAUNCHER

FIGURE 7



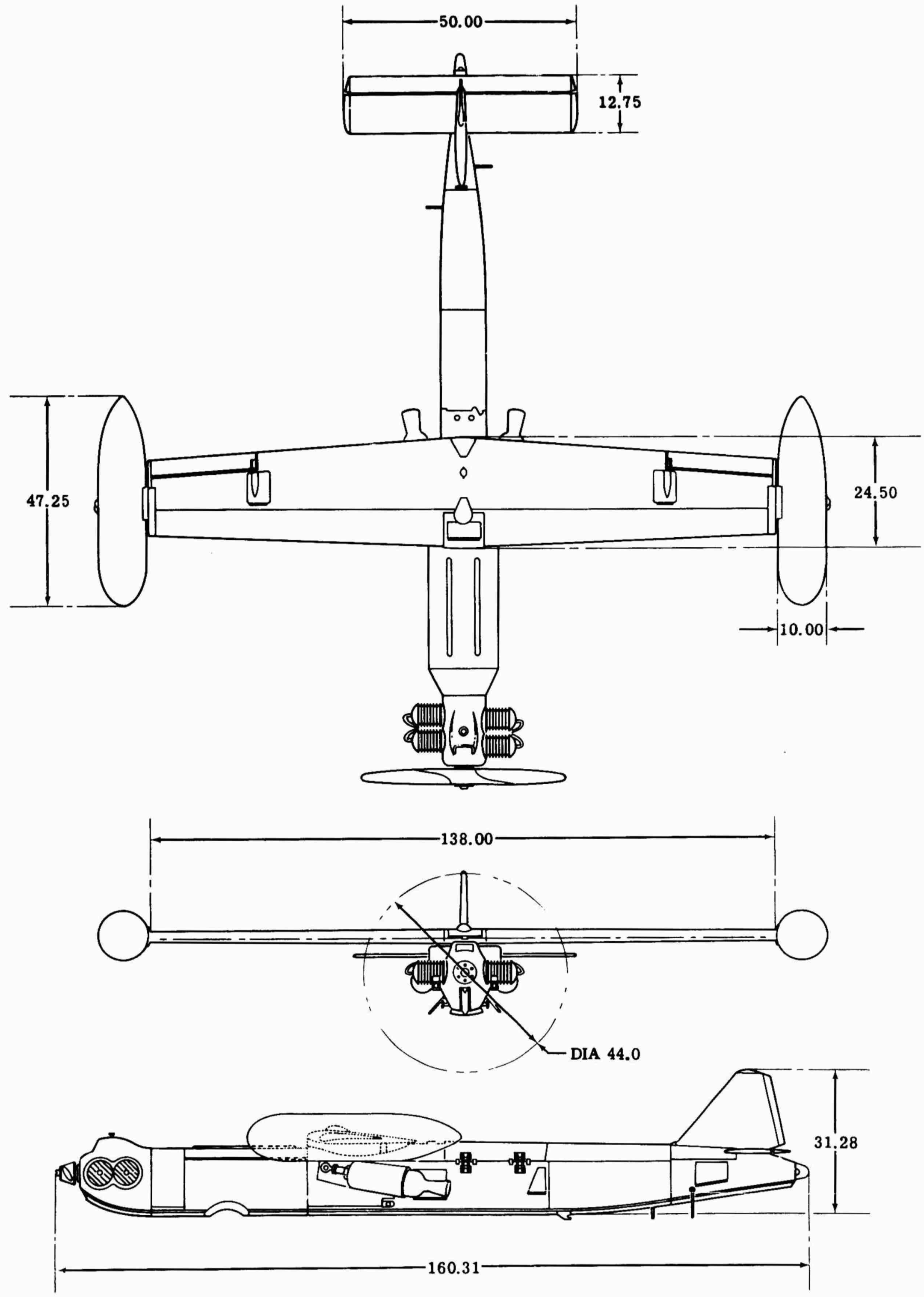
SD-1 SURVEILLANCE DRONE LAUNCHING

FIGURE 8



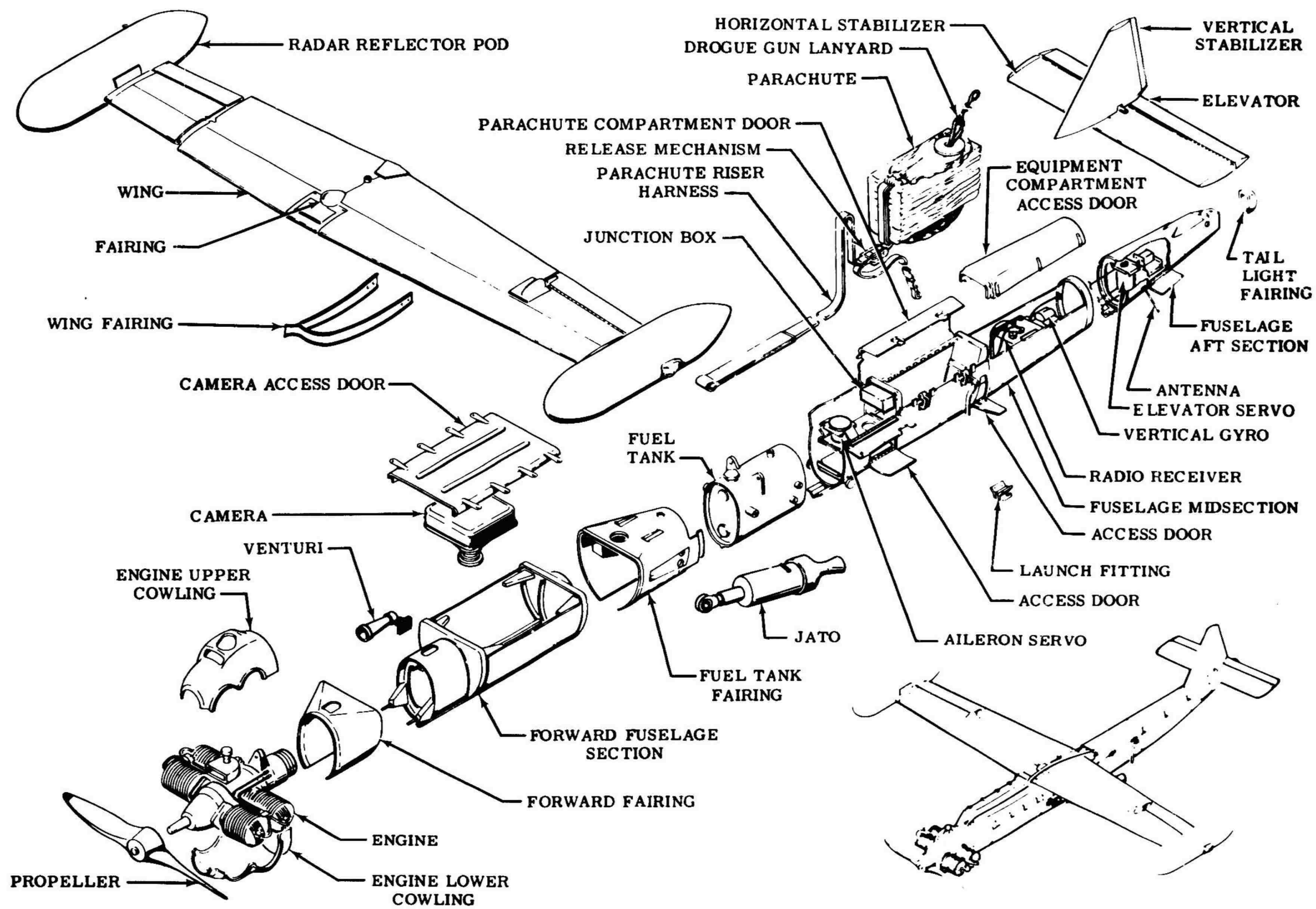
SD-1 SURVEILLANCE DRONE RECOVERY

FIGURE 9



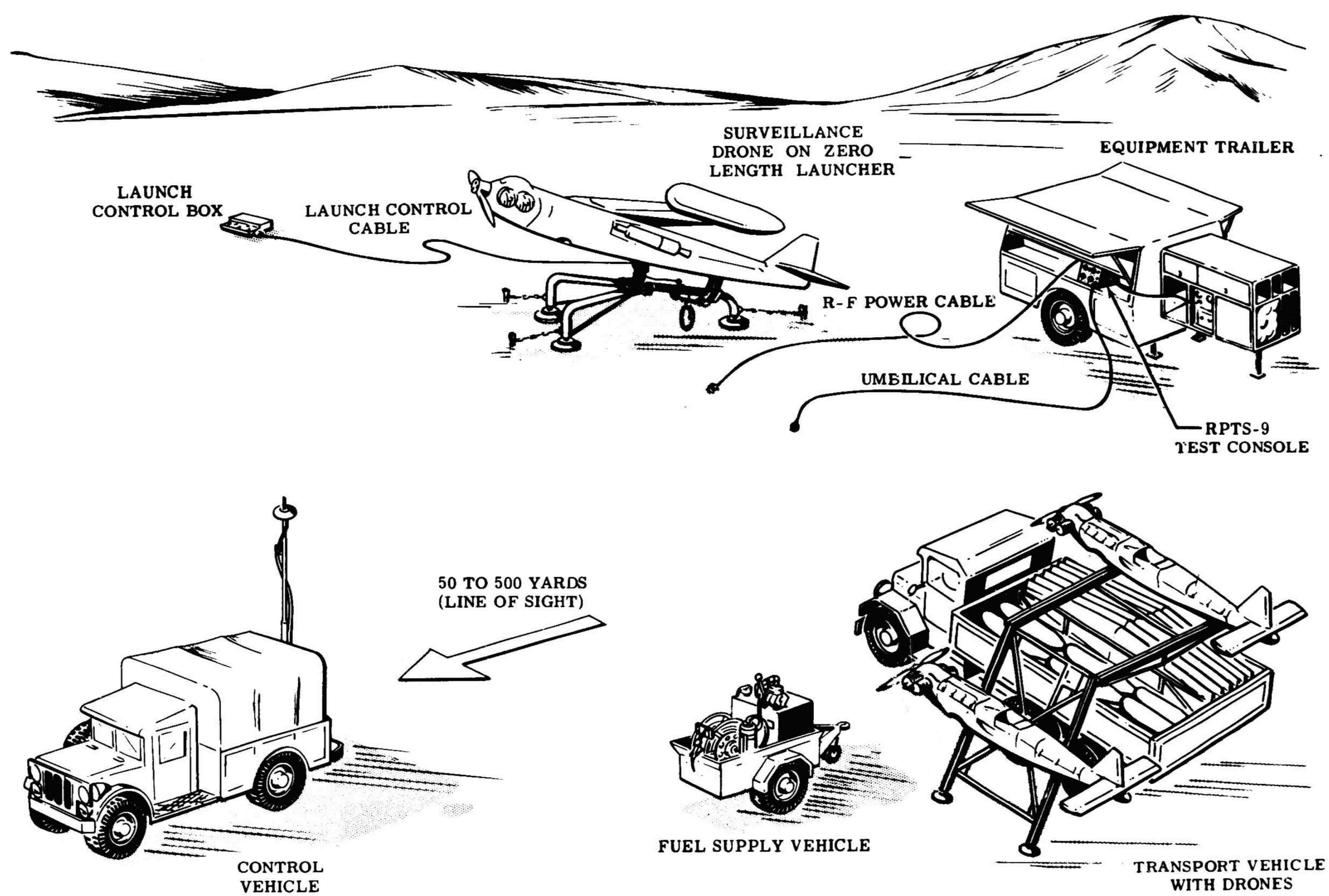
SD-1 SURVEILLANCE DRONE-THREE-VIEW

FIGURE 10



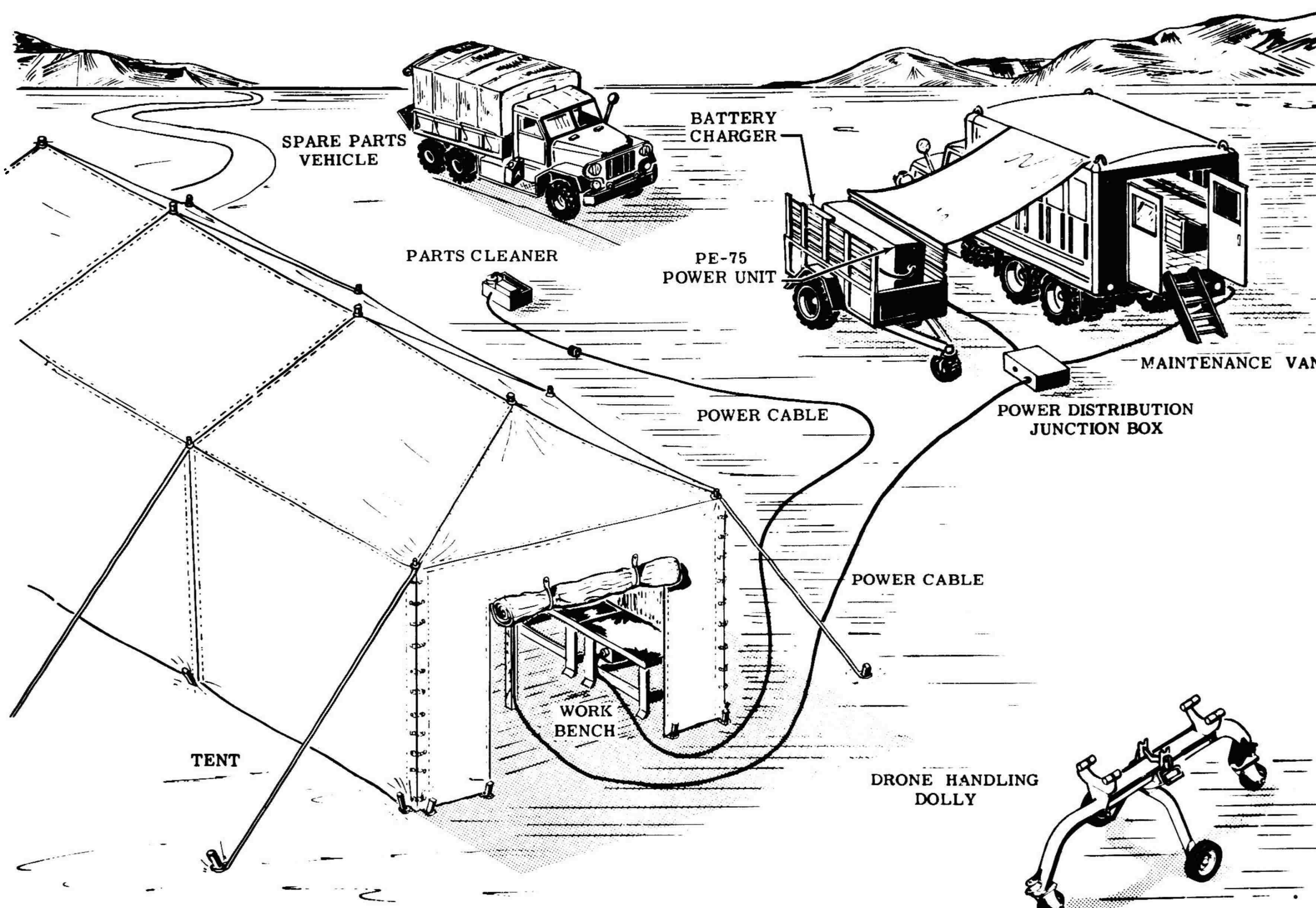
SD-1 DRONE EQUIPMENT-EXPLODED VIEW

FIGURE *11*



SD-1 DRONE LAUNCH AREA - PICTORIAL

FIGURE 12

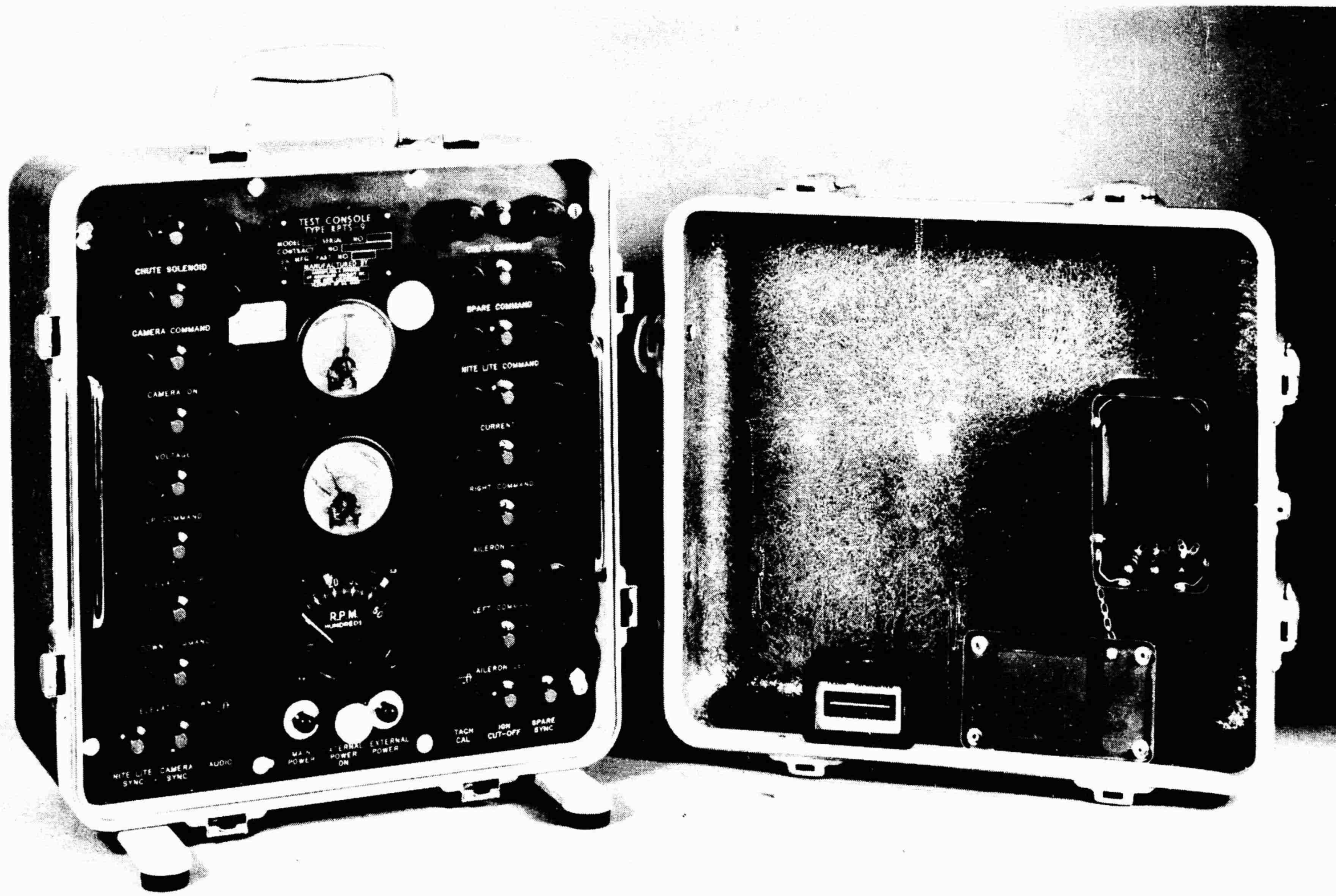


SD-1 DRONE FIELD MAINTENANCE AREA - PICTORIAL

FIGURE 13

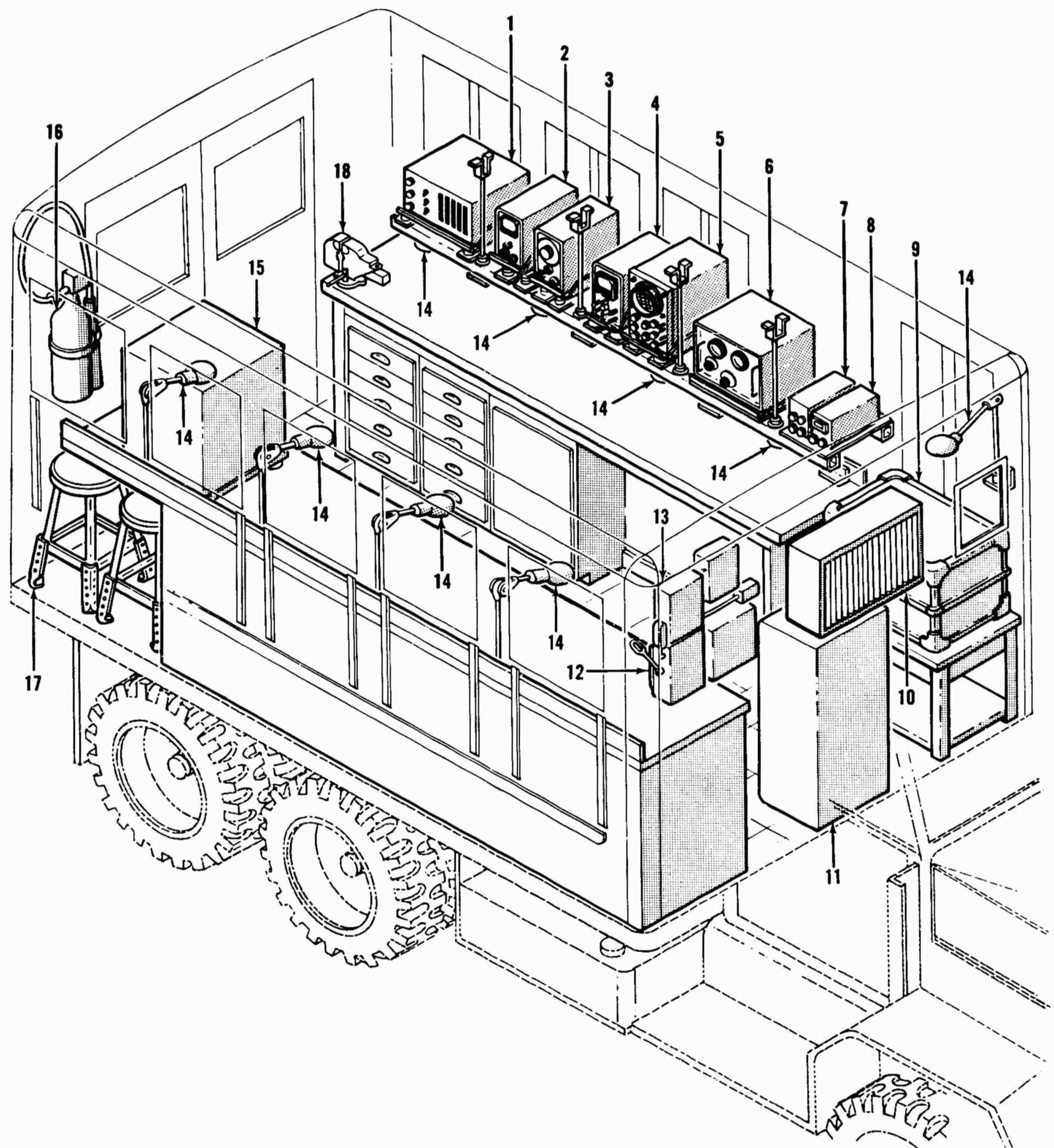
SD-1 DRONE LAUNCH AREA EQUIPMENT TRAILER

FIGURE 14



SD-1 DRONE LAUNCH AREA -
RPTS-9 ELECTRONIC TEST SET

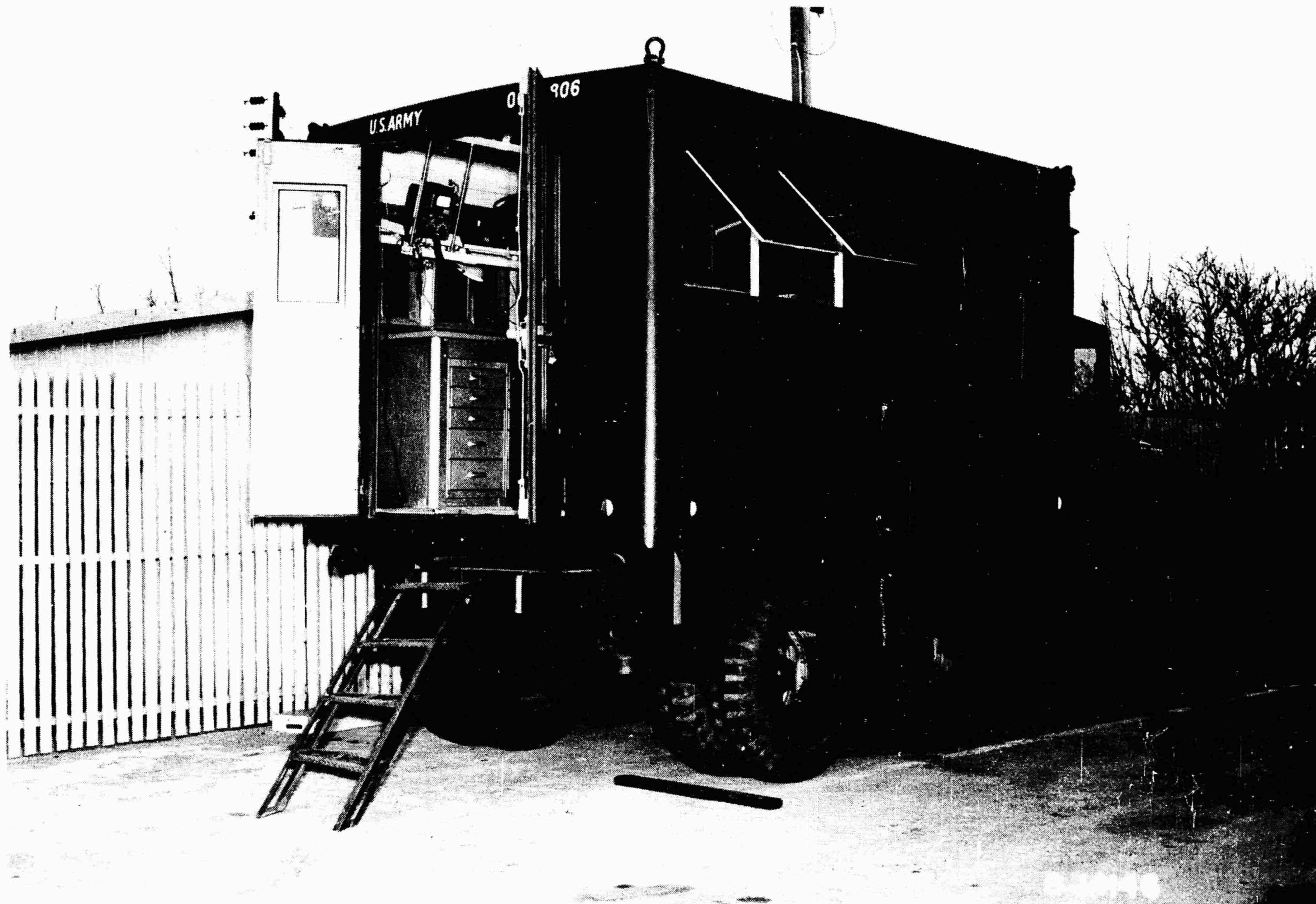
FIGURE- 15



1. FREQUENCY COUNTER
2. VACUUM TUBE VOLTMETER
3. OSCILLATOR
4. VACUUM TUBE VOLTMETER
5. OSCILLOSCOPE
6. SIGNAL GENERATOR
7. AUDIO FREQUENCY CODER
8. AUXILIARY CODER
9. TEST SET
10. AIR CONDITIONER
11. POWER SUPPLY
12. MAIN POWER SWITCH
13. MASTER CIRCUIT BREAKER PANEL
14. BENCH LIGHTS
15. SPECTRUM ANALYZER
16. FIRE EXTINGUISHER
17. STOOLS
18. VISE

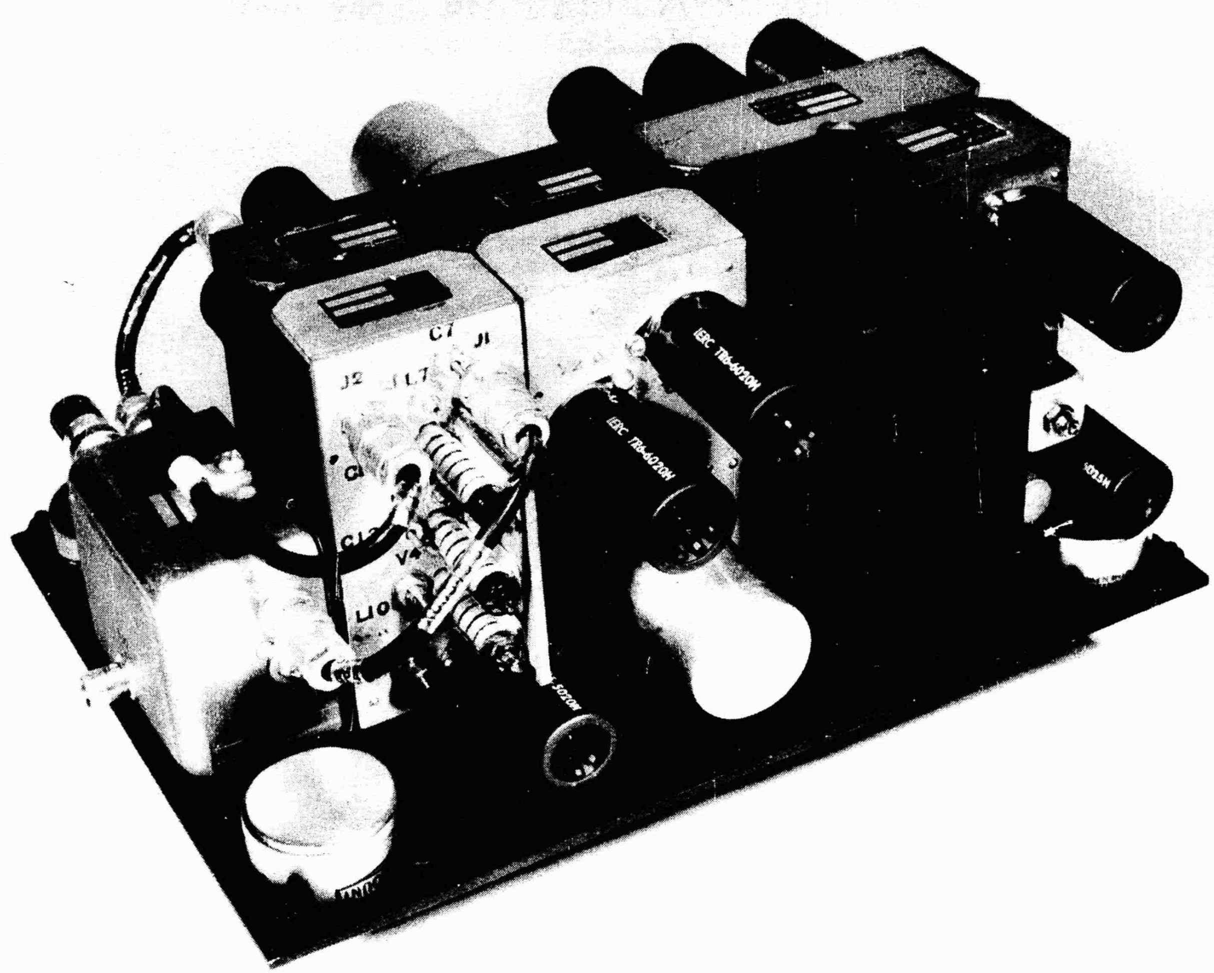
SD-1 DRONE ELECTRONIC MAINTENANCE VAN
INTERIOR PROFILE

FIGURE 16

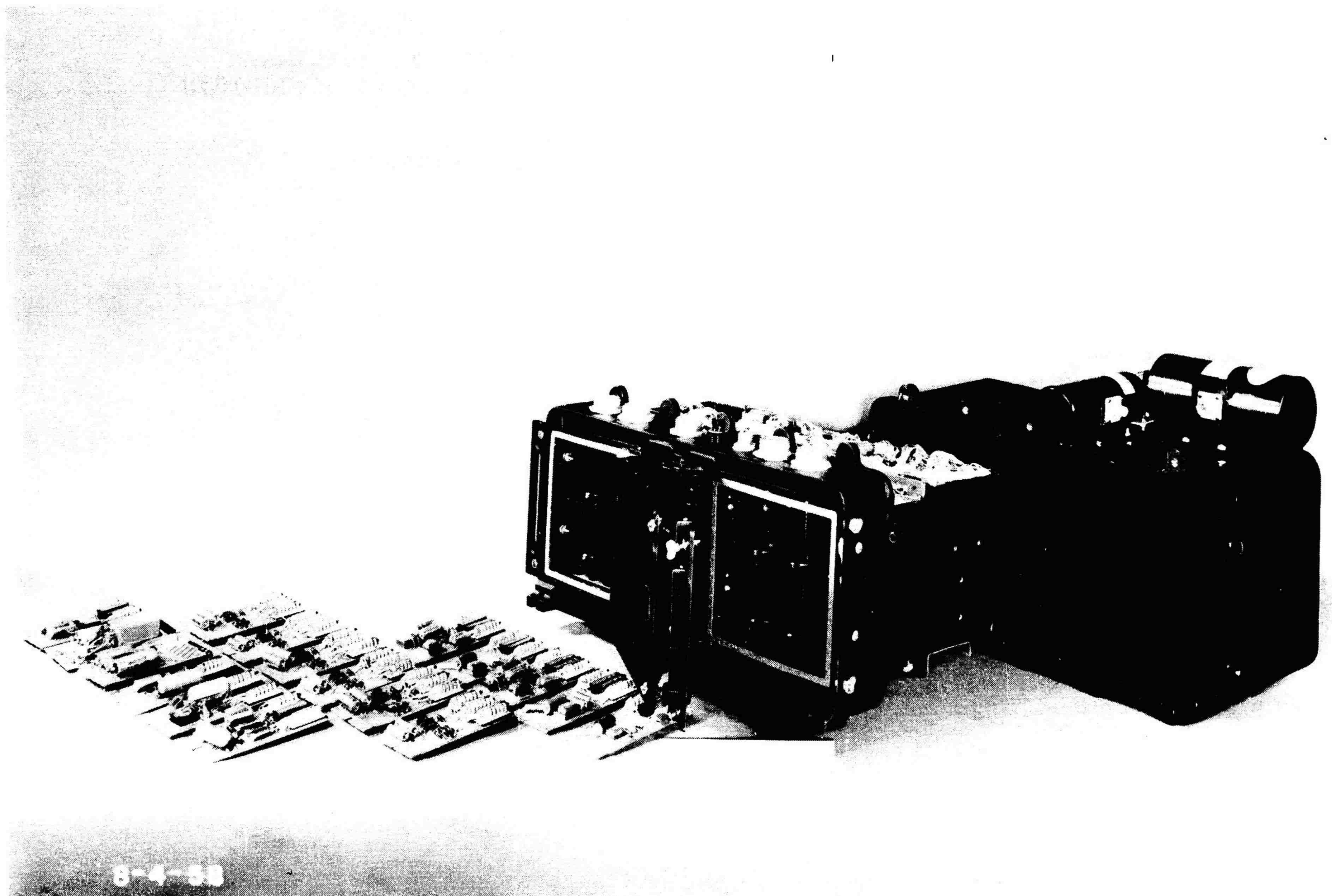


SD-1 DRONE ELECTRONIC MAINTENANCE VAN EXTERIOR

FIGURE 17

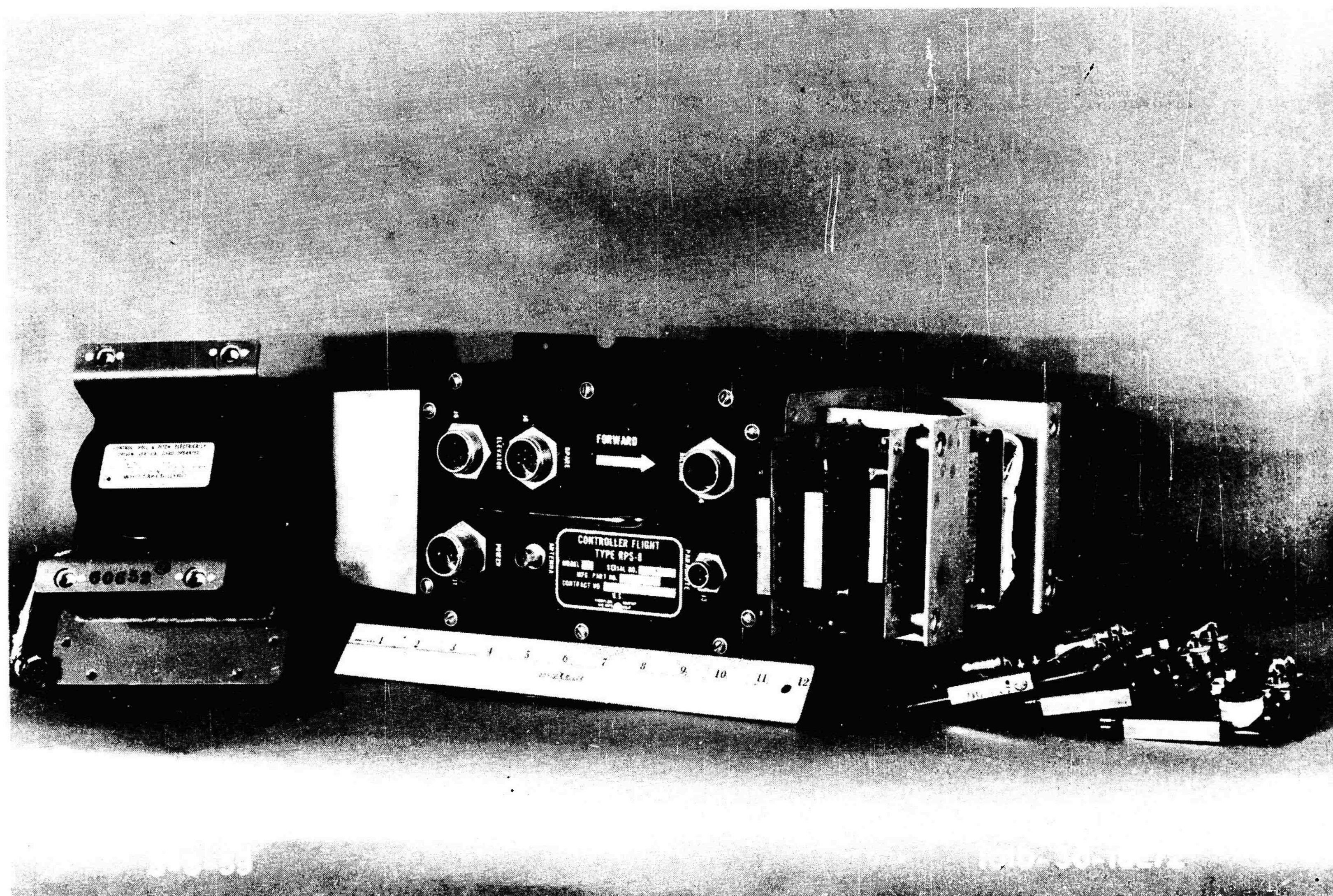


RADIOPLANE DEVELOPED LOW-COST DRONE SCORING EQUIPMENT
WITH CONVENTIONAL PLUG-IN MODULES
FIGURE 18



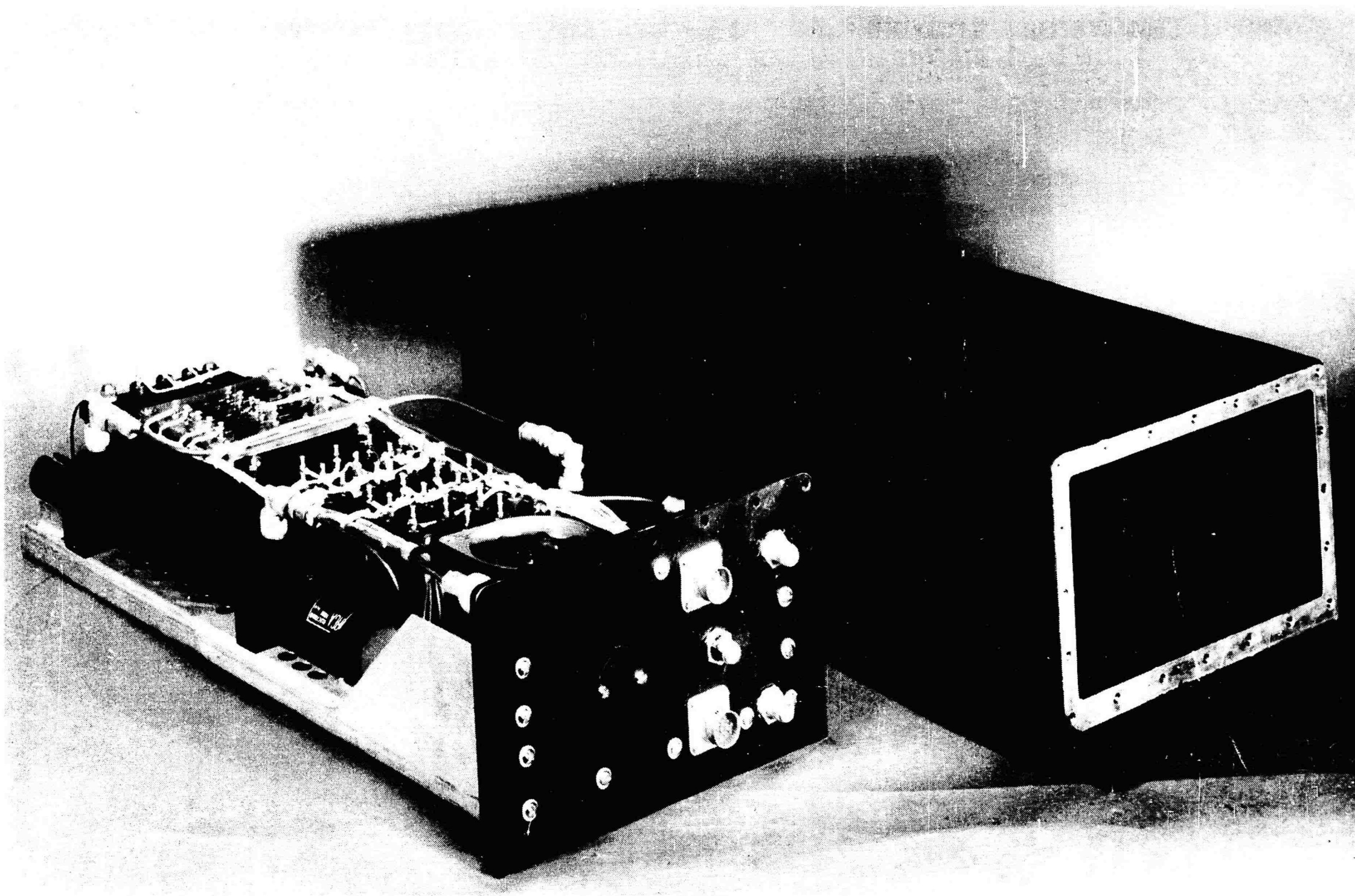
RADIOPLANE DEVELOPED EVALUATION DRONE FLIGHT CONTROL EQUIPMENT
WITH SUBMINIATURE PLUG-IN PRINTED CIRCUIT MODULES

FIGURE 19



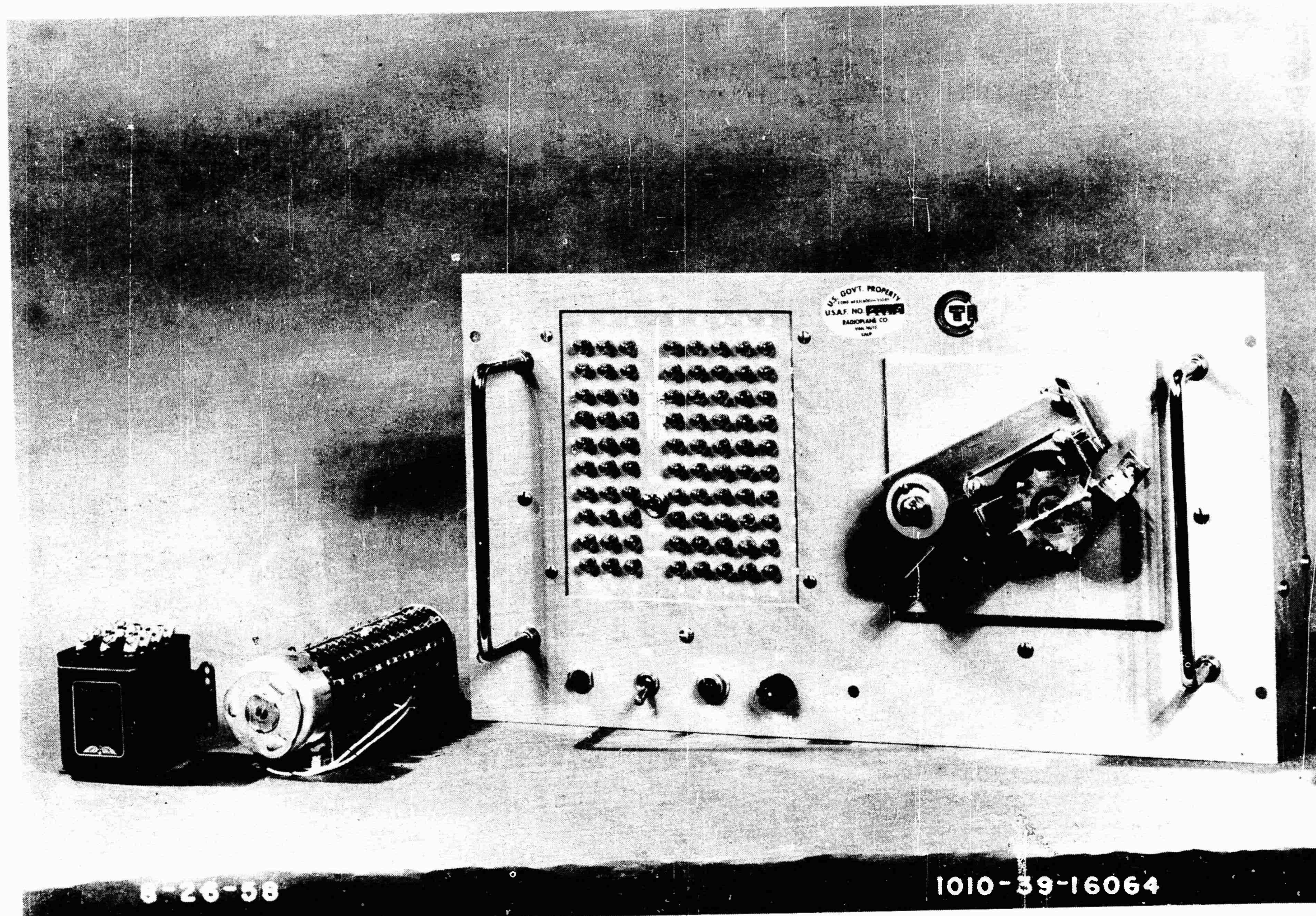
RADIOPLANE DEVELOPED LOW-COST DRONE FLIGHT CONTROL EQUIPMENT WITH SUBMINIATURE PLUG-IN TRANSISTORIZED PRINTED CIRCUIT MODULES

FIGURE 20



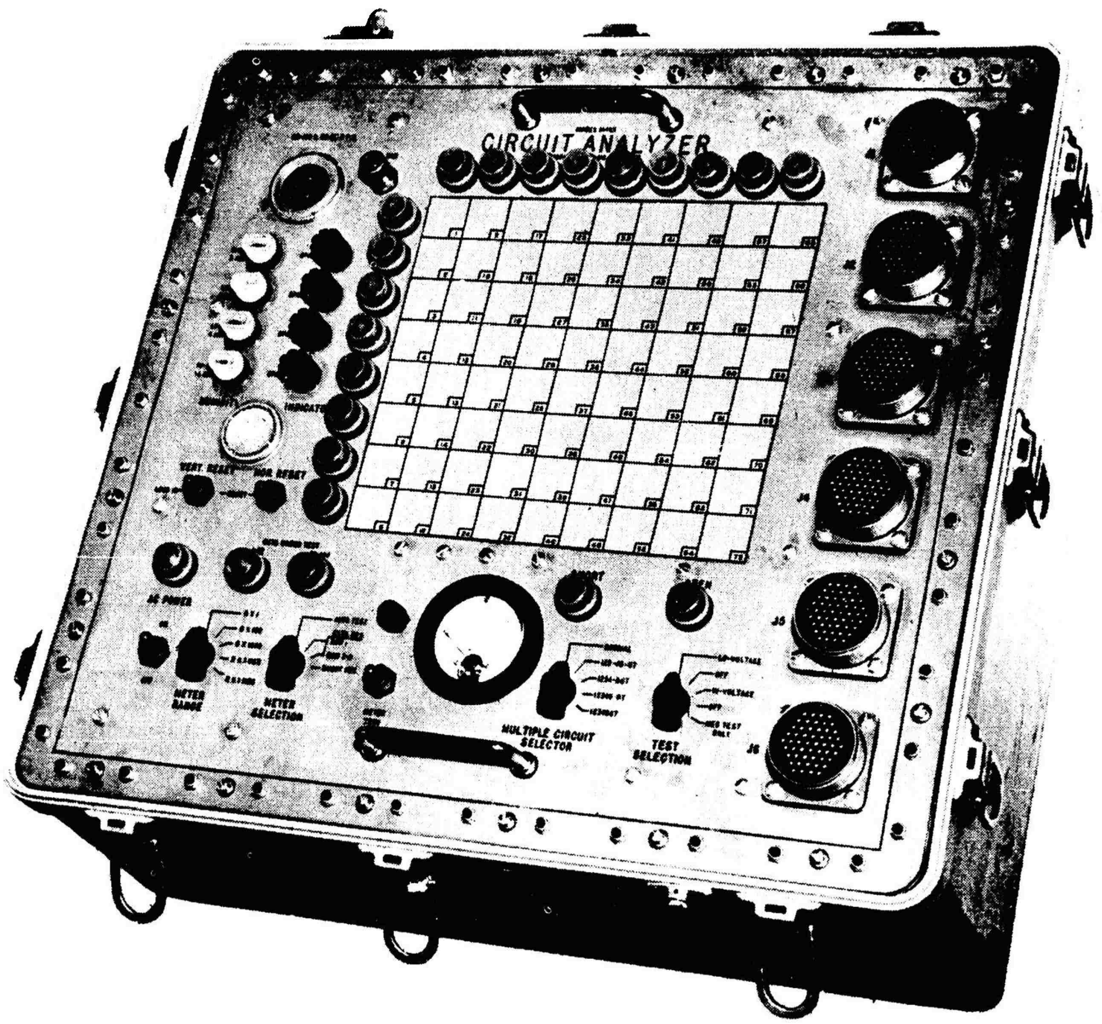
RADIOPLANE DEVELOPED RADAR AUGMENTATION EQUIPMENT
WITH TRAVELING WAVE TUBES

FIGURE 21



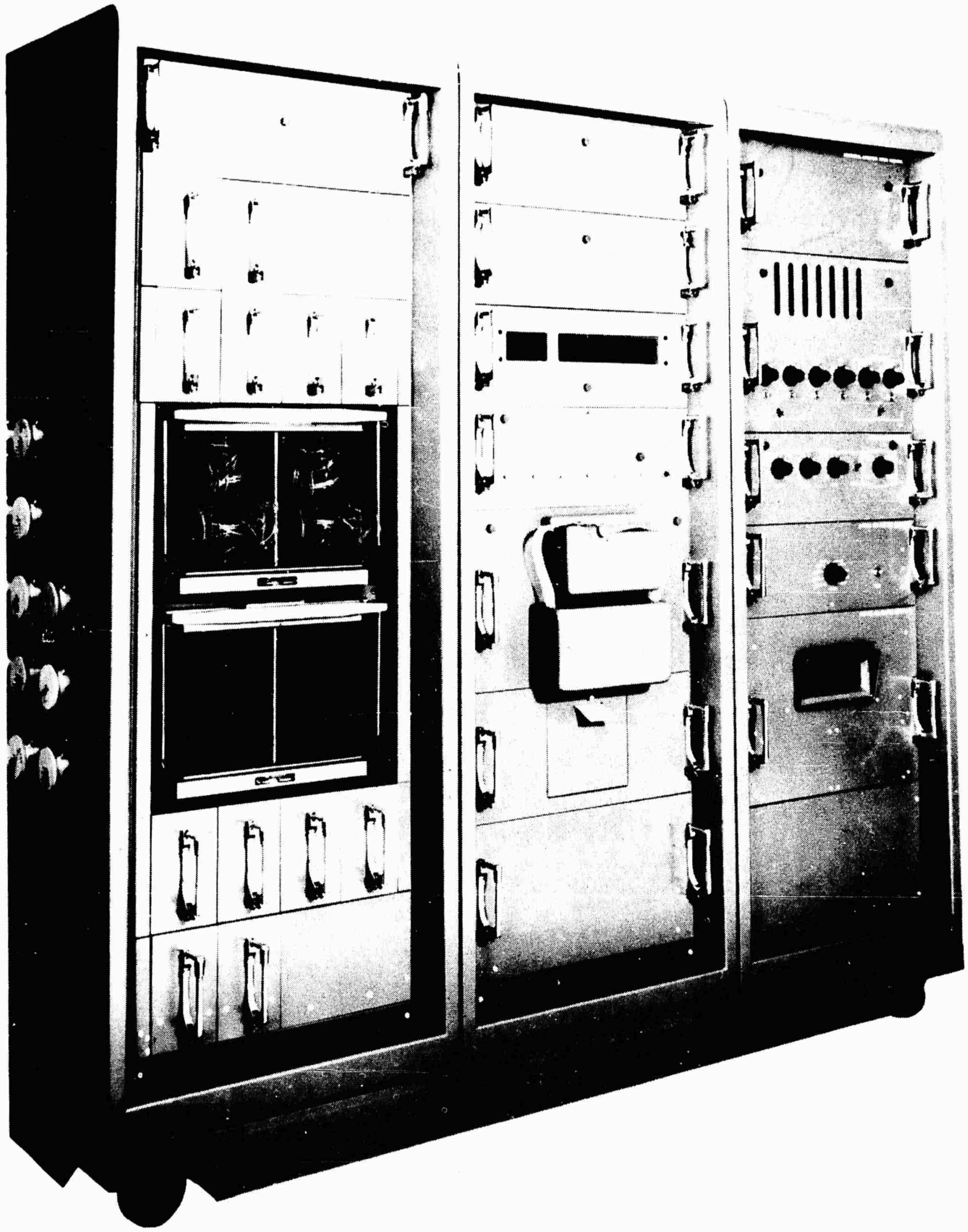
EXAMPLE OF PROGRAMMING EQUIPMENT FOR MAINTENANCE EQUIPMENT
(L. to R. - RELAY, STEPPING SWITCH, PUNCHED-TAPE PROGRAMMER)

FIGURE 22



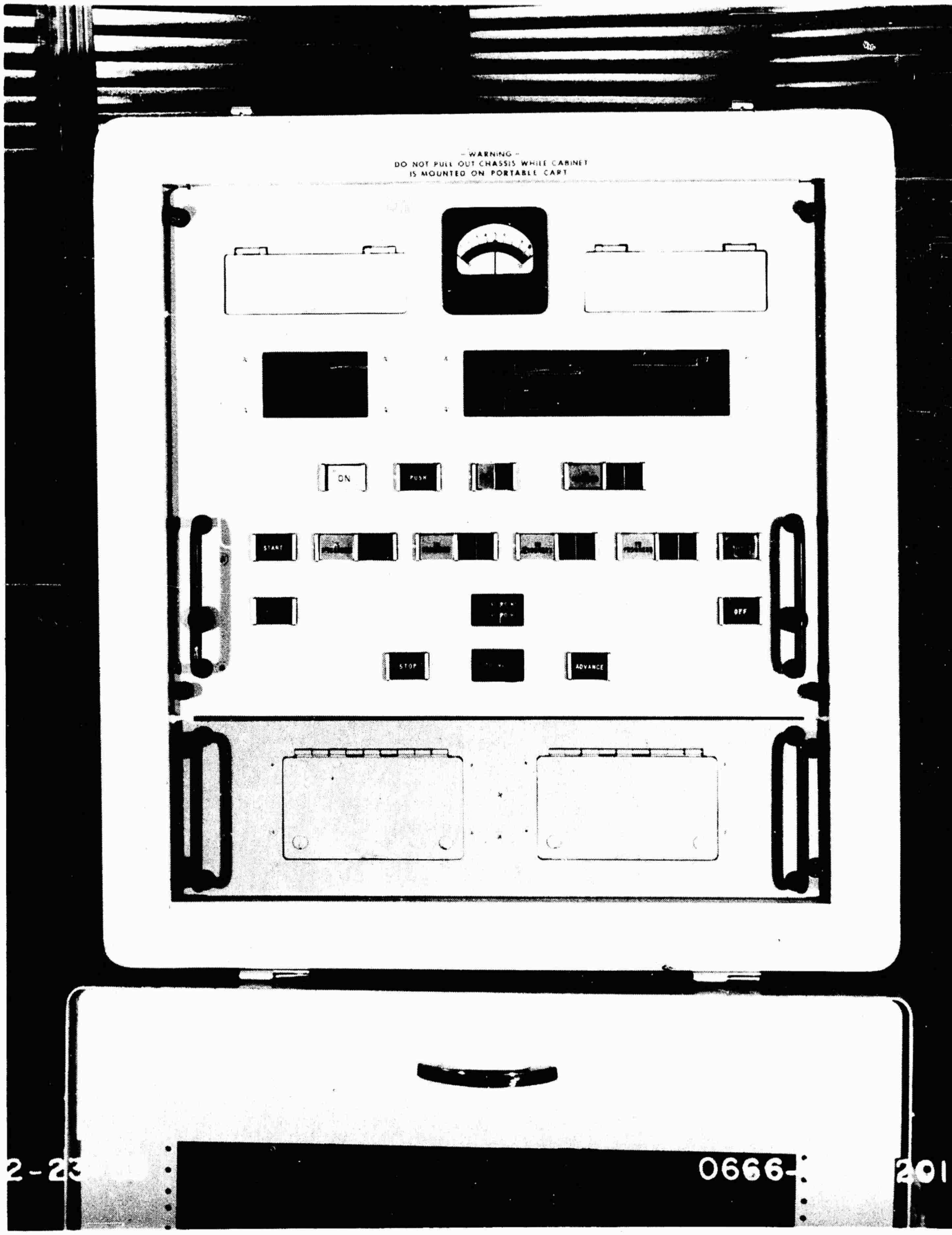
DIT-MCO HARNESS AND ELECTRICAL TEST SET

FIGURE 23



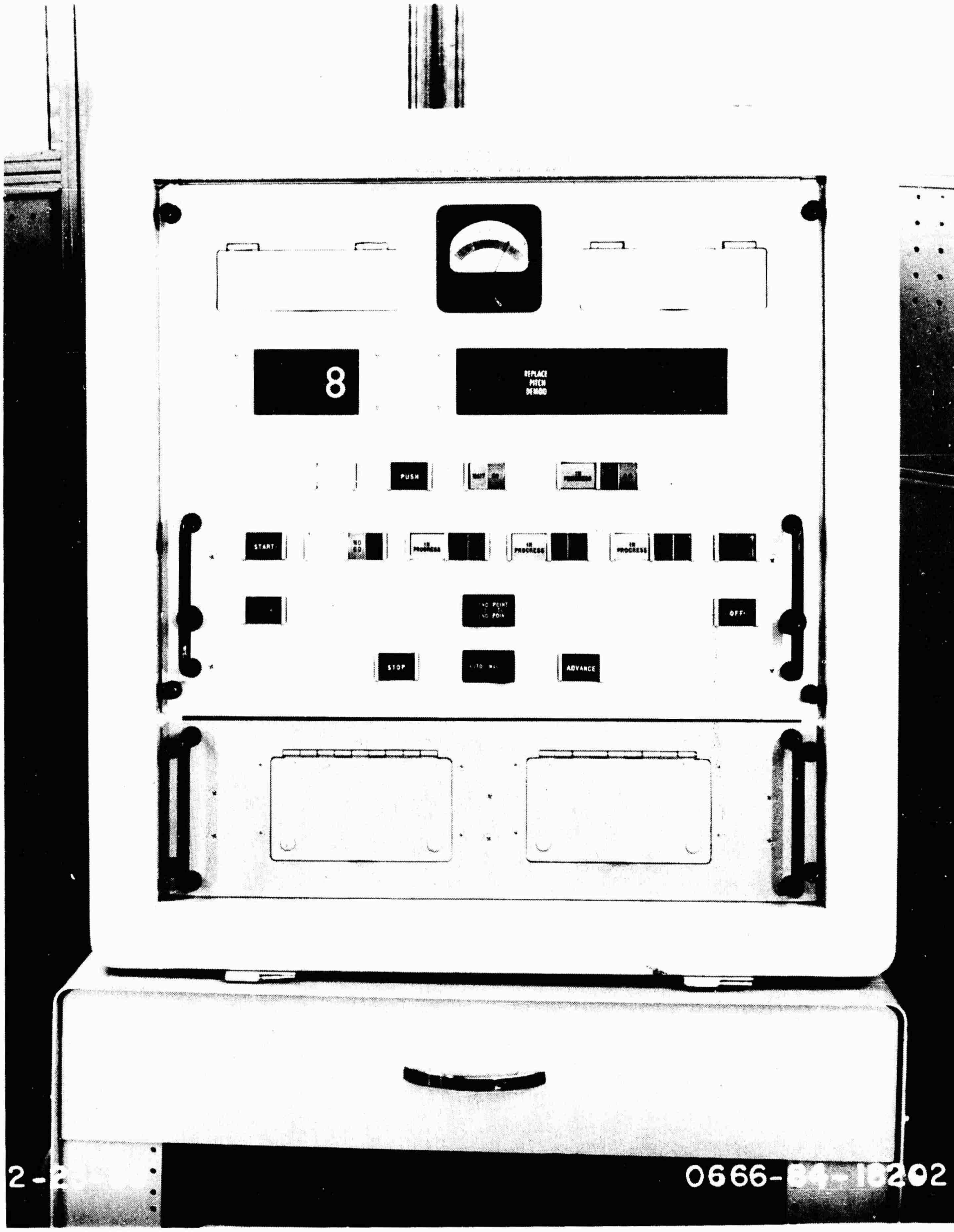
NORTRONICS - DATICO
TAPE-PROGRAMMED AUTOMATIC TEST EQUIPMENT

FIGURE 24 11-36



EVALUATION DRONE AUTOMATIC FIELD MAINTENANCE TEST SET
("GO" CONDITION)

FIGURE 25 11-37



EVALUATION DRONE AUTOMATIC FIELD MAINTENANCE TEST SET
("NO-GO" CONDITION)

Figure 26 11-38

DISCUSSION

MR. EMIL WALCEK AND MR. C. J. SULLIVAN SUBSTITUTED FOR MR. WALTER PETERSON ON DRONE SYSTEMS

MR. D. HUEWE, HUGHES AIRCRAFT COMPANY: I would like to know what you do with the cards that you have in those particular boxes that you mentioned. What level of maintenance do you perform on them out at the site and what degree of skill does this individual have to have in performing the maintenance on a particular replaceable card that you showed in your modular concept?

ANSWER: We didn't discuss the equipment that was used to maintain the card. This would be decided on an economic basis whether it should be a throwaway or repairable unit. This equipment we discussed was more at the systems level and black box level. But we didn't get to the controversy of whether the card should be thrown away or repaired.

MR. HOWARD BARRY, REPUBLIC AVIATION CORP: Early in your talk, you stated there was an advantage to having self-check equipment in the drone, and if this were properly done, it wouldn't increase the weight or the size. My experience indicates that this is very difficult to do. I don't quite see the advantage to having the self-check equipment in the drone. Self-checking equipment, once the drone is in the air and since it is an unmanned vehicle, seems to me to be of little importance. Could you amplify those statements?

ANSWER: A simple power-on light is actually a self-test feature on a piece of electronic equipment, and even in the drones field this type of thing is visually observed prior to launch as one of the standard operating procedures. Now, of course, I cited a very crude example, but another such thing would be, say, a multimeter with a selector switch to check out, let's say, the condition of a command receiver. What you are saying is right. Once the thing is under way, it is useless, but it is an invaluable aid prior to launch.

CURRENT MAINTENANCE PHILOSOPHY IN THE CORPS OF ENGINEERS

Col. Robert P. Tabb, Jr.
Office of the Chief of Engineers

The Corps of Engineers welcomes the opportunity to participate in this, the Third Signal Maintenance Symposium. We know that there is much to be gained from an interchange of ideas on the vexing subject of maintainability of equipment in the modern Army. Each Technical Service of the Army has somewhat different considerations in solving this problem, yet there is a vast area of common interest where techniques employed by one service may have application to the circumstances existing in another Service. With this latter point in mind, it is my intention to high-light some of the current efforts of the Engineers which may have some application to the maintenance operation in other Services.

To begin with, it should be pointed out that most of the equipment of the Corps of Engineers is basically of commercial design. Approximately 85% of all our procurements are for commercial off-the-shelf items or military adaptations of such items. Naturally, our maintenance philosophy and our procedures are essentially directed toward maintenance of this type of equipment in the Army. We do have some purely military design items and in supporting these items we are generally following accepted procedures employed by the Signal and Ordnance Corps in maintaining their military type items.

Our support problem has been somewhat complicated by the recent trend toward the weapon system development approach. Here we find equipment of types for which we have logistic responsibility being introduced into the supply system with very little control or influence on our part over the development or selection. I imagine that Signal Corps has experienced this same difficulty at times. It is an area which needs further study to insure the proper application of maintenance engineering and support techniques on the part of Technical Services which have a secondary interest in weapons system development.

In supporting our commercial type equipment, what are some of the factors which influence the maintenance effort? Here are a few.

1. Since we are dealing with a highly competitive industry, the government is able to take advantage of commercial research and development effort. This insures a continual program of product improvement with ease of maintenance an important consideration of every manufacturer who must meet dynamic competition.

2. Our purchases, more often than not, represent a very small percentage of total industry sales. Consequently, we are seldom in a position to exert a controlling influence over the commercial product.

3. We generally find that for the products we buy there is a well-organized factory and distributor system available for service or maintenance support in CONUS and the more progressive overseas areas.

4. The Armed Forces procurement legislation is such as to preclude the arbitrary selection of a supply source. As a result we find ourselves plagued with a multiplicity of makes and models of the same item.

5. Our procurement lead time is generally short, because we are buying products already basically engineered and because, since they are generally support type in nature, they are required in a hurry.

6. Performance type specifications are generally employed and while this system offers advantages from some points of view it does not always insure the close control over the situation which maintenance engineers would like.

7. Our equipment is subject to a wide range of operating conditions which permits of procurement savings afforded by purchasing items only good enough to perform under one set of conditions. As a consequence we find a great number of different types of items in each family of equipment. Tractors, for instance, may vary from the common rubber-tired truck garden variety to the large, low ground pressure, heavy crawlers used on the icecap. Tractors, unlike rifles or flashlights, are not just tractors.

Among the factors mentioned above, the great variety of makes and models, coupled with low end-item densities, causes the greatest difficulty in devising an effective Engineer maintenance system. Accordingly, most of our efforts are bent toward alleviating the difficulties which this make-model mix situation generates. I think it is unnecessary to explain to this group just why this situation causes maintenance difficulties. You can appreciate that the necessary fragmentation of our effort in maintenance engineering, provisioning, parts resupply, maintenance operations, and technical assistance prevents us from doing the best job possible on all our varied items.

In describing the efforts of our maintenance people, I shall highlight some of the programs of interest which occur chronologically in the life-cycle of a piece of equipment. By life-cycle I refer to the stretch of time beginning with a "gleam in the eye" in the Research and Development phase to the death of the item by elimination from the Army system.

Before proceeding to a discussion of Research and Development, I might point out that in the Corps of Engineers all maintenance staff elements, including Maintenance Division, OCE, and all maintenance operating agencies and units are responsible not only for maintenance service but for repair parts supply as well. We feel this marriage is essential to prevent the routinizing of parts supply and to insure that at all echelons all the ingredients are controlled to insure successful accomplishment of the maintenance mission. We have recently added to the parts supply mission of the Engineer Maintenance Center the responsibility for supply of special maintenance tools.

To guide our Research and Development effort in the office of the Chief of Engineers we are presently preparing a list of type items within each family (such as tractors or generators) which to the best of our present knowledge will meet the requirements of the Army for the next five years. The family, once agreed upon by various Engineer elements, is staffed with other interested Army agencies such as CONARC and the Technical Services and ultimately submitted to the Chief of Research and Development for review and approval. Once approved, this family of items serves as a guide for Research and Development and for the Supply system in the five-year materiel program. Our maintenance people exercise a predominant interest on behalf of Military Supply in developing these families. We attempt, of course, to restrict the number of items included, accelerate item replacement for those items difficult to maintain, and provide advice on phasing to the end that we derive full benefit from the economic life of items in the system. This family approach has helped tremendously in staffing and reviewing day-to-day actions, for it insures that all staff elements examine a problem within an agreed framework for present and future guidance. As unforeseen developments occur, the families affected will be reviewed and updated.

These family listings serve as a basis for our reviewing the annual Research and Development programs. They further serve a very useful purpose in guiding the actions of members of the Corps of Engineers Technical Committee. A maintenance engineer participates in all sub-committees of this Technical Committee and we further make a critical review of all actions on the agenda of the Committee itself. Through this participation we are able to give advice based on our maintenance experience which in many instances may have a controlling influence on decisions. Our main concern, of course, is to try to restrict the numbers of types, sizes, and stock number variations.

We feel that this family approach may also be of benefit in our dealings with other Technical Services, particularly those involved in systems development. It would be our desire that a system developer would examine our family and select therefrom an item suitable for integration into the new system rather than engineering a new piece of equipment which would later appear in the system and require support. In the case of generators, for instance, we in Maintenance prefer to have a reasonable spread in capacities and operating characteristics. We rather favor a decision to furnish one all-purpose unit of a given size and characteristics suitable to all applications rather than developing a general purpose unit on one hand and a special purpose unit on the other. We feel that the resultant increase in end-item density of this all-purpose unit will permit us to do a much better maintenance support job in combat than would be the case if we had to support two types of units.

Remember also that it is not a question of whether to have one or two items of a given type. The make-model mix more often means you are speaking of supporting six make-model variations as opposed to twelve. And generally any one make-model variation requires the same amount of massaging effort on the part of the maintenance structure. In making our recommendations on sizes within a range we are particularly alert to recommending specific sizes so that equipment is not generally required by the preponderance of users to operate at full rather than optimum capacity. As you can appreciate, tailoring a selection too severely (to a narrow range of operating conditions) may result eventually in marginal items due to rapidly changing quantitative and qualitative requirements. Thus, too restrictive an initial selection of items in the face of constantly changing requirements often leads to increased maintenance difficulties and shortening the period of usefulness before a new, more refined, and larger item must be introduced.

To sum up our maintenance viewpoint on selection of items in equipment families, we strive to reduce the variety of sizes and types and insist on quality products which will not be marginal in operation. It might be said that we prefer an item to be slightly over-designed in the belief that the extre initial costs will be more than offset by savings in maintenance support and a stretch-out of time before a new item must be introduced to meet every increasing user demands.

It is in the design and development of a new piece of equipment that maintenance engineers have the greatest opportunity to influence the ease of maintenance. This is accomplished by careful analysis, screening, and evaluation of items from a maintenance standpoint. The Corps of Engineers has now instituted specific review points at critical stages during the development cycle in accordance with DCSLOG directives on this subject.

The details of implementing these maintenance review points have been delegated to the United States Army Engineer Research and Development Laboratories (USAERDL) and the Engineer Maintenance Center (EMC) with the added requirement that design, development, and production engineering activities stress the following factors during design of Engineer materiel:

a. Ease of maintenance, without significant reduction in performance.

b. Maximum use of standard component parts.

c. Elimination of unnecessary variations of equipment, components, and parts.

The development engineers are required to give consideration to ease of maintenance features and use of standard components during the early development phases, and they are responsible for notifying the Engineer Maintenance Center when the specific review points are reached. Coordination between the laboratories and the maintenance center includes forwarding significant information, such as drawings and photos, to EMC in advance of official review meetings. Reviews at each specified review point are made jointly by the development engineers and representatives of EMC.

Working with our Research and Development staff, the maintenance elements of the Corps of Engineers have given their support to two programs designed to alleviate maintenance problems. These two programs are referred to as the Qualified Products List or Industrial QPL engine program and the small military engine program. Both programs strive for greater standardization of parts and improved quality - features which naturally are an assist to maintenance.

During World War II, over 100,000 different repair parts were required to support approximately 345 different makes of industrial gasoline engines in our system. As a direct consequence of this, the

Munitions Board initiated corrective action which resulted in a program to standardize high mortality parts in the larger industrial gasoline engines.

The Corps of Engineers, through our Chicago Procurement Office, monitors and administers the DOD Industrial Gasoline and Diesel Engine Programs. We have the responsibility for negotiating and administering the necessary qualification tests and maintaining the Qualified Products List, which lists the engines successfully completing the test program. The over-all program applies to all engines for ground service, other than tactical, and is currently divided into two major programs:

Industrial Gasoline Engine Program

Diesel Engine Qualification Program.

Generally, an engine must be on the QPL before a contractor can offer it on his product. Engines are qualified at the manufacturers' expense.

In the first of these engine programs, standardized high mortality parts include pistons, piston rings, piston pins, valves, connecting rod bearings, and main bearings. Twelve different bore sizes cover the 10- to 300-horsepower range. Engines using standardized high mortality parts are tested in accordance with a detailed testing procedure from which is derived a Qualified Products List of industrial engines. At the present time, 85 different models of industrial gasoline engines are on the QPL. When this program is completed, it is expected that 90% of parts formerly required to support these commercial engines will be superseded by the interchangeable high mortality parts.

As for the second program related to diesel engines, the effort is primarily directed toward insuring specified standards of performance. To date there has been no success in introducing any feature of parts interchangeability in this diesel program. At the present time, 34 different models of diesel engines are on the QPL and 10 additional are under test.

In addition to providing maximum interchangeability of high mortality gasoline engine parts, the QPL program offers increased sources of supply, consolidated purchases, improved engine design, greater assurance of product reliability, and numerous other savings. It continues to grow increasingly acceptable to industry, the other defense services, and the technical services of the Army.

The Corps of Engineers is also developing a military family of small gasoline air cooled engines. The family of six engines, 1/2 through 20 horsepower, will replace some 78 different makes and models now used by the military forces. The military engines are lightweight, have built-in long life, are compact, easy to service, and have many interchangeable parts among the six sizes.

The 78 different makes and models previously used required the stockage of some 23,000 separate and distinct parts, while the military family requires only some 800. It is proposed to stock only a small percentage of these parts. This procedure permits a great reduction in cost of stocking and distributing repair parts. The actual stockage of all parts to support the first three sizes (1/2, 1-1/2, and 3 HP) is 28 line items.

Another very important feature in this program is standardization which results in high interchangeability of parts between different size engines and the use of standard hardware wherever possible. All high mortality parts and about 30% of all other parts of the four sizes of engines in the smaller end of the family are interchangeable. The two larger engines have similar interchangeability of parts.

Maintenance and distribution are simplified. Bulk of required parts in the field is reduced and repairs are kept to a minimum. The engines have been designed to permit easy repair and maintenance, as accessories and parts may be reached with little difficulty. The long engine life (1500 hours without major overhaul) results in military efficiency and the saving of money. Production runs have already been completed on the first three engines and the 1-1/2- and 3-HP engines have been included in recent procurements of 1/2- and 1-1/2-KW generators.

In addition to the two engine standardization efforts I have just discussed, the Corps of Engineers has given considerable emphasis to another program which takes form later in the life cycle of an end item. I refer to the Procurement Standardization Program which has already afforded considerable concrete savings to our military supply system.

Procurement Standardization is simply buying more of a few carefully selected models chosen from assets you already have in the supply system so that the newly procured item can be supported to a large measure with the parts stock and publications already on hand. Section 10, USC 2304(a)(13), Public Law 1028, 84th Congress, authorizes procurement by negotiation for equipment which the agency head determines to be "technical equipment whose standardization and the interchangeability of whose parts are necessary in the public interest and whose procurement by negotiation is necessary to assure standardization and interchangeability." The Procurement Standardization Program is designed to minimize supply and maintenance problems by restricting purchase of various items of equipment to a limited number of makes and models.

The selection of specific makes and models, including the number of manufacturers involved, is based on several factors. These factors include, but are not limited to, current world-wide end item assets, stocks of supporting spare parts, interchangeability of parts between makes and models of the same manufacturer and between the particular item and other end items, mobilization capability coordination with other Departments, and others. To be most effective, the number of selected models for Procurement Standardization on any one adopted type should be held to the minimum necessary to meet BOB requirements and/or Secretarial restrictions.

The Department of the Army has placed two regulatory restrictions on the program which have prevented us from going as far as we would like. These requirements are that (1) a minimum of two makes and models must be selected to obtain competition between suppliers, and (2) the assets of each of the selected models must represent at least 15 per cent of the particular end item in the system.

Despite these restrictions and the laborious administrative effort involved in preparing cases for Secretarial approval, we feel the program has been rewarding.

To date, thirty items have been approved for procurement standardization. This has resulted in a reduction from 141 makes and 203 models to 47 makes and 58 models. On this basis, the presently estimated total of 4000 models in our supply system potentially could be reduced to about 1100 models. Since FY 1955 we have been able to obligate about 15 per cent of our procurement dollars through negotiation with selected suppliers in purchase of items under this authority.

An example of the dollar savings accrued through our efforts can be illustrated by facts concerning a single item - a 20-ton truck mounted crane. In three successive years beginning in FY 1954, we were able to buy 975 cranes costing over $32 million from the same source. It is estimated that had a new source been awarded the contract each time we would have invested $3 million in concurrent spares. However, in this case, due to the high degree of interchangeability, only about $45,000 was spent for concurrent spares with no additional expenditure for parts on the third order of 295 cranes.

My staff is currently discussing with the Air Force an approach to joint procurement standardization with the end in view of lightening the burden we carry on common service repair parts supply and depot maintenance support of common Engineer items procured on MIPR's for the Air Force.

One other area in which we are involved with procurement is the provisioning effort for new items. Here the short procurement lead time of most of our Engineer items makes for difficulty in orderly provisioning. We have recently revised our procedures in an attempt to insure a more workable arrangement with manufacturers. We have been particularly successful in identifying parts interchangeability and as a result, by careful screening of parts lists submitted by manufacturers, we have realized substantial savings. For instance, in the past calendar year we introduced only 6,000 new parts out of some 144,000 parts screened and studied.

The provision of manuals for new equipment is fraught with the same difficulty as that experienced by repair parts - that of being ready in the relatively short procurement lead time of the end item. The prior preparation of a maintenance package has had little practical benefit to us since we buy so many items on performance specifications and do not know exactly what we will have to plan for until after contract award. To accelerate the production of prescribed DA publications we have recently required in many contracts the provision of a second preproduction model. This item is turned over to the Engineer Maintenance Center for manual provisioning and is retained thereafter for study on applicability of Modification Work Orders as required. In a sense we have a reference library of hardware available to our maintenance technicians until the items are well established in the system.

You will note that so far I have talked little of maintenance operations. This is not an accident. More and more at the Chief of Technical Service level the maintenance staff is involved in projects designed to reduce the maintenance effort in the field before it takes shape. At least half our staff effort is bent on trying to put the other half of the staff "out of business." I'm afraid we will never achieve our goal - but it is a reflection of the greater emphasis on maintenance during the entire life cycle of our equipment items.

On the operational side of the house, one of our main efforts since the Korean War has been the Modernization Program. Essentially this has been a team effort with the maintenance man directing the judicious disposal of undesirable assets while the supply man phased in modern items through procurement. To accomplish our maintenance responsibilities we have had to look at our entire asset picture bearing in mind the desirable families of items I discussed earlier, the continuous requirements of the Army, and limitations on procurement dollars. To provide direction to our program, we have published for each family of items Supply Bulletins designed to prohibit repair and overhaul of undesirable items and prescribing repair expenditure limitations for all our various makes and models. As a point of departure we have established an economic life for various types of items and from that we have prepared our various restrictive criteria. We have been successful in eliminating from the system many old and undesirable makes and models, and the reduction in our national stock of parts is in part due to this program. Our goal is to insure that undue maintenance effort is not expended beyond the desirable economic life of the item and to reduce in part the great variety of makes and models introduced in the Korean War. Our hope is that we can maintain this reduction in the number of makes and models by resorting to negotiation under procurement standardization authority or in some cases resorting to military design items.

In this latter area our laboratories have programmed development of military design specifications for certain generators and pumps to be coupled up with the small military engine. Likewise, they are now working on an airborne tractor of military design which it is hoped will ultimately replace three or four engineer construction items now required by Engineer units of the field army.

In our depot maintenance operations in CONUS there are about three points I should like to make that may be of interest.

All Engineer shops operate primarily on a job or bay type system of repair due to the relatively small quantities of a great multiplicity of makes and models of Engineer equipment requiring depot maintenance support. To hold repair costs to a minimum, we developed years ago a system of repair which closely adheres to the basic concepts of IROAN recently adopted by the Army. We feel, however, that we must still insist on a high standard of repair in order to produce a high degree of reliability in the equipment after overhaul. This is particularly true for items returned to stock, which may be shipped anywhere in the world, and also for missile support items, reliability of which is critical.

Army Industrial Fund is used to finance three of our shops, Atlanta, Marion, and Utah. One of the biggest advantages to this system of financing is the ease with which cross-service work can be performed for other agencies such as the Air Force. The present system of authorizing and funding work on a quarterly service order works very smoothly and effectively.

Contract repair is used to supplement government shop production. In 1956 a total of about 90 of these facilities were utilized throughout the country to do about 35 per cent of the total workload. In 1959 the number has been reduced to about 45. These contract shops are located near concentrations of equipment in the field or near depots to minimize transportation costs and down-time to the user. These shops are a very important part of our repair base in peacetime and in mobilization we have a potential of 300 to 400 such facilities, largely dealer distributor service shops, who would be able to do work for us.

In the area of maintenance operations our most current effort which may be of interest is a rather comprehensive Operations Research contract designed to examine our repair policies - with primary emphasis on the direct support level. This project started out essentially as an examination of the feasibility and extent to which we should resort to sub-assembly replacement as opposed to "piece-part" repair. It has now been expanded into an examination of the various different feasible policies and an examination of their effectiveness. In the past year and a half we have developed a basis for evaluating each of the many forms this repair policy might take; we have identified the factors and variables which must be analyzed in developing a policy; and we have designed a trial mathematical model and have been collecting data for over a year to permit analysis and evaluation of the factors and the variety of feasible policies.

From this contract we hope to obtain an accurate definition of the theory and principles on which the design of a repair policy should be based. We further hope to develop the techniques and procedures for applying the theory and principles to design an optimum policy.

Finally, by way of summary, I think you have noted that our efforts in the Corps of Engineers are not unique though perhaps our emphasis is different because of the nature of the maintenance problems we face. I feel that maintenance people in all the Technical Services must be aggressive in pushing the various standardization programs, in improving the quality of products introduced into our system, in rapidly perparing the user and the maintenance system to receive and support new items, and in constantly striving to make our techniques more efficient and responsibe to the nuclear age Army.

MR. BERNARD PEAR, SIGNAL CORPS LOGISTICS EVALUATION GROUP: I'd like to ask the Colonel's pardon if this will be embarassing to him. How did you get approval for that contract? Did that clear through General Magruder?

COL TABB: I don't know. Maybe General Magruder knows about it. After all, he delegates many of his responsibilities.

MR. PEAR: Well I'm glad to see you got one in. We've been trying to get a number of them like that and we've had an awful time of it.

COL STANWIX-HAY: Colonel Tabb, in fairness to you I must tell you that Mr. Pear has raised quite a lot of us in the Signal Corps since we were that high and he's vitally interested in these problems.

ANSWER: I think one of the clues to this thing is ORO -- don't associate this thing with the management improvement, but associate it with the development area. If you go about it that way, you'll get your approval. This is the time when maintenance people and research and development people really get chummy. There is research and development money to be spent in the supply and maintenance field.

MR. PEAR: I would like to put you on the spot, Colonel Tabb, and perhaps the Signal Corps even more and ask you what success you're having with the Signal Corps in having the Signal Corps use your small engine program in connection with their equipment.

COL TABB: That's a double-pronged question, actually. The engineers, I think, are probably more involved in holding up the success than the Signal Corps. As you may know, we originally made a proof production run of the three smaller size engines and it was our intent, and had been agreed by DSCLOG, that these engines would be farmed out on free issue to all the technical services and other agencies who wished to play with them in the field of applications engineering. However, that proof production run developed certain bugs which we feel must be de-bugged, and we are now in the process of doing it before we release these engines all over the landscape. We don't want the engines to get a black name because of minor engineering changes which have been made on production runs going into our end items, so at the present time I'm not sure whether the Signal Corps actually has any of the engines or not, and frankly if they came to us they probably couldn't get a modern revised version of it immediately. They may have some of them as they were originally proofed, but those had a few bugs in them.

COL F. H. DRAKE, U.S. ARMY GENERAL DEPOT, PIRMASENS: I don't like to let Bernie get away with this. I think he was digging at me and Stan. This may sound a bit critical, but I have a feeling that these ORO efforts and some of these projected contracts which run into quite a bit of money many times don't really pay off, because it takes us 6 months of using our own people and our own facilities many times to get these experts to the point where they know enough about our business to make a study of it. And I feel that if we could bring ourselves to give some of our own people, that know this game, time enough to make the study themselves that we could come up with just as good a solution and maybe a better solution.

COL TABB: Well, I felt essentially as you did and I still feel quite a bit that way. However, in working very closely with this cased contract, I've changed my viewpoint on certain things. First is, they are working on the study; the people on our payroll are not working on it; they are working on day-to-day problems. This is one thing, you can channel your effort and start to thinking about optimizing a system and not one fragment of it. Secondly, they have very well pointed out deficiencies in data and information available to us as managers, supply for maintenance managers -- things we don't know about: what our operating conditions are, what people are doing in the field. We really don't know. We don't have information on which to make a fair evaluation. They've highlighted this and they've helped us in putting in a data collection system. Unfortunately, the data that we are collecting is, I'm afraid, not going to be broad enough to be truly representative and when we have finished gathering it we'll still have a problem of translating it to combat conditions. This is one of my real worries. We don't have data selected under combat conditions which will permit an ORO-type man to examine a system and optimize it. But actually, we are so frustrated in this maintenance effort that I think we have to try everything we can, including resorting to the ORO-type people. We're getting a lot of good ideas from them, and they're not all impractical. Actually, the man we have running this project has been in combat and has had maintenance experience in combat, so he knows what I'm talking about. It's not costing us too much money, because, as you indicated, the government ends up doing most of the leg work. selecting the data, and so on. We don't pay for that; we won't even admit that there's such a thing as an RCS. We sort of get it under the counter.

MAINTENANCE SALESMANSHIP

Col. Royal S. Copeland

For years we have heard that maintenance is a command responsibility. We know that proper maintenance and particularly preventive maintenance is extremely important and that equipments given proper care will do their job better.

How many of you have read further in AR 750-5 to know that there is also such a thing as "direct responsibility" -- the responsibility of individuals for equipment entrusted to them.

This wraps up the package very well and gives everyone a pretty clear picture of who does what.

Yet, in spite of a regulation which pinpoints responsibility we still find a general laxity in implementation of the spirit of the directive. This brings us to the meat in the coconut. "What are we doing to sell this program?"

What must we, the maintenance experts, do to convince everyone else that a good program will save not only dollars but lives as well.

Recently I had the good fortune to attend the Senior Officers Preventive Maintenance Course at Fort Knox. Here I found an enthusiastic group of officers and men whose mission is to sell commanders on the vital importance of preventive maintenance in the Army's training and combat mission. In the short space of a week, they cover the elements necessary for an effective program and teach the procedure, techniques, and criteria for establishing, maintaining, and evaluating a good Preventive Maintenance Program.

In this very excellent course of instruction, presented by all the Tech Services with the blessings of the Arms, we have made a great step forward in bringing to our Senior leaders a lasting impression of the part that maintenance plays in support of combat operations.

When the Commander is convinced or at least appreciates the problem, our job of selling is infinitely easier, but we cannot and must not assume an attitude of complacency. If anything, we must increase our efforts to do a better job of selling.

What is salesmanship? Basically, it is the ability of one individual to convince another that the produce or service offered is the best on the market and is not only desirable but necessary.

Most of you should have been impressed in your youth with the old fashioned type of salesmanship. The famous trip to the woodshed were (figure 1) father's strong arm administered a most convincing sales talk on the facts of life.

This was usually most effective and created a high degree of motivation but, unfortunately, is a method which modern psychiatrists frown upon. We must find some other way to develop a desire within each individual to not only appreciate why we must have a program but to actually pitch in and do a job.

A good maintenance program is somewhat similar to a good insurance program. When you are young and in good health, or equipment-wise have a small population of new equipments, limited coverage will serve you well. As you grow older, marry and accumulate additional responsibilities, or as your equipment population increases and the equipments begin to show signs of wear, you need more and more coverage to give the protection necessary to fulfill all of your obligations.

In both cases, the program must be sold, and in both cases the selling job does not stop when the head man has accepted the program. We not only have to sell the boss but we have to sell each member of his organization and not just once but constantly.

Salesmanship is something we encounter every day. I feel that the most important item in selling anything is first selling yourself.

Ask yourself each morning whether you are ready for the job. Are you thoroughly prepared? Do you have a comprehensive knowledge of your mission. Have you looked at it from all angles? Have you studied your job so that you know every line and every fault as a jewel cutter studies a raw diamond before he makes the first cleavage. The expert cutter knows that if he makes one mistake he will end up with a pile of worthless chips.

But even knowing your job is not enough. A few years ago before World War II, I was in the foreign freight forwarding business. We had finally managed to secure some business from IBM and one of my partners had occasion to visit the New York office with some important documents. He was almost thrown out on his ear, we almost lost the business, and I shall never forget his expression when he told of his experience. The manager told him that Thomas J. Watson had established certain unwritten rules about personal appearance and no individual, even if he had an idea worth millions, would gain audience unless he was properly dressed, barbered and shined.

This lesson in appearance has had a lasting effect on me and has impressed me with the importance of maintaining a good "front".

The combination of knowledge of job with good appearance can result in confidence. When a salesman is confident, he also acquires a certain fluency, an ability to communicate thoughts to others.

Here, practice is necessary to train ones brain to organize thought into proper sequence, to plan a course of action which is logical and devoid of immaterial subject matter.

Let me apply what I've covered so far to our own situation. In the U. S. Army Signal School we are training men as potential repairmen and the young men we graduate are relatively new to the army. Everything they see and hear leaves, we hope, an impression. So one of our jobs in selling is to insure that the things taught to them and the manner in which it is done is presented in such a way that they receive only the best impression.

Starting with the instructor we try to select those individuals who have a good knowledge of the technical subject. We then subject them to an all too brief, but nevertheless rather thorough, course of Instructor Training, designed to improve their ability to sell technical subject material. We not only stress teaching methods and techniques but emphasize personal appearance, thorough preparation, neatness and class room discipline.

While the instructor is responsible for the care of the equipment he uses, we give him every possible assistance in supply and maintenance matters. However, since he is responsible for the equipment entrusted him, we have instituted a system of checks and balances to insure that he is keeping up to snuff. Training instructors from Instructor Training Branch make frequent observation visits to help him improve his instruction. Our school inspection team gives him a thorough look every six months to discover equipment deficiencies, and a maintenance team visits him on an average of every 90 days, not only to pull a PM check but to correct deficiencies.

We feel that the appearance as well as the techniques used by observer, inspection and maintenance personnel is every bit as important as the appearance and manner of the instructor -- again to sell proper maintenance to the students, so when they leave here for other assignments it will make the job of the receiving Commander that much easier.

Also as part of our program to make every individual maintenance conscious, we include in both our Instructor Training Observation program and our Inspection program a numerical evaluation of the account holder.

In those cases where an individual is doing an outstanding job, we point this out so that if the individual is doing a good job in other respects he can be considered for an outstanding or sustained performance award. However, if he is not up to standard this will preclude such an action.

As an example of what can be done with an effective program of inspection and preventive maintenance, let me give you some figures of our accomplishments in the school (figure 2).

Each six-month period shown on the chart covers essentially the same equipments. There have, of course, been some changes in courses taught but the total quantity of equipments inspected in each period over the two years indicated is about the same.

As you see, the first two rounds showed no great improvement, but, as we perfected our technique of inspection and the people being inspected learned why we were interested in their problems, by the third round there was a decided drop in deficiencies from the high of 1,923 down to 887 and a further drop to 675 in the last cycle.

During this same time, increased emphasis on regular preventive maintenance checks increased the production in the school maintenance shop. By discovering deficiencies prior to the time they become major repair tasks, more equipments can be handled by the same number of people and the time the equipments are away from the user decreases.

But all of this does not always convince the individual that he has a large part to play in the maintenance scheme.

I think that one of the reasons is the lack of motivation to participate in such a program, and a further analysis of this leads to the con clusion that those individuals who have the least knowledge or understanding of the whys and wherefores of maintenance are the ones who do the least to keep up a good program.

So we come back again to training, or shall we say the advertising part of salesmanship.

For most people maintenance is a rather dull subject. It lacks glamour and requires patient hard work with nothing to show for the effort but personal satisfaction. So we must do something to stimulate the interest in the same manner (figure 3) that the homely girl appeals to the men by her excellent cooking.

Fortunately, we have several means available to us to inform our personnel of the importance of a strong program.

The annual command letter is a valuable tool to keep subordinate commanders informed of the interest in maintenance, and particularly preventive maintenance, and the part that proper care of facilities and equipments plays in keeping the requirement for funds to the minimum.

Pinpointing trouble areas and presenting solutions thru the Daily Bulletin and the post newspaper are excellent means of reaching a large audience.

Most important, a good clear set of Standard Procedures will keep you before your public.

In the publication field "PS", the Preventive Maintenance Monthly, properly distributed, will stimulate thought and generate ideas.

And finally, full use of the Suggestion Award program will not only develop better ideas on how to do the job but will provide monetary reward to thoughtful individuals.

We have gone one step further in the School by having a one hour TV presentation each year on Supply and Maintenance. We first solicit questions and problems from the instructors, then take those which seem to be most general and work our script around them. Through the media of TV we are able to reach all interested personnel at one time.

I feel that all of these methods of advertising are good, but they represent an indirect approach. Their success depends on the receptivity of the individual to the written word, or in the case of TV, to the spoken word presented in a casual manner.

Only by direct contact can the salesman hope to get the full impact of his message across. In face to face meeting, the salesman can temper his "pitch" to the mood and attitude of his customer.

In selling maintenance we must get out of the rut of keeping to ourselves. We must get away from the office and talk to people in their own environment.

Each day and each week we must budget time to visit the elements we service and talk to them about their problems, find the best solution, and do something about it.

We can sell maintenance. How well we do it depends on individual effort. If we are thoroughly prepared, if we know our capabilities and limitations, if we have a sound plan of attack that still permits flexibility, if we and our subordinates present a good front and display neatness, enthusiasm, and a willingness to do a little more than required, we can enjoy a ripe old age in retirement with the satisfaction that we have accomplished our mission of selling maintenance and keeping our command's equipments ready and combat effective.

Figure 1

INSPECTION PROGRAM

USASCS

PERIOD OF REPORT	NUMBER OF DEFICIENCIES
JAN thru JUNE 1957	1923
JULY thru DEC 1957	1768
JAN thru JUNE 1958	887
JULY thru DEC 1958	675

Figure 2

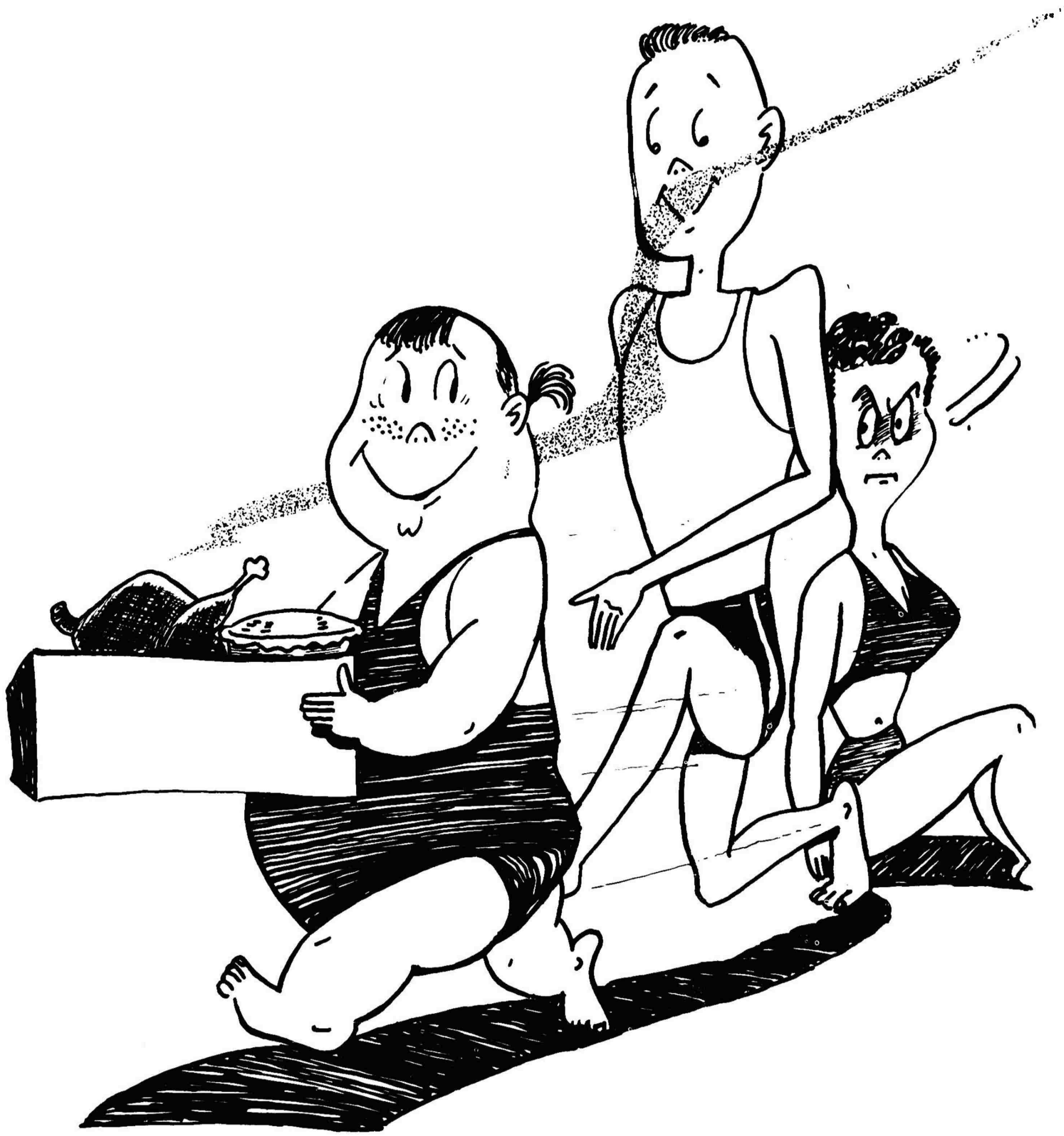


Figure 3

RELIABILITY AND MAINTAINABILITY OF MILITARY ELECTRONIC EQUIPMENT

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of
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In a broad sense, a user, military or otherwise, endeavors to procure an equipment to perform a specific function in a specific range of environments when it is needed. It is the producer's obligation to provide such an equipment. This, we feel, is axiomatic.

Fundamentally, then, a user will consider an equipment satisfactory if, when he has need for it, it will do what he wants it to do. The user's judgment is based upon his own experience with the real, physical, manufactured product in the environment when he has need for its use. Stated in other terms, user satisfaction is determined by the capability of an equipment to satisfy his needs. Unfortunately, these statements are qualitative and cannot be stated directly in terms that can be specified and measured.

It will be assumed in this paper that military requirements, including the intended function, environments, etc., are completely defined. With these adequately specified, it appears that there are two basic attributes of an equipment which can be defined, specified and measured, which do determine user satisfaction. These attributes are reliability and availability. In our present thinking, we look upon maintainability as the economic-logistic problems associated with availability. Maintainability derives from system design and manufacture, as does availability, but I have seen no definition that states all that it is and excludes all that it is not

For mutual understanding, it is necessary to state the meaning of the terms reliability and availability as used in this paper. Reliability is defined as follows:

RELIABILITY IS THE PROBABILITY THAT AN EQUIPMENT WILL PERFORM ITS INTENDED FUNCTION FOR A SPECIFIED PERIOD OF TIME WHEN USED IN THE MANNER AND FOR THE PURPOSE INTENDED.

Backing up this definition must be a complete appreciation of the reliability concept. First, the intended function must be adequate to satisfy the needs of the user. The design and development function must translate the intended function into design objectives which, in turn, can be reduced to hardware capable of manufacture but, of equal or greater importance, capable of being efficiently operated, maintained, and supported in the military environment where its use is desired.

A measure of this capability is availability, which is defined as follows:

AVAILABILITY OF AN EQUIPMENT IS THAT AVERAGE FRACTION OF TOTAL TIME WHICH THE EQUIPMENT IS IN CONDITION TO PERFORM ITS INTENDED FUNCTION.

Before expanding upon this definition, it appears desirable to develop the terms we employ in the reliability field since they are used directly in estimating availability.

The experience we have gained over the past three years indicates that the product rate is generally applicable. This is indicated in figure 1 in equation (1). Likewise, the probability of success of a subsystem element is the product of the probabilities of the various subassemblies as indicated in equation (2). These probabilities are, in turn, the product of the individual component part probabilities as shown in equation (3). Thus, the over-all success of an equipment is the product of the individual in-line component part probabilities of success.

In the electronic systems under consideration, there are large populations of many different types of component parts which are operated at varying degrees of severity with respect to their ratings in a variety of physical environments. The failures which have been observed in such systems are generally distributed randomly throughout the system.

When failures occur in this manner, the failure times are generally found to be exponentially distributed and, therefore, the probability density can be expressed by equation (4):

$$P_{(n,t)} = \frac{\frac{t^n}{\bar{T}} \cdot e^{-\frac{t}{\bar{T}}}}{n!} \qquad (4)$$

Where $P_{(n,t)}$ = probability of having n failures in time t, when the observed mean time between failures is $\bar{T}$.

This formula has proved adequate to both determine and predict the reliability of a system and it is a major factor in determing availability. For reliability, the probability of success or zero failures is required, then equation (4) reduces to:

$$P_{(o,t)} = e^{-\frac{t}{\bar{T}}} \quad \text{with } n = 0 \qquad (5)$$

If $\bar{T}$ for an equipment or system can be predicted, its reliability can be stated for an interval t, where (t) is the mission time. Further, when it has been determined that the failure times of an equipment or system are distributed exponentially, equation (5) can be used to determine the reliability of the equipment. Generally, it is possible to produce equipments having known capabilities with respect to the parameters generally specified in the military requirements. These requirements can all be met, but if the reliability and availability are not known or predictable, the number of equipments and manpower required to satisfy a specific military situation cannot be intelligently determined. As reliability and availability become part of the military requirements, the need to establish reliability assessment techniques during the development and manufacturing phase takes on the same importance as the ability to measure other military requirements. If the mean time between failures is predictable, the availability and repair activity can be forecasted.

In the military development area of the Bell Telephone Laboratories, a reliability prediction plan is used which is based on the inherent life capabilities of the electronic parts presently available, and an empirical multiplier which reflects the reduction in life resulting from the design, manufacturing, and use phases of an equipment. The development of such a plan has required a feed-back system which makes it possible to monitor the inherent capabilities of the parts as well as an evaluation of at least the degradation of life resulting from activity in the three general areas, namely design, manufacture, and use. These latter allocations must be known to effectively administer a reliability program. The inherent mean time to failure of the component parts is determined by continuous review of experiments in process along with certain equipments in the field where parts are operated at less than 25 percent of rating in a controlled environment having an ambient temperature in the 15° to $25^{\circ}C$ range.

This mean time between failures $\overline{T}_i$ (figure 2) is multiplied by K_D, representing loss attributable to design; K_M, representing loss attributable to manufacture; and K_u, representing loss attributable to use and the $\overline{T}$ for the equipment; a subsystem is thereby obtained.

$$\overline{T} = \overline{T}_i \cdot K_D \cdot K_M \cdot K_u \tag{6}$$

The factors included in the empirical multiplier, then reflect the degradation in life resulting from design, manufacture, and use.

The contribution of these factors can be determined by the analysis of system failures. The contribution of each area is mainly of interest in determining where a given amount of reliability effort will provide the greatest improvement in reliability. In predicting reliability, the product of these K's is of major interest. Equation (6) can be further simplified as follows:

$$\overline{T} = \overline{T}_i \cdot K \tag{7}$$

where

$$K = K_D \cdot K_M \cdot K_u \tag{8}$$

Considerable simplification is achieved by substituting failure rate for mean time to failure since the latter can be added directly. This is accomplished by changing the mean time between failure for the various types of component parts to failure units, where one failure unit is the failure rate equal to one failure per 10^9 component operating hours as indicated by equation (9):

$$\frac{10^9}{\overline{T}_{P_i}} = b \text{ (failure units)} \tag{9}$$

Where $\overline{T}_{P_i}$ is the mean time to failures for a type of part.

The total failure units for a subsystem element are equal to B_1 in formula (10):

$$B_1 = \sum_{1}^{x=m} S_x b_x = S_1 b_1 + S_2 b_2 \cdots\cdots + S_m b_m \qquad (10)$$

Where $S_1 b_1$, $S_2 b_2$ ... $S_m b_m$ represent

S_1 component parts having a failure unit rating of b_1

S_2 component parts having a failure unit rating of b_2

S_m component parts having a failure unit rating of b_m

In the preliminary prediction the total failure unit count is determined using equation (10) and selecting the applicable failure units for the parts as indicated on figure 3. The failure units indicated are for preliminary estimates to provide initial guidance relative to need for revision of the system functional design, the development of certain high reliability parts, the application of redundancy techniques, and the equipment level at which it should be applied, the application of marginal checking and whether it should be automatic and continuous or performed as a manual routine, the development of built-in failure detection equipment, and the development of adequate support test equipment. In addition to the foregoing, the initial prediction can be used to predict the number of spare plug-in units of each type required to provide a given assurance that a replacement is available as a function of various repair intervals. Note that this chart has two columns of ratings, one column applicable to equipments not having marginal checking and a second column for use when marginal checking is applied. This second column provides a two-to-one improvement for certain active elements. It must be pointed out that this second column should be used only for predicting reliability and is not applicable for predicting the maintenance load, except that it is inferred that the second column reflects the corrective maintenance load where marginal checking is employed, and the first column reflects the total repair activity either with or without marginal checking.

The total failure unit count for each subsystem section is determined by multiplying the estimated number of component parts by the failure unit values indicated.

The mean time to failure then for the subsystem unit represented by B_1 failure units is shown in figure 4 in equation (11):

$$\bar{T}_1 = \frac{10^9}{B_1} K_1 \tag{11}$$

The mean time between failures $\bar{T}_1$ for the first subsystem unit is also the mean time between repairs when marginal checking is not used. When marginal checking is employed, equation (11) reflects the mean time between unit malfunctions during the performance of its intended function. Thus, when marginal checking is employed, two values of B are required, one for computing reliability, B_1, and the other, B_1', to ascertain the repair interval. The repair interval is represented by equation (12):

$$\bar{T}_1' = \frac{10^9}{B_1'} K_1 \tag{12}$$

When marginal checking is employed, $\bar{T}_1 < \bar{T}_1'$ and the ratio $\frac{\bar{T}_1'}{\bar{T}_1}$ represents the predicted improvement in mean time between operational failures afforded by preventive maintenance.

The total inherent failure units for a system is the sum of the subsystem failure units as indicated in equation (13):

$$B_i = B_1 + B_2 + \ldots\ldots B_n \tag{13}$$

The total of the inherent failure units B is of interest only in that it can be used to predict the ultimate reliability and the minimum maintenance condition relative to the use of presently available parts assuming a K of unity. The predicted number of failure units for each subsystem is increased by the applicable K factor which reflects an increase in failures due to design, manufacture, and use, and is indicated in equation (14):

$$B = \frac{B_1}{K_1} + \frac{B_2}{K_2} + \ldots\ldots \frac{B_n}{K_n} \tag{14}$$

For reliability consideration, the probability of success for a specified time, the quantities in equation (14) are related to mission time as indicated in equation (15):

$$P_{(0,t)} = e^{-\frac{t}{\frac{10^9}{B}}} = e^{-\frac{t_1}{\frac{10^9}{B_1} K_1}} \cdot e^{-\frac{t_2}{\frac{10^9}{B_2} K_2}} \ldots\ldots e^{-\frac{t_n}{\frac{10^9}{B_n} K_n}} \tag{15}$$

Simplifying equation (15) by substituting equation (11), equation (16) provides a general solution for reliability:

$$P(0,t) = e^{-\frac{t}{\overline{T}}} = e^{-\frac{t_1}{\overline{T}_1}} \cdot e^{-\frac{t_2}{\overline{T}_2}} \cdots\cdots e^{-\frac{t_n}{\overline{T}_n}} \qquad (16)$$

This equation takes into account the fact that the mission time for subsystems may not all be alike and permits each to be treated separately.

To illustrate the reliability prediction concepts, two fictitious subsystems will be used. The first of these (figure 5) is a fictitious 100 vacuum-tube subsystem. The failure units per part are bogey values and, in general, are representative of the inherent life of such parts. Note that the number of parts used were adjusted to provide 250,000 failure units when marginal checking is not employed. The number of failure units with marginal checking is approximately 55 percent of that obtained without the check. According, the inherent mean time between failure $\overline{T}_{i_{MC}}$ with marginal checking is 1.8 times longer than that without, $\overline{T}_i$.

A fictitious transistorized subsystem is indicated in figure 6. Again, the quantity of parts have been adjusted to provide 250,000 failure units for the condition not employing marginal checking. With marginal checking, the number of failure units is reduced to the same extent as that indicated for the fictitious vacuum-tube subsystem. The intent is to establish two comparable units for further treatment of the reliability and maintainability problems. The mean times between failure $\overline{T}_i$ and $\overline{T}_{i_{MC}}$ are the predicted values representing the capabilities of existing parts. It was previously indicated that this capability is reduced by the less-than-perfect accomplishments in the design, manufacturing, and use areas. The product of these imperfections is represented by an empirical K factor which is related to the end use environment as indicated in figure 7. These values have been determined from data obtained from several systems in the various areas and are representative of present achievements in those areas. It is expected that exposure of this situation will result in changes in design philosophies with consequent improvement in the K factors. The effect of the K factor on the two fictitious systems is indicated in figure 8. The conditions represented are equivalent subsystems, designed and manufactured for the end use indicated. The ground station equipment is not subject to very relaxed requirements relative to space and weight, while the other equipment reflects the present inability to fully cope with the space and weight restrictions along with the more severe environmental conditions. The improvement in K factors for the transistorized equipment is largely due to the greater case in reducing size and weight plus the fact that considerably less power is dissipated in the subsystem to generate the desired functions. If the means time to affect a repair were the same for each subsystem in each operational environment, it is easy to understand the reaction of the repair activity, since in the case of the vacuum-tube system, there is a ratio of 75 to 1 between the maintenance effort required at the ground based station to that for an equivalent amount of equipment in a missile on its launcher, assuming equal periods of operation, which is quite unlikely. The situation is still more obvious if 100 subsystems are considered. At the ground station, a repair would only be required every 36 hours, while in manned aircraft, repair would be required every 1.2 hours. If the average repair interval were one hour, the maintainability of 100 subsystems in manned aircraft takes on the aspects of the impossible. There is probably less concern for the maintainability than there is for the availability of the equipment. The assumption that the mean time to repair could be constant throughout the environments indicated is probably optimistic and it is more likely that the lower the K factor the greater will be the mean time to repair.

Many attempts have been made to define maintainability in a manner such that it can become a part of contracts and specifications for military electronic systems. Obviously, the reason for requiring such a definition is to place a control or measure on the maintenance activity required to assure that an equipment will continue to reliably perform its intended function. The maintenance activity considered is the total including scheduled checkouts, pre-use checks, marginal tests, routine replacements, lubrication, peaking adjustments, and all corrective maintenance.

Probably the need for such a definition stems from the customer dissatisfaction with equipments requiring an abnormal amount of maintenance activity. A measure is required which will, to a high degree, reflect customer satisfaction. The principal ingredients of user satisfaction are high reliability and a reasonable cost to maintain this reliability. It is suggested that a reasonable cost not exceed 10 to 20 percent of the initial cost per year of use. Obviously, equipments in storage should not require such an extravagant maintenance program.

Believing that the major problems of the future will be associated with the systems of increased size and complexity, a yardstick is required which will assure greater user satisfaction. Such a yardstick must include reliability and the effort, equipment and dollars required to maintain it. It appears that the term availability, when used to reflect the percentage of time that an equipment is available for performing its intended function may, if adequately defined, reflect a measure of user satisfaction. Further, it seems reasonable to relate time in terms of the mean time between failure of an equipment. This is indicated in figure 9. Time is shown divided into two segments, $\overline{T}$ and $\overline{T}_R$, where $\overline{T}$ is the mean time between failures and $\overline{T}_R$ is the mean time between repairs. In a period of time T much, much greater than $\overline{T}$ we would expect a down time indicated by equation (17). The number of failures is represented by the ratio of time of one mean failure cycle equal to $\overline{T}$ plus $\overline{T}_R$. The down time for a time T is then the product of the number of failures and $\overline{T}_R$ the mean time to repair.

The fraction down time is the ratio of down time to total time as indicated in equation (18). The availability then is the fraction of time an equipment is capable of performing its intended function. This is indicated in equation (19) as:

$$\text{Availability} = 1 - \frac{\overline{T}_R}{\overline{T}+\overline{T}_R} \qquad (19)$$

$$\text{where } \frac{\overline{T}_R}{\overline{T}+\overline{T}_R} = \text{Fraction down time} \qquad (18)$$

The foregoing represents the case for an equipment where either no routine maintenance is performed or where it is insignificant with respect to $\bar{T}_R$. This condition is generally applicable to small systems, and it can be expected that the user will consider such an equipment satisfactory if its availability is 99 percent or higher. It would be naive to assume that the foregoing is the only reasonable solution. A system can be conceived having a low mean time to failure with a built-in continuously self-checking and failure locating system requiring a large quantity of replacement plug-ins and very little maintenance skill required to keep the system operating, but considerable support effort to affect the repair of the replaced units. The 99 percent availability might still be attained, however, the maintenance costs could be so high as to result in user dissatisfaction.

Recent statements indicate that the cost of equipping the military with new weapons is far less expensive than the operation and maintenance of such systems. Once a large system is issued to the using forces, it must be deployed, operating and maintenance personnel must be continuously trained, a support operation must be established and maintained. It has been stated that the maintenance of some systems is ten times its initial cost. Buying a dollar's worth of equipment which carries with it a mortgage of ten dollars of future funds should be a greater challenge for increased reliability then is presently recognized.

New objectives must be established which will result in the development of systems, such that the annual maintenance charges do not exceed 10% to 20% of the initial cost. The average citizen could not afford to own a home, car, radio, TV set, or other appliances if his costs were comparable with those presently experienced in current weapon systems.

In figure 10, a more general solution for availability in large systems is developed. The mean routine and scheduled maintenance time is indicated by $\bar{T}_M$. It is assumed that it reduces the availability of the equipment for performing its intended function. The fraction down time for repairs has been carried forward from the previous slide and is designated equation (18A). Equation (20) for fraction of time for routine maintenance is similar to equation (18A). The equipment unavailability is the sum of the repair and routine fractions as indicated in equation (21). The availability is then found to be as indicated by equation (22):

$$\text{Availability} = 1 - \frac{\bar{T}_R + \bar{T}_M}{\bar{T} + \bar{T}_R} \qquad (22)$$

It is obvious that $\bar{T}_M$ can be made insignificantly small by the use of designed-in self-checking equipment which will routine the equipment during intervals when the normal function is not being performed. Need of the normal function would automatically reprogram the routine to the next idle period. As pointed out previously in discussing marginal checking, this does not reduce the number of repairs but schedules them to enhance the equipment reliability.

It is obvious from this discussion that mean time between failures $\overline{T}$ determines the repair frequency and is, therefore, a major factor in maintainability. Availability, which is an inverse function of the mean scheduled maintenance time $\overline{T}_M$ and the mean time to repair $\overline{T}_R$, directly reflects the continuing usefulness of the equipment. Low $\overline{T}_M$ and $\overline{T}_R$ result in high availability, but, if $\overline{T}$ is not large also, the problem of supplying spares may be prohibitive.

It is strongly recommended that the military organizations consider very seriously specifying both reliability and availability requirements for future weapon systems as the best solution now available to the maintainability problem.

$$P_0 = P_1 \times P_2 \times P_3 \times \cdots P_N \qquad (1)$$

WHERE P_0 = OVER-ALL PROBABILITY OF SUCCESS AND P_1, P_2, ETC. ARE THE SUB-SYSTEM UNIT PROBABILITIES.

$$P_1 = P_{SA_1} \times P_{SA_2} \times \cdots P_{SA_N} \qquad (2)$$

WHERE P_{SA_1}, ETC. ARE THE SUB-ASSEMBLY PROBABILITIES.

$$P_{SA} = p_1 \times p_2 \times p_3 \times \cdots p_N \qquad (3)$$

WHERE p_1, p_2, ETC. ARE THE INDIVIDUAL COMPONENT PROBABILITIES.

$$P_n = \frac{(t/\bar{T})^n e^{-t/\bar{T}}}{n!} \qquad (4)$$

P_n IS THE PROBABILITY OF HAVING n FAILURES IN TIME t

$\bar{T}$ IS THE MEAN TIME BETWEEN FAILURES

$$P_0 = e^{-t/\bar{T}} \text{ WHEN } n = 0 \qquad (5)$$

Figure 1

$$\overline{T} = \overline{T}_i \cdot K_D \cdot K_M \cdot K_u \qquad (6)$$

$$\overline{T} = \overline{T}_i \cdot K \qquad (7)$$

WHERE $$K = K_D \cdot K_M \cdot K_u \qquad (8)$$

$$\frac{10^9}{\overline{T}_{P_i}} = b \text{ (failure units)} \qquad (9)$$

WHERE $\overline{T}_{P_i}$ = THE INHERENT MEAN TIME BETWEEN FAILURES FOR A PART.

$$B_1 = \sum_{1}^{x=m} S_x b_x = S_1 b_1 + S_2 b_2 \ldots\ldots + S_m b_m \qquad (10)$$

WHERE $S_1 b_1$, $S_2 b_2$ ... $S_m b_m$ REPRESENT

S_1 COMPONENT PARTS HAVING A RATING OF b_1 UNITS

S_2 COMPONENT PARTS HAVING A RATING OF b_2 UNITS

S_m COMPONENT PARTS HAVING A RATING OF b_m UNITS

Figure 2

CHART A1

FAILURE UNIT RATINGS

	Normal	With Marginal Ck.
Resistors	10	10
Capacitors	10	10
Inductors	20	20
Plate chokes	20	20
Transformers (filament and plate)	20	20
Transformers (If and pulse)	100	100
Motors	150	150
Relays	100-500	100-500
Variable resistors	500	500
Potentiometers (WE computing)	5,000	5,000
Jacks and plugs (per connection)	10	10
Switches (per connection)	30	30
Semi-conductor diodes (germanium)	300	150
Semi-conductor diodes (silicon)	200	100
Semi-conductor diodes (silicon carbide)	20	20
Transistors (germanium)	900	450
Delay lines (fixed)	150	150
Delay lines (variable)	3,000	3,000
Capacitors (variable)	1,000	1,000
Vacuum tubes - reliable receiving	2,000	1,000
reliable power	10,000	5,000
thyratrons	5,000	5,000
(replaced after 250 hr.) Magnetrons	100,000	100,000
Power pulser	20,000	20,000

Figure 3

$$\bar{T}_1 = \frac{10^9}{B_1} K_1 \qquad (11)$$

$$\bar{T}_1' = \frac{10^9}{B_1'} K_1 \qquad (12)$$

$$B_i = B_1 + B_2 + \cdots\cdots\cdots B_n \qquad (13)$$

$$B = \frac{B_1}{K_1} + \frac{B_2}{K_2} + \cdots\cdots\cdots \frac{B_n}{K_n} \qquad (14)$$

$$P_{(0,t)} = e^{-\frac{t}{\frac{10^9}{B}}} = e^{-\frac{t_1}{\frac{10^9}{B_1} K_1}} \cdot e^{-\frac{t_2}{\frac{10^9}{B_2} K_2}} \cdots\cdots\cdots e^{-\frac{t_n}{\frac{10^9}{B_n} K_n}} \qquad (15)$$

$$P_{(0,t)} = e^{-\frac{t}{\bar{\bar{T}}}} = e^{-\frac{t_1}{\bar{\bar{T}}_1}} \cdot e^{-\frac{t_2}{\bar{\bar{T}}_2}} \cdots\cdots\cdots e^{-\frac{t_n}{\bar{\bar{T}}_n}} \qquad (16)$$

Figure 4

FICTITIOUS 100 VACUUM-TUBE SUBSYSTEM

QUANTITY	PART	FAILURE UNITS PER PART	FAILURE UNITS: LESS MARGINAL CHECKING	FAILURE UNITS: WITH MARGINAL CHECKING
94	VAC. TUBES	2,000	188,000	94,000
4	POWER TUBES	10,000	40,000	20,000
2	THYRATRONS	5,000	10,000	10,000
500	RESISTORS	10	5,000	5,000
500	CAPACITORS	10	5,000	5,000
4	RELAYS	200	800	800
10	TRANSFORMERS - FIL. & POWER	20	200	200
10	TRANSFORMERS - IF	100	1,000	1,000
1124	TOTAL		250,000	136,000

$$\bar{T}_i = \frac{10^9}{.25 \times 10^6} = 4000 \text{ HOURS} \qquad \bar{T}_{i_{MC}} = \frac{10^9}{.136 \times 10^6} = 7350 \text{ HOURS}$$

Figure 5

FICTITIOUS TRANSISTORIZED SUBSYSTEM

			FAILURE UNITS	
QUANTITY	PART	FAILURE UNITS PER PART	LESS MARGINAL CHECKING	WITH MARGINAL CHECKING
260	TRANSISTORS	900	234,000	117,000
800	RESISTORS	10	8,000	8,000
400	CAPACITORS	10	4,000	4,000
100	TRANSFORMERS	20	2,000	2,000
10	RELAYS	200	2,000	2,000
1570	TOTAL		250,000	133,000

$$\bar{T}_i = \frac{10^9}{.25 \times 10^6} = 4000 \text{ HOURS} \qquad \bar{T}_{i_{MC}} = \frac{10^9}{.133 \times 10^6} = 7500 \text{ HOURS}$$

Figure 6

K Factor for Use with System A (Vacuum-tube Circuits)

Laboratory	1.0
Military Ground Station Equip.	.9
Shipborne Equipment	.1
Trailer-mounted Equipment	.05
Manned Aircraft Equipment	.03
Missile-borne Equipment	.012

The K factor is used to calculate approximately the effect of several variables such as environmental temperature, vibration and shock, maintainability, necessary design compromises, difficulty of manufacture etc., on equipment life. The values given above are estimates derived from the failure rates of various shipborne radar systems and aircraft communication and radar systems. They should be used with considerable discretion.

K Factor for Use with System A (Transistor Circuits)

Laboratory	1.0
Military Ground Station	.9
Shipborne Equipment	.13
Trailer-mounted Equipment	.07
Manned Aircraft Equipment	.04
Missile-borne Equipment	.016

The K factors for transistors are derived from those for vacuum tubes by giving suitable weight to ease of miniaturization, reduced stress on other components, lower power dissipation, etc. They should be used with considerable discretion.

Figure 7

EFFECT OF K FACTOR

FICTITIOUS VACUUM-TUBE SUBSYSTEM

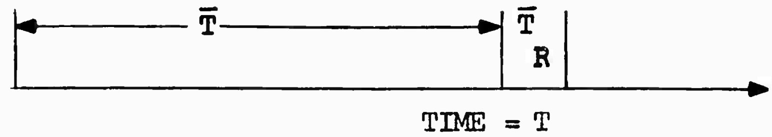
OPERATING ENVIRONMENT	K	$\overline{T}_i$	$\overline{T}$	$\overline{T}_{i_{MC}}$	$\overline{T}_{MC}$
GROUND STATION	.9	4000	3600	7350	6615
SHIPBORNE	.1	4000	400	7350	735
AIRCRAFT-MANNED	.03	4000	120	7350	220
MISSILE*	.012	4000	48	7350	88

FICTITIOUS TRANSISTORIZED SUBSYSTEM

OPERATING ENVIRONMENT	K	$\overline{T}_i$	$\overline{T}$	$\overline{T}_{i_{MC}}$	$\overline{T}_{MC}$
GROUND STATION	.9	4000	3600	7500	6750
SHIPBORNE	.13	4000	520	7500	975
AIRCRAFT-MANNED	.04	4000	160	7500	300
MISSILE*	.016	4000	64	7500	120

*ON LAUNCHER

Figure 8



$\bar{T}$ = MEAN TIME BETWEEN FAILURES

$\bar{T}_R$ = MEAN TIME TO REPAIR

IN A PERIOD OF TIME $T >> \bar{T}$

$$\text{DOWN TIME} = \frac{T}{\bar{T}+\bar{T}_R} \cdot \bar{T}_R \qquad (17)$$

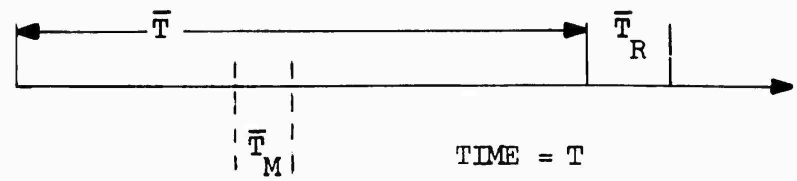
$$\text{FRACTION DOWN TIME} = \frac{T.\bar{T}_R}{\bar{T}+\bar{T}_R} \Big/ T = \frac{\bar{T}_R}{\bar{T}+\bar{T}_R} \qquad (18)$$

AVAILABILITY = FRACTION OF TIME AVAILABLE

= 1 - FRACTION DOWN TIME

$$= 1 - \frac{\bar{T}_R}{\bar{T}+\bar{T}_R} \qquad (19)$$

Figure 9



$\bar{T}_M$ = MEAN TIME FOR MAINTENANCE
(SYSTEM PRODUCING NO USEFUL DATA)

IN A PERIOD OF TIME $T \gg \bar{T}$

$$\text{FRACTION DOWN TIME FOR REPAIRS} = \frac{\bar{T}_R}{\bar{T}+\bar{T}_R} \qquad (18A)$$

$$\text{FRACTION TIME FOR ROUTINE MAINTENANCE} = \frac{\bar{T}_M}{\bar{T}+\bar{T}_R} \qquad (20)$$

$$\text{FRACTION TIME UNAVAILABLE} = \frac{\bar{T}_R+\bar{T}_M}{\bar{T}+\bar{T}_R} \qquad (21)$$

$$\text{AVAILABILITY} = 1 - \frac{\bar{T}_R+\bar{T}_M}{\bar{T}+\bar{T}_R} \qquad (22)$$

Figure 10

ADDENDUM
TO
RELIABILITY AND MAINTAINABILITY OF MILITARY ELECTRONIC EQUIPMENT

This addendum is prepared to illustrate more thoroughly the concepts developed in this paper.

Referring to Figure 8 of the paper, the mean time between failures $\overline{T}$ for 100 vacuum tube subsystems is indicated to be 3,600, 400, and 120 hours for three different operating environments; namely, ground station, and shipborne and manned aircraft respectively. It should be repeated that this is not the same equipment operated in three different environments, but it could be subsystems designed to satisfy the same intended function, but each specifically designed for use in the end environment indicated.

In figure 1 of the addendum, a system is assumed which is comprised of 10 subsystems, each assumed equivalent to the fictitious subsystem just referenced. For such a system, the average operating time between repairs is indicated in hours and days and is taken as one-tenth that for a single subsystem.

In figure 2 of the addendum, curves are shown which reflect the per cent of time available as a function of average time to repair and the average time between repairs. The upper curve is for an average repair time of 2 hours, while the lower curve assumes an average repair time of 10 hours. These curves were computed using equation (19) of figure 9 of the main text. For an availability of 90 per cent, it can be seen that the mean time between failures must be nine times the average repair time, for 95 per cent availability a ratio of 19 to 1 is required, while for 99 per cent availability, a ratio of 99 to 1 is required. It seems obvious that this consideration has resulted in the emphasis on maintainability. Frequently, the obvious should be questioned. Emphasis costs time and dollars, therefore let us look further at the maintenance situation which can be expected in the manned aircraft area.

In figure 3 of the addendum, the availability of fictitious 1,000 vacuum tube systems is indicated as a function of three average repair times and the assumed mean time between repair of 12 hours per system. The top line assumes an average system repair time of 1/3 hour. This assumes time to isolate fault to a specific subsystem and replace that subsystem with a unit which restores system operation. This average repair time would provide an average system availability of 97 per cent, assuming 12 hours as the average time between failures. The next lower line assumes an average repair time of 2 hours indicating an average system availability of 86 per cent at the 12 hours average time between failures. The lower line represents availability when the average repair time is 10 hours and is indicated for reference only.

It is of interest to consider a two-step maintenance system: the first step being the replacement of a subsystem in the system as being representative of the 1/3 hour repair time, followed by a repair of the subsystem at hangar or back-up repair point with an average total repair interval from plane to spares of 10 hours.

Figure 4 of the addendum illustrates the repair activity required to maintain 100 systems in aircraft. The first column indicates the system restoration times of 1/3 and 2 hours. The second column indicates the per cent of time systems available as a function of the average repair time in the first column and a mean time between repair of 12 hours. The third column indicates the average subsystem repair activity each hour. It indicates the average input to subsystem repair back-up activity as well as the average output of repaired subsystems per hour to sustain the availability indicated in the second column. The fourth column indicates the number of 100 vacuum tube subsystems in repair during an average 10-hour period. The fifth column indicates the spare subsystems required to maintain the indicated availability 90 per cent of the time contingent upon the back-up repair activity performing its function of delivering repaired subsystems at the rate indicated in column three. The first number in the fifth column assumes that the ten subsystems per system are identical, while the number in parenthesis assumes ten different subsystems but having equal failure rates. The problem for ten different subsystems having different failure rates can be easily solved.

The upper part of this figure summarizes the required maintenance activity to support 100 systems of 1,000 vacuum tubes each in manned aircraft as a function of an assumed average of 12 hours between failure versus system and subsystem average repair times.

The lower part of this figure indicates the improvement in the maintenance activity which would result from a change in design to improve the mean time between failure from 12 to 120 hours. Although not indicated in this figure, it is assumed that the reliability of the equipment (the probability of success per mission) would reflect the improvement in mean time between failures.

The effect of the increased reliability on the repair activity indicates that an availability in excess of 98 per cent can be achieved with a system repair time of 2 hours and that to support 100 systems, a repair activity capable of handling eight subsystem per 10-hour period seems very reasonable compared to present loads. The change in spare subsystems is far less significant than the great reduction in repair activity obtained from increased reliability. The cost to develop systems for manned aircraft having the improvement indicated should be small compared to the present maintenance costs on 100 systems presently available. After development, the cost per system should only be slightly higher than those presently obtained since it seems reasonable to expect that the improvement desired can be obtained by the application of design philosophies and techniques making full use of existing reliability concepts. The improvement suggested should be achievable, using presently available parts with a probable initial cost in weight and space. Once the desired reliability is achieved, further development can be directed toward gaining back the weight and volume loss which may be required initially.

ASSUME A SYSTEM COMPRISED OF 10 SUBSYSTEMS

(Each Subsystem as Previously Defined)

Operating Environment	Avg Operating Time Between Repairs	
	Hours	Days
Ground Station (Permanent)	360	15
Shipborne	36	1.5
Manned Aircraft	12	.5

Figure 1

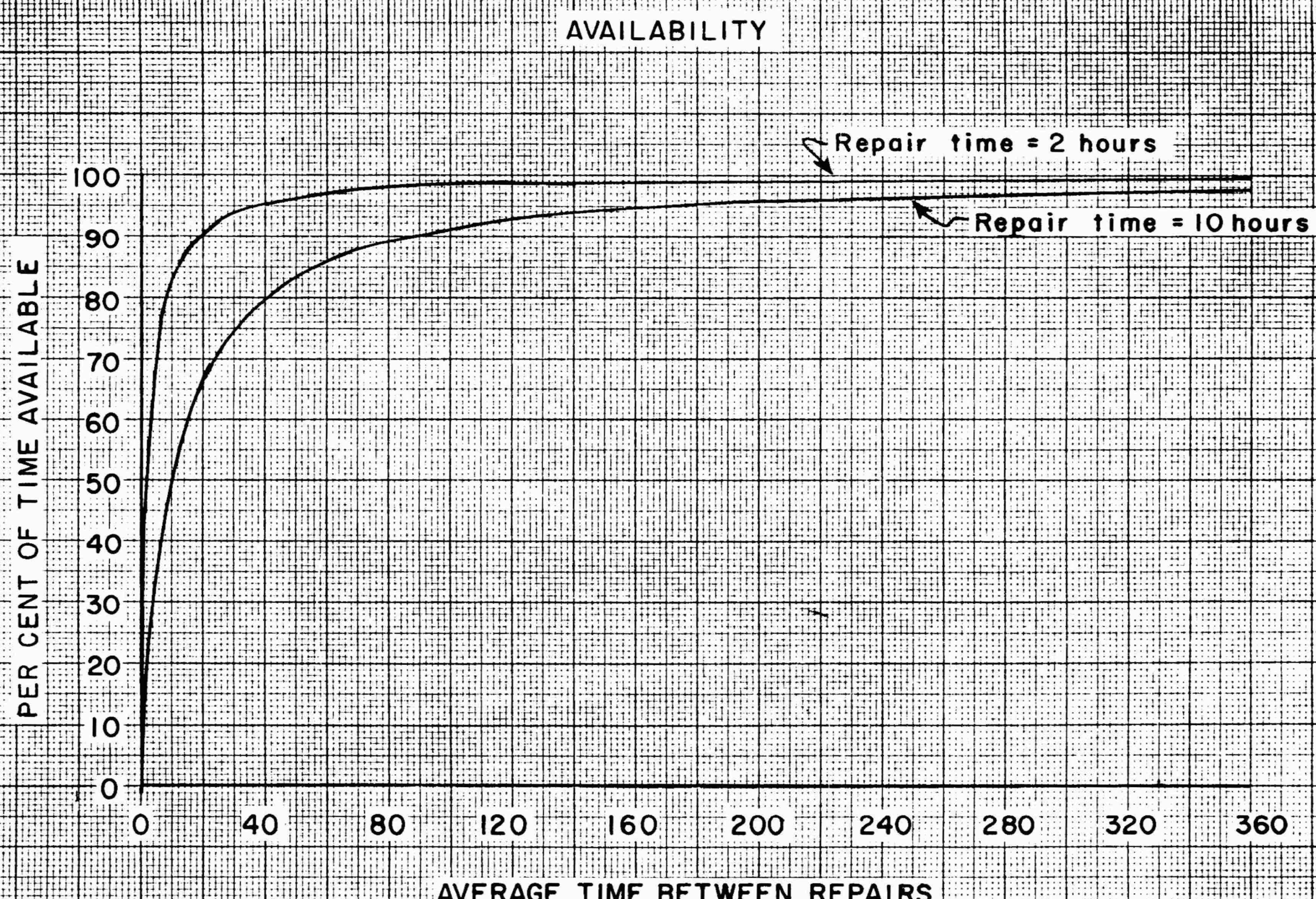

AVAILABILITY
Repair time = 2 hours
Repair time = 10 hours
PER CENT OF TIME AVAILABLE
100
90
80
70
60
50
40
30
20
10
0
0
40
80
120
160
200
240
280
320
360
AVERAGE TIME BETWEEN REPAIRS

Figure 2

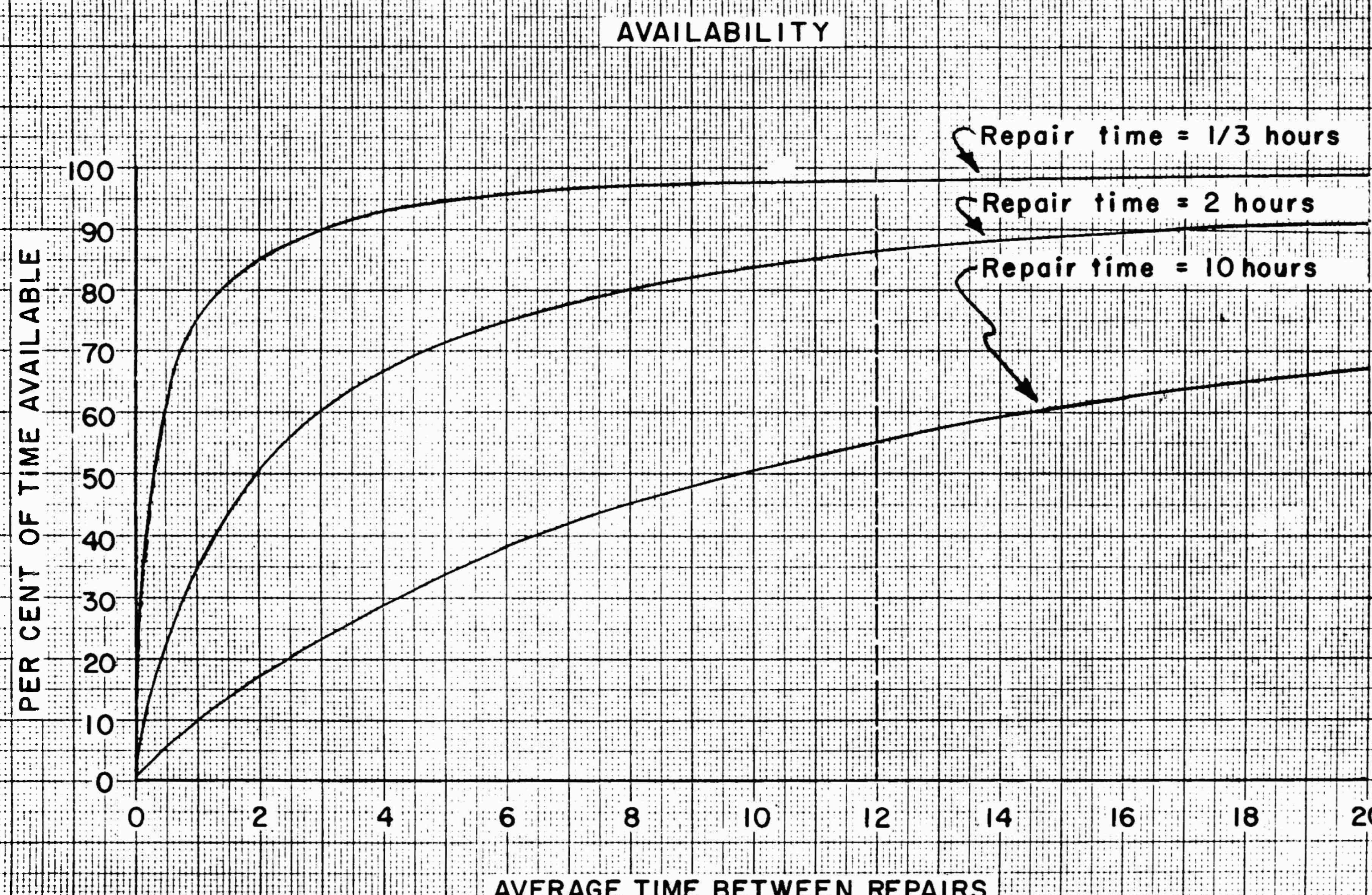

AVAILABILITY
Repair time = 1/3 hours
Repair time = 2 hours
Repair time = 10 hours
PER CENT OF TIME AVAILABLE
0
10
20
30
40
50
60
70
80
90
100
0
2
4
6
8
10
12
14
16
18
20
AVERAGE TIME BETWEEN REPAIRS

Figure 3

REPAIR ACTIVITY TO MAINTAIN 100 SYSTEMS IN AIRCRAFT

System Repair Time Hours	Per cent Systems Available	Subsystem Repair Per Hour	Shop Repair Activity Assume 10 Hours to Repair No. of Systems in Repair	Spare Subsystems Required to Maintain Indicated Availability 90% of the Time
1/3	97	8.25	82.5	12 (20)
2	86	7.10	71.0	11 (18)
Mean Time Between Failure Increased from 12 to 120 Hours				
1/3	.997	.9	9	2.2 (10)
2	.984	.8	8	2.0 (10)

Figure 4

MR. FRANK A. HARTSHORNE, RCA: In your basic failure rate listing, you show 900 bits for transistors which appeared in the list as almost twice the value for relays and only about 1/2 for common receiving tube types. Have you learned anything recently that makes you feel that value should be lower or are you still holding to about 900.

MR. HERSHEY: We currently have a program under way to try to reduce this by a factor of 10 to 1. We don't see at the present moment a chance of getting transistor reliability at a point where it is competitive with resistors and capacitors. We do think that the two jobs, doubling the reliability of resistor and increasing the reliability of transistors by a factor of 10 to 1, are equal-sized jobs. We think that the work involved to accomplish these two are essentially equal. Does that answer your question?

QUESTION: In your illustration to increase availability on the aircraft system, I noticed that design of modular maintenance was a great factor here. How do we propose to provide backup for this. Will this be predominantly modules of a disposable nature for all the modules or will we require maintenance shops to back up such a system?

MR. HERSHEY: Well, there are two parts to this problem. In a current analysis of one system, we have found that 33% of the chassis are responsible for 83% of the trouble. We know that provisioning techniques of the past have loaded warehouses with chassis that will never be plugged into these systems. We think that the prediction technique applied earlier is the black box prediction. This is followed up by another prediction system in which we take into account the temperature that the box operates in, the severity of use of each part, temperature and actual rating of the part versus the catalog rating of the part, so we get a very much more accurate prediction in this second case and we predict on every circuit; it is presently possible in initial review of circuits to predict where the first redesign activity will take place on that chassis. The more designers we convince that we know this now, the less redesign we will have to do. We can include it in the initial design activity. We are not presently disposed, let us say, to the belief that we have arrived at the throwaway package concept. In a new design where we are packaging some four elements of data processing logic in a single package, 4 transistors, 12 resistors, 4 capacitors, etc, we are encapsulating the resistors and capacitors. We are not soldering any connections because we believe that the soldering iron applied to the terminal of the device takes the life out of it. We are wire wrapping all of the connections, and provisions are made for removing the transistors and replacing them. In a package of 4 transistors with the associated parts, we believe that 5 out of 6 repairs of this unit will require replacement of the transistor, and on the average, on the sixth repair you throw the package away. We will not dig into the encapsule. We do not believe at the present time that elements have arrived at that state where it is necessary to throw away the rest of the gear. I don't think that we can support this from the standpoint of our natural resources situation. So at the present time, I vote in the direction that we try to design to replace the devices which are going to fail first, that they be easily available, that you never bury an active device under an inactive device, and that you make packages small. I get horror stricken when I see a sheet this big of printed wiring with parts on. The poor devil who has to shoot trouble on this -- I can't understand where you start your training -- certainly won't know how to shoot trouble by the time he's been here two years, so I think that the designer has to carry the burden. At the present time, over 50% of all of the difficulty is that you have unreliability which is the fault of design. The other 50% would be divided between the manufacturer and the user with the manufacturer taking the smallest piece out of the pie. He's been economy minded for years and he knows that he can't scrap products if he is going to make money. So he has generated a practice which results in a higher reliability product. The thing that I am concerned about is the problem 5 years from today. What will the military do in the 5 years that the development and manufacturing area find out where they are and move forward and you fellows have 80% of the pie left. I'm sure that you are going to wind up with it. Five years from now I can forsee 80% of current unreliability of products being due to the mishandling, abuse, and misuse of Electronic parts. I don't think any developer can develop products which are damn fool-proof. I saw on the staff car that I rode in a price tag on the dash. I don't know how you get into the user's thinking that Uncle Sam is not a pot of gold. A piece that you can hold in your hand can cost anywhere from 25 cents to $25,000. How does the GI who is using equipment discriminate between the 25 cent and the $25,000 item? How would we handle this job in industry? Currently at our place, my boss would have to pull out the $25,000 piece. He wouldn't trust this to me.

MR. A. J. FINOCCHI, ITT LABORATORIES: I have two questions: One, would you care to cite an instance around a military installation where you have achieved 90% of the true life of the parts" And two, the most recent I've gotten, I'm not going to mention the name -- TR 1100, sort of show a transistor has a failure rate in bits approximately equal to resistors. Would you comment on both, please?

MR. HERSHEY: Let me answer the second part first. This depends upon whose failure rate on resistors you are using. If you are using ours and you find one that is equal, we'd like to know the name of the vendor that you can buy this from. The thing that you have to worry about is, do you have enough failures to find out what your failure rate is? The first failure can be 2.3 times the expectancy and still be within the 95% competence limit for the first failure. It isn't until you get 50 or 60 failures that you are within ±20% of knowing what the failure rate of an equipment is. So that if you had good transistors, you would probably already have been operating 100,000 of these to know that you have a failure rate at the present time as good as the resistors, because you would have had to start about 4 years ago with about 100,000 to find out that they are as good as resistors today, and if you've got an experiment that big we would like to see some of the data. As for the other part of your question, I can't give you the name of this equipment where we are getting .9 of what we think the inherent capability of the part is, but I can tell you that this is a 2,000-vacuum tube system, and, on the average, we have to make a repair every 10 days. It is operated by the military, maintained by the military, and we have better than a 95% accounting of the reporting.

MR. FINOCCHI: I wish you would make clear under what conditions the gear is working. Is it air conditioned? Is it largely spread out? Is it in a single building? That's the sort of thing I am interested in.

MR. HERSHEY: It's in an air conditioned space; the temperature is closely regulated. The heaters on all vacuum tubes are regulated at approximately 5% below normal heater voltage. The system operates 24 hours a day; no part of it is ever shut off; some of the systems are approaching 50,000 hours of operation. So we know that this is not the first fly-by-night feeling that everybody is warm inside. We have enough failures to know what we are talking about. This job was developed on an easy schedule; it was built without beating yourself over the head to get it out of the door; it was installed by ourselves when the whole system was working; and the transfer of property was accomplished by transfer of the key of the building to the using people.

CARL E. SOHLGREN, BENDIX PACIFIC: I have a question concerning soldering of components. You mentioned that all components are wire-wrapped and not soldered. How do you attach components to printed circuit boards using this process?

MR. HERSHEY: We don't.

MR. SOHLGREN: Would that mean that Bell Telephone does not have printed circuits?

MR. HERSHEY: I didn't say that. I would rather not get into this particular hassle. In this effort to find out how far you can go reliability wise, there is no wiring on the module as such. This four-element logic element has no wiring on it except the connections of the parts. Wire-wrapped terminals have been provided at the strategic points necessary to connect to the device which makes the circuit. There is not a bit of fettered wiring; there is not a soldered connection. The connection of this unit into the rest of the system is done by the same technique by which the wires are attached to it, namely: wrapped wire terminals. We believe that we will get a failure rate of 1/3 per day in 100,000 such packages connected into a system. This is our objective: a 100,000 package system which is 400,000 transistors, 1.2 million resistors, etc. We are expecting to experience a failure rate no higher than 1 in 20 hours when we get done. To do this, we are trying all the techniques that we know how to apply, printed wiring not being one of them.

THE ARMY MICRO-MODULE PROGRAM AND ITS IMPACT ON MAINTENANCE AND LOGISTICS

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In the continuing effort to increase our electronic pay load, various methods of making equipments lighter and smaller without any reduction in reliability and maintainability have been exploited. New materials, new processes, and new technologies have within recent years produced some remarkable advances in effective micro-miniaturization. These advances have, unfortunately, been somewhat random and uncoordinated without an over-all plan of objectives. This lack of unity has negated to an extent the value of the amazing high parts density achieved by certain micro-miniaturization techniques. To overcome this deficiency is one of the objectives of the Army's Micro-Module Program.

To bring the picture into proper perspective, let us examine some typical equipments. In Figure 1, on the right, is an example of practical miniaturization using hand wiring and conventional, random dimensioned, electronic parts. This is the Army's Handy Talky with an electronic parts density of about 8000 parts per cubic foot. The Army's Helmet Radio, on the left, with miniature parts (including transistors) and printed wiring arranged in an orderly, disciplined layout, makes much better use of space. Here an electronic parts density of over 50,000 parts per cubic foot has been achieved. This is nearly a sixfold improvement. Figures 2 and 3 also illustrate the use of transistors and an orderly layout, with parts densities in the same order of magnitude. Figure 2 shows some of the telemetry of the Jupiter and Figure 3 may be recognized as a satellite deck. Both of these items were constructed by the Army Ballistic Missile Agency.

From these examples it can be recognized that, even with smaller electronic parts, we are rapidly approaching a limit beyond which, with these techniques, only small incremental size advantages can be gained. The goal for Army Electronics has been established as a ten times reduction in size and weight.

The Army Micro-Module program we consider to be a logical and practical step forward toward this goal, embodying as it does uniform dimensions of the basic parts. These basic parts or micro-elements, when united with other micro-elements and then protectively encapsulated, become a rugged reliable monolithic aggregate or micro-module. This actually is a new viewpoint utilizing known principles and proven techniques. To illustrate: Figure 4 shows the well known Navy Tinkertoy technique as commercially applied by A C F Electronics.

This technique called for the fabrication of parts on standard shaped wafers, 7/8" x 7/8". As may be seen from the illustration, the dimensions selected were keyed to the miniature vacuum tube and did not emphasize miniaturization as a particular attribute. Parts densities averaged about 10,000 parts per cubic foot. However, automatic assembly is made possible.

An example of acceptable proven techniques is shown in Figure 5. The single stage transistor audio amplifier on the right illustrates a ten to one size reduction over the conventional parts and construction shown on the left. A high parts density of 700,000 parts per cubic foot has been achieved through this microminiature construction. These examples illustrate useful techniques but they do not give us that needed coordinated approach. A complete family of electronic parts is not available and the uniform parts geometry so necessary for the achievement of high parts density is completely lacking. Accordingly, the first basic need is to provide the maximum attainable number of parts functions in an essentially two-dimensional system and having parts (micro-elements) of a uniform geometry to allow efficient integration.

Figure 6 displays a group of basic micro-elements in the standard 0.310" square shape established for the Micro-Module Program. The assembled micro-module (center) is made by stacking and interconnecting the individual micro-elements. Encapsulation would then follow. Three functioning experimental micro-modules, one a receiver converter circuit and two 455 kc I-F amplifier stages with parts densities in the order of 600,000 parts per cubic foot, are shown in Figure 7.

The system will be capable of performing a full range of basic electronic circuit functions involving a 1-watt maximum power dissipation per module, an upper frequency limit of 70 mc with progressive capability to 150 mc and a maximum digital switching rate of 10 mc. Specific micro-modules have been designed and constructed to demonstrate and to provide for adequate evaluation of a full range of basic audio, I-F, R-F, digital computer, and oscillator circuit capability. The life and environmental acceptance test program is quite extensive and includes 676,000 test-unit hours for modules. Over 12 million unit hours will be devoted to environmental testing of micro-elements. The test program is covered in some detail in the Second Quarterly Report of the Micro-Module Production Program.

The receiver circuit of the AN/PRC-36 Helmet Radio (Fig. 1, Figs. 8, 9, 10, 11), circuits from the AN/TCC-26 (Figs. 12, 13, 14) Time Division Multiplexer, the Pulse Generator for use with AN/TSQ-8 (Fig. 15), and an electric tuning subassembly suitable for tuning the receiver portion of the AN/PRC-35 are being micro-modularized.

Figure 16 displays the spectrum of environmental requirements for the five categories of Army equipment for the full program. Temperatures range from -55°C to 85°C for ground portable devices and projectiles, from -55°C to 125°C for vehicular devices and satellites, and up to 200°C for missile applications; the range from 85°C to 125°C is our goal for the first two year phase of the program. Vibration requirements range from the standard 10 to 55 cycles for the ground and vehicular equipments to 10 to 2000 cycles for the other equipment categories. The ability of Army equipments to work in rare-field atmospheres is defined by the following requirements: portable and vehicular equipments must operate without malfunction of any kind at altitudes up to 10,000 feet. Missile and projectile altitude extremes have been set down as complete vacuum for all practical purposes. All micro-modules will be required to withstand 50g 10 millisecond shocks as a minimum and, in addition, the projectile and satellite modules will be required to withstand 15,000 g's of 8-millisecond duration, as well as a spin of 20,000 rpm.

For general military use MM must be at least as reliable as conventional construction. Reliability goals in terms of a 50-part module are spelled out in the Technical Requirements as 15,000 hours Mean Time to Failure with progressive capability to 100,000 hours. The temperature range of -55°C to 85°C is encompassed with long term storage of 30,000 hours at 71°C. Expressed another way, this initial goal is an average part failure rate of about one tenth of one percent per 1000 hours. To illustrate, assuming the exponential law to apply, such parts in a 500-part missile equipment would have a 0.99 probability of surviving a 15-hour period of operation; that is, 99 out of 100 of these 500-part equipments would be expected to complete 15 hours of operation without failure. It is believed that this goal can be reached because of the following inherent reliability advantages of micro-modules:

1. There is the basic simplicity in circuit part construction.

2. The circuits and micro-elements are simultaneously designed for compatibility.

3. There is the complete freedom to explore new materials, new configurations, processes, and assurance measures.

4. The high degree of mechanization toward which micro-modules have been designed means greater uniformity and reliability.

5. Reliability risks due to improper electrical and mechanical application of parts would be eliminated.

6. The rigid one piece construction offers extreme ruggedness.

In addition to these inherent reliability advantages the small size of equipments now possible through the MM technique make feasible, in some instances, the incorporation of redundant circuits as a reliability measure.

Let us review the micro-elements already available for the Micro-Module system, particularly their capabilities and ranges. First, a look at the basic substrate wafer. Figure 17 shows the standard design with twelve termination notches. It is 0.310" by 0.310" and 0.010" thick.. The thickness dimension will vary somewhat depending upon the type of micro-element. Some capacitive micro-elements use the substrate as the dielectric. Substrate materials in current use are alumina, glass, and "Fotoceram" for semiconductors. The terminal areas at the notches will consist of fired-on silver for all micro-elements, while the terminals on the two end wafers of a micro-module will be made of platinum. Thirteen-mil diameter tinned riser wires are used to interconnect micro-elements.

Figure 18 shows a vapor deposited nichrome film resistor on a glass substrate. Present capabilities for such metal film micro-elements range up to 200,000 ohms per pattern. Four patterns, two to a side, can be accommodated. These metal film resistors have a temperature coefficient of between 20 to 60 ppm per degree C. Tin oxide resistors in values to 20,000 ohms per wafer with a temperature coefficient of 12 to 24 ppm per degree C have been made. These give us 1, 5, and 10%, 1/8-watt resistors with ranges adequate for transistor circuits.

Figure 19 illustrates a capacitor which uses the substrate as the dielectric. By suitable selection of the material for the substrate, the characteristics of such units can range from precision temperature coefficient types to general purpose high capacitance by-pass and coupling capacitors. Through the use of high-dielectric constant materials and alternately depositing layers of dielectric and electrodes on a substrate, capacitance values as high as 1300 mmf for the precision types have been obtained in a ten-layer monolithic construction. With still higher dielectric constants capacitance values as high as 0.3 mf have been achieved. Electrolytic capacitors will cover the capacitance range from 0.2 to several microfarads. Solid tantalum capacitors with a sintered slug 20 mils thick have been adapted to the micro-element configuration. The capacitance voltage product is about 50.

Toroids have been chosen initially for inductors. Inductance requirements for the AN/PRC-36 and the AN/TCC-26 range up to 1.5 mh. Tuned circuits may be formed by mounting a toroid on a capacitor micro-element (Fig. 20). Quartz crystal units are being successfully redesigned into the micro-element configuration.

Lastly, let us consider the active parts that make this micro-miniaturization effort possible, the semiconductors. Semiconductors are illustrated in Figure 21 and also in Figure 6. Technical requirements for the transistors cover the range of audio and switching frequencies, 12.5 to 30 mc I-F and 70 mc I-F. Requirements for diodes cover the following types: general purpose diodes, including low frequency rectifier types, and the fast switching computer type (silicon junction); regulator; reference; and variable capacitance diodes. The variable capacitance diodes will be used in the electric tuning subassembly, which is intended for possible application for tuning the receiver portion of the AN/PRC-25 equipment. Transistors and diodes have been successfully fabricated in the micro-element configuration and hermetically sealed to provide the identical performance and parameters obtainable in non-micro-modular packaging.

Prior to discussing the integration of the micro-modules into operating circuits, I would like to comment on the progress that has been made toward the mechanization of the module assembly process. Although the mechanization aspect is a part of the final phase of the over-all planned program, the demonstration of the feasibility of mechanization is required within the scope of the currently active phase of the program. A semi-automatic machine has been built and successfully used to assemble micro-elements into micro-modules. However, the modules appearing in the various illustrations have been manually assembled by soldering the interconnecting riser wires into the terminal notches. An assembly jig greatly facilitates this operation. After assembly the module is encapsulated in an epoxy resin.

Continuing with module interconnecting or integration, two illustrations will serve to present the current practice of using printed wiring as an interconnecting medium. Figure 22 illustrates a 25 mil coordinate layout and Figure 23 shows a 50 mil layout, which offers greater compatibility with the commonly used 1/10" printed wiring grid system. While various other integration approaches have been proposed and appear feasible, our discussion will be limited to the techniques used in the circuit packaging of the equipments to be considered next.

An integration concept using printed wiring boards as applied to the receiver portion of the AN/PRC-36 receiver is shown in Figure 8. The I-F amplifier subassembly is comprised of six serially connected micro-modules. This subassembly is electrically connected by means of four printed wiring boards to the remaining two modules to make up the receiver. A circuit packaging density of 216,000 parts per cubic foot has been achieved. Replacing the audio-input transformer with an emitter-follower gives some improvement in packaging density. Five printed wiring boards are used to interconnect micro-modules. An arrangement (Fig. 10) which features side mounting of the modules to two printed wiring boards provides an electronic parts density of 244,000 parts per cubic foot. The fourth arrangement (Fig. 11) is similar to the previous one but is more realistic concerning dimensions. This is considered the preferred method with respect to shielding, electrical properties, and dimensions. It is anticipated that the AN/PRC-36 receiver item to be delivered to the Signal Corps will be fabricated in this circuit packaging arrangement. This arrangement provides for the minimum number of interconnections and appears the best approach for production, reliability and maintenance.

The Micro-Module concept provides the designer with considerable latitude in the matter of design for maintenance. Repair may be effected to the micro-module level. While the capability of replacement of individual micro-modules is present regardless of the micro-module interconnection method it is quite impractical to consider user replacement of individual micro-modules with present micro-module interconnection methods. Depot or factory replacement of individual micro-modules is presently feasible and no doubt future micro-modules with reliable individual plug-in capability will make replacement feasible even at the user level. Presently, however, it is appropriate to group the proper micro-modules into subassemblies which are, by use of connective devices, capable of pluck-out and replacement. Replacement permits the detection and isolation of a malfunctioning subassembly in a forward area perhaps by the user himself. This would achieve the minimum of equipment down time. Two areas of service may prove practical, the "replacer" echelon and the "repair" echelon. Reduced manpower, storage and simplified facilities follow as natural consequences.

Maintenance procedure for micro-module equipments consists of the identification and replacement of faulty subassemblies of modules at the user echelon and identification and replacement of either individual micro-modules or an aggregate of micro-modules, a sub-assembly, at a repair echelon. In comparison with conventional equipments which may involve perhaps 10% maintenance by user replacement of subassemblies and 90% maintenance at other echelons, the micro-module concept reverses this condition with 90% maintenance through replacement by the user and 10% repair of defective subassemblies at other echelons. This latter situation results in less equipment down time, the goal of all maintenance, and reduced repair skill and transportation requirements.

In considering the repair of subassemblies of micro-modules at a repair echelon one of the main factors is the mechanical and electrical interconnection method. In Figure 25 interconnecting methods which may be applicable to computer type subassemblies are shown; on the left is the single ended type on which it is relatively easy to effect the removal and replacement of a micro-module. A special soldering iron heating all 12 of the riser wire terminations at once will accomplish this. Repair of a plug-in subassembly of this type is quite practical to the micro-module level. Examining the double ended package on the right reveals that repair of this subassembly is not quite so simple. To remove any one micro-module requires complete disassembly by unsoldering 72 soldered joints, 36 at a time. The repair of such an item although possible may prove impractical in practice. Communication equipment usually has straight through signal paths which allow serial connection of modules. This in-line fashion of interconnection can be done by soldering together the appropriate riser wires as shown in the various illustrations of the Helmet Radio receiver.

A critical examination of the micro-module receiver portion of the AN/PRC-36 which is an example of equipment designed for maximum density rather than maximum ease of repairability shows that field repair of this unit is by complete substitution only. In any proposed field testing of early models of PRC-36 equipments using micro-modules, it is highly desirable that repair of replaced subassemblies be performed at the factory or depot or at least at a location where accurate information on malfunction can be obtained and cataloged. This will accumulate the maximum amount of reliable information of failures for feedback to designers for analysis and resultant redesign of subsequent equipments. From this information, new aggregates of micro-modules could evolve with those requiring the most frequent replacement provided pluck-out capability. This approach is presently being used to obtain data on 2600 of the Helmet Radio sets now fabricated using printed wiring (Fig. 1 left). First echelon repair is confined to cord replacement and tube replacement; the replacement of either of the two plug-in sub-assemblies is at the 2nd or 3rd echelon, and all other repair is effected at the 4th or 5th echelon. This study is providing guidance for the establishment of a policy on maintenance of the current non-micro-modularized AN/PRC-36 Helmet Radio.

Returning to serially interconnected micro-modules, there is a proposed type of interconnection believed to have merit particularly for production (Fig. 26). Small conductor strips are soldered to the edge terminations of adjoining micro-elements. These small bridging links are prepared by etching from a strip of copper foil (Fig. 26 right) and are handled and applied in this continuous strip form. The serial interconnection either by riser wires or strips allows unsoldering of connections and the replacement of a faulty module with an operating module. The AN/TCC-26 which illustrates computer-type circuits would no doubt be designed with maintenance features including plug-in subassemblies of micro-modules (Fig. 27). It could also incorporate even more elaborate self-testing than in the present equipment which has an internal tone oscillator for checking all 14 audio channels. Plug-in sub-assemblies would be layed out on the basis of function, ease of fault location, and ease of maintenance. With the space saving achieved through micro-module construction, it may be feasible to incorporate redundant circuitry with the possibility of automatic switching to the standby circuits if a malfunction occurs. Running time devices can also be used to indicate when a subassembly has approached its anticipated life.

As shown by the experimental circuit packaging examples used as illustrations, the designer has freedom in his choice of design ranging from the optimum maintenance, with little sacrifice in parts density, as in the AN/TCC-26 to the practical maximum in parts density as in the highly compact Helmet Radio. The micro-module concept in addition to yielding a 10 to 1 size reduction will be the basis for marked improvement in reliability maintainability and numerous economies in supply and logistics.

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Frankel, H. C., Maintainability Aspects of Unit, Modular and Printed Circuit Construction Concepts, Second Signal Maintenance Symposium, 1959, Fort Monmouth, N. J.

Frankel, H. C., The Feasibility of Throwaway Maintenance Symposium on Military Electronics Reliability and Maintainability, Rome Air Development Center, ARDC, Griffiss Air Force Base, New York, November 1958

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Radio Corporation of America, Surface Communications Department Quarterly Report No. 2, Prepared under Signal Corps Contract No. DA-36-039-SC-75968

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Ross, Irving J., The Role of Semiconductors in the Army Micro-Module Program Symposium on Microminiaturization of Electronic Assemblies, Diamond Ordnance Fuze Laboratories, 20 Sept-1 Oct 1958, Washington, D. C.

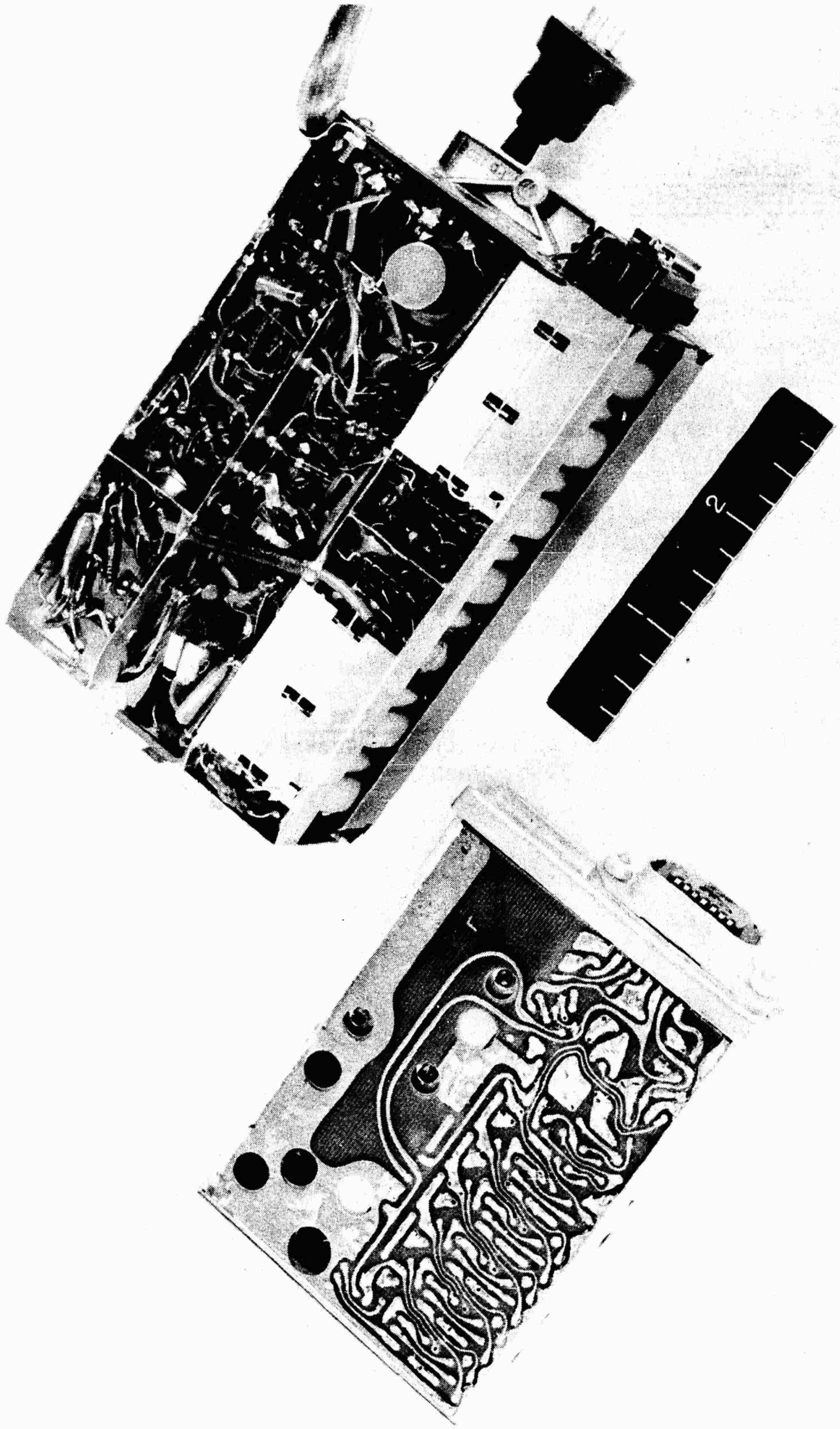


Figure 1

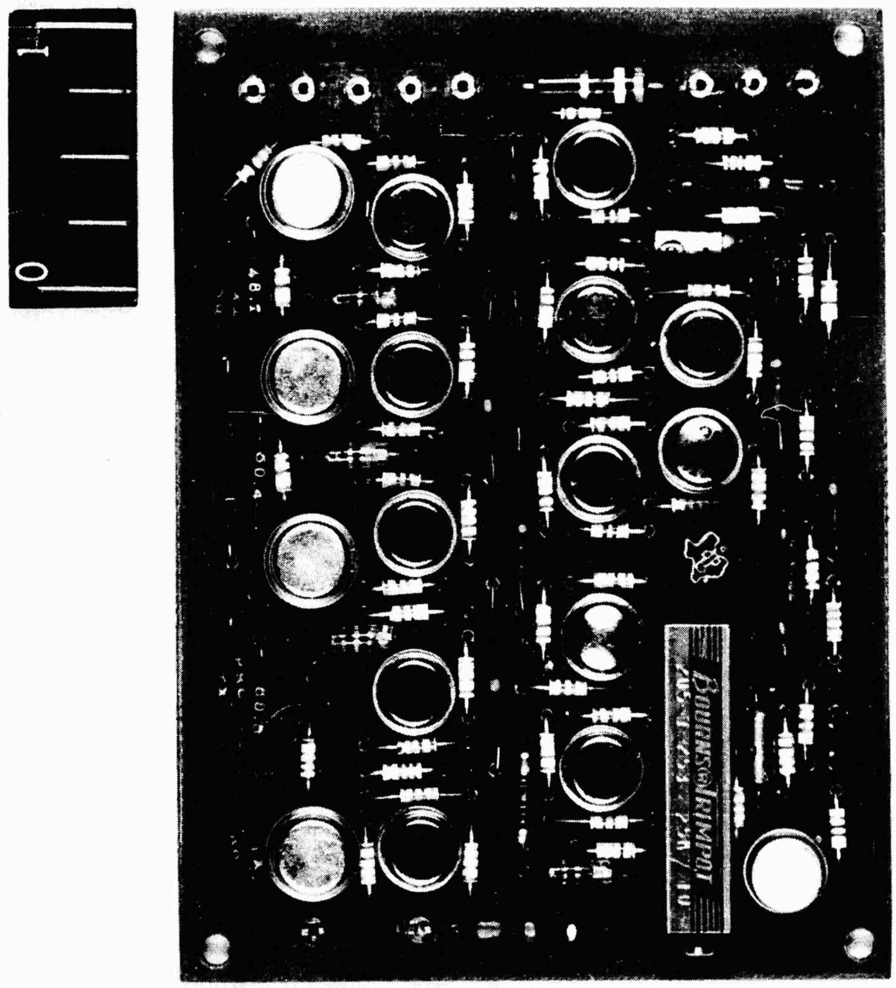


Figure 2

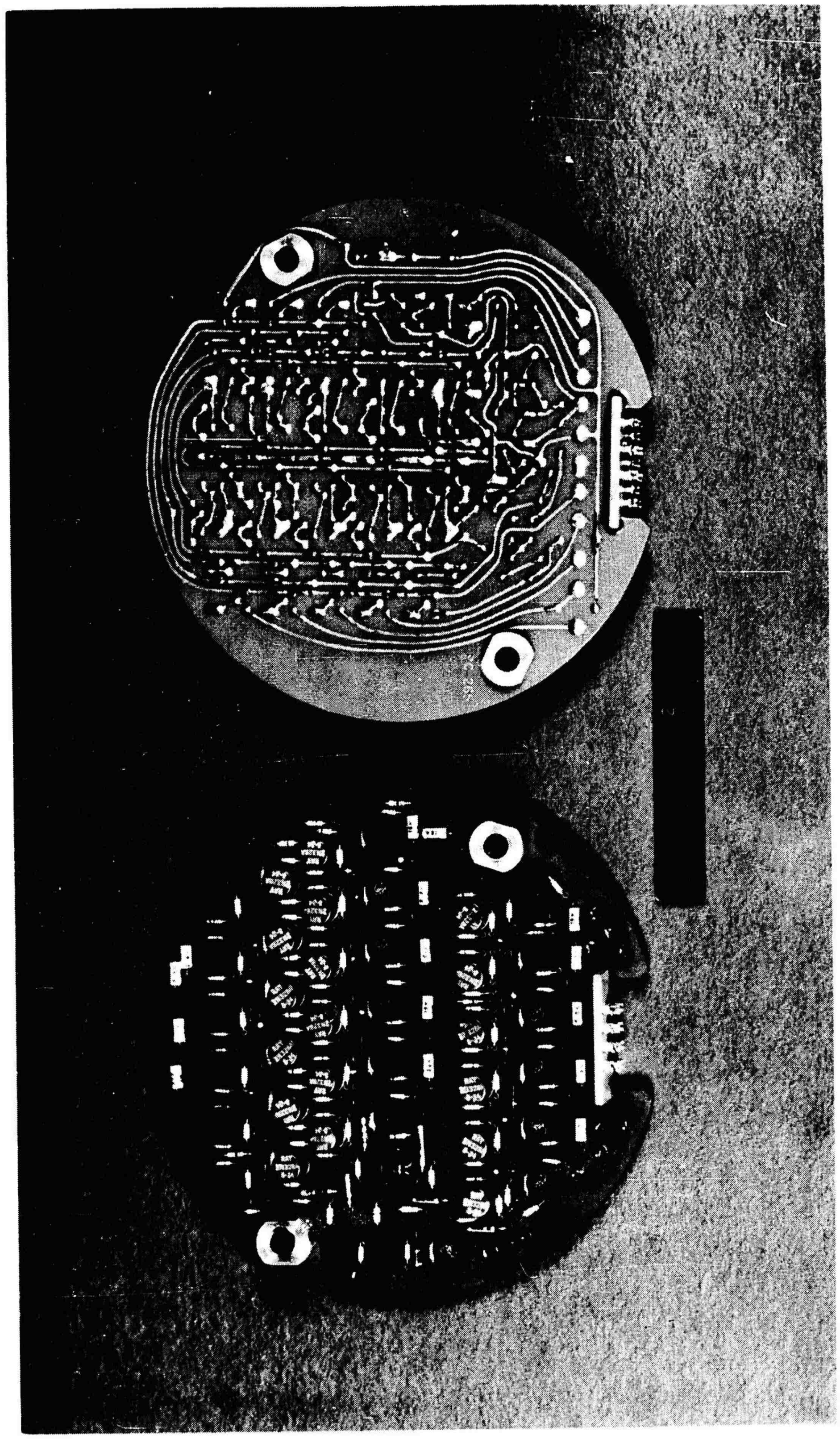


Figure 3

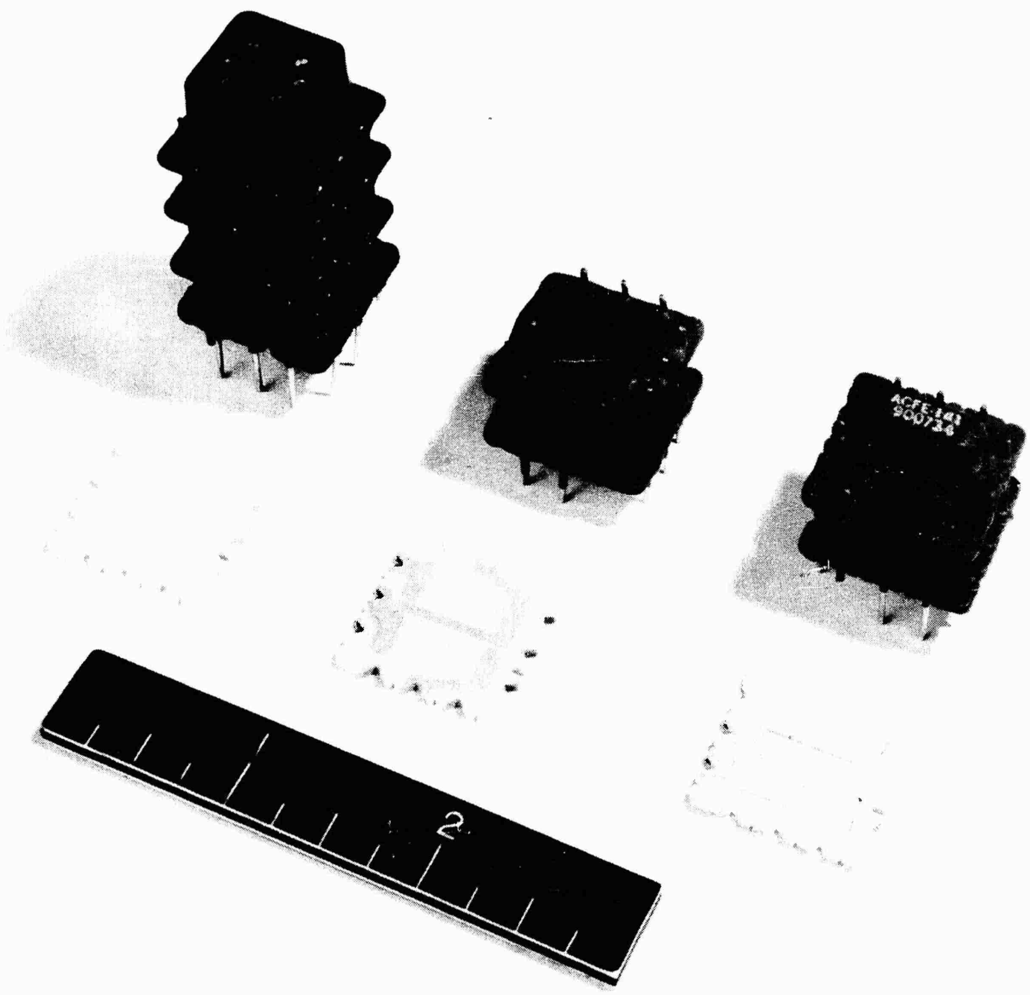
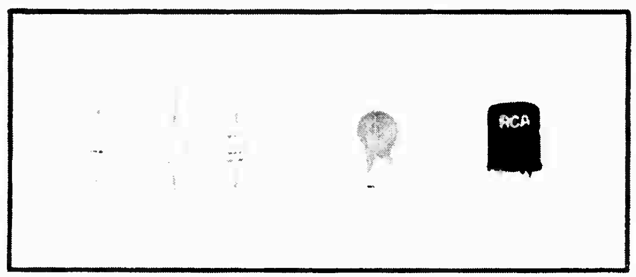


Figure 4

TRANSISTOR AUDIO AMPLIFIER

(SINGLE STAGE)



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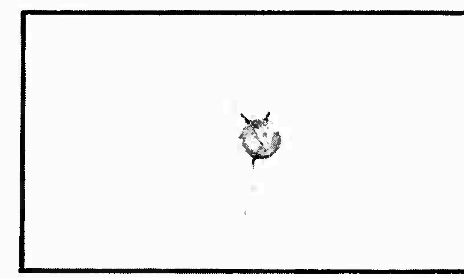


3 RESISTORS + 1 CAPACITOR + 1 TRANSISTOR	3 RESISTORS + 1 CAPACITOR + 1 TRANSISTOR
(CONVENTIONAL CONSTRUCTION)	IN ONE ENVELOPE — CENTRALAB INC.
PRACTICAL VOLUME DENSITY	(MICROMINIATURE CONSTRUCTION)
(PARTS PER CUBIC FOOT)	VOLUME DENSITY (PARTS PER CUBIC FOOT)
75,000	700,000

SIZE REDUCTION

10.1

Figure 5

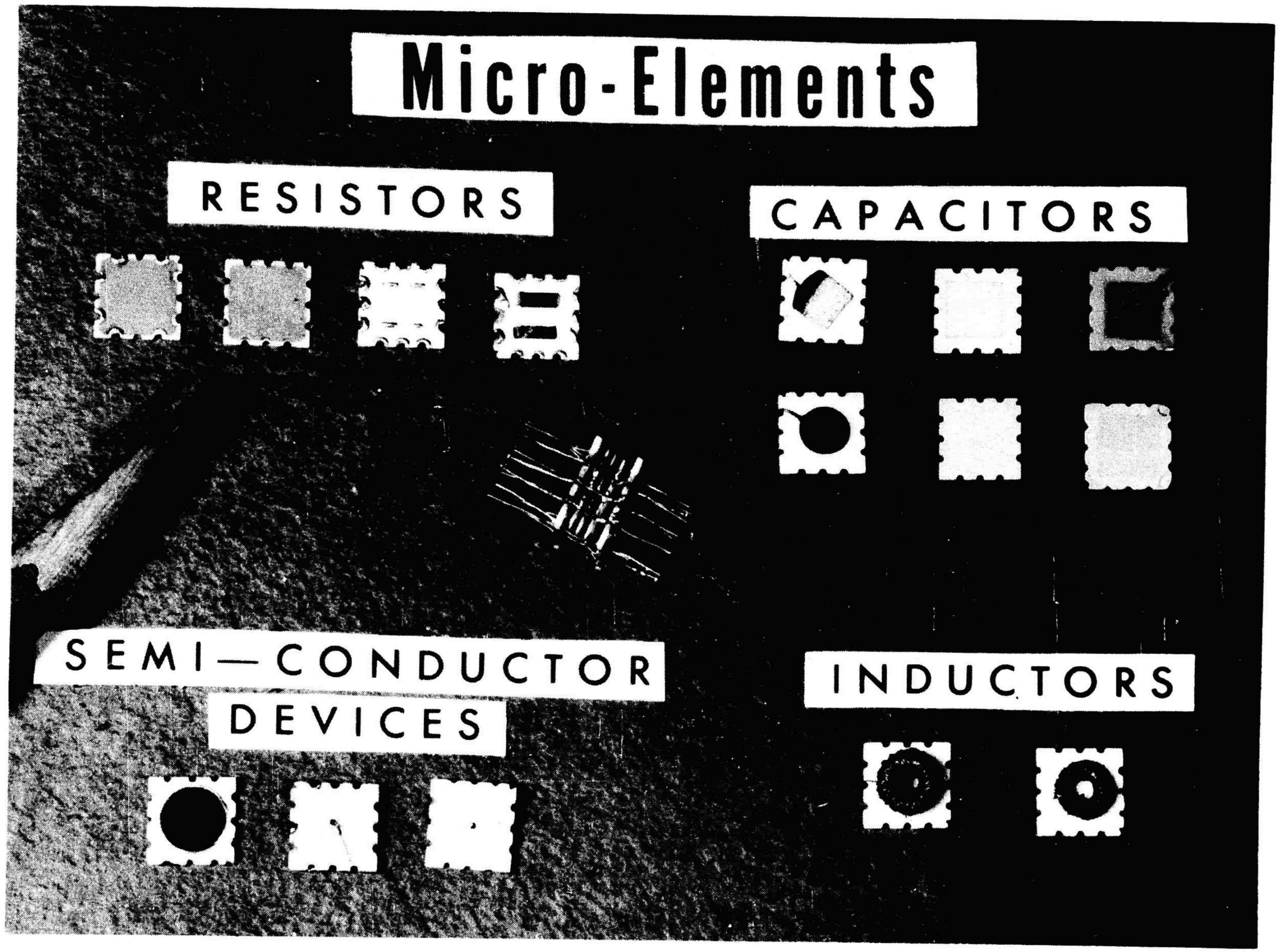

Micro-Elements
RESISTORS
CAPACITORS
SEMI—CONDUCTOR
DEVICES
INDUCTORS

Figure 6

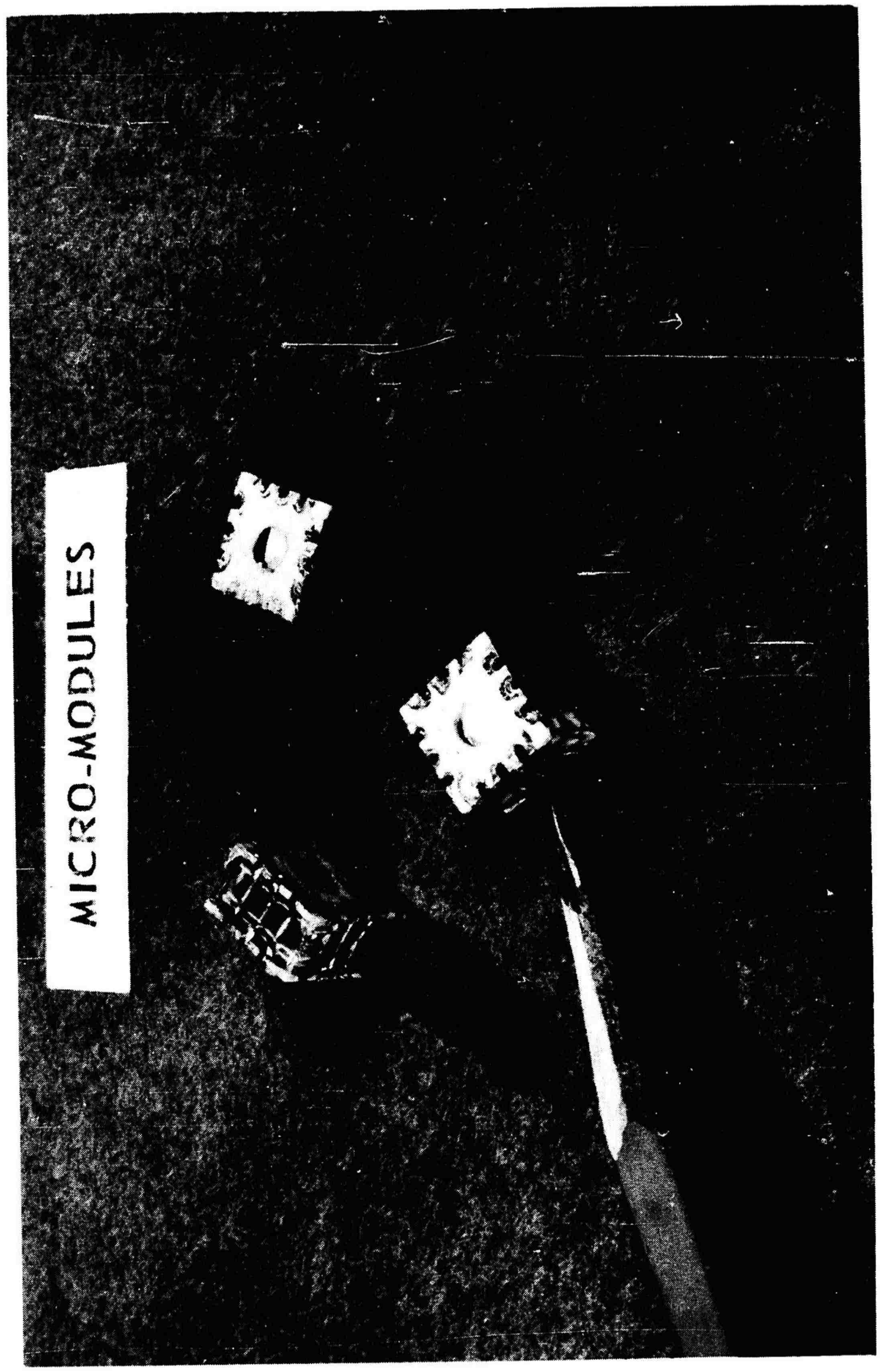


Figure 7

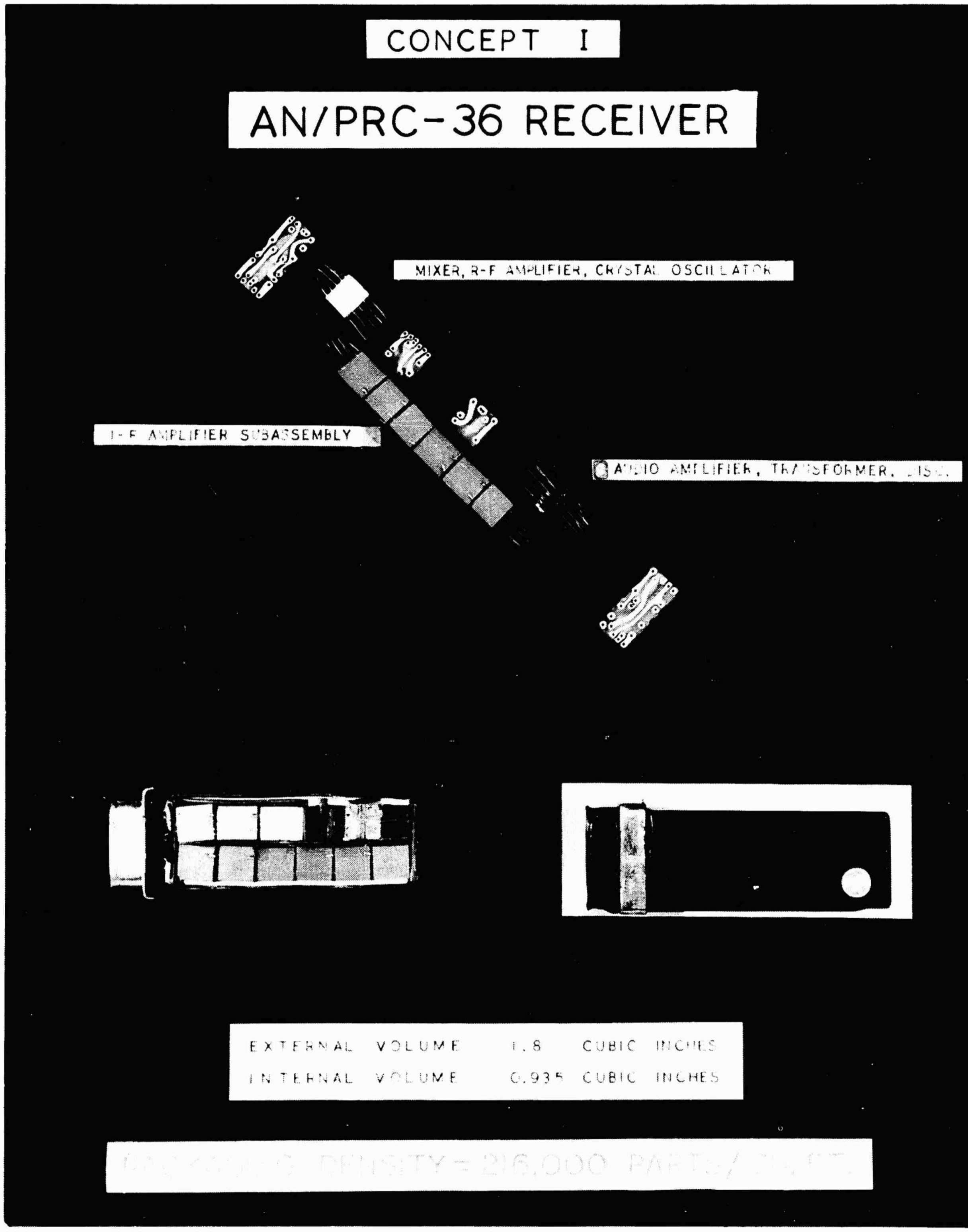

CONCEPT I
AN/PRC-36 RECEIVER
MIXER, R-F AMPLIFIER, CRYSTAL OSCILLATOR
I-F AMPLIFIER SUBASSEMBLY
AUDIO AMPLIFIER, TRANSFORMER, DISC.
EXTERNAL VOLUME 1.8 CUBIC INCHES
INTERNAL VOLUME 0.935 CUBIC INCHES
DENSITY = 216,000 PARTS/

Figure 8

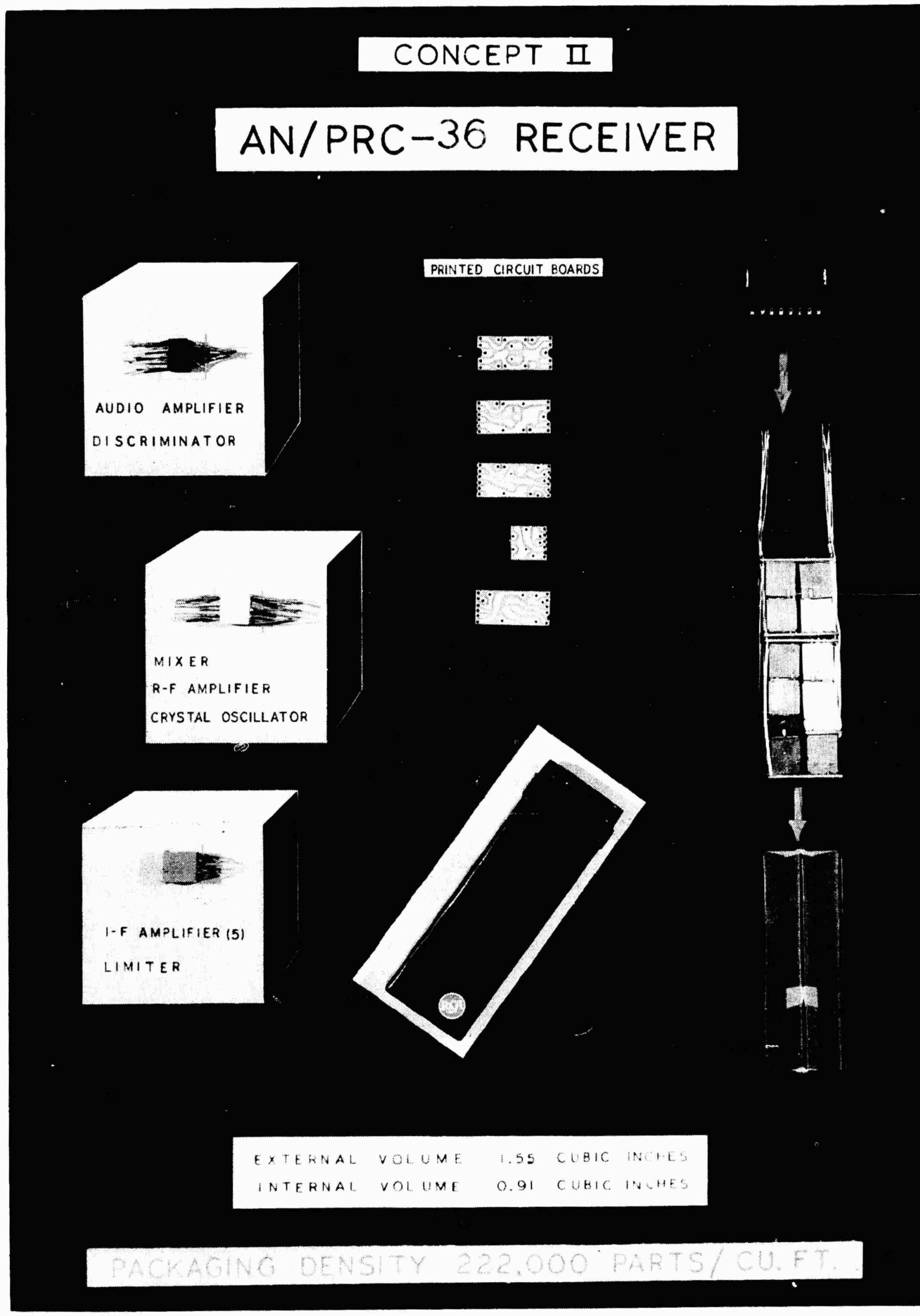

CONCEPT II
AN/PRC-36 RECEIVER
PRINTED CIRCUIT BOARDS
AUDIO AMPLIFIER
DISCRIMINATOR
MIXER
R-F AMPLIFIER
CRYSTAL OSCILLATOR
I-F AMPLIFIER (5)
LIMITER
EXTERNAL VOLUME 1.55 CUBIC INCHES
INTERNAL VOLUME 0.91 CUBIC INCHES
PACKAGING DENSITY 222,000 PARTS/CU. FT.

Figure 9

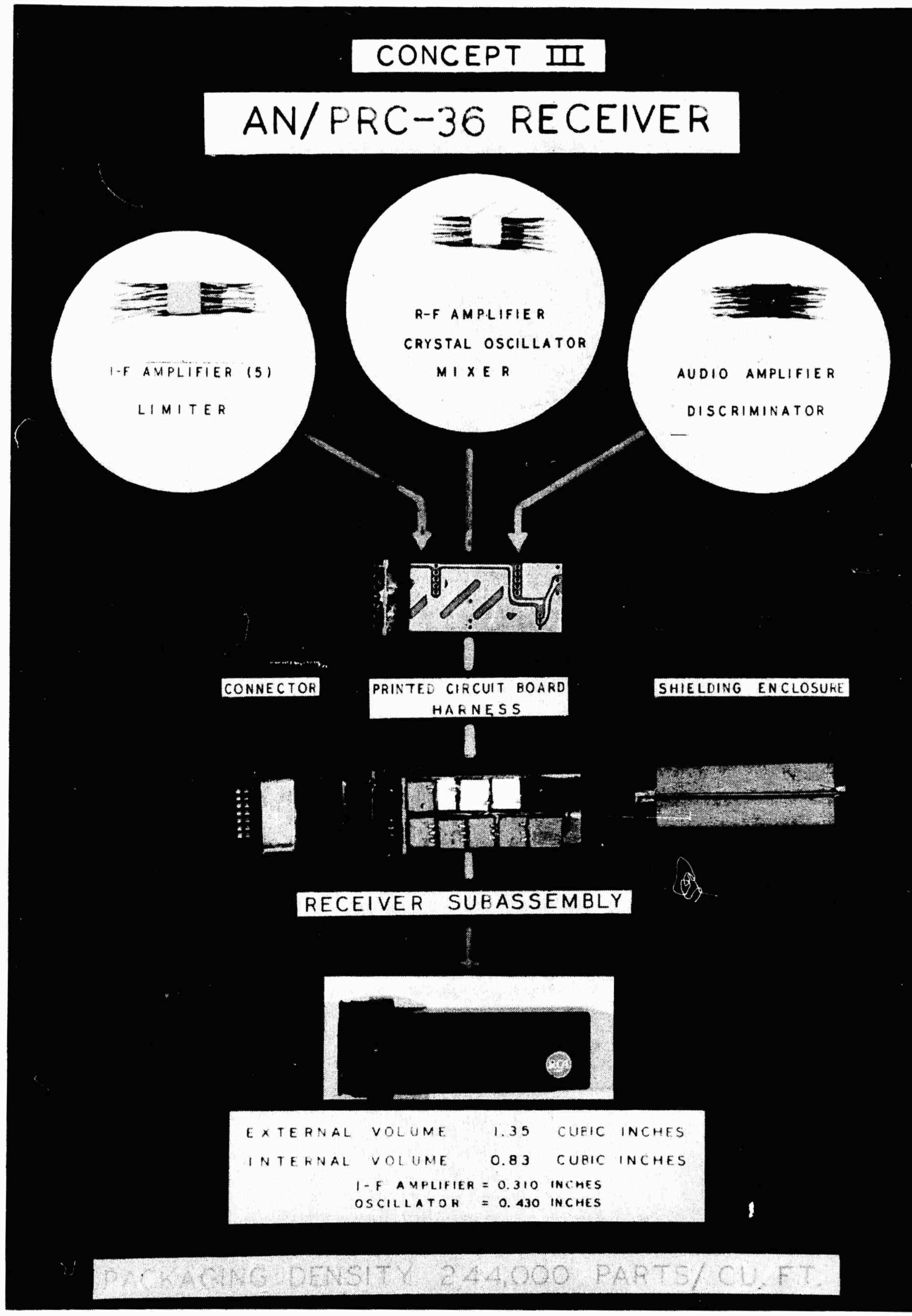

CONCEPT III
AN/PRC-36 RECEIVER
I-F AMPLIFIER (5)
LIMITER
R-F AMPLIFIER
CRYSTAL OSCILLATOR
MIXER
AUDIO AMPLIFIER
DISCRIMINATOR
CONNECTOR
PRINTED CIRCUIT BOARD
HARNESS
SHIELDING ENCLOSURE
RECEIVER SUBASSEMBLY
EXTERNAL VOLUME 1.35 CUBIC INCHES
INTERNAL VOLUME 0.83 CUBIC INCHES
I-F AMPLIFIER = 0.310 INCHES
OSCILLATOR = 0.430 INCHES
PACKAGING DENSITY 244,000 PARTS/CU. FT.

Figure 10

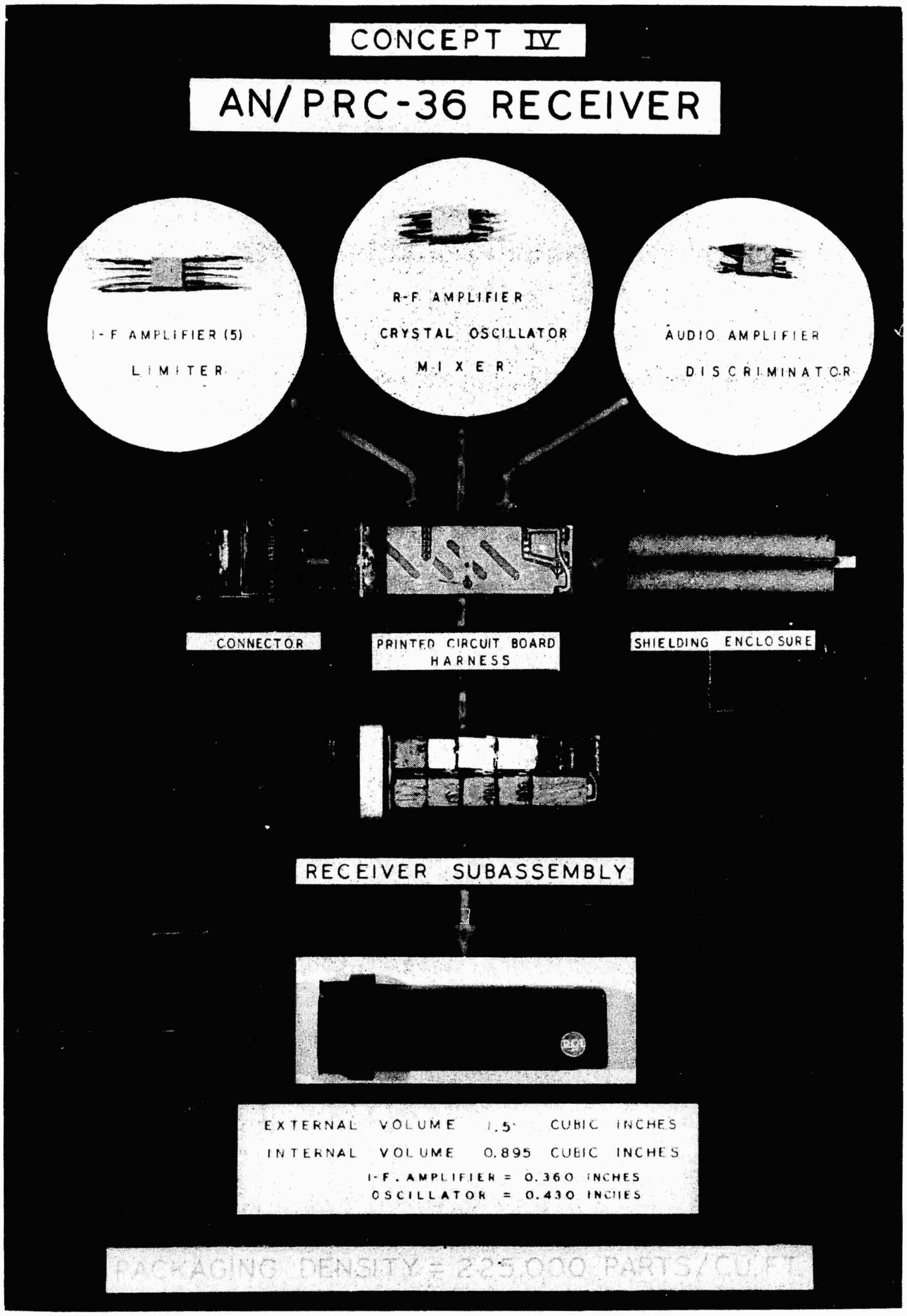

CONCEPT IV
AN/PRC-36 RECEIVER
I-F AMPLIFIER (5)
LIMITER
R-F AMPLIFIER
CRYSTAL OSCILLATOR
MIXER
AUDIO AMPLIFIER
DISCRIMINATOR
CONNECTOR
PRINTED CIRCUIT BOARD HARNESS
SHIELDING ENCLOSURE
RECEIVER SUBASSEMBLY
EXTERNAL VOLUME 1.5 CUBIC INCHES
INTERNAL VOLUME 0.895 CUBIC INCHES
I-F. AMPLIFIER = 0.360 INCHES
OSCILLATOR = 0.430 INCHES
PACKAGING DENSITY = 225,000 PARTS/CU.FT.

Figure 11


MICRO-MODULE
PULSE WIDTH MODULATOR
CONVENTIONAL
MICRO-MODULE
SAW TOOTH GENERATOR
TIME MODULATOR
SIZE REDUCTION 6 TO 1

Figure 12

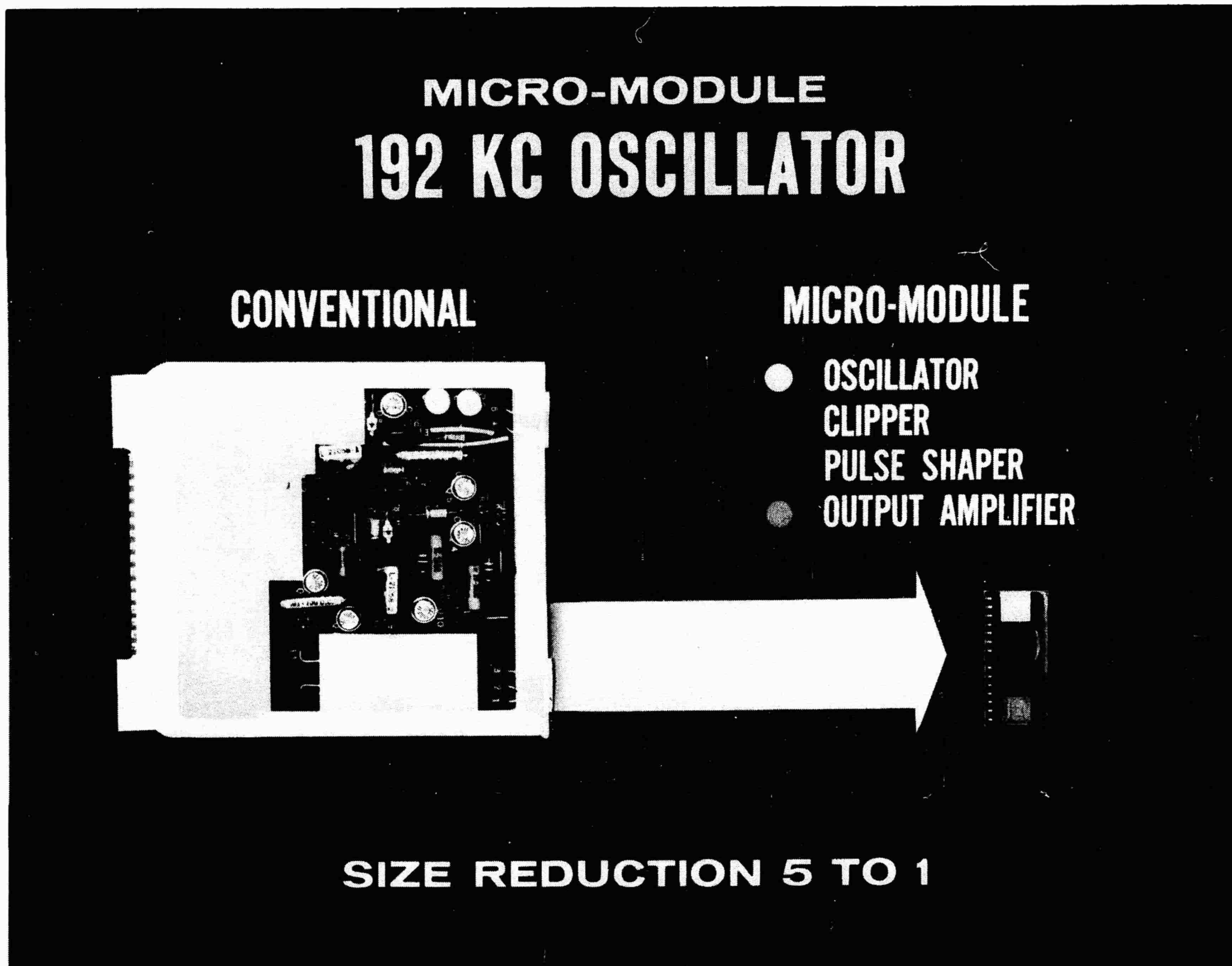

MICRO-MODULE
192 KC OSCILLATOR
CONVENTIONAL
MICRO-MODULE
OSCILLATOR
CLIPPER
PULSE SHAPER
OUTPUT AMPLIFIER
SIZE REDUCTION 5 TO 1

Figure 13

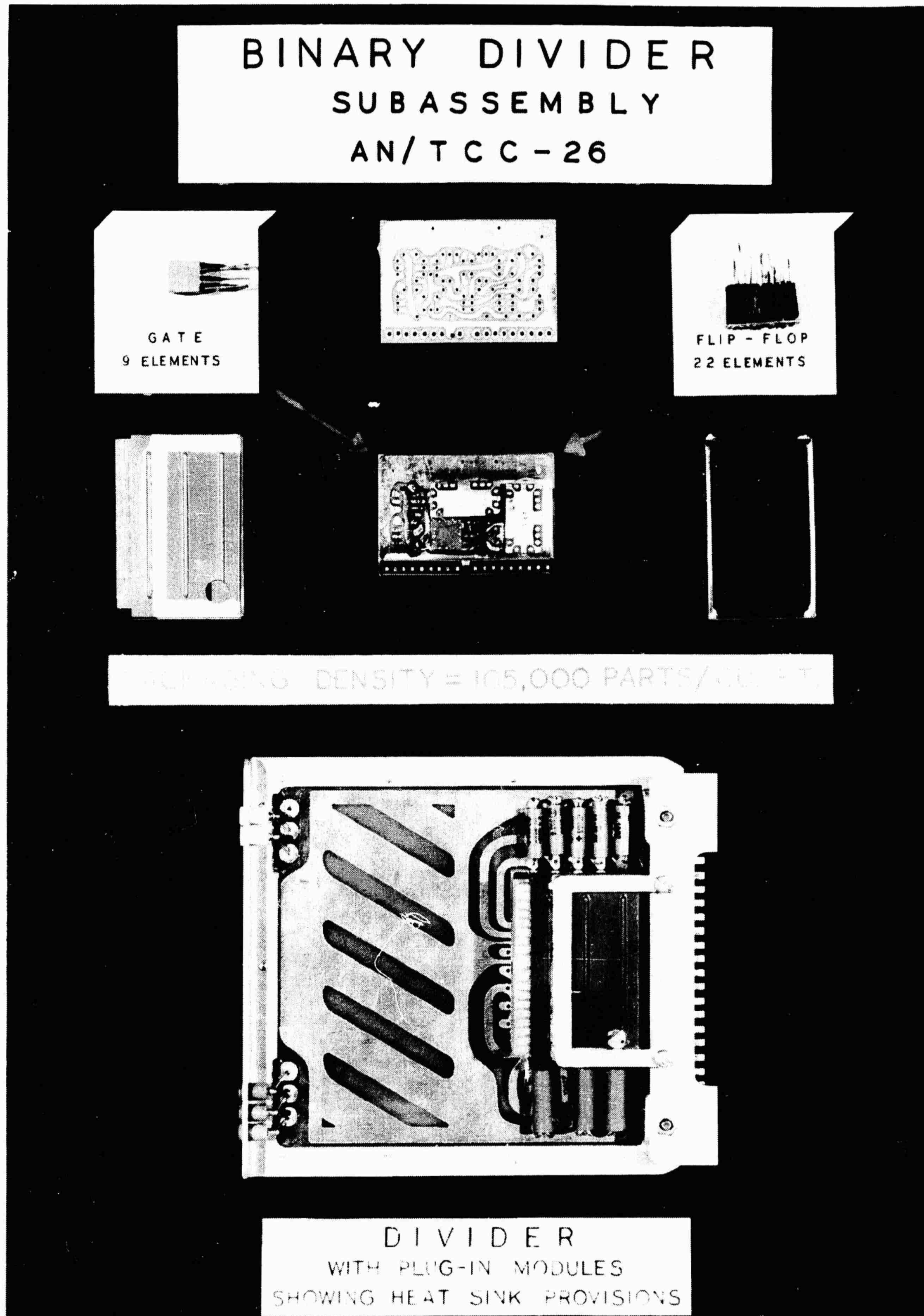

BINARY DIVIDER
SUBASSEMBLY
AN/TCC-26
GATE
9 ELEMENTS
FLIP - FLOP
22 ELEMENTS
DENSITY = 105,000 PARTS/
DIVIDER
WITH PLUG-IN MODULES
SHOWING HEAT SINK PROVISIONS

Figure 14

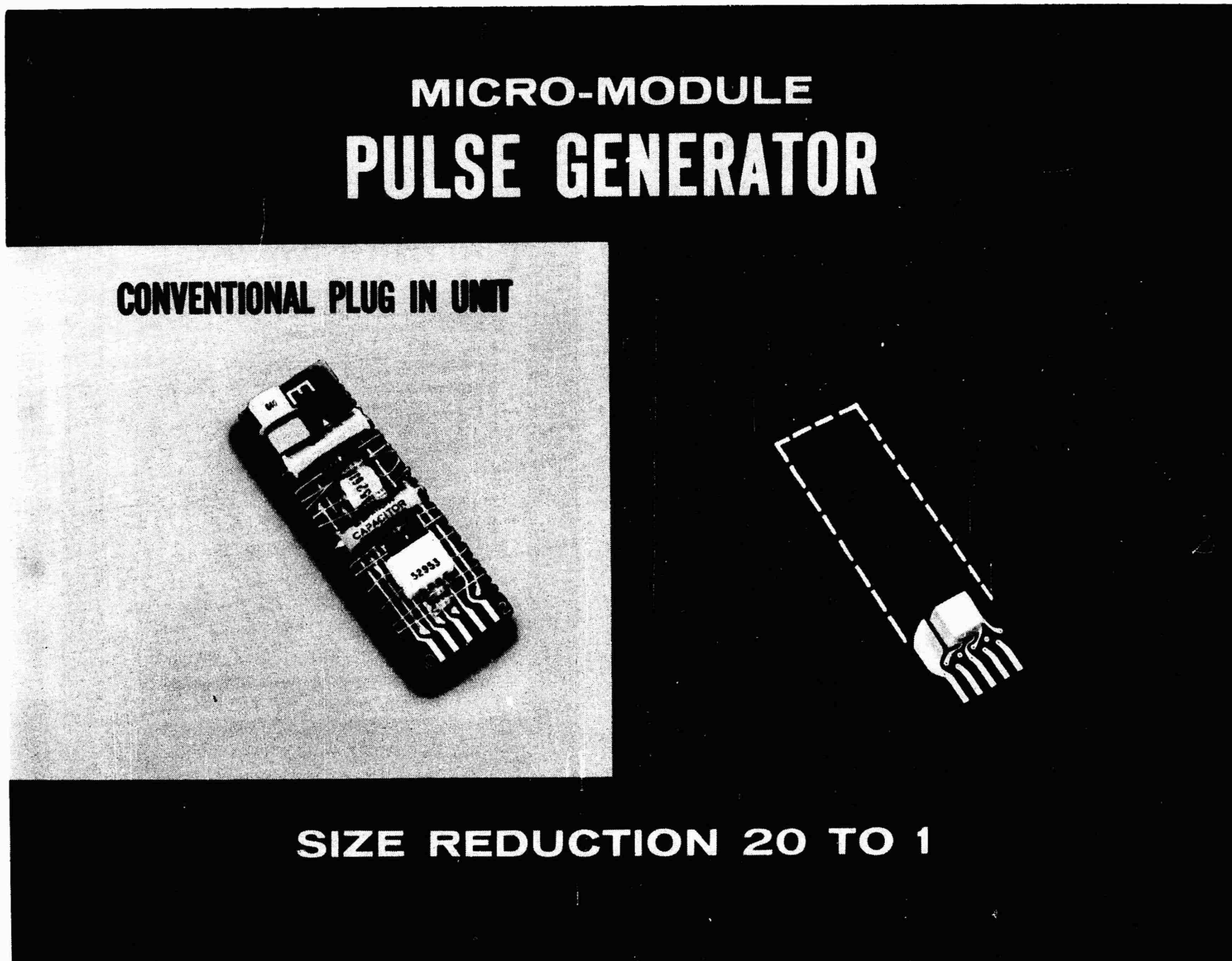

MICRO-MODULE
PULSE GENERATOR
CONVENTIONAL PLUG IN UNIT
CAPACITOR
SIZE REDUCTION 20 TO 1

Figure 15

ENVIRONMENTAL SPECTRUM

	AMBIENT TEMPERATURE RANGE °C	VIBRATION CPS	ALTITUDE FT.	SHOCK G	SPIN RPM
PORTABLE	-55 To +85	10-55	10,000	50	
VEHICULAR	-55 To +125	10-55	10,000	50	
GUIDED MISSILE	-55 To +200	10-2000	150,000	50	
PROJECTILE	-55 To +85	10-2000	150,000	15,000	20,000
SATELLITE	-55 To +125	10-2000	VACUUM	15,000	20,000

Figure 16

M-9985

STANDARD SUBSTRATE WAFER

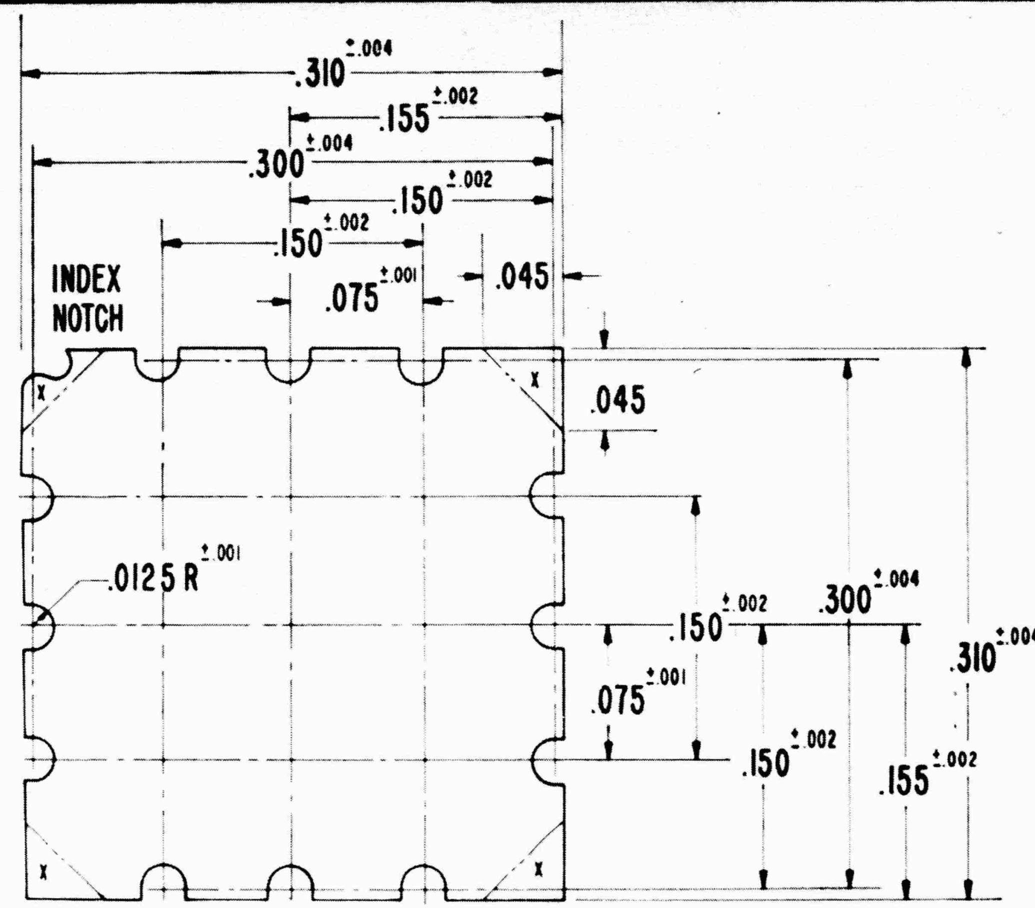


Figure 17

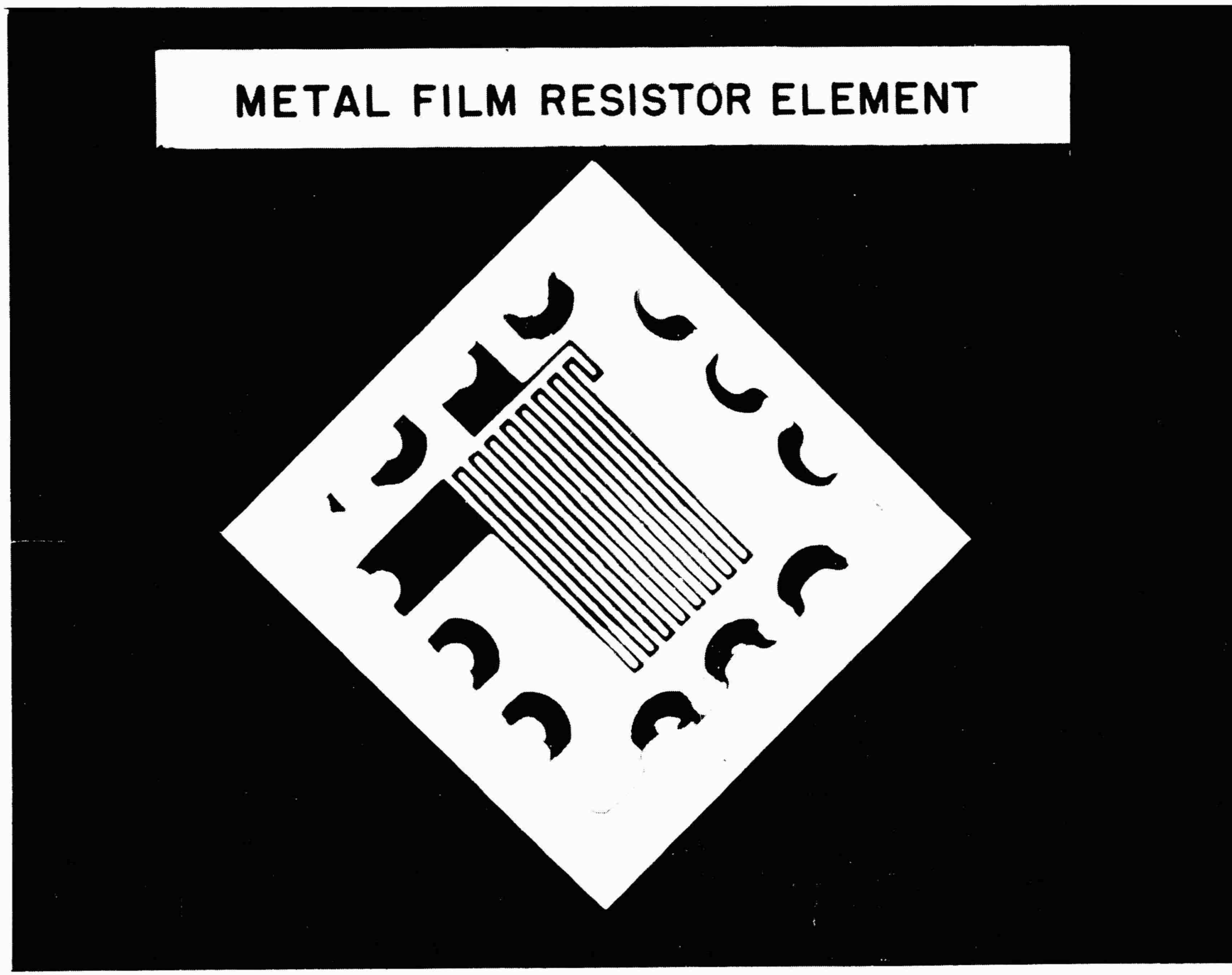
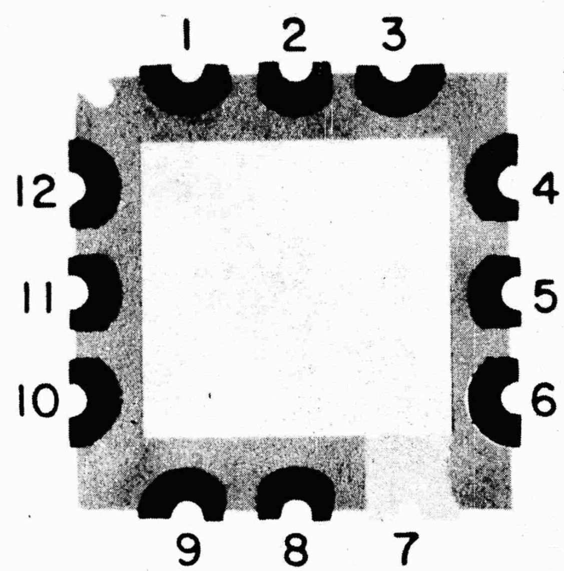


Figure 18

UNIVERSAL CAPACITOR PATTERN
(TERMINATIONS ADDED AS REQUIRED)



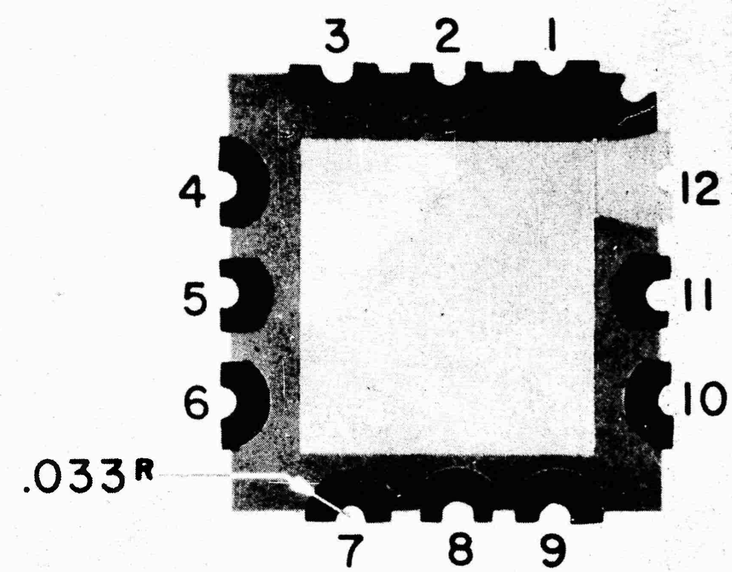


Figure 19

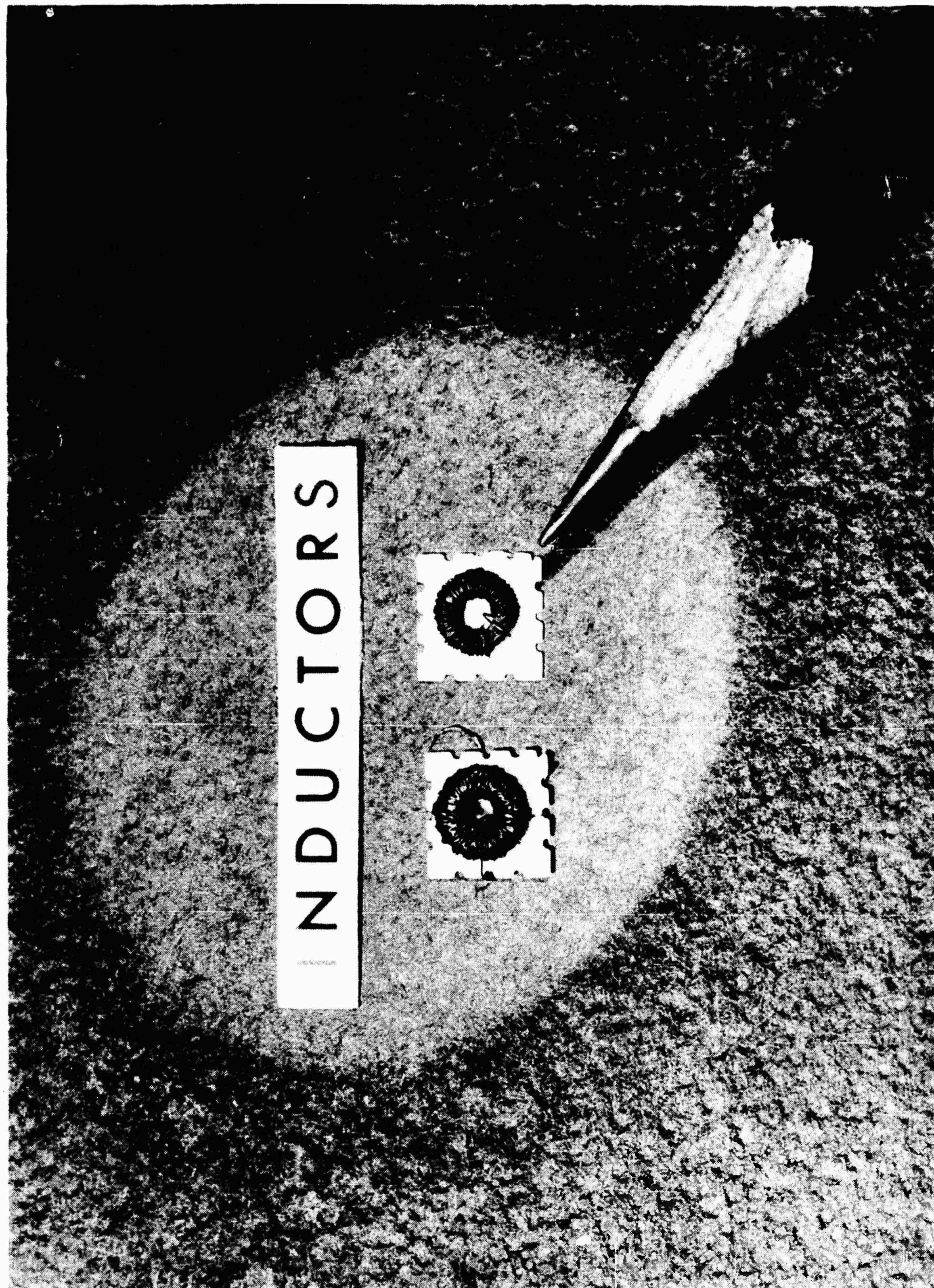


Figure 20

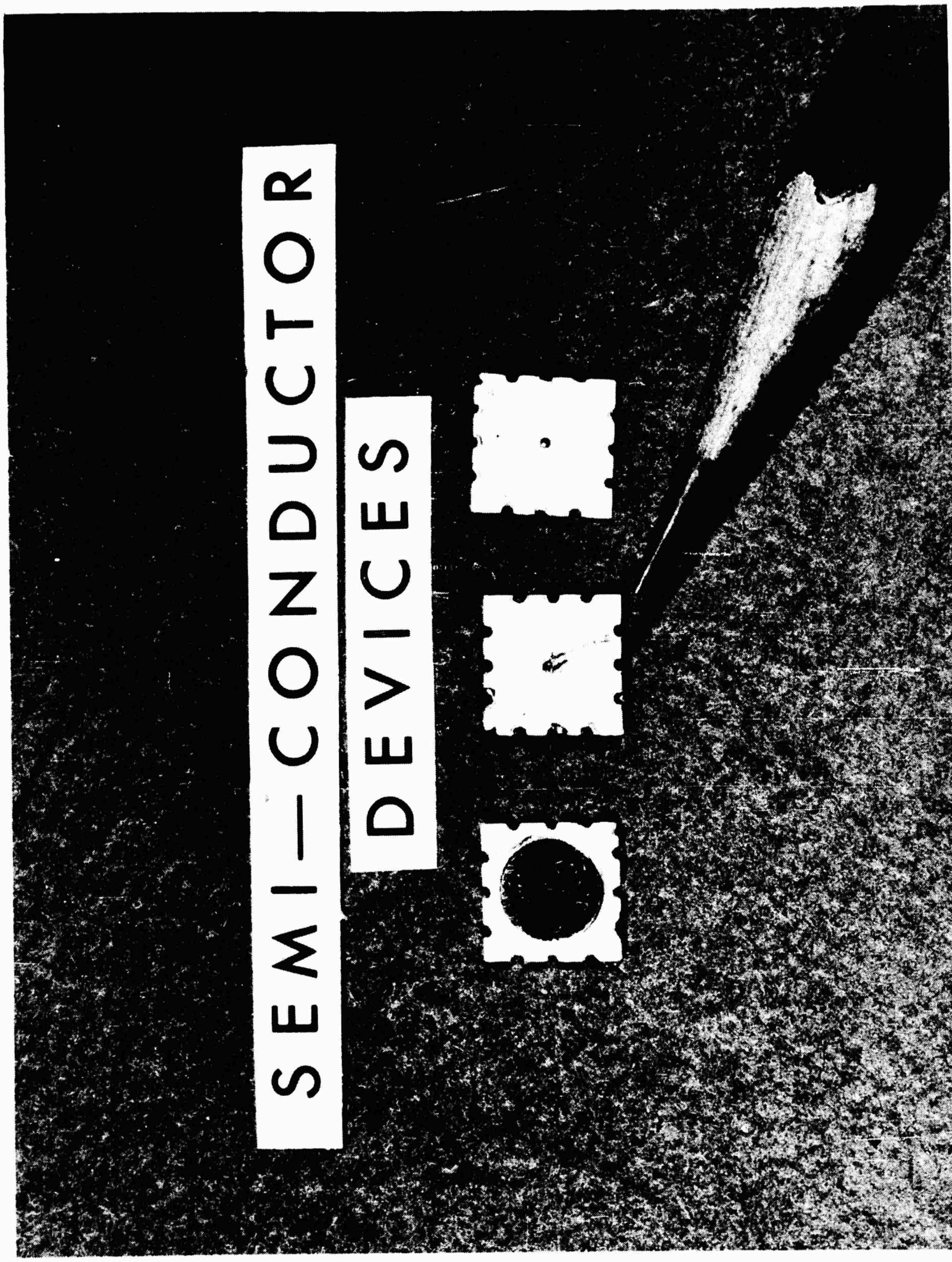


Figure 21

25 MIL GRID MODULE

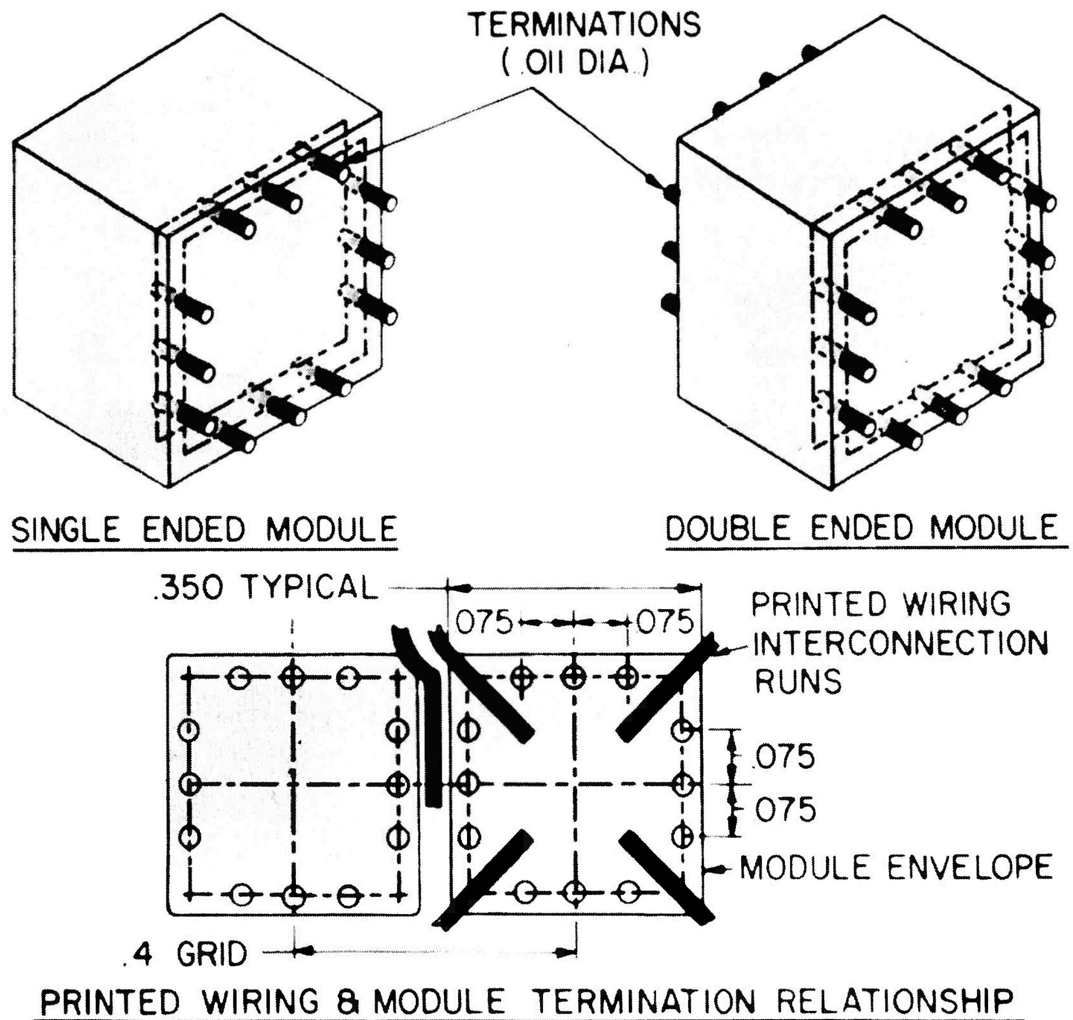


Figure 22

50 MIL GRID MODULE (TYPE II)

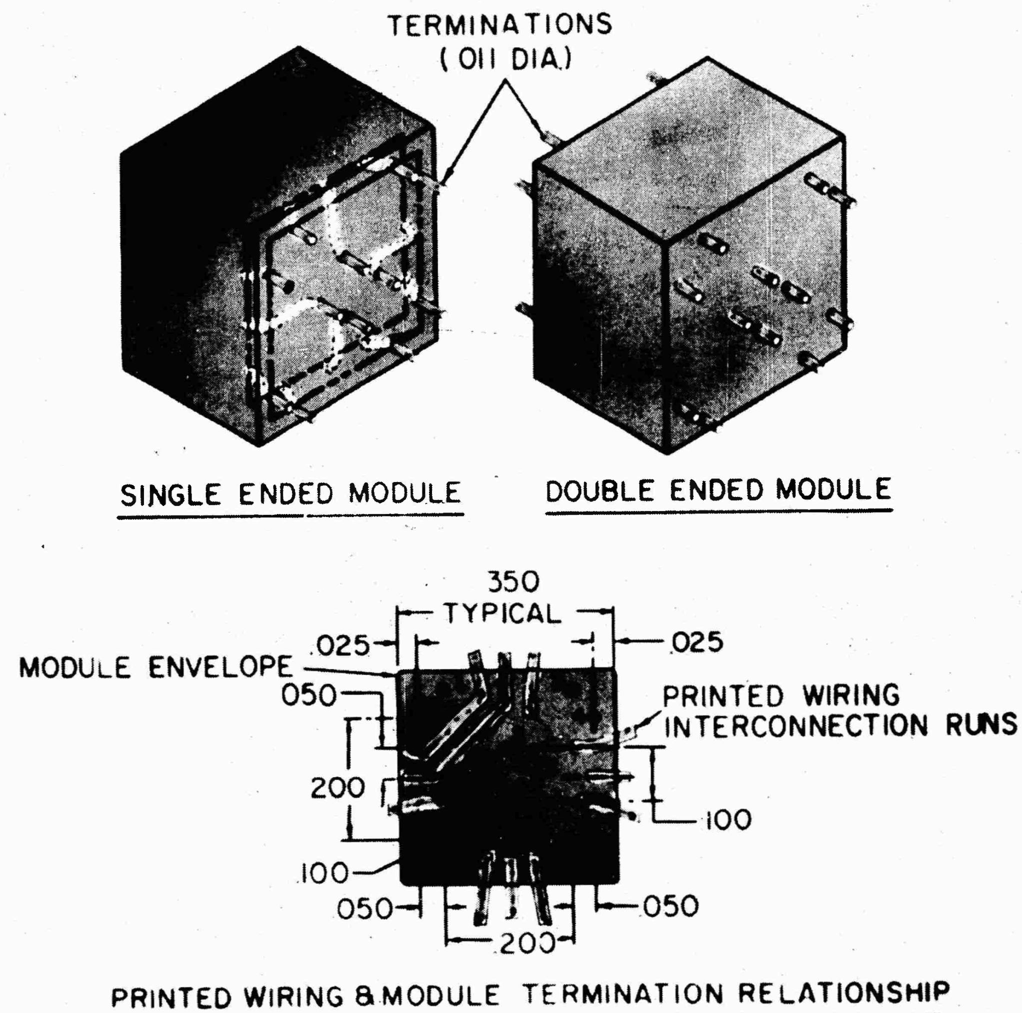


Figure 23

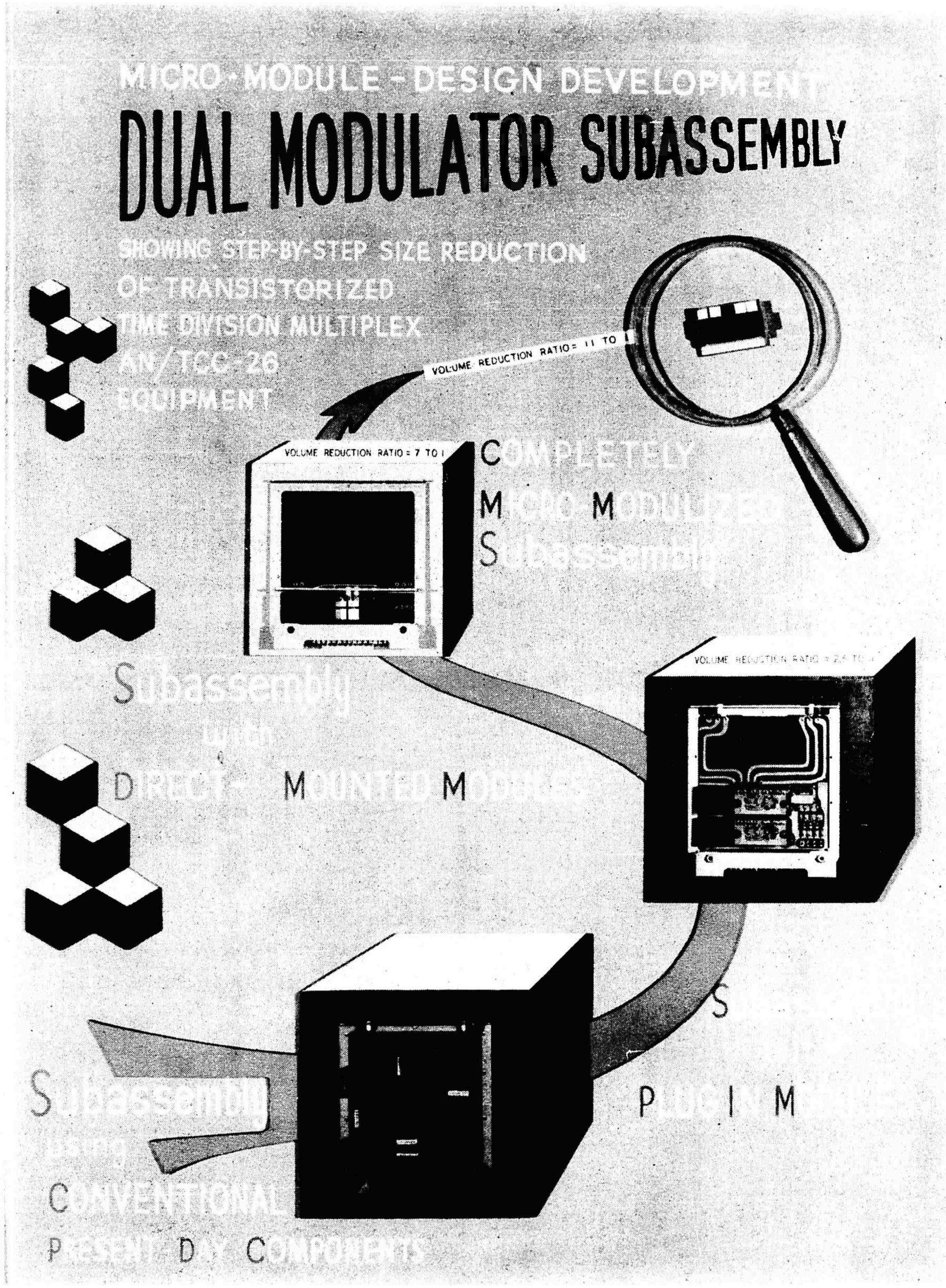

MICRO-MODULE-DESIGN DEVELOPMENT
DUAL MODULATOR SUBASSEMBLY
SHOWING STEP-BY-STEP SIZE REDUCTION
OF TRANSISTORIZED
TIME DIVISION MULTIPLEX
AN/TCC-26
EQUIPMENT
VOLUME REDUCTION RATIO = 11 TO 1
VOLUME REDUCTION RATIO = 7 TO 1
COMPLETELY
MICRO MODULIZED
Subassembly
Subassembly
with
DIRECT- MOUNTED M
VOLUME REDUCTION RATIO = 2.5 TO 1
PLUG IN M
Subassembly
using
CONVENTIONAL
PRESENT DAY COMPONENTS

Figure 24

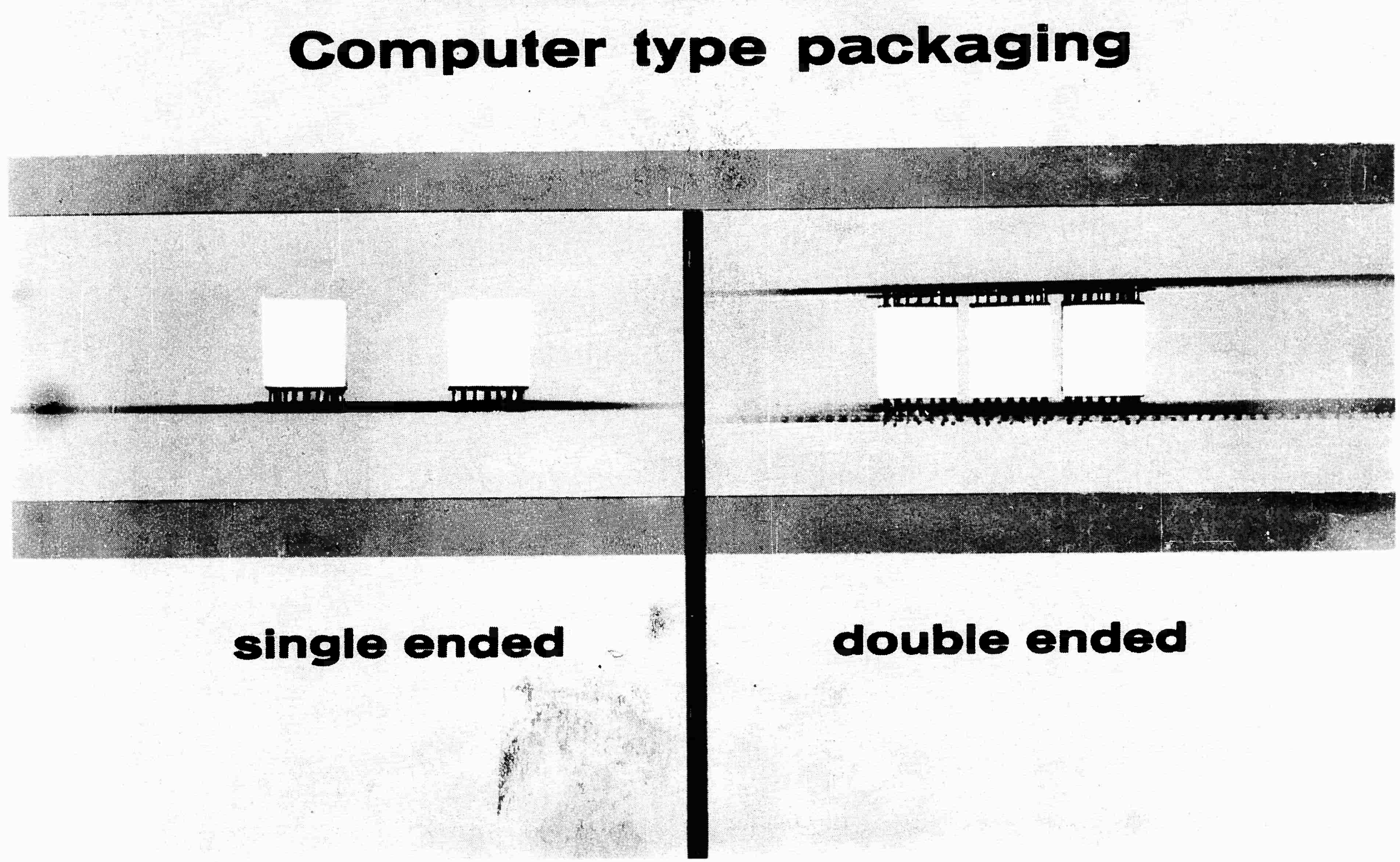


Figure 25

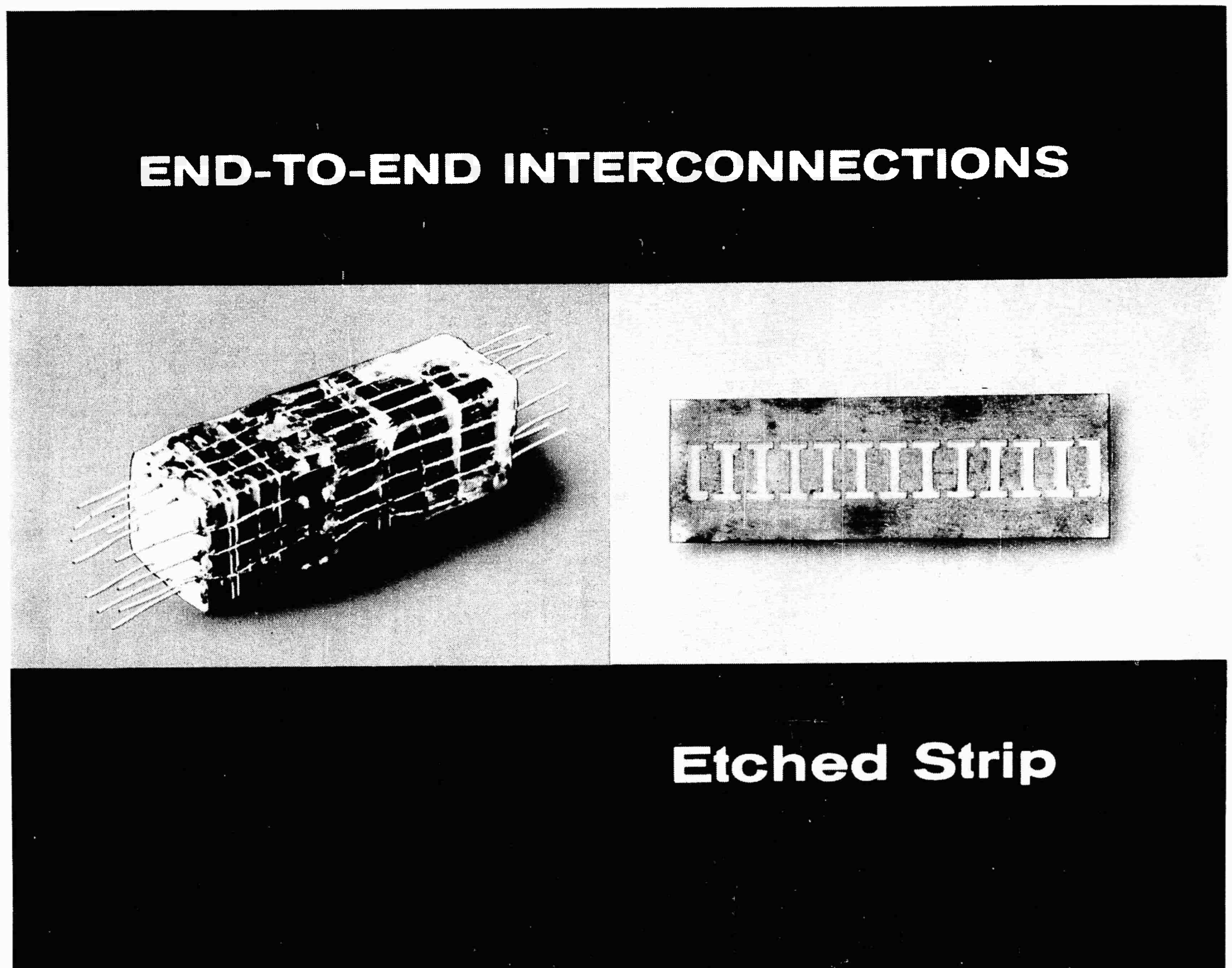


Figure 26

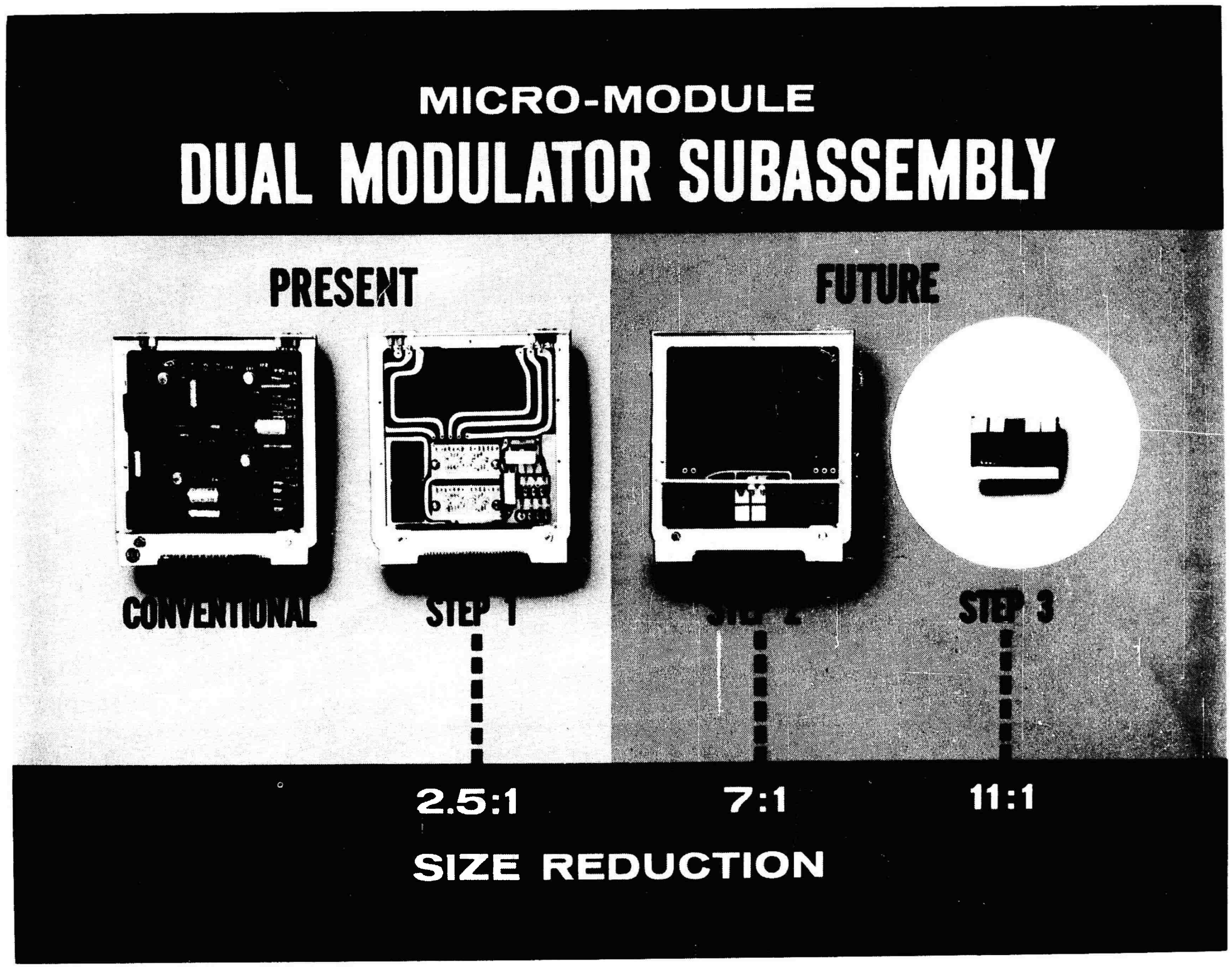

MICRO-MODULE
DUAL MODULATOR SUBASSEMBLY
PRESENT
FUTURE
CONVENTIONAL
STEP 1
STEP 3
2.5:1
7:1
11:1
SIZE REDUCTION

Figure 27

MR. KENT VIEHOEVER, HUMAN RESOURCES RESEARCH OFFICE: It is plain to see from your presentation that sometime in the future a considerable part of the equipment could be constructed this way. I realize that it is difficult to make time estimates because this depends on the degree to which the manufacturers will change over and so forth. But on the basis of your knowledge so far, could you give any estimate as to when this sort of thing may be actually expected in standard equipment?

MR. BASSLER: I don't think I would be able to make any such estimate, but perhaps to illustrate the confidence that the contractor has, RCA is issuing data sheets on the 13 subassemblies which are now available. The date of delivery, in case you contemplate ordering any of these, I wouldn't want to state; but it's inevitable that military equipment, just as we accept and use printed wiring now, will also apply these micromodule techniques into equipment.

MR. D. HUEWE, HUGHES AIRCRAFT COMPANY: Were there any dollars allocated in this study contract to study the feasibility of the actual maintenance in the field over and above the actual research and development of the product itself?

MR. BASSLER: No, there has not been any allocation of funds specifically directed toward maintenance. In the course of the contract, of course, there is a very elaborate set of technical requirements which involve the reliability in that approach but, for a specific study of maintenance or maintainability factors, there have been no monies allotted.

MR. HUEWE: Another question, if I may, please. Have you made any effort to examine the present TM's as to possibility of changing the maintenance philosophies that the Signal Corps is used to working with to possibly correspond with this equipment if changes in maintenance characteristics are available in the field?

MR. BASSLER: I am not aware of any plans at this time for such an action. I think illustrative of this is the time it takes to get such new techniques into the field. At this time, it would not be practical for such a development to be initiated.

MR. HUEWE: Don't you think it would be advisable to add to the R&D contract the study of the maintenance feasibilities of this?

MR. BASSLER: I would like to correct the use of the term. This is not an R&D contract. This is an IPS contract out of Philadelphia which is to record the state of the art as it is today. While there is some little amount -- $90,000, to be exact, in this $5,000,000 -- that is allocated for research, the intent of the program was to take available state of the art as we have it today and convert it to microelement geometry. Future work -- there is some R&D planned in certain areas -- will no doubt give us wider application of micromodules and enable us to use new techniques and incorporate the solid state techniques, but this is strictly a production-type contract.

MR. HUEWE: I would like to know how much more reliable these micromodules are in comparison with the standard components as we know them today?

MR. BASSLER: The complete reliability of micromodules is not available yet. The vast testing program that is incorporated in this study is under way but has not been completed. The requirements for micromodule reliability are certainly set high enough, but I can't at this time give any exact figures on the comparison.

MR. JOSEPH J. RAEVIS, USASESA: I would like to know then exactly -- if these items do find their way into the field -- will the soldier in the field whose life depends on the equipment used in these new techniques, will he have as much faith or be able to trust this new type of equipment as he has the old equipment?

MR. BASSLER: Well, I certainly wouldn't be able to say how much faith he's going to have in any kind of equipment but, from what reliability would be built into these things, he certainly should have as much faith. I might ask you the same question. Do you have as much faith in printed wiring as you have in conventionally wired sets? That controversy can be developed to quite a degree, as you know, by commercial advertising. Even people not in industry or commercial applications whole heartedly accepted printed wiring. I think the military has made proper application which we certainly indorse. By the same token when the reliability of micromodules has been thoroughly established, we certainly should have complete confidence in it.

MR. ROBERT E. REDFERN, USASESA: This is to answer the gentlemen from Hughes Aircraft. In order to keep abreast of the micro module program as it may affect maintenance in the future, we are currently preparing the requirements for a new study contract which we hope will be in effect in the next year or two. This contract will embody a study of the entire revised maintenance concept post 65.

FIELD MAINTENANCE

OF

PRINTED CIRCUITS

Jay E. Reddicks
Hughes Aircraft Company

I. Introduction

As we all know, the recent trends in the state-of-the-art in producing electronic systems is toward more and more use of printed circuits and digital techniques. The printed circuit itself, of course, is applicable to both analog type circuits and digital circuits. Along with the application of this advance in the state-of-the-art, comes the very important considera-- tion of field maintenance of printed circuits, which is the topic for discussion this afternoon.

As there are so many factors involved when one considers the field maintenance problems, it might be best to approach the subject by discussing some of the factors which have a direct bearing on this maintenance problem. A brief resume of points which will be covered this afternoon follows.

Outline

1. Why printed circuits.

2. Types of printed circuits being considered and their use as "building blocks" in present electronic systems.

   a. Advantages
   b. Disadvantages

3. Factors which influence the field maintenance problem.

4. Troubleshooting technique.

5. Card repair technique.

6. Economy of field maintenance and logistic requirements.

Initially we will take a look at the "why" of printed circuits. Next, in order to put us all in the same frame of reference, we will observe and discuss some of the types of printed circuits under consideration today, and their use as "building blocks" in present and future complex electronic systems. This will include a brief summary of some of the advantages and disadvantages, because many of these items have a direct impact on the field maintenance problems. We will then briefly examine other factors which influence the field maintenance of printed circuits. This will in clude such considerations as the basic operational and maintenance concept. With this in mind, we can logically go to the actual troubleshooting technique or process and the actual repair technique or cycle. A brief discussion of the economy that can be expected from doing field maintenance on printed circuits and some of the logistic requirements will complete the picture.

I realize that this will be a fairly broad discussion for the most part since I intend to cover areas which we all know could be the subject of weeks of discussion, and many are quite controversial. It is felt, however, that the actual detailed repair of the card is one of the lesser problems associated with present day and future electronic systems. The techniques used to locate the failed component on a card and to perform the final soldering operations to effect repairs are not difficult.

II. Discussion

Why Printed Circuits

As mentioned previously, the trend is definitely towards the use of printed circuits in both analog and digital applications largely because they are tailor made for mass/automatic production techniques for both military and commercial applications. The digital nature or use of printed circuits will be emphasized, because this is where the emphasis really lies, dictated by the very rapid data handling requirements that we must consider with present complex systems. The extreme accuracy required and the significant reduction in size and weight of systems to meet the Army concept of high mobility and self sufficiency also adds emphasis to use of digital circuitry.

Types of Printed Circuits Under Consideration

Figure 1 depicts typical printed circuit cards that are being discussed today. In general, these can be classified as standard and non-standard digital element cards.

The cards are made up of the laminated board with metal frame and locking mechanism to hold the card in its mounted position. The electrical circuits are etched metal for both contact and component connecting. Eyelets and stand-off terminals are used for feed-through (one side of card to the other) and multiple component connection to one signal source. The use of wire is held to a bare minimum and is utilized only where the component (transformers, tube, etc.), because of its size, does not permit direct connection to the card. The standard card may be adapted to large component mounting by changing the metal mounting frame.

By way of explaining the "building block" principle, start with a typical component which has a function such as a J/K flip flop. This would be about the lowest division of the building blocks. From here consider building logically into a card, a box (birdcage), a drawer, and finally into a cabinet. Figure 2 shows this in simple form.

Many of the inherent advantages of the printed circuit are as follows:

Standardization
Miniaturization
Ruggedness
Ease of Inspection
Flexibility
Ease and Speed of Design
Ease of Maintenance

Standardization

From a maintenance point of view, standardization means that the same card or circuit will be used in many applications, hence a large amount of uniformity and redundancy in the type of printed circuitry card requiring repair can be obtained. In addition, there is uniform construction, both mechanical and electrical, and a consistency in the location of test points and components on these cards.

Miniaturization

Miniaturization obviously leads to compactness with the inherent saving of size and weight along with increased system capabilities.

This feature makes possible the requirement for mobility while system complexity and sophistication increases to keep pace with new defense demands.

Ruggedness

This means in essence the ability to withstand shock, vibration, and rough handling. Considering mobility aspects of equipment and the handling by maintenance personnel, a certain amount of increased reliability can be expected because of this factor.

Ease of Inspection

This simply means that everything is visible. There are no "rats-nests" of wiring to hinder the maintenance or inspection job.

Flexibility

Printed circuit cards provide considerable flexibility for incorporating system design changes through card replacement and/or component replacement. This is particularly important from a field modification point of view. Where a major modification is required, it is possible to substitute a new card (one of the "building blocks") rapidly, hence equipment down time for modification should be significantly reduced.

Ease and Speed of Design

Particularly in the digital field, use of printed circuits in many instances can eliminate the breadboard design stage. There can be a direct transition from the drawing to the finished item. Use of "building blocks" in the digital applications field appears to offer great possibilities by significantly reducing the research, design, and development cycle to give the military what it needs "now" rather than two years from now.

Ease of Maintenance

As will be seen later on, the maintenance job is simplified because of some of the advantages we have already mentioned. I would like to do something a little out of the ordinary today in order to stress a point relevant to the repair of printed circuits. With me today is the Head of our AN/MSG-4 (Missile Monitor) Project for Field Operations, and he will stage a short demonstration of the repair of a typical printed circuit card used in our system. It is hoped that this will bring out three important points; namely,

(1) that the repair job is simple,

(2) that the time element for repair is exceptionally short, and

(3) that a minimum amount of tools and skill are required.

Many of us are intimately familar with the old problems associated with repair of electronic gear. I can remember personally spending upwards of two to three hours in digging through a "rats nest" of wiring somewhere way down in a non removable chassis to replace a burned out resistor, choke, etc. When one reflects on this and makes a comparison with the present state-of-the-art in electronics circuitry and packaging, you have to be somewhat amazed and thankful for the technological advances.

The present day use of printed circuits, however, is not without certain problem areas and these circuits do have certain inherent disadvantages not only from a maintenance point of view but in the manufacturing process itself.

A few of these problems are as follows:

Delamination
Eyelet Flange Fracturing
Bridging "Opens"
Contact Problems

Delamination

When the adhesive bond between the foil circuitry and the card fails, delamination occurs. In general, the delamination problem is caused by age, flexing of the card, and overheat of the card during repairs. This problem is being rapidly eliminated through improved card materials, adhesives, processing techniques, and card construction and mounting techniques. The overheat condition, which is largely caused by improper soldering techniques, can be eliminated through proper education of the repairman.

Eyelet Flange Fracturing

It could be pointed out that several companies have experienced as high as a 60% rejection rate on printed boards during final inspection because of this flange fracturing problem. This has been corrected to a large degree through development of proper drilling, crimping and soldering techniques.

Bridging "Opens"

The difficulty in bridging "opens" on the printed circuits themselves has been somewhat of a problem in the past. Perhaps the best method of taking care of this in the field is through a jumper wire from one terminal post or eyelet to another. Printed circuit gaps greater than 1/32nd of an inch can not be successfully bridged with solder alone. We will look into this problem in more detail later on.

Contact Problems

For those printed circuit boards which are "plug-in" types, considerable trouble has been encountered in the past with obtaining reliable and solid electrical contact. Very often this causes the type of intermittent trouble which is the maintenance man's worst headache. In general, this problem is caused by such things as:

1. Dirt or oily film getting on the contacts. (This can be caused by fingerprints.)

2. Moisture and corrosion.

3. Fatigue of the spring contacts.

4. Mis-alignment of contacts during manufacture or rough field handling.

The success we have experienced to date in solving this problem on the Missile Monitor System is primarily because of the following features:

1. New design of a bellows or spiral spring type contact.

2. Contact is made on both sides of the card.

3. Contacts are put through a gold plating process. Exhaustive testing of card insertion and extraction from its mating connector has indicated that gold plated contacts are very reliable. Not only is the gold an excellent conductor, but it acts as a lubricant for the sliding contact.

Factors Which Influence Field Maintenance of Printed Circuits:

OPERATIONAL REQUIREMENTS

High Mobility
Self Sufficiency
High Operational Ready Status

MAINTENANCE CONSIDERATIONS

"On-Site" Maintenance
Personnel Requirements
Facilities Requirements

LOGISTIC CONSIDERATIONS

Spares
Tools
Test Equipment

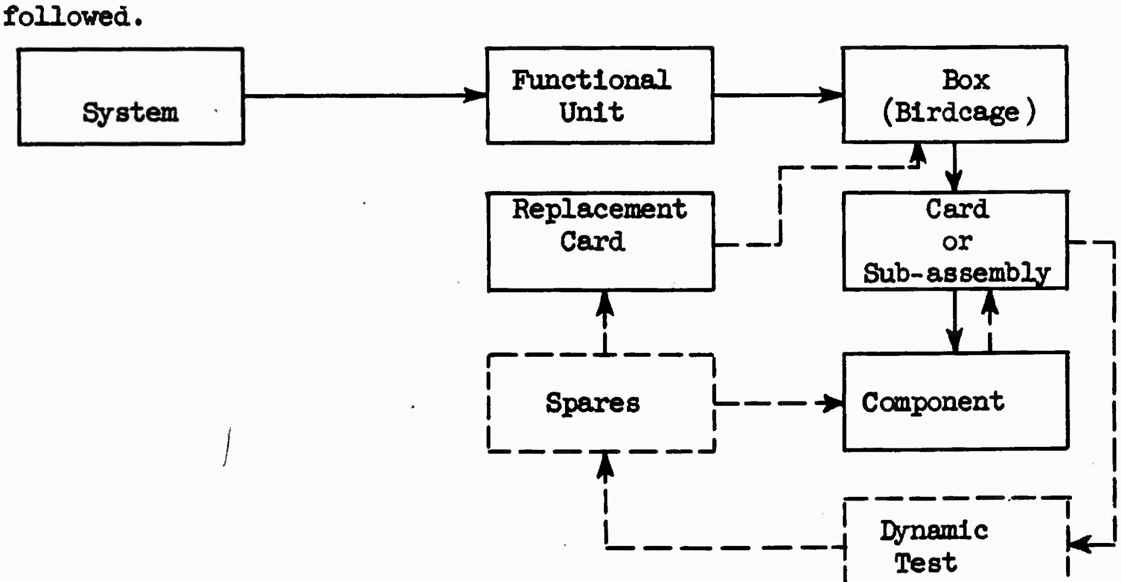
EQUIPMENT DESIGN CHARACTERISTICS

Self Test Features
Test Points
Reliability and Maintainability

By operational requirements, of course, we mean the aspects of high mobility, self sufficiency, and a 23 out of 24 hour a day operational ready status. Obviously, imposing these requirements on a field organization largely determines the maintenance and logistics requirements which must be considered on any particular complex defense system. For the specific case in point, namely, experience gained to date on certain sub-systems of AN/MSG-4 (Missile Monitor) System, the ultimate has not yet been reached whereby maintenance can be performed by low skilled individuals or operators. Thus, we are concerned with the first item on the chart under maintenance considerations, namely, that maintenance can be performed "on-site". To perform this maintenance, we must have maintenance personnel both in proper quantities and trained to a sufficient skill level to do the troubleshooting and maintenance job. Also, along with these requirements, we must have the proper tools, test equipment, spares, and facilities to make maintenance possible. The last item listed above influences the extent to which we must go in meeting all support requirements to live within the specified operational requirements. Obviously, with more designed-in reliability and maintainability features, the simpler the support problem becomes.

<u>Troubleshooting Technique</u>

The diagram below shows the troubleshooting procedure which is normally followed.



In essence, the troubleshooting technique involves a determination that the system is not functioning as specified and then, through a logical troubleshooting process, isolation of the failure or malfunction from the system to: (1) functional unit, (2) a box, (3) a card or sub-assembly.

Once the card causing the failure has been located, the next step is to replace the card with a good card from spares. This fulfills the requirement for minimum down time on the system. In sequence then, the failure is rapidly isolated to a plug-in unit, the unit replaced, and the system is operating again.

Accomplishment of the steps outlined above will require test equipment, such as an oscilloscope, multimeter, and digital element tester. In addition, the maintenance man, during the isolation process, will make use of the self-test features of the equipment by performing what are termed overall closed loop system tests and then closed loop tests of the major functions within the system. An additional fact, which is of significance to the maintenance man, is the use of available test points. As an example of this latter point, the front end of each box in the MSQ-18 System has a test block plug which is accessible from the front panel. This plug has 258 test points and is composed of all box-card connections and box inputs and outputs. In addition, as indicated on the standard digital card shown in a previous slide, there is a test plug on each card with eight test points for detailed functional measurements of card signals. These again are readily accessible to the maintenance man.

Let us now consider the troubleshooting technique of isolating the malfunctioning component on the card or sub-assembly.

Accomplishment of this isolation is done through use of the same equipment used in isolating the faulty card. The multimeter is used almost exclusively in troubleshooting the cards since the majority of the failed parts are transistors or diodes. (The low voltages used for the operation of digital equipment has practically eliminated resistor and condenser failures because of the very low current capacity required of the power supplies.) The failed component is therefore found in most instances by resistance measurements. In the case of semi-conductors, front-to-back and back-to-front resistance ratios are measured, which normally indicate the condition of the component. In doubtful cases or those cases where the trouble cannot be rapidly isolated by the above process, the card can be processed through a dynamic check by use of a digital element tester. Use of an oscilloscope for troubleshooting at this point is desirable and usually results in rapid isolation of the fault.

At this point, if one were to make a quick comprehensive summary of the facilities required at each location where maintenance is performed, it would be as follows:

<u>Maintenance Facilities</u>

Special and common tools
Workbench
Spares
Handbooks
Test Equipment
Self Test Features

Card Repair Technique

(At this time I would like to have a practical demonstration of a card repair performed. By way of ground rules, it is assumed that we have a standard digital element card and that a transistor has been found to be faulty. The time work is started and completed will be noted. Since this auditorium is rather large, you may not be able to observe the repair cycle; however, there are several sample pieces of hardware and tools available with me today and you are invited to take a look at these after the conference, if you so desire.)

Once the faulty component has been isolated, the repair process simply involves the removal of the bad component, and replacement with a new component. The tools required for the job (figure 3) are few and simple as can be seen by the following list:

1. Soldering Iron
2. Long-nose pliers
3. Soldering Aid (pick) and brush
4. Diagonal Cutters
5. Needle Nose Pliers

In addition to the tools listed above, certain materials such as rosin core solder (60% tin, 40% lead), isopropyl or denatured alcohol for cleaning off residue flux, and a small supply of copper or brass shim stock or tinned bus wire (about 0.025" thick) should be available.

Before proceeding into the general repair procedure, there are a number of precautions and maintenance hints which I might mention relevant to working with and handling printed circuit cards.

1. Soldering - With printed circuits, excessive heat or prolonged application of heat during the soldering operation will damage the board itself and cause delamination of the circuit. Improper application of heat can also damage delicate components such as transistors and diodes.

   The soldering iron selected should have a good idle temperature (roughly 600 degrees F.) and sufficient heat capacity so that the dwell time on the joint can be very short (about 3 - 5 seconds). It is most desirable to apply instant high heat and get off the joint fast. A 40 watt pencil type iron, such as the American Beauty or Hexacon, has these desirable characteristics.

2. Handling - When the printed circuit cards are removed from the system for servicing or replacement, they become susceptible to damage through improper handling. This damage to the card, components, and printed circuitry can be minimized by observing the following:

   a. Store the card in a protective padded bag while it is awaiting repair. This will keep the card from lying around on the workbench until such time as the maintenance man finds time to effect the repair.

b. Handle the cards with care to avoid fingerprints, particularly on the contacts of a plug-in type card.

c. Avoid handling the cards by the mounted components.

3. Repair Aid - Although our experience to date with card repairs has been very successful without any particular aids, it is desirable to have a simple vice and jig (such as used on manufacturing lines) to hold the card while repair is being made. This could make the maintenance job easier and possibly prolong the life of the card.

The actual steps to be performed in the removal and replacement of a component on the card can be summarized as follows:

The component to be removed is assumed to be soldered on both ends to eyelets on an etched board, and the board is lying on a workbench.

1. Using long-nose pliers or a soldering aid in one hand and the 40 watt soldering iron in the other, locate the component to be removed.

2. Grasp the wire lead of the component to be removed as close to the corresponding solder connection (eyelet) as possible.

3. Place the tip of the iron against the solder joint to be melted in such a position to be able to exert pressure against the card. This pressure will be used to overcome that force being used to remove the component from its eyelet with the long nose or soldering aid.

4. As soon as the solder flows, remove the component from its eyelet with a steady force sufficient to cause the separation. The soldering iron should be removed as soon as the wire lead comes free of the joint, to prevent over heating and blistering of the card body.

5. Repeat the same procedure for the other end or ends of the component to be removed.

6. It may not always be desirable to remove the complete component (e. g.- a diode that is to be checked for front-back and back-front resistance).

7. It is not necessary to remove excess solder or clean the eyelet of solder for reinsertion of the new component lead or the old one.

To reinsert a new or same component the reverse procedure is followed.

1. Grasp the wire lead of the new component with the long nose pliers and cut to the same length as the one just removed.

2. A 90° bend may or may not be placed in the wire lead. Assuming a bend was not placed in the wire lead, place the component in such a position as to be ready for insertion into the eyelet as soon as the solder flows at the joint.

3. Insert the lead into the eyelet a distance that would permit no more than 1/32 of an inch protrusion on the opposite side of the card. Excess wire may be clipped if it extends too far from the card.

4. Place a 90° bend in the wire along the path the component lies in reaching its connection on the other end. The point of this bend is determined by the diameter and the desired position the component is to be placed. The leads should be kept to the minimum for shock and vibration reasons. In no case should the bend be closer than 1/8 inch from the body of the part.

5. Place a 90° bend in the remaining lead or leads and insert as described for the other lead of the component. When the job is completed, the part should be off the board by at least .016 inch.

6. It may be necessary to flow new solder on the eyelet to dress it.

7. Excess solder is removed in the normal way via the soldering iron.

The following procedure is to be used for removal and replacement of components placed on a lug of an etched board.

1. Hughes manufacturing techniques leaves 1/32nd of an inch tip of the component wire lead protruding from the stud to which it is soldered.

2. Grasp this tip with a pair of long nose pliers and unwrap the lead from the stud while holding the card with the remaining hand.

3. Replace component by wrapping the wire lead of the component about the stud several times.

4. Heat the stud and apply solder if necessary, sparingly.

5. Replace other end of component as described above.

6. Excess wire over 1/32nd of an inch may be removed by cutting with side cutters.

7. Multiple leads on a stud may be encountered. This does not present any problem in carrying out the above procedure.

Another type of repair generally made in the field is that of "bridging" an open in the printed circuit conductor itself. The general technique and procedure is as follows:

a. For breaks not in excess of 1/32 inch the open can be bridged with solder only providing delamination has not started.

b. Conductors with unbonded areas (delamination) or breaks greater than 1/32 inch should be repaired by replacing the conductor with a jumper wire or bridged with a piece of shim stock.

(1) The damaged portion of the conductor should be removed by cutting it about 1/8 inch beyond either side of the break or affected area and lifting the conductor off the card.

(2) A jumper wire (No. 22 tinned copper wire is satisfactory) is prepared of the proper length to run by the most direct route possible between one terminal post or eyelet to another. It is also satisfactory in some cases to tie onto the lead of a component rather than disturb a good eyelet joint.

Helpful Hints

1. Keep the soldering iron clean and tinned.

2. Pre-cut the leads of the component to the desired lengths.

3. Do not leave excess solder on any joint.

4. A drop of molten solder on the soldering iron tip improves the heat transfer.

5. Use of a heat shunt may be desirable until the maintenance man becomes proficient in soldering.

6. When adding solder to a joint always take the solder away first, then the iron.

7. Heat the joint so that all solder flows.

It is noted that the procedures as described above did not consider those cards which have a protective plastic coating. The repair job is complicated or at least lengthened in this case. The protective coating must be removed from the joint (both sides) before heating. This can be accomplished by scraping carefully with a clean sharp knife or by some solvent such as toluene. After repair, the joint should be re-coated.

At this point, the repair operation has been completed and a like-new card is ready tobe put back into the spares -- Maybe!! One final step, that is often overlooked, must be performed -- a dynamic check by the maintenance man to assure that the repair was successful. Depending on the operational ready status of the system, this dynamic check may be made at any convenient down time or during the one hour of scheduled maintenance time where the system can be used as a mock-up.

Economy of Maintenance and Logistic Requirements

Considerable research time and effort is being expended by both the military and industry in such areas as:

1. Repair of cards or sub-assemblies vs throw-away cards or modules.

2. Extended use of build-in self-test features which will allow trouble-shooting and repair to be done by less skilled personnel.

These and other support studies are of prime importance if we are going to continue to cope with the growing defense demands which, in turn, place additional demands on the maintenance and support budgets.

Economy in maintenance of printed circuits, of the type described today, is effected by being able to make repair to the cards. This is logical since the cost of the component, compared with the cost of the card, is extremely small. A card may cost several hundred dollars whereas an individual component may cost a few cents or at most a few dollars. This is not a new concept.

From a logistics (supply) standpoint the requirement is for an adequate initial quantity of spare cards along with the piece parts or components on-site to make maintenance and repair possible. Economy is effected through the standardization or use of the same building blocks in many applications throughout a system thus cutting down a significant amount on the cards and components required in spares back-up.

The "time" element reduction in troubleshooting and repair, brought about by improved self-test features and maintainability of present and future systems, should certainly have an affect on the personnel picture. These items together with the much higher reliability factor that can be expected with digital circuitry will certainly, we hope, decrease the maintenance personnel requirements.

III. Summary

In summary, then, the "why" of printed circuits in modern electronic systems and their impact on the field maintenance problem has been highlighted and the maintenance and operational concepts which relate to and influence field maintenance problems have been discussed. The troubleshooting technique and repair cycle has been demonstrated and, in very general terms, the economy and logistic requirements have been brought out.

It is felt that industry as a whole is very cognizant of and has a deep appreciation for the support requirements of these more advanced electronic systems and are doing their very best to design in the very necessary reliability and maintainability features. We are all aware of the seriousness of the trained personnel problems and the tremendous amount of money spent in all logistic areas each year. I believe that each new system that enters the military inventory will show marked contributions in lessening the maintenance problem.

I would like to extend my personal thanks to the symposium committee members who made it possible for me to talk with you today, and I will be happy to answer any questions you may have at this time.

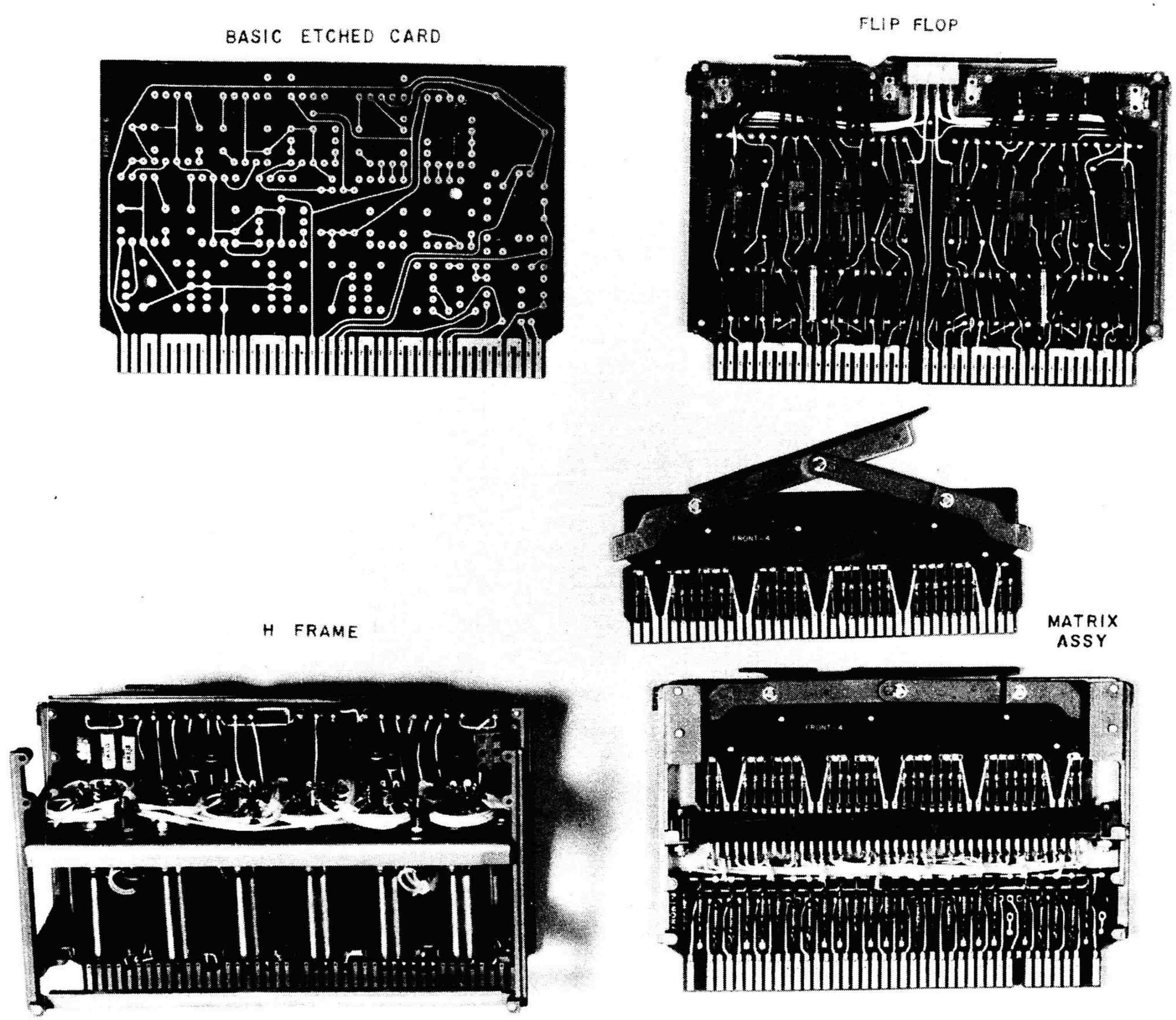


Figure 1

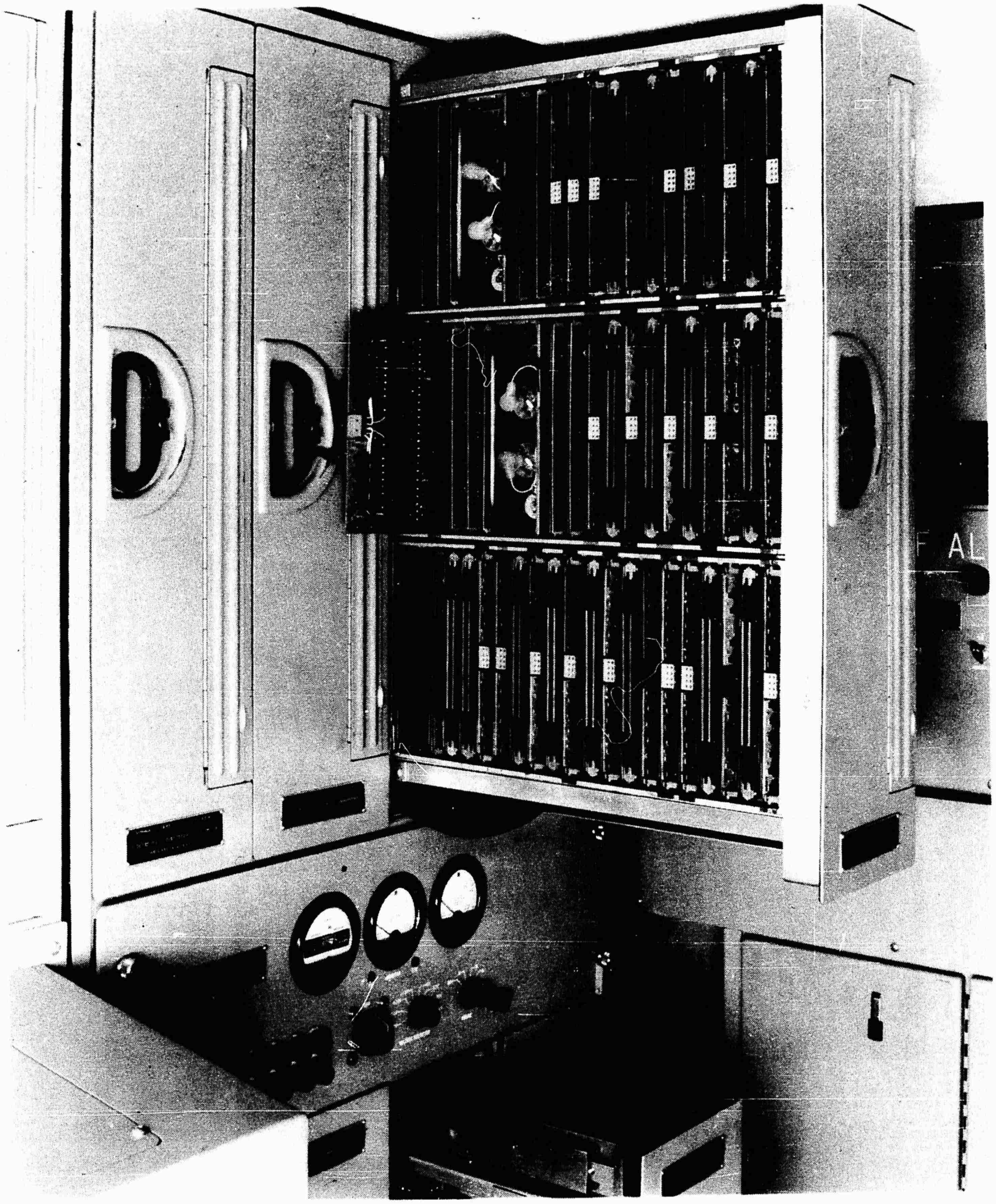


Figure 2

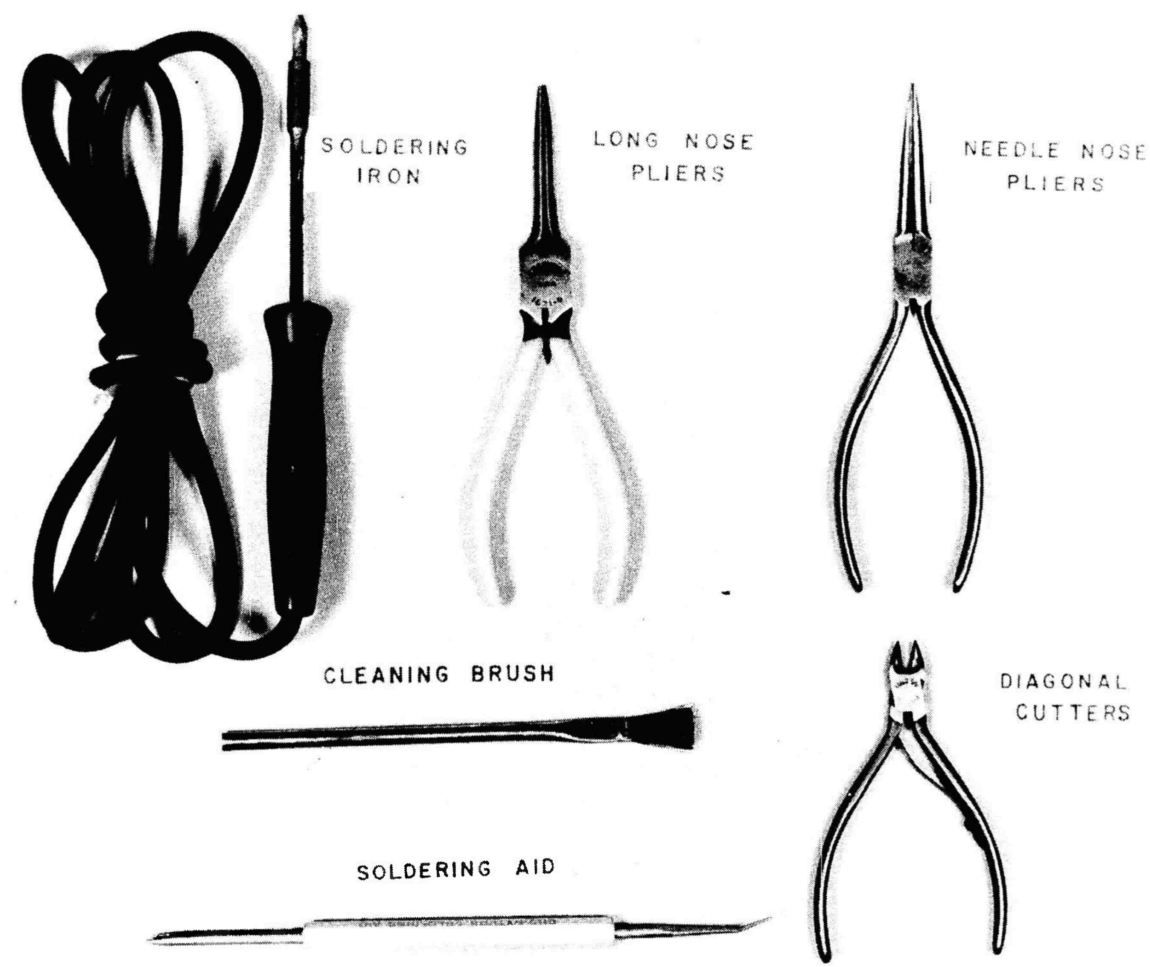

SOLDERING
IRON
LONG NOSE
PLIERS
NEEDLE NOSE
PLIERS
CLEANING BRUSH
DIAGONAL
CUTTERS
SOLDERING AID

Figure 3

MR. HAROLD EARL, SYLVANIA: What type of card do you find to be more reliable, the epoxy glass or the paper base?

MR. REDDICKS: Did you say what type of card do we feel is more reliable? Well, at the present time, we feel that the epoxy glass and the new silicone glass are probably the most reliable of all. They are a little more expensive.

MR. AUGUST R. PARK, WESTINGHOUSE ELECTRIC CORPORATION: With reference to the last comment, we have done quite a bit of research on printed circuitry and I agree with the epoxy glass. In fact, I think that we are going almost exclusively to it. My question is with reference to your problems on the connector. You went into quite a bit of detail about ways to improve the printed-type connector. Have you considered the use of a pin-type printed circuit connector? -- the adaptable kind that goes on the board but has a pin-type connection? Are you familiar with this kind?

MR. REDDICKS: Yes, didn't we try that, Duane? Could you answer that question? In my experience in the ground system so far, I don't know of any attempt to use these small pin-type connectors.

MR. PARK: I suggest trying it. It works quite well.

MR. R. G. BENSON, WESTERN ELECTRIC COMPANY: How many times can you apply heat to any one joint, after your card has been manufactured?

MR. REDDICKS: Gee, that's hard to say. Duane, you've been out in the field working on these for many months. Do you have any idea of the life cycle that you could apply heat and remove it?

MR. DUANE: We have done this many times to particular units and we have had no problem to speak of yet on strips coming loose, which I think you are referring to. We have had no problem in this area.

MR. FRANK L. LODGE, WRIGHT PATTERSON AIR FORCE BASE: I would like to ask a question not of you but of the Signal Corps. Do you people make any effort in your training schools to teach people how to repair printed circuits?

MR. REDDICKS: I can answer that from the contractor's point of view. We happen to be training military personnel on the MSC-4 system and we indeed do teach them how to solder on these printed circuit cards.

COL STANWIX-HAY: We can get the answer to this question, sir. We'll get it and let you have it.

CWO ERNEST RIPOLI, WASHINGTON NATIONAL GUARD: I was wondering if you experienced any hairline cracks in your printed circuits like those we find in commercial radio works --- for intermittent and so on.

MR. REDDICKS: If I understand you, are you referring to cracks in the metal itself or in the board?

CWO RIPOLI: In the metal itself.

MR. REDDICKS: I don't think we have had too much experience with cracks in the metal itself, but we did have problems with cracking in the early experience with the cards. This is a problem that I didn't point out because we have solved it now. Initially, we had problems with the eyelet itself in drilling the hole out, inserting a little rivet, and then crimping it down. Just because of the variation in thickness among cards and points on one card, it's pretty hard to regulate the pressure that you have to exert to squeeze the eyelet down. Often you hit a little thicker spot in the board, then squash it down with the same pressure, and get cracks that sometimes you can't even see initially. But, eventually, it will cause a leaky path and give you a real headache. We did experience this problem, but it is largely being corrected now through the use of plated-through circuitry. Rather than putting one of these rivets in, the circuitry is plated through from one side to another. This almost completely eliminates the problem.

MR. BEN LUEPKE, USASESA: In reference to the question on whether the military was making any attempt to educate the maintenance personnel on the repair of printed circuitry -- I would like to note at this time, we have a contract with Bethtell Memorial Institute to update our Signal Technical Bulletin 222. This has been a rather extensive survey of all of the types of printed circuit cards, the techniques required to repair the cards, the soldering tools, and the soldering materials. The whole area comes under survey, and the target date for the termination of this contract is the end of May. This means that possibly 6 months thereafter we should have a well updated technical bulletin to the user in the field to guide him in repairing printed circuits.

COL STANWIX-HAY: One administrative announcement: -- previously the question was asked whether or not the Signal schools were teaching printed repair circuits. The Signal schools are not teaching repair of printed circuits in organized courses. They are teaching familiarization courses only; when the equipment becomes of such density, the repair courses will start. This is true here at Fort Monmouth, it is also true at Gordon, and in checking with the Canadian representative, we were told that the same exists in the Canadian schools at the present time.

THE THROW-AWAY CONCEPT FOR MAINTENANCE

Col. S. J.Espelund
Director, Maintenance Division
U. S. Army Logistics Management Center

The blame for the perennial parts problem that harasses us today can probably be placed on Eli Whitney when, in 1820, he developed mass production techniques in the manufacture of parts for small arms. However, not until the internal combustion engine made three dimensional warfare a reality did the problem approach today's scope. In World War I, the Army was not organized to cope with mechanization on the scale actually obtained and, consequently, manufacturer's representatives were employed to perform most maintenance. It was also at this time that parts support was based on complete duplication of all the bits and pieces that made up the end item.

During World War II, the experiences of the first World War were repeated, but to a greater degree. With mobilization came a rapid and multiple expansion of the many military supply pipelines. This was especially true in the Army's seven technical services. Each procured from industry its material, and each identified items in its own individual manner. Each technical service found it necessary to procure the bits and pieces making up each end item. Thus duplication multiplied the complexities of an already difficult task. I might also say that this was true in the Navy and the Air Force. The consequences of such system were inevitable. It resulted in chaotic supply and added cost.

One writer stated, "The United States could never have lost World War II 'for want of a nail' because its total resources were much greater than that of all other allied and enemy combatants combined, and the United States could afford lots of nails." However, in the period following World War II, evidence accumulated to indicate that the supply position of the armed forces would not be as strong in a future period of all-out conflict. As a result, steps were taken to reduce the quantities of line items. Ordnance adopted from industry Project 170 -- today's Army Field Stock Control System. This system reduced considerably the quantities of repair parts to be carried into the field. Several of the technical services introduced programs such as Operation Trim, Operation Rasp, and Operation Rip -- all in an attempt to reduce the number of line items in the Army supply system. Maintenance evaluation procedures were established as a means of more intelligently selecting repair parts needed to support the item. These, in turn, led to a greater standardization of repair parts.

We have found, however, that the diligent effort devoted to reducing the number of line items has not accomplished all that is desired. As increasingly complex items are added to the supply system, more and more line items became necessary. Therefore, the systems heretofore developed have been unable to cope with the ever increasing number of line items. Other means had to be found in order to keep to a minimum the parts needed to support an end item in the field. New problems also arose. With the complexity of equipment, additional skills were required and, although we may have had plenty of nails to lose, we do not have an unlimited supply of technical skills. As a result, greater emphasis has been placed on ease of maintenance, maintainability, and modular or unitized construction.

Keeping equipment in good working order is one of the most difficult problems in maintenance. Adequate supplies of repair parts as well as technicians are necessary. Our current tactical concepts which call for wider dispersion of our troops, increased mobility of units, and increased firepower serve to magnify the problem.

These are some of the facets of the maintenance problems which, when considered in the light of our national economy and the possible scope of warfare, have led the military services to consider the throw-away concept for maintenance.

Let us briefly define the throw-away concept of maintenance. It is a disposal-at-failure maintenance philosophy. It indicates that upon failure of the assembly, component, module, or end item, it will be discarded. No repairs will be made. Therefore, the item in question must be designed for throw-away. I will later in my discussion develop some of the considerations that must take place during the design of an item for throw-away.

Some types of equipment are more adaptable to the design for throw-away than others. Signal equipment or electronic equipment lends itself to unitized or modular construction and, perhaps, offers greater opportunity under the throw-away concept than other types of equipment such as vehicles, compressors, pumps, or mechanical type equipment.

But even in the mechanical type equipment, a great deal of progress is being made. After all, the throw-away concept is not new. The light bulb is in a sense a module as it is composed of several parts. When the light bulb burns out, we dispose of it or throw it away. This is the principle which we are attempting to approach in the design of many of our repair parts and also in some of our minor secondary items.

Let us briefly consider the extent of throw-away or design for throw-away that has been accomplished in certain commodity areas. The vehicular field is not as susceptible to the modular design concept as electronic equipment. However, there is another way of expressing modular design in vehicular equipment. It can be expressed as unit design and interchangeability. A combination of engine, transmission, steering, and brakes in a power package, all replaceable as a unit and susceptible to repairs and testing outside the vehicle and adjustments while installed in the vehicle, is an application of the principles of modular design. Interchangeability of axles, wheels and other components in a family of wheeled vehicles is another application of modular design. In the design of these components or assemblies, some progress has been made in developing these items for throw-away. Examples of vehicular equipment or parts that can and have been designed for throw-away items are the ignition distributors, magnetos, carburetors, pumps, solenoids, and like items. The Army, in conjunction with industry, has developed a family of small, multi-purpose gas engines ranging from one-half horsepower to twenty horsepower. The Corps of Engineers is seriously considering the one-half horsepower engine as a throw-away on a modified basis. The low cost of the engine is a deciding factor in determining it to be a throw-away after the engine reaches its normal rebuild point. Under this concept, there will be no repairs to or replacement of fourth or fifth echelon type parts. Replacement parts will be limited to easily accessible high-mortality items, such as points, condensers, spark plugs, and those gaskets involved in minor service operations.

But considerably more work remains to be done. I might say this, that the mood of industry is not entirely in accord with our throw-away concept as far as vehicles are concerned. After all, manufacturing concerns are in the business of manufacturing repair parts for the end item which they manufacture, and development of throw-away items are of no particular benefit to them.

On optical and optical-mechanical type items, considerable amount of work has been done in the past few years. At Frankford Arsenal, a project known as the Modern Army Maintenance System has been underway for the past several years. The purpose of the project is to promote, develop, and activate any philosophies or ideas which will improve and modernize the approach to and solution of the maintenance problems as related to Ordnance. Within this project, considerable progress has been made on the throw-away concept. To date, a throw-away sight for the 3.5 rocket launcher has been developed and is now undergoing tests with the 101st Airborne Division. The prototype of a throw-away elbow telescope and binoculars have been designed. A test will begin shortly on a throw-away watch. Work is presently being done on other like equipment.

As I stated, perhaps the field of electronics or electronic type equipment offers the greatest potential in design for throw-away. Modular construction, printed circuitry, miniaturization, all point to an era of disposal-at-failure maintenance. Certainly in the design of modules where the general environmental considerations must be considered, we approach the throw-away concept in many instances. As an example, where we design the module to give protection from the effects of moisture or fungus, the module must be encapsulated, potted, or enclosed in a sealed protective environment. Consequently, encapsulation of the module usually results in a throw-away upon failure.

The Signal Corps and industry have used the modular concept for some years. The portable radio AN/PRC-10, designed about 1946, featured complete intermediate-frequency (IF) amplifier stages sealed in small plug-in cans. These cans were disposed of upon failure. Since that time, all aircraft communications under development have employed almost 100 percent modularized assemblies.

Our newer missile systems are being designed to take advantage of the modular concept. The progress in the missile area was slow at the beginning. The Nike Ajax was built with less than 1 percent of its circuits modularized, whereas the Nike Zeus will have over 60 percent of its circuits in an optimum modular unit.

I have listed only a few of the areas to give some indication as to the progress to date.

You will have perhaps noted that I keep referring to modular construction. In the electronic field, there is a definite relationship between modular construction and the throw-away concept of maintenance. I do not mean to imply that all modules will be disposed of. Modular construction only encourages the design of throw-away items.

What factors must we consider in designing an item for throw-away? This question warrants a considerable amount of thought, and a lot of the answers have yet to be found. I will attempt to develop some of the factors that go into determining an item for throw-away. Those I will mention are not all inclusive, but they will give you some idea as to the complexity of the problem.

The design concept should be directed toward developing equipment which requires no or little maintenance and no or very few repair parts. In addition, the item should be one which can be readily manufactured and procured. By attaining these objectives, we can provide the best support for the highly mobile and widely dispersed units, which are visualized in our current tactical concepts. It is recognized, of course, that these are ideals. Nevertheless, our thinking should be guided in this direction and compromised only by technological or economic restraints.

The first factor we will consider in designing an item for disposal is economics. This is, in reality, a two-edged sword. Economically speaking, we can save money by adopting the throw-away. On the other hand, we can go much too far -- costs may well be higher and outweigh the advantages gained. The cost of a throw-away program must be weighed against the benefits, tangible and intangible, which will accrue to the services. Therefore, limits within which it is economically justifiable to employ disposal-at-failure maintenance should be defined where possible. But we cannot define or establish limits across the board. Each item and each type of commodity must be considered in its own light. Generally speaking, low cost, non-critical items can be discarded. We must consider, however, not only the initial cost of the item but also the time and cost of repairing the item. Some items have a long useful life and a comparatively high cost of repair; therefore, from the point of economics, it is well to discard the item and replace it rather than to evacuate and repair. However, there are other items more difficult to produce and, therefore, it would probably be profitable to repair these.

The Corps of Engineers, as an example, is currently considering all items costing less than $10 for throw-away. Ordnance, however, in dealing with minor vehicular assemblies is considering throw-away only after the cost of repair exceeds one-half the acquisition value of the item or assembly.

Other economic factors, not quite so evident, must also be considered. By adopting a disposal-at-failure type maintenance, we reduce the number of line items in the logistical system. This,in turn, has a snowballing effect on the reduction of costs. We realize a saving by not procuring as many parts, by not provisioning for the part, by not cataloging, and by not providing storage and distribution. To these savings we may add those realized from reduction of transportation and pipe-line costs.

As an example, no one has come up with a good cost figure for supporting a line item in the system. We have a number of estimates. Ordnance, in developing the throw-away watch, determined that the cost of supporting a line item in the system approximated $2,000 a year. This did not include the costs relative to the entry of the item into the system. By the adoption of a throw-away watch, Ordnance determined that 375 line items of repair parts could be eliminated. However, as a point of interest, a study presented to this symposium last year pointed out that throw-away maintenance costs tend to rise sharply as the number of assemblies per component increase, i. e., as the condition of piece-part maintenance is approached. This study further pointed out that it perhaps would be wise to build and dispose of the whole component rather than repair.

One of the major problems in the area of maintenance today is the general shortage of skilled personnel. With the increased complexity of equipment being introduced into the system, a higher degree of skill and a larger number of technicians are required. Some means, then, must be found to reduce the number of technicians and also the degree of skill required. Then, too, the skills we develop are attracted by employment in industry, with its present high wage level and the introduction of ever-increasing fringe benefits.

A study recently completed by ORO of the Johns Hopkins University revealed that the number of technicians and mechanics in the Armed Services had increased from 34 percent at the end of World War II to 45 percent as of 30 June 1956.

Another factor, then, of the throw-away concept is the reduction in the number of personnel trained to high skill levels. A lesser technical competence will achieve quality, corrective maintenance in the field. I don't mean to say that this is panacea for our problem on our shortage of skilled technicians. But it's one means of reducing the requirements both as to degree of skill as well as the number of technicians. Again the best example that I can cite is the adoption of the throw-away watch, to which I previously referred. By such adoption, the watch repairmen were no longer required and those skills could be transferred to other assignments.

This leads into another consideration. The mean net time to repair failures should decrease. With appropriate test equipment and test points for localizing faults, repair will then consist of replacing the defective unit by a serviceable one, thereby returning equipment to operable status in a minimum of time. This seems to have important advantages under our current tactical concepts where units are widely dispersed and most maintenance will be performed on a replacement basis, either replacement of the end item or replacement of modules or assemblies. It may be assumed, though, that under peculiar circumstances a complete system or end item may be disposed of more than once by increments during its useful life, depending on the distribution of failures within the system or end item.

The throw-away concept or disposal-at-failure concept should greatly assist in maintaining a given reliability level during the life of the item. By the reduction of excessive maintenance operations, which tends to decrease reliability, we should be able to retain or improve the reliability level. By the reduction of parts, we minimize the faults due to mishandling during transportation.

Pursuing this concept further, we should realize a reduction in depot repair costs. Another savings, perhaps not quite so tangible, should be realized in field maintenance activities.

Therefore, the throw-away concept should permit attainment of maximum efficiency with a minimum of maintenance activity and would help solve the growing problem of providing sufficient numbers of adequately trained personnel.

The advantages I have discussed are not the cure for all our maintenance problems. The throw-away concept is not a panacea. This concept coupled with other design concepts such as modular construction, printed circuitry, and miniaturization will assist in meeting our maintenance problems of today.

There are some definite disadvantages that must be considered and I will attempt to bring some of these to light. One major consideration is the ability of industry to support the throw-away item, not during peacetime but during full mobilization. Is the material of such nature that a shortage might develop during wartime? Then consideration must be given to repair. But what about industry's capability? Let's go back to the throw-away watch developed by Ordnance. One of the prime considerations in making final determination was the ability of the watch industries to support a throw-away watch. Much of the watch industry's production facilities during war is devoted to other technical type items, thereby reducing their watch production capacity. There must be an assurance that the item can be produced by industry under war conditions.

Another consideration that will tend to restrict the use of the throw-away concept is production problems. Where the item is such that production methods such as spinning, cementing, bonding, and cycle welding can be incorporated to eliminate costly production processes such as threading, machining, and introduction of screws,etc., we have a good candidate for throw-away. But if the nature of the item is such that it requires a high degree of manufacturing proficiency, then consideration should be given to continue to repair the item. The item should lend itself to production methods of manufacture, using relatively inexpensive material and still provide high reliability and ruggedness. (As a possible criterion where the established rebuild cost would be comparable to the production cost, it would appear that we would have a likely candidate for the throw-away.)

I have mentioned the advantage of reducing the number of line items by incorporating the throw-away concept. There are some pitfalls worthy of note. We may do away with a group of parts used to support an assembly. Yet the space and weight of the assembly replacing the group of parts may be considerably greater than the line items deleted. This is an important factor when we consider the necessary mobility of units in the field. It may be wiser in some instances to stock a kit of high-mortality parts rather than to design a throw-away assembly. Each item, component, assembly, or module must be examined separately as a possible candidate for throw-away.

Many items in order to be considered for throw-away require major redesign. Under these conditions it may be necessary to postpone any action until a new item, a new model, or a new type is introduced into the system.

Reliability is another factor that must be considered. If we cannot redesign an item and retain its reliability or if we cannot gain reliability, then possible consideration should be given to continue to repair.

As I indicated at the beginning of my discussion, the area of throw-away concept for maintenance is in its infancy. The throw-away must be designed. It is not something that we can determine once the piece of equipment has been introduced into the field.

A great deal of thought is now being given at the Ordnance Tank-Automotive Center in the development of a throw-away tank engine. The people in OTAC contend that the conventional objective of building engines that perform well over a long time must be re-examined. Long life may not necessarily be important in vehicles used almost exclusively in combat. Engines which outlive vehicles they power are wasteful. So engines of low-cost construction, engines that could be factory tested, sealed, issued and written off are necessary. We might carry this thinking a little further and apply it to a complete vehicle. By good design we should be able to design good reliability and life into the major components of a vehicle so that they would have all the same or equal life. At that time when failure occurred, the entire vehicle could be disposed of.

We must recognize that during the service life of an item, we may spend for maintenance of that item 3 to 5 times its acquisition cost. Every means must be explored to reduce these maintenance costs. The throw-away concept for maintenance offers us such a means. The future may see a greater application of this philosophy.

COL STANWIX-HAY: Do you believe that a policy such as that which we have spoken about here this morning will ever be declared to be an army policy one way or the other.

COL ESPELUND: From my observation, Colonel, I doubt that it will be army-wide policy in the near future at least. There is too much work to be done, too much documental work; there are too many considerations. It would be difficult to establish a criteria that would be applicable to all the technical services considering the wide variety of commodities that we are dealing with.

MR. BERNARD PEAR, SIGNAL CORPS LOGISTICS EVALUATION GROUP: Colonel Espelund, you spoke about the case 170 which, of course, was the springboard to a great many activities, some of which I think we have lived to doubt the value of. Isn't it a fact that Ordnance has recently decided that the basic conclusions drawn at the time case 170 was studied were in error?

COL ESPELUND: I won't say that Ordnance has concluded that the concepts as the principles of development of the project 170 as we in Ordnance know it are completely in error. I think perhaps the error has developed in its attempt to apply this across the board to all technical services including Signal Corps.

MR. PEAR: And including Ordnance.

COL ESPELUND: Right, I'll grant you that.

MR. PEAR: Might we then not conclude from that that the Army field stockage system is also in error?

COL ESPELUND: What you are trying to get me to say is that the system is bad, and I don't believe it is. I've seen it operate and I have operated it. But I believe it is subject to change and should be modified. I'm sure you will agree with me on that.

MR. PEAR: Well I certainly do, because the element that was left out of it was, of course, economics. You see, in other words, the dollar value of either demand or the item was left out of consideration. As a result, we found premium transportation and premium handling frequently spent on an item worth only a few dollars. Try to stock it and you go to premium handling.

COL ESPELUND: You are introducing the mass concept now.

MR. PEAR: Well, the mass concept is an outgrowth of field stockage. I am really advocating now the economic inventory policy that is currently under test in the Signal Corps. Now I'm going to stop tearing your talk apart. Could you tell us more about the modern army project at Frankfort Arsenal? Is that devoted largely to a study of equipment design or of a maintenance system?

COL ESPELUND: I should like to have Captain Kneuton comment on this, but I understand that he is not here at the moment. It is devoted to both--the design because they have done a lot of work in the modular construction for optical and optical-mechanical type items.

MR. PEAR: Is Capt. Kneuton in charge?

COL ESPELUND: No. He's from Frankfort and he's directly involved in this. They are going further on repair by replacement of assemblies and components and not so much piece parts.

MR. PEAR: Well, we would like to get together with him. Who is in charge of that particular project? Do you happen to know, Colonel?

COL ESPELUND: I can get that for you.

MR. PEAR: I have just one other question that's in reference to throwaways. Has any consideration been given to another element that might be of value in designing throwaways--recovery of basic materials? I can see that if we go to any large throwaway policy you might find nothing but throwaways marring the landscape. After a while there would be a tremendous pile of throwaways. Has any consideration been given to recovery of basic materials which in all-out war, for instance, might become a very important product.

COL ESPELUND: I'm going to answer this probably indirectly. I didn't mention all of the considerations for throwaway because there are a large number that you well note must be brought to light. But you have a very good point; when we get into the type of materials where it would be desirable to retain or salvage, it would be quite proper, I would think, to collect it. One way would be to get a direct exchange--turn in one unserviceable item for a serviceable one. Whether you repair that item or not, it is the means of controlling and assembling the unserviceable material. Does that answer your question?

MR. PEAR: Yes sir.

MR. FRANKEL, USASRDL: If you did try to collect all of these unserviceable parts, wouldn't you run into the same condition again of having a lot of unnecessary cost of transportation and storage of these items? Also, in trying to reclaim these materials, won't you be spending the manpower which also adds to the cost? It might be just as well to repair them to start with.

COL ESPELUND: As I indicated in my discussion, each item, each module, anything that we consider for throwaway must be considered only in its own light. We can't really establish any criteria across the board. The designers and the maintenance engineers would have to at that time determine whether the item is one that we would dispose of, junk, throw in the field (litterning the battlefield with it), or collect it and return it to the rear for some salvage.

MR. G. A. KRONE, FORT WORTH: Did I detect in your reference on backup from industry, for instance in the manufacture, the thought that we could get this continual backup and support from the manufacturer of these modules as the equipment continued in use?

COL ESPELUND: Would you restate your question?

MR. KRONE: Well, basically, let me go back to an older problem. As the government gets equipment and it's been in use for a number of years, progress has a way of getting ahead of use, and we have items which the manufacturer no longer makes. Now, is it intended in this backup from industry on the manufacture of this modularized equipment to continue in production these particular modules?

COL ESPELUND: Well, I believe, and this is a very general answer, that as long as we have the item in a system, that we are going to request industry to support the item; otherwise, there is no point in having the item in the system, even these modules that are necessary to support the end item.

MR. KRONE: Well, it would seem to me, although this has not actually happened in the past, we are reducing the number of parts and components, but we still have with us the problem of this support after a period of time. It's a time phase proposition--what period of time for support of these modules. Nowhere in the presentation on this module concept have I heard any indication of a solution to this particular problem, either from the standardization of these modules so that they would be interchangeable across the board equipment-wise or otherwise.

COL ESPELUND: Really, you are getting into a much broader and much larger problem: the entire system of managing our materiel--and how long should we keep the item in the system--and how long do we continue to support it. I don't think from what you are bringing up here it's something for which we can find a solution by the throw. The throw is something that is intended to support or reduce the number of line items necessary to support an item that is in the system and in the field but not necessarily as a means of cleaning the system out of modules or of cleaning the system out of end items. This gets into the big problem of materiel management.

MR. KRONE: Well this part is true, but support is one of the weak parts and no matter whether you went to the module concept or not, unless we resolve that portion of it and have a guarantee that we could have the backup support of these modules, we in effect have only solved a part of a problem.

COL ESPELUND: Well, certainly we must have assurance that we are going to be able to continue to provide the modules of the items that we have in the system if it is a modularized unit.

MR. KRONE: That's right. There are so many possibilities in this field.

MR. E. P. O'CONNEL, FEDERAL ELECTRIC CORPORATION: Colonel, you indicated, I think, that the industry was not in support of the throwaway concept because of the fact that they are in the business of supplying spare parts. Now, I would expect that just the opposite would be true because, in the throwaway concept, I would imagine that there would be an increased consumption of parts or assemblies. Could you elaborate on that further please.

COL ESPELUND: I qualified my statement to the vehicular field. I didn't include the entire industry. I qualified my statement to the vehicular field, and I make that statement on the basis of the reaction that OTAC has received in their approach to industry. I am speaking of the Ordnance Tank Automotive Center. That is a very general statement, and again I say it applies to only the vehicular or automotive industry.

"INTRODUCTION OF NEW EQUIPMENT INTO THE FIELD ARMY AND ITS IMPACT ON MAINTENANCE"

Maj. Charles J. Dominique
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Three major items will be discussed during this presentation:

I. Tactical concepts for the Field Army of the 1960's.

II. Communications-Electronics equipments being developed in support of tactical requirements, and

III. The Impact of new equipments on maintenance.

The introduction of new weapons capabilities, which bring about changes in organization and tactics of ground forces, also influence, in a revolutionary manner, military communications-electronics concepts and techniques.

It is visualized that tactical elements of the 1960's will be required to fight day and night, in all weather, over very widely dispersed fronts with great depths.

Figure 1 is a schematic drawing of a division area. Compare the one for the future with that toward which the Pentomic division is working and that we thought appropriate for World War II. The battle area in which the division will operate will consist of dispersed units disposed in depth. The warfare will be fluid, with the offense and defense becoming similar. The presence of atomic weapons will influence the battlefield. Brief, vicious engagements by units which grow progressively smaller as we go farther into the next decade may predominate.

The size of the enemy area in which the division can exert its influence will also increase. To cover these areas will be a major task for the division combat surveillance effort. Similar increases are to be expected in other echelons of the Army, with the field Army being responsible for a depth within the friendly area of up to 500 miles and having an area of influence requiring the collection of information 300 miles into enemy territory.

As the area to be occupied and controlled by tactical forces and weapons expands, greater range is required from electronic gear. As the capacity of weapons progresses, more detailed coordination is required between operating, supporting, adjacent, and command elements. This increases the amount of information generated and the frequency of contact between and within all echelons, as well as the number of points where information and coordination are required. The ranges and effects of new weapon systems create new requirements for combat surveillance and target acquisition, timely evaluation of reported information, and much higher degree of responsiveness to command control. In turn, the ability to react quickly places increased emphasis on communications-electronics systems. Thus, we must satisfy the demands for:

a. Increased reliability to assure the responsiveness of all elements, to reduce maintenance floats, spare parts requirements, and possibly echelons of maintenance.

b. Increased mobility of communications - to keep pace with the elements being served.

c. Higher capacity systems - to handle increased traffic loads.

d. Electro-magnetic compatibility - to assure that full operational capability is realized.

e. Increased range - to cover larger areas of operation.

f. And, of equal importance, increased speed of service, systems flexibility, and invulnerability and recouperability of communications-electronics facilities.

Based upon known requirements, a type Corps of the 1960's will be equipped with approximately 15,000 electronic devices - as compared with the 9000 electronic devices used by a Corps of 1945. Fifteen thousand could be a conservative figure. This was indicated during a recent field exercise conducted by the Seventh U. S. Army in Europe. For test purposes, radios, AN/PRC-10, were issued for Command Nets from rifle company to rifle platoons, and radios, AN/PRC-6, were used from rifle platoon to rifle squads. The use of radios from rifle platoons to rifle squads is a new requirement but one that is considered necessary due primarily to dispersion factors. It was interesting to note that 37 FM radio nets were used within one test battle group, and four additional radio maintenance personnel were attached to the test battle group during the period of the exercise. I have mentioned but one indication of the changing requirements for electronic equipments. As previously mentioned, new firepower and tactics change the types and quantities of electronics equipments required by all tactical elements.

Major conceptual, developmental, and test efforts are currently in progress to satisfy the communications-electronics needs of the field army. Time available and the classification of the symposium will not permit complete coverage of all these capabilities, but I would like to discuss several equipments and systems that have significant maintenance implications.

TACTICAL COMMUNICATIONS SYSTEMS & EQUIPMENTS:

One such equipment is the radio, AN/VRC-12 (Figure 2). This one radio will replace the present AN/GRC-3 through 8 series. In addition to providing greater number of channels (920), complete flexibility of channel assignment, and increased range, it will provide a considerable reduction of components and because of sectional construction, plug-in units, and transistorization, will provide increased reliability and be easier to maintain.

(SLIDE 6 on)

The AN/MRC-66 is the first equipment specifically designed for operation as a Radio Central (Figure 3). The central station consists of a single-sideband transmitter-receiver and associated switchboard and multiplexing equipment and is to be mounted in a 3/4-ton truck.

I should mention that these slides indicate engineering models of equipment. Production models will be smaller, transistorized, and adaptable to automatic switching, and the latest modular construction techniques will be utilized.

Subscriber stations consist of a single-sideband transmitter-receiver and control unit and can be mounted in 1/4-ton vehicles, armored vehicles, or aircraft (Figure 4).

The system will provide some 12 to 18 full-duplex subscriber channels, each requiring 7.6-kc bandwidth and each capable of accommodating as many as four subscriber stations on a netting basis (Figure 5). Under normal conditions, the central will provide the same type of service as is provided by local-to-local and local-to-trunk wire switching. Wire locals and trunks may also be connected into the switching facility located in the radio central and are handled in the same manner by the switching facility. The system as a whole is capable of operation while in motion.

Although the radio central is intended primarily for use at Battle Group level of the division, it will be equally applicable to many other elements and echelons of the field army.

Studies to date indicate that units equipped with the radio central will have reduced requirements for both radio and wire equipments.

Also under development is an automatic switching capability for the field army. When this capability is fully realized, the telephone, teletype, or facsimile user will be able to dial (or punch) his party over a completely automatic army system.

This picture may be of a Local Telephone Central Office, a Division Tandem Central Office, or a Long Distance Central Office (Figure 6). All three are similar in appearance and will be installed in the same type, same size shelter for mounting on a 2-1/2-ton truck. The fourth central office, for use within the Division area, can be mounted in a shelter on a 3/4-ton vehicle.

A total of four different types of central offices will be used to satisfy the requirements of the field army. (This does not include boards for low level, such as company, use.)

Although the term dialing is still in use, the dial will be replaced, as can be seen in figure 7 showing the field telephone, by a 10-position key sender consisting of ten push buttons. This permits much faster "dialing" by a calling telephone user and speeds up the switching process throughout the system.

A unique feature and the factor which increases the life and reduces the maintenance requirements on this equipment is that the mechanical switches and relays are replaced by miniaturized, transistorized, electronic switches (Figure 8). This comparison shows the card system of miniaturized solder dip circuitry alongside our current mechanical dial switching equipment.

Figure 9 shows the reduction in size and increased mobility of the automatic switching system as compared with our present day manual systems.

The reliability factors which set these items apart are shown in figure 10. Switching is accomplished electronically using transistors, crystal diodes, and similar semi-conductors.

All of the components of these new equipments will be tested for 20-year life. Only very limited moving parts are incorporated into the circuitry; therefore, malfunctions due to wear and mechanical maladjustment are greatly reduced.

Maintenance in the sense of cord repair, relay adjustment, and replacement of parts rendered inoperative from wear does not apply to the electronic switching centrals. By use of test equipment incorporated in the central, it is anticipated that trouble can be isolated to five plug-in circuit cards. By substitution, the defective card is determined, and this card is replaced with a spare card furnished with the central. The trouble, therefore, can be readily cleared. Additionally, automatic switching offers other worthwhile advantages, such as:

a. Ability to switch all types of traffic.

b. Faster operation.

c. Better facilities for working with wire or radio.

d. Easier to use.

e. Improved transmission characteristics, and

f. Greatly reduced operating manpower and accompanying logistic support requirements.

AUTOMATIC DATA PROCESSING SYSTEMS:

Automatic Data Processing Systems will constitute a new capability for the tactical field army. The feasibility of applying computer techniques in a tactical warfare environment has been established. A high priority program is under way to place a prototype Automatic Data Processing System into the Army's tactical organization within the next 5 years. It is anticipated that this system, organizationally, will consist of data processing centers and supporting data transmission capabilities for use within the field army structure. More than 70 areas of possible application of ADPS within the field army are being studied. Possible major areas of application are:

1. Command and Operations.

2. Combat Intelligence.

3. Personnel and Administration.

4. Logistics.

5. Special.

It is visualized that a large computer, such as the one indicated in figure 11, will be used at Corps and Army levels and that a medium size computer, such as reflected in figure 12, will have an application at division level. Smaller computers will be used at lower levels, such as battle group, if requirements are established.

The applications of ADPS selected will depend upon operational needs, the results in analyzing and programming the functions, and the availability of equipment. The first of the FIELD DATA family of equipments planned to be installed for operational use will be a Mobile Digital Computer, short title MOBIDIC, for the Army Security Agency in Seventh Army during 1960. This will probably be followed shortly by a MOBIDIC for the Seventh Army Supply Control Center.

Experience indicates that maintenance personnel for computers need about 4 to 6 months of formal training, while maintenance personnel for the auxiliary type equipment, such as magnetic tape units and paper tape readers, need somewhat less.

COMBAT SURVEILLANCE:

Progress made in electronic and associated technology in the past few years has greatly extended combat surveillance capabilities. Handicaps due to weather, darkness, and inaccessible terrain are being overcome.

Drone aircraft carrying such devices provide a formidable addition to combat surveillance capabilities. Figure 13 is a picture of the SD-1, the first drone to be adopted for use by the army. It is considered an interim capability and is being deployed to Europe and the Far East during this calendar year. Four other drones, possessing greater capabilities, are being developed for use from division to army.

A whole family of ground radars for use from army to squad levels are being studied and tested. In addition, infrared, accoustic, seismic, and nuclear burst locating devices are being studied and tested to improve the Army's over-all competence in the art of combat surveillance.

COMMUNICATION SECURITY:

Security of our communications is an area that is of considerable importance. For the foreseeable future, a great percentage of the communications requirements for the field army will be satisfied by means of electro-magnetic radiating devices or, in other words, some type of radio circuitry. Compared to other intelligence sources, radio interception can provide cheap, timely, and often incredibly important intelligence to an enemy. There are means of minimizing the vulnerability to intercept, but since there is no completely effective way to stop the enemy from intercepting radio transmissions, the information must be denied him prior to transmission.

In securing tactical communications circuits or systems one requirement is paramount - no appreciable amount of time can be lost due to encryption and decryption processes. This means that such devices must be directly associated with the transmission and reception means so that encryption and decryption are not separate functions. Such equipments, to secure speech, teletype, facsimile, and data transmissions, are being studied, developed, and tested.

In terms of logistics and maintenance support, it should be appreciated that the introduction of these equipments in many instances will not be a replacement program but rather an introductory program designed to provide a means of communications security not previously available.

ELECTRONIC WARFARE:

The field of electronic warfare covers two opposing areas: electronic countermeasures for reducing the effectiveness of the enemy communications and electronic systems and electronic counter-countermeasures for preventing his doing the same to us.

In the area of countermeasures, the Army has a skeleton capability in being for attacking communications systems. We will expand this capability in the next decade. In the 1960's we will also introduce a new capability in the field Army. This will be a capability for countermeasuring other targets such as VT fuzes, radars, and navigation and guidance systems.

In the area of counter-countermeasures, we have an extensive and continuing effort to reduce the vulnerability of all electronic equipment.

The electronic warfare field generates three related maintenance-type problems:

a. First, we must provide for the normal maintenance of the new (and complex) countermeasures equipment to be introduced.

b. Second, we must provide for field re-design and modification of our countermeasures equipment. This will be needed to give us a capability for attacking new type electronic systems as they appear in the battle area or to cope with improvements made in the enemy's old systems in the never ending battle between countermeasures and counter-countermeasures development.

c. Third, and related to the above, we must provide for field modification of our own communications and electronic equipment as we find they are becoming vulnerable to enemy countermeasures.

AVIONICS:

In the field of Avionics, the various electronic equipments which are carried in Army aircraft, for purposes of communication, navigation, and identification, have continued to grow in quantity and complexity. Where Army aircraft could once operate without a radio or, at best, with one or two channels of communications, the aircraft of the 1960's will require more channels for communication with the many different elements of the Army over whom they range in the pursuit of many and varied missions.

More precise position information and means of identification are paramount if tactical aircraft are to perform their missions and survive over the atomic battle field. In addition, radars are being developed for installation in Army tactical aircraft to provide a surveillance capability.

Tactical requirements for refinements to existing equipments and the steadily increasing demands for greater capabilities are adding to the problem of placing more and more equipment into the same physical space available within Army aircraft. Every advantage must be taken of miniaturization, modular construction, and throw-away components.

Figure 14 gives an over-all indication of the communications-electronic capabilities being developed for echelons of the field army of the 1960's.

Although command-control capabilities presently exist at all echelons, the availability of new firepower and change in tactics will continue to generate new requirements. In the areas of surveillance electronic warfare, automatic data processing, and communications security, new equipments will be introduced which will provide capabilities not previously available to tactical elements. This is also true in the fields of avionics and air defense which are not reflected in this figure.

Up to this point I have discussed tactical concepts for the field army of the 1960's and the communications-electronics equipments and systems being developed in support thereof. Now I would like to make a few observations directly related to the field of maintenance that may be of interest to you.

The impact of new communications-electronics equipments, regardless of their quantities and complexities, would have no significance from a maintenance standpoint if one hundred percent reliability and indefinite life-span could be achieved. Although tremendous strides have been made toward increasing the reliability and life-span of equipments, the complete solutions are most difficult. Nevertheless, these factors hold the key to the reduction of maintenance floats, spare parts requirements, and reduced numbers of skilled maintenance personnel.

Factors such as increased quantities of electronic equipments, equipment complexities, and dispersion on the battlefield all attest to the fact that, for the foreseeable future, the provision for adequate and timely maintenance are factors that will grow rather than decrease in importance.

Considering dispersion, mobility, and self sufficiency of units on the battle field, commanders can no longer afford the time required for World War II methods of evacuation and repair. Defective items must be restored to operation or be replaced within the shortest possible time. Equipments must be built so that defective parts can be quickly located and replaced by relatively unskilled personnel. In fact some studies indicate that low-echelon units should possess only a replacement capability and that highly skilled technicians should be pooled at higher levels under skilled supervision.

I would like to conclude with some comments made by Lt. General Carter B. Magruder, Deputy Chief of Staff for Logistics. He stated:

"...in spite of increases in mechanical and electronic equipment, we can and must be able to establish a major downward trend in the tonnage requirements of our troops.

"...it is important that our equipment not break down, or if it does, that it can be readily repaired by semi-skilled mechanics in a relatively short time.

"...all possible steps should be taken to reduce the number of technicians..and to make complicated equipments easier to operate and maintain..."

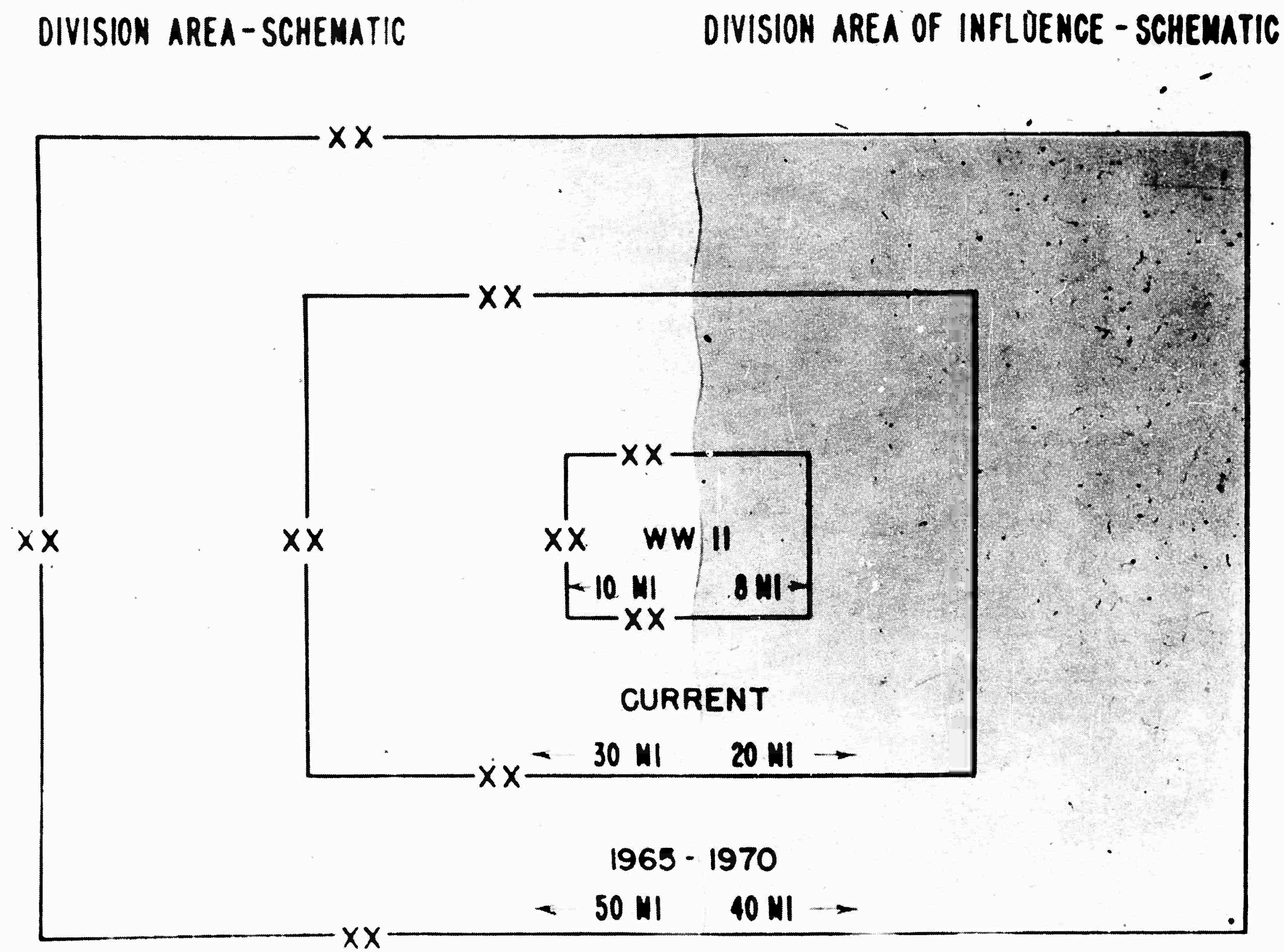
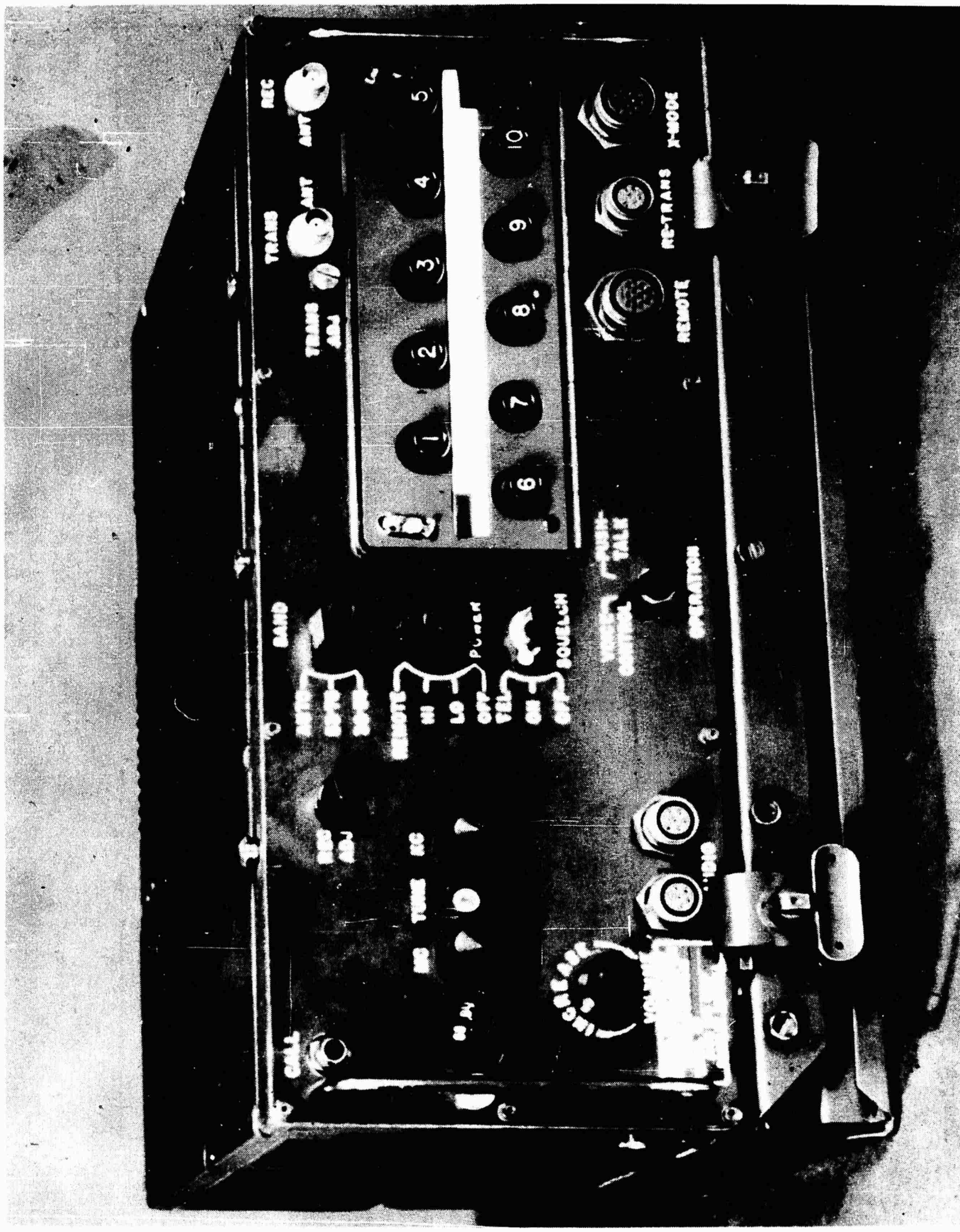

DIVISION AREA-SCHEMATIC
DIVISION AREA OF INFLUENCE - SCHEMATIC
XX
WW II
10 MI
8 MI
CURRENT
30 MI
20 MI
1965 - 1970
50 MI
40 MI

Figure 1


REC
ANT
TRANS
ANT
TRANS
ADJ
BAND
POWER
SQUELCH
OPERATION
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X-MODE
1
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Figure 2

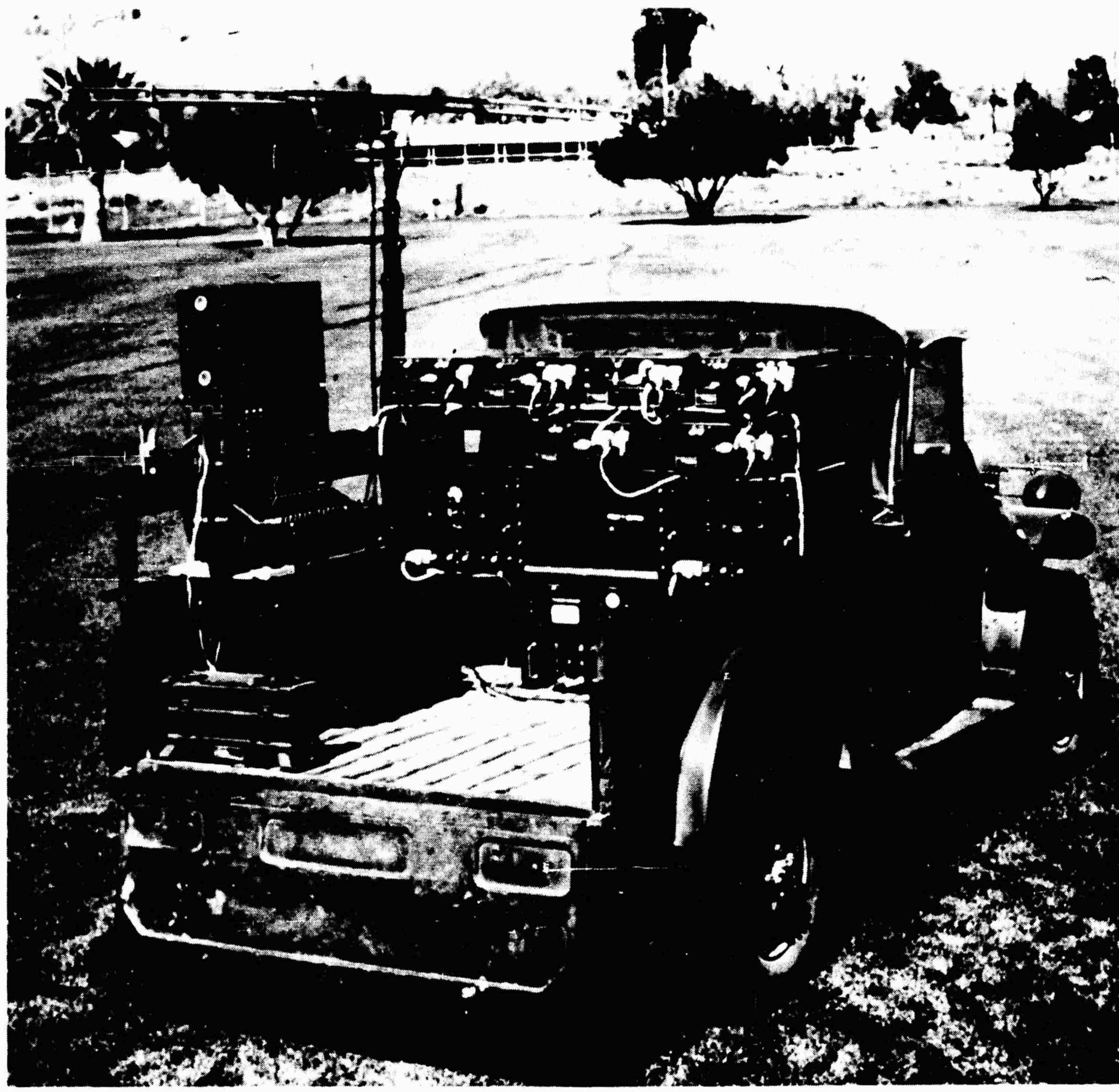


Figure 3

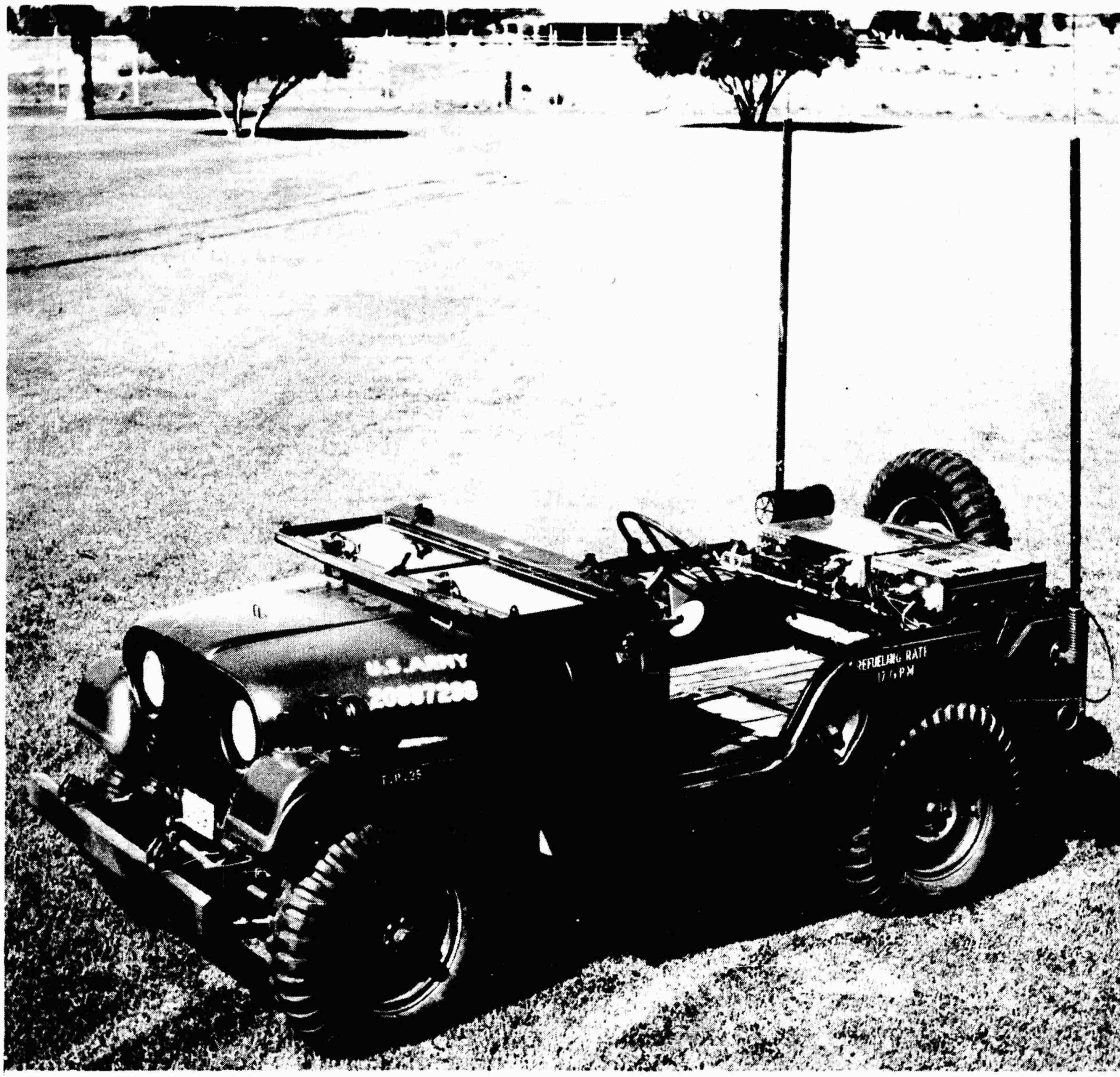


Figure 4

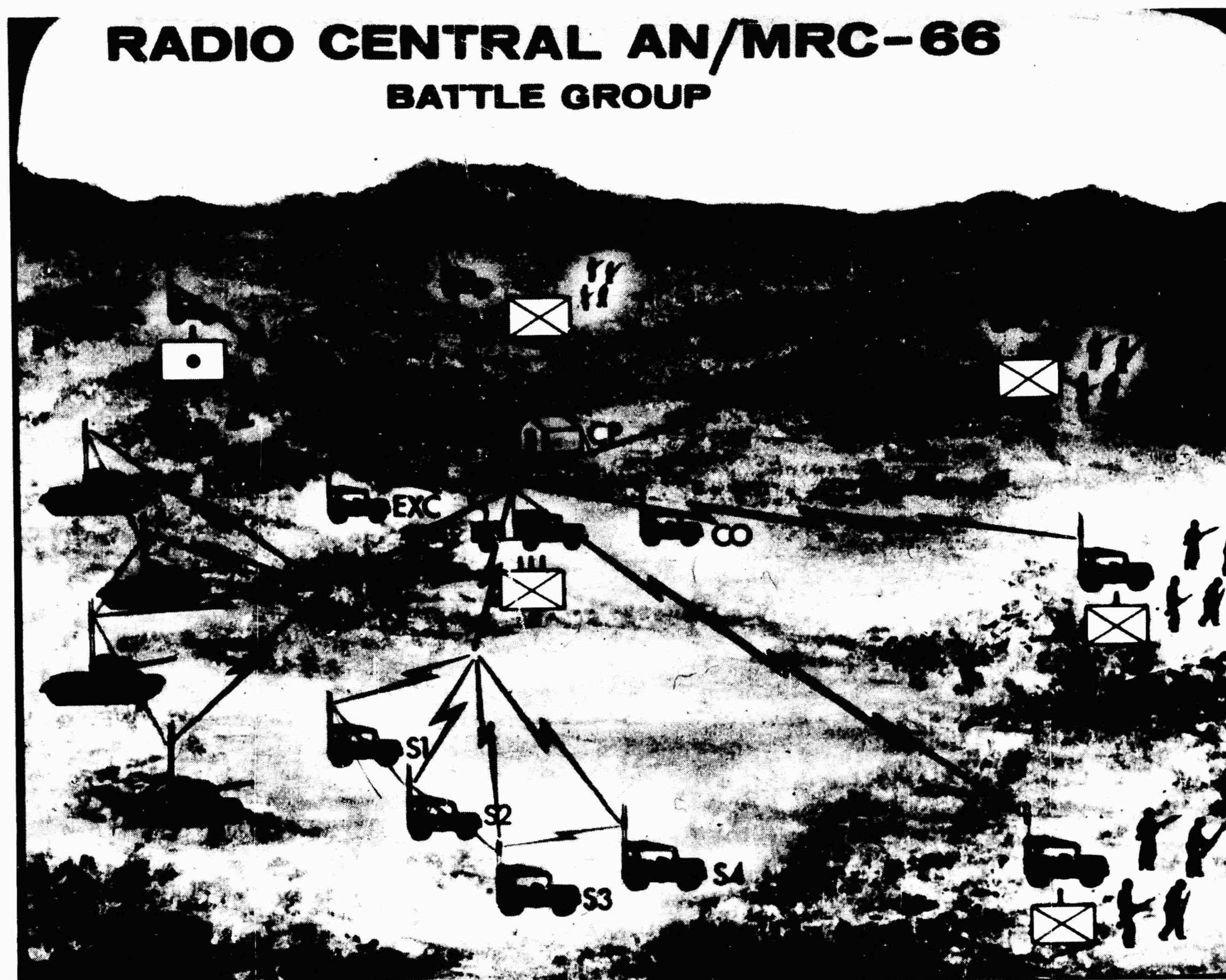


Figure 5

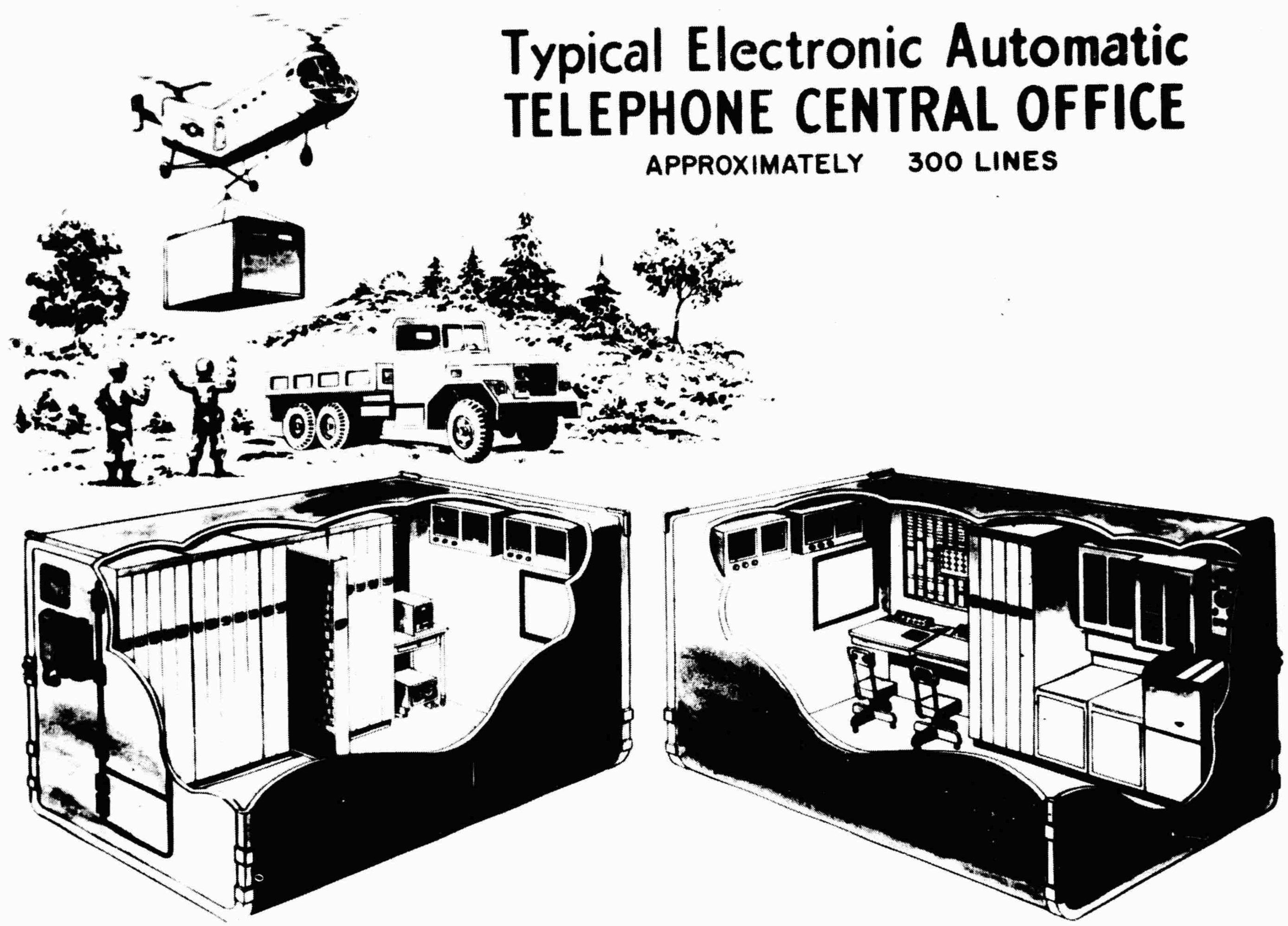

Typical Electronic Automatic
TELEPHONE CENTRAL OFFICE
APPROXIMATELY 300 LINES

Figure 6

Figure 7

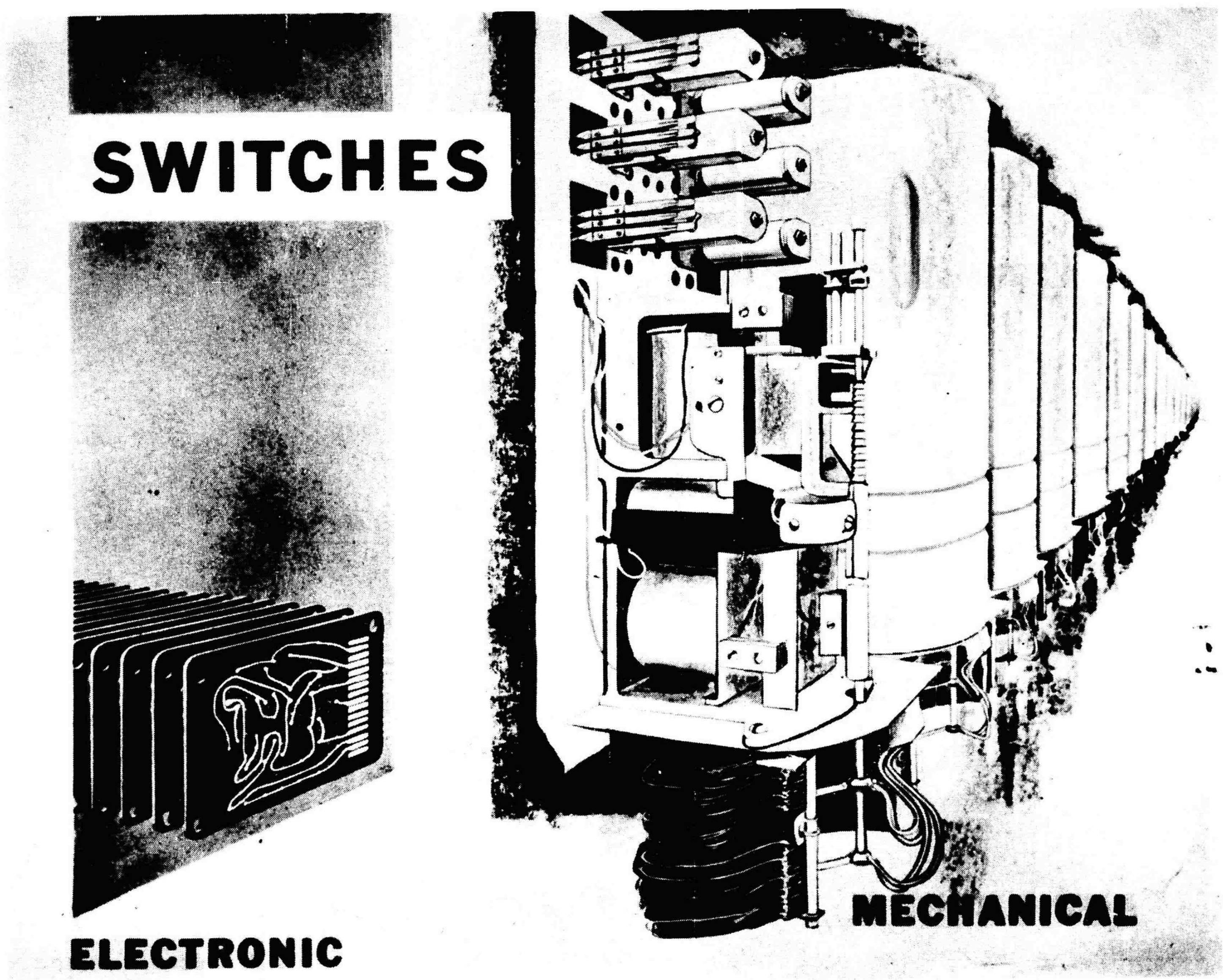


Figure 8

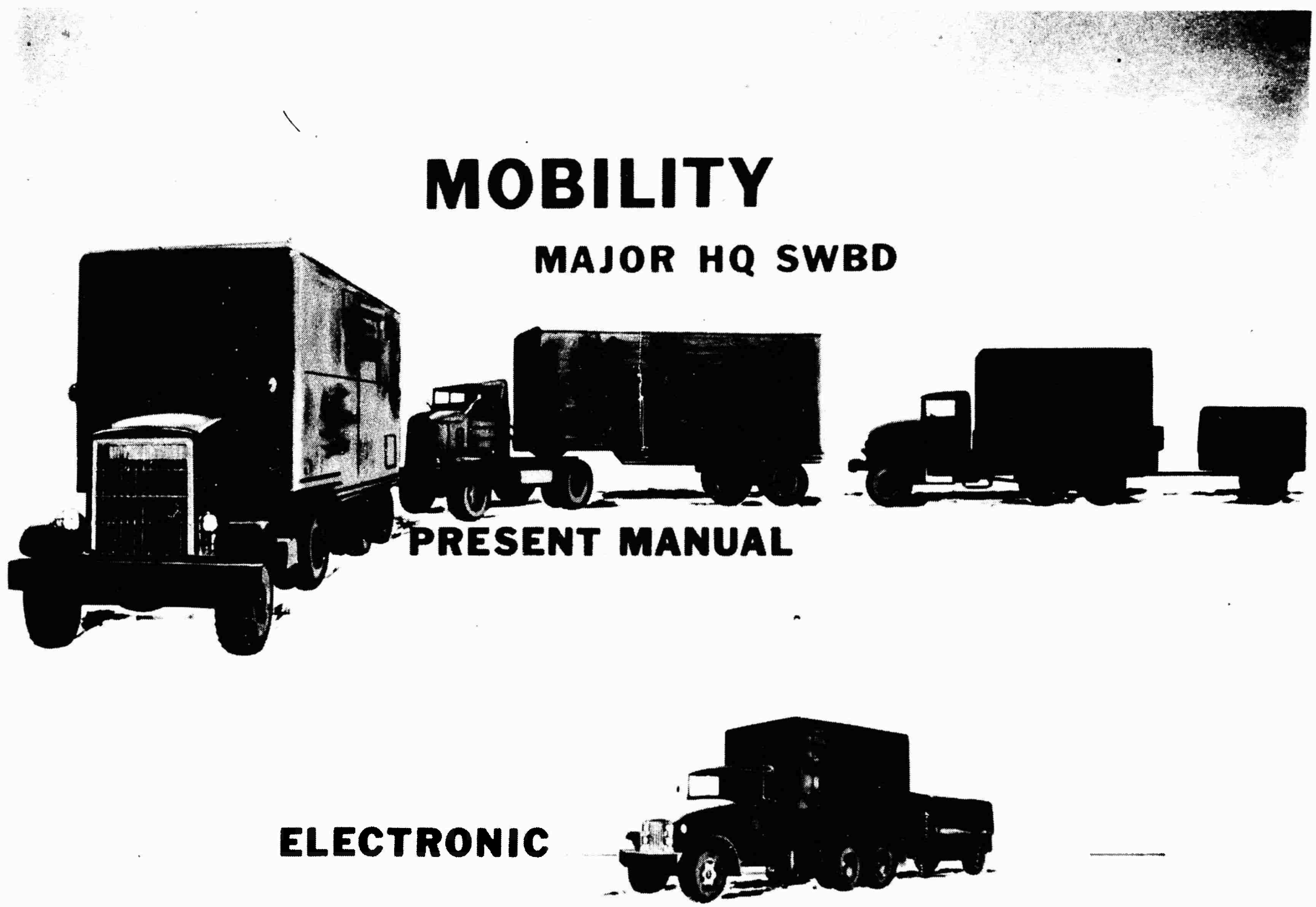
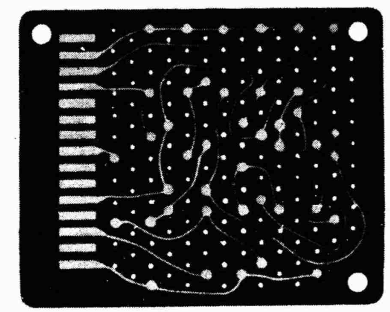


Figure 9

RELIABILITY FACTORS



NO MOVING PARTS

20 YEAR LIFE

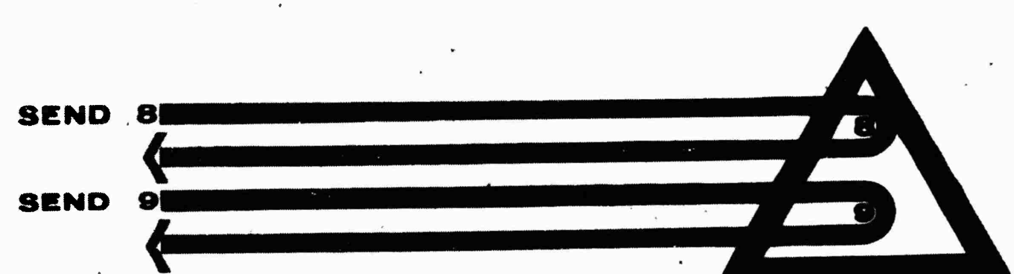
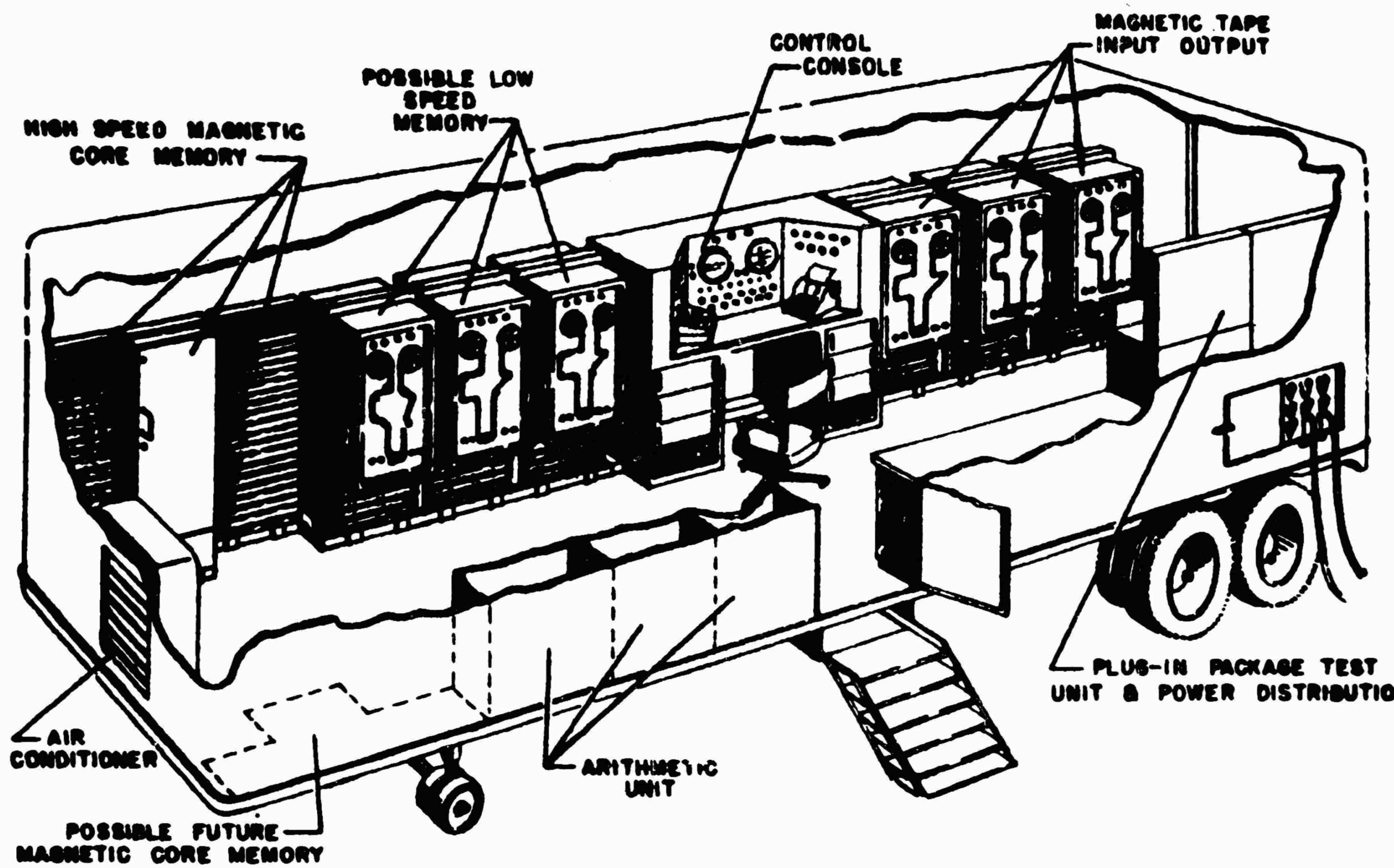
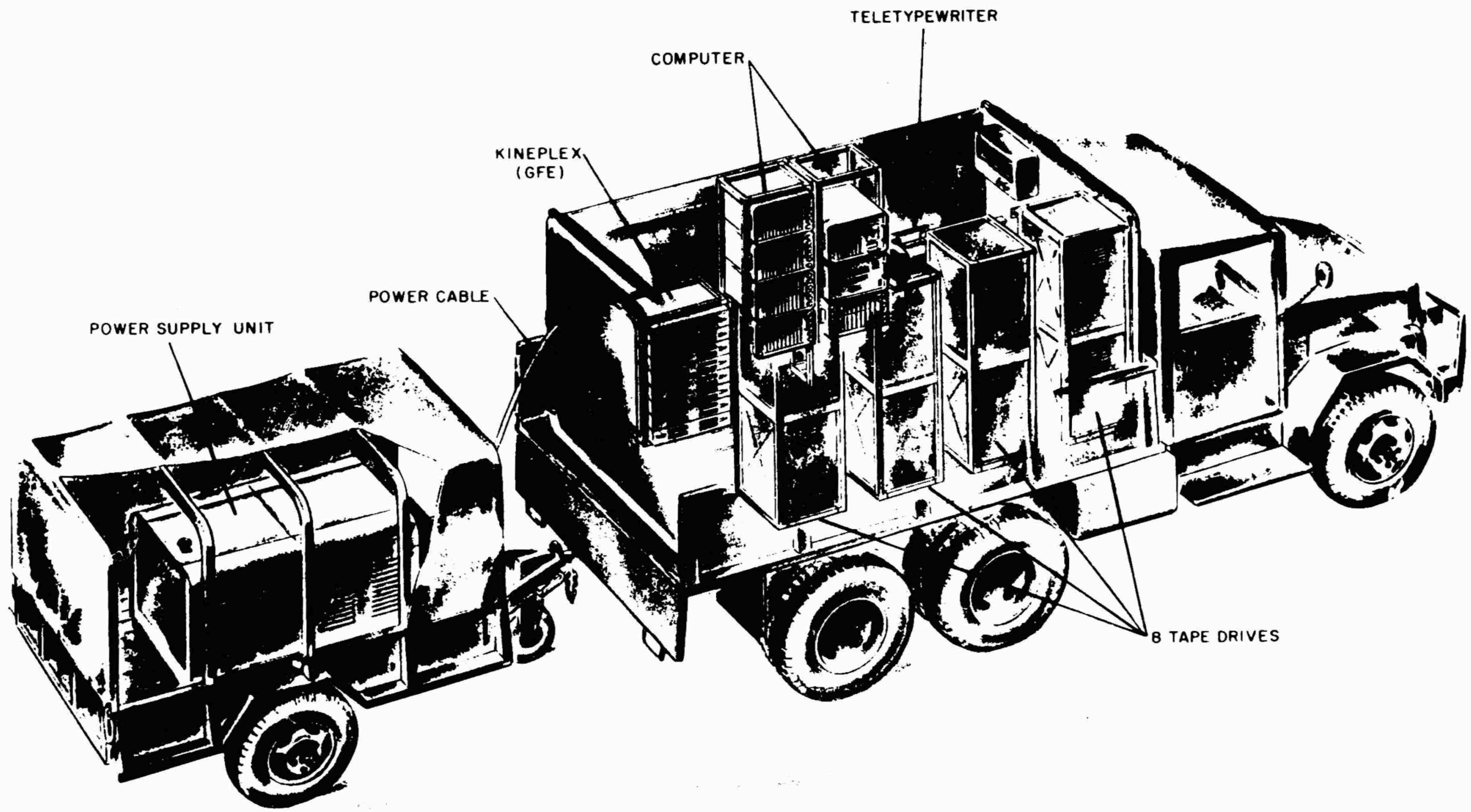


Figure 10



MOBILE FIELD COMPUTER

Figure 11



Logicpac Installation

Figure 12

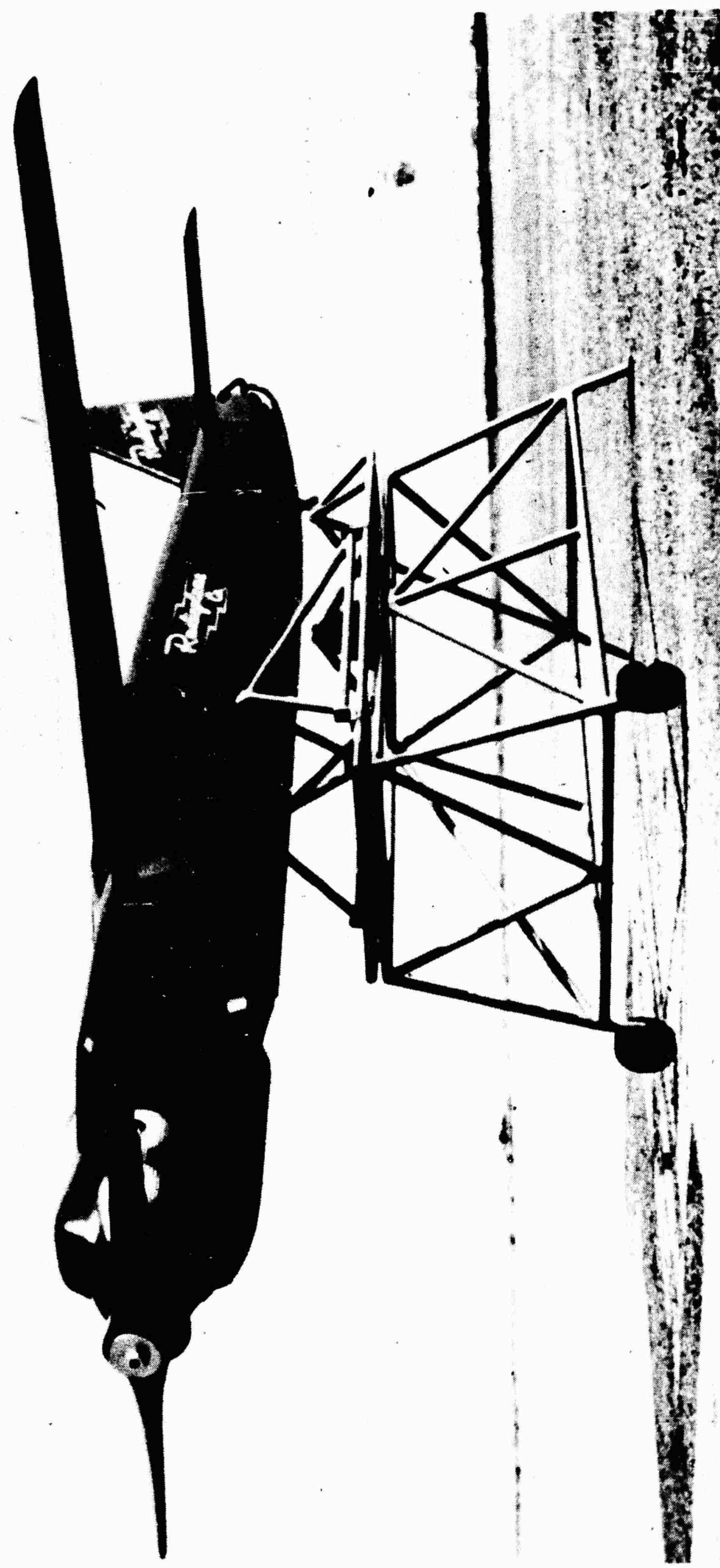


Figure 13

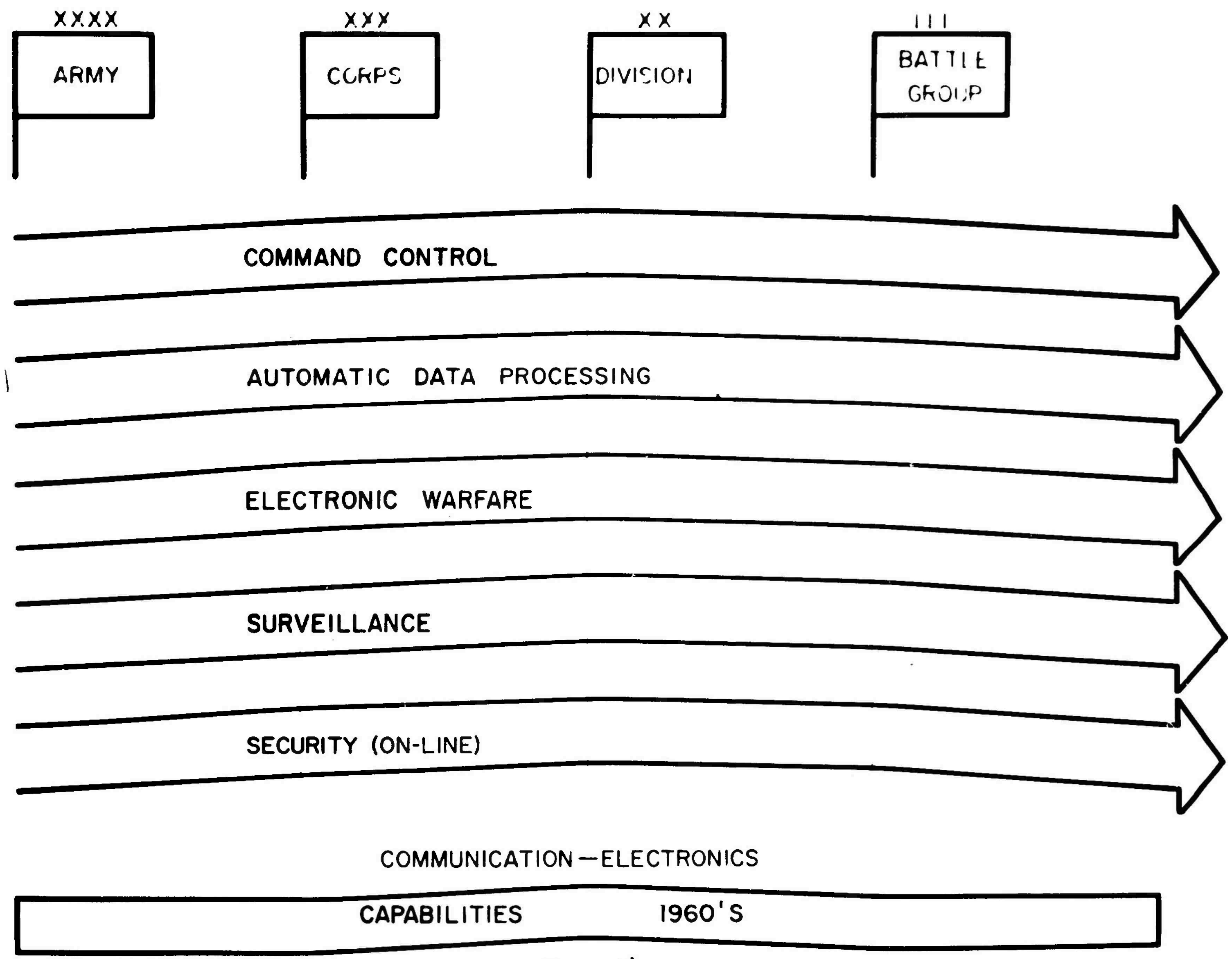

XXXX
ARMY
XXX
CORPS
XX
DIVISION
III
BATTLE GROUP
COMMAND CONTROL
AUTOMATIC DATA PROCESSING
ELECTRONIC WARFARE
SURVEILLANCE
SECURITY (ON-LINE)
COMMUNICATION—ELECTRONICS
CAPABILITIES 1960'S

Figure 14

(Major Dominique was promoted to Lieutenant Colonel upon arrival at the Maintenance Symposium.)

MR. CARL E. SOHLGREN, BENDIX PACIFIC: I have a question regarding the first equipment you showed on the screen. I believe it was the MRS-66. What would happen to the -66 if the central were destroyed.

LT COL DOMINIQUE: There is a very definite answer to that. It has built-in capabilities. If the central becomes inoperative for any reason, it has a capability of going to emergency netting so that all subscribers to the system can net on a common frequency operating on a directed net until the central is restored.

MR. F. PALUMBO, USASESA: Colonel, has any consideration been given to bypassing the modular program in favor of a micromodular program with a view towards reducing some of our problems in the light of throwaway maintenance and tonnage, and so on.

LT COL DOMINIQUE: Well, of course thats an extremely difficult question for me to answer being from Combat Developments. I think R&D could answer that better. But I heard an interesting observation made, and I wonder if it isn't quite applicable here: that Russian philosophy is that the better is often the enemy of the good enough. Now take that for what its worth -- do we want to wait? do we want to hold back on this for the future? I don't know. The micro modular program is coming along. We feel it's a wonderful technique with tremendous advantages, but do we want to hold off? How fast could we introduce it if we hold back on it?

QUANTIFICATION OF EQUIPMENT MAINTAINABILITY

Robert E. Redfern
U. S. Army Signal Equipment Support Agency

Before Maintainability can assume its full stature of importance along with equipment performance and reliability, it is essential that a method be devised for quantitatively stating design requirements and evaluating resultant hardware. To be effectively applied the method must be comprehensive of all facets affecting equipment maintenance; readily understood by all levels of technical and semitechnical personnel; and capable of being quickly computed without resource to lengthy computation or data gathering. This paper presents such a method now being developed by the American Institute for Research under a contract with the U. S. Army Signal Equipment Support Agency.

Introduction to the Problem

Reliability has long been recognized as an important virtue in equipment design by any designer or producer who took pride in his product, but in recent years added emphasis has been placed on reliability of military electronic gear because failure and down-time have become increasingly intolerable. As a result, most of our producers are engaged in active reliability programs. It is obvious, however, that reliability at its best has its limits. We are still a long way from producing components with infinite life. In recognition of this limitation, a growing emphasis is being placed on maintainability in order that equipment, even "reliable" equipment, once failed, may quickly be restored to service.

Reliability and maintainability are actually conflicing problems. If either one could attain 100% the other would not be important. Within the present state-of-the-art this does not appear likely of attainment. Neither are we capable of astute prediction as to how long an equipment will operate before requiring repair or replacement. Even when we do attempt to predict or control mean-time to failure, we are dealing with inherent equipment failure. Added to this must be consideration of, and allowance for, externally induced failure, or damage. We must, therefore, strive for a realistic compromise between, or combination of, reliability and maintainability.

The Air Force, Navy, and Army have all promulgated doctrine and, to varying degrees, specifications that require incorporation of maintainability in equipment design. These requirements vary from broad term generalities to specific requirements for measured values. Obviously the only real control is in terms that can be quantitatively measured to determine acceptability. All that remains is to find out how to implement it. Unless a specific quantitative degree of maintainability can be specified for equipment design, and measured from the resultant hardware, any broad term requirements for "ease-of-maintenance" will be brushed aside by the efforts to attain specified performance and reliability.

Engineering management must meet this requirement by establishing design criteria and indoctrination of their design engineers until the use of maintainability disciplines becomes as automatic as those governing performance and reliability. It will then be the responsibility of the development engineer to make the necessary trade-offs with performance, reliability, and packaging, but in making the trades maintainability will retain an equal priority instead of being in Nth place. Performance is no good if it can't be kept performing. Reliability is defeated if, when it fails, as it surely will, it can't be quickly restored to service.

Statement of the Problem

Our basic problem now becomes one of communication. Design and development personnel, in general, are poorly informed on the fundamentals of maintainability. Even granted an adequate knowledge of fundamentals, they are given no interpretive criteria by which to relate these fundamentals to the design of a specific equipment, for a specific mission, to be used and maintained under specific conditions by personnel with specific capabilities, under specific support conditions.

These critical, controlling criteria are not served by such lip-service as we find in current R&D specifications containing this phraseology: "If the equipment is to meet the needs of the Government, is it imperative that reliability and ease-of-maintenance be of prime importance in the design of the system? The contractor shall employ all methods practicable which will ensure quality, high-reliability, and minimum maintenance consistent with the state of the art. The design shall include all practical features which will result in reduced frequency of failure, reduced requirement for maintenance, and simplified maintenance, thus reducing requirements for highly skilled maintenance personnel."

Obviously such broad term objectives can - and will - be given widely divergent interpretations by bidders. The bidder who employs the maximum interpretation and bids accordingly will find himself at a serious disadvantage with his competitors who may bid as much as 50% lower based on a much looser interpretation. The contracting officer also finds himself at a loss to interpret such loose terminology and ultimately the award will go to a low bidder for want of concrete justification for award to a high bidder. The ultimate responsibility for obtaining maintainability in equipment design would, therefore, appear to rest with the military specification or technical requirement writer. If he supplies to industry detailed requirements of the maintainability levels required, based on an analysis of the maintenance support facilities, personnel capabilities, environmental usage conditions, permissible down-time limitations, and other important considerations, industry will be in a position to intelligently pursue the development of means to fulfill the requirement and to prepare bids based on a more consistent interpretation. Those of you who attended previous Symposia on maintainability will recall that industry spokesmen have frequently said "Tell us what you want and we can give it to you."

This brings us to a consideration of what we, on the military side, can do to ensure maintainability. What can we do in the area of specifications, technical requirements, and contractual items to recognize the conditions affecting maintainability?

Definition of the Problem

Let's first consider the definition of maintainability. It seems as though everyone concerned has taken a crack at defining the term "maintainability."

First - for obvious reasons - we have the Department of Defense definition: "Maintainability is a quality of the combined features and characteristics of equipment design which permits or enhances the accomplishment of maintenance by personnel of average skills, under natural and environmental conditions in which it will operate."

Then we have a definition by AGREE Task Group 9:

"Maintainability is defined as the reciprocal of mean net time to repair failures, where both failures and repairs take place under specified simulated field conditions."

RCA under contract AF30(602)1623 sponsored by RADC developed another definition:

"Maintainability is the average man-hour requirement rate for all maintenance performed per unit of equipment complexity, with existing personnel under the specified environmental and usage conditions."

American Institute for Research under RADC Project No. 7502, WADC Task No. 71502 stated:

"Maintainability is a function of the rapidity and ease with which maintenance operations can be performed to help prevent malfunctions or correct them if they occur."

In an unpublished Technical Memorandum No. 242, Dr. Bean at NEL discusses various approaches to measuring Maintainability and proposes the following formula.

$$\text{Maintainability (M)} = 1 - \frac{Ms + Mc}{24 \times 91}$$

Where Ms = Total net down-time, in hours, for scheduled maintenance over 91-day period.
Mc = Total net down-time, in hours, for corrective maintenance over 91-day period.
24 = hours in a single day.
91 = representative at-sea period for Navy ships.
(Obviously this has limitations peculiar to the Navy that would be inappropriate for other Services.)

Next, and enticingly concise, is the definition proposed by Captain J. L. P. McCallum of Navy's Bu Ord:

"Maintainability is the ease with which the device can be kept operating."

Not to be outdone, ~~yours truly~~ Robert E. Redfern, USASESA, took a hand in this game a year or so ago and defined Maintainability as: "The degree of facility with which an equipment is capable of being retained in, or restored to, serviceable operation. It is a function of parts accessibility, internal configuration, use and repair environment, and the time, tools, and training required to effect maintenance."

I do not propose to beat down each of these definitions in turn and move for the universal adoption of my pet brain-child. Obviously each definition was evolved after serious consideration and, in some cases, at considerable expense, to fulfill a specific concept of maintainability.

Instead, let us consider each briefly in the light of what guidance it provides the development engineer or contractor personnel in acquiring a concept of what the military establishment means by "maintainable equipment."

Let's take the DOD definition. We see "a quality of the combined features and characteristics." What quality? - the highest? - optimum? or some lesser degree such as medium? What features and characteristics? Then we see "by personnel of average skills." What are average skills? Where do we find such personnel? "Under natural and environmental conditions in which it will operate," this distinction between "natural" and "environmental" escapes me. I assume we are primarily concerned with environmental conditions - but not only those in which it will operate - but also those in which it will be maintained, i. e. repaired, serviced, tested, etc. This environment often becomes very limiting for tactical equipment. So we see that this definition is one of broad concepts, probably entirely adequate for use at a level such as DOD where broad policies are promulgated for overall program guidance, but it is less than useless in defining maintainability for the development engineer, or as a specification requirement.

The AGREE definition encompasses only one factor of the multitude of factors bearing on maintainability - that of "mean net time to repair failures." Does "repair" include the total act of locating the fault; securing the replacement, materials, and tools; effecting the repair, and checking out the repaired equipment? "Time to repair failures" also ignores preventive maintenance and its associated replacements, as well as calibration, alignment, lubrication, etc. Furthermore, the factor of frequency of repair is not tied to any specific time interval. This definition might more appropriately apply to repairability, which is one facet of maintainability.

The third definition goes a long way toward answering the problems associated with the first two, but it creates new ones of its own. It requires lengthy monitoring of equipment performance under field conditions and compilation of numerous data logs, plus a count of total equipment piece part population. Such a system would not lend itself to development model evaluation prior to going into production. The time element alone is against it. Furthermore, it has obvious deficiencies as a design parameter. How can the development engineer determine in advance all the details of design that must operate together so that after a trial run, for example, one year in the field, and the compilation of statistics recorded, the equipment will measure comparable to a preset man-hour requirement rate per replacement? The statistical research alone could take longer than the equipment development, and be upset each time a change or modification was effected during development.

The fourth definition approaches the type that covers all conditions bearing on maintenance. It does not include any ambiguous terms or limiting conditions, nor does it imply a necessity for statistical fact gathering over a long period of time. It does fail to include any reference to environment as a factor bearing on maintainability. This is important, as I am sure we all recognize that the environment under which preventive or corrective maintenance is undertaken will have a definite effect upon the rapidity and ease with which it can be effected.

Since the formula proposed is tailored to conditions peculiar to Navy, it does not have universality for discussion here except to say that it could be modified to any other time base where such a limitation would be pertinent. General use electronic equipment, however, such as that in use by Army and Air Force must be evaluated without restriction to a limited time base.

I wish we could live with the very concise, and cogently expressed definition proposed by Capt. McCallum. In essence it says everything we want to say about maintainability. Unfortunately, however, it does not give us the basic data on which to start computing a quantitative quality of maintainability.

Let's analyze the last definition and see what it offers in support of a quantitative determination of total maintainability.

"Degree of facility" immediately tells us that we must express a quantity which will bear a relationship to a maximum or optimum condition of maintainability. "Retained in, or restored to" covers consideration of both preventive and corrective maintenance. The definition also covers the pertinent factors and conditions which must be considered in arriving at a total determination of an equipment's maintainability.

<u>Elements of Maintenance</u>

Let us now consider what is involved in the term "Maintenance," in order that we may recognize all the elements that must be considered in identifying the factors that affect maintainability. The job segments or elements which make up the total maintenance function are:

1. Checking (preventive and corrective)
   a. Inspections
   b. Control checks
   c. Test equipment checks
2. Adjusting (preventive and corrective)
   a. Mechanical adjustments
   b. Electrical adjustments
3. Servicing
   a. Lubricating
   b. Replenishing

c. Changing

4. Troubleshooting

    a. To major unit

    b. To sub-unit

    c. To part

5. Replacing (preventive and corrective)

    a. Major units

    b. Sub-units

    c. Parts

6. Repairing

Each of the above maintenance elements is affected, to varying degrees, by certain factors of equipment design. Figure 1 portrays the variable factors of design and the variable conditions which affect the elements of maintenance.

Accessibility for purpose of internal adjustments or replacing of parts, or even the accessibility of the total equipment in its installed condition, affects practically every element of maintenance. The inclusion of built-in Test Points affects the facility with which checking, adjusting, and troubleshooting can be accomplished. Alignment and Adjustment controls and displays must be designed for rapid, nonambiguous, and conclusive determinations. Test Equipment must correlate quickly and efficiently with the equipment. Whenever absolutely essential, the needs of the equipment for special Test Equipment, Tools, or Lubrication should be fulfilled by concurrent design, but more essential is the endeavor to obviate special requirements by design adjustments.

Each of the elements of maintenance is also variously affected by conditions of field use. Environment of Use and the Repair Environment under which maintenance must be performed are the first and most obvious controlling variables. Environment of Use affects the performance of preventive maintenance. Equipment in open field use will require more frequent and extensive preventive maintenance than that housed within a shelter, and even the type of shelter will have a variable effect. Corrective maintenance will be variously affected by the environment of use (for those minor repairs permitted by user) and by environment under which repair will be performed. Corrective maintenance is further affected by the variables of permissible Down-Time, Facilities (tools, test equipment, work area, and equipment), and Personnel Capabilities.

The effect of the various design factors and conditions upon the elements of maintenance is not a constant. It varies in accordance with the mission of the equipment. Time will not have the same value of importance for mobile equipment as it would for fixed equipment, nor would it be as important for some communication gear as for surveillance items. Facilities such as test equipment, can be extensive and bulky in support of fixed equipment, but would defeat the mission if required to support mobile equipment. These illustrations serve to point out the variables that bear on the mission. Situations of use (or missions) impose varying pressures on the variable conditions under which each maintenance element is performed. Obviously, then, the maintainability of any piece of equipment will depend on the weighted value of these variables, and, if an equipment is of a type to be employed in more than one situation, it may very well have different degrees of maintainability; in fact, it may even have very good maintainability in one situation and very poor maintainability in another.

The USASESA is currently under contract with American Institute for Research to explore this field of variables, analyze the factors for situation, condition, and operations, and develop a system of arriving at an Index of Maintainability for Electronic Equipment.

Approach to the Problem

The purpose of this procedure for deriving an Index of Maintainability is to provide USASESA with a tool for evaluating equipment submitted to it for maintainability review. Ancillary purposes are to provide a systematic basis for identifying design faults, and, to provide the capability for establishing design criteria for the required degree of maintainability to be incorporated in design specifications.

The procedure developed will provide the evaluator with a check list of design features which he can score objectively - either "yes" or "no" - the design feature is present or not, and it will provide a technique for establishing the minimum acceptable score for design factor and condition of use, for each type of equipment to be evaluated.

During the initial phase of the study some 290 design features were identified which affected one or more of the factors or elements comprising maintenance. These provide the basic check list for scoring.

During the second phase methods of determining minimum acceptable scores related to "conditions of use" were explored.

Determination of Maintenance Consequence Areas

To establish the desired relationship between design features and conditions of use, the concept of "maintenance consequence areas" was developed. A maintenance consequence is defined as the way in which inadequate design for maintainability will affect maintenance load and operations, or mission accomplishment.

Analysis of the design features to determine the effect of the absence of each feature yielded a preliminary list of consequences. Analysis of these consequences resulted in refinement and consolidation into five primary consequence areas, namely:

1. Equipment down-time

2. Maintenance time

3. Logistics requirements (personnel, skills, facilities, support equipment, spares, and tools)

4. Equipment damage

5. Personnel injury

Using these consequence areas we are able to relate design features to the standards for maintainability required by the field. This is done by comparing the degree of consequence, or score, resulting from the absence of specific design features, with the tolerance the field has to meet the resultant consequences.

Design Consequences Questionnaire

To determine the extent of the consequences resulting from absence of design features, a Design Consequence Questionnaire was developed (figure 2). This questionnaire was submitted to experienced NCO maintenance personnel at several installations who were asked to score each design feature that would result in the maintenance consequence. The results, after analysis and correlation, will provide a weight for each design feature for each consequence area to which it is related.

Equipment Standards Questionnaire

It was determined that if types of equipment were made sufficiently specific, their maintainability standards would be highly correlated to field conditions. It then became evident that the most effective procedure would be to establish minimum acceptable scores for each type of equipment. The following types of equipment were initially established for use in determining standards.

1. Radio

    a. Airborne

    b. Permanent ground installation

    c. Fixed field emplacement

    d. Mobile installation

    e. Operator carried

2. Radar

    a. Permanent ground installation

    b. Fixed field emplacement

    c. Mobile installation

3. Telephone

    a. Fixed field emplacement.

b. Permanent ground installation

c. Operator carried

4. Airborne compass system

5. Airborne radio direction finder

6. Test equipment

a. Airborne

b. Portable (shop use)

c. Portable (field use)

7. Telegraph

a. Permanent installation

b. Fixed field emplacement

8. Teletype

9. Photographic equipment

10. Recorder-reproducer

11. Power supply

a. Permanent installation

b. Fixed field emplacement

12. Meteorological equipment

An Equipment Standards Questionnaire (figure 3) was developed for submission to field command and Army Staff personnel. In responding they were asked to assess the effect of each consequence area on the effectiveness of an operating unit, or accomplishment of a mission, for each equipment type or group of types which they considered had common requirements.

Maintainability Index

The basic check list of 290 items was analyzed and each feature stated in a manner to permit "yes" or "no" evaluation. For advantageous sequential evaluation the features were grouped according to the condition of the equipment under which they could be evaluated; e.g., operating, disassembled, etc. (figure 4).

Further, the features were grouped into categories of design factors, each factor representing a single characteristic of the equipment, or system.

The 11 resulting design factors are:

1. Displays and controls
2. Accesses
3. Labeling and coding
4. Location and mounting
5. Cables and connectors
6. Fasteners
7. Covers and cases
8. Test points
9. Test equipment
10. Tools and parts
11. Procedures and instructions

Index Format

1. Double page spread in evaluation booklet for each factor. One side, a listing of the design features with space for indicating presence or absence. On the other side, the consequence weights for each feature, a score to sum the consequence weights, and comment section to locate design faults and make suggestions (figures 5 and 6).

2. A scoring sheet on which raw scores are entered and totals are drawn for each consequence and design factor.

3. A conversion table to transform raw scores into standard scores.

4. A summary sheet for profile presentation of the minimum acceptable scores for the type equipment being evaluated, and the profile of the obtained score for the particular piece of equipment evaluated (figures 7 and 8).

Tryouts

After tryout of the check list and the prototype of the Index by AIR personnel, using Signal equipment in their own shop, necessary modifications were incorporated in the procedures and instructions.

The experimental form of the Index resulting from the AIR tryout was then brought to USASESA where extensive tryouts were performed on a full cross section of equipment types by three levels of regular operating personnel. The suggestions and observations resulting from this tryout are now being incorporated in the final form of the Index.

Result

The result of this program represents a significant break-thru in the state-of-the-art of maintainability evaluation. Coincident with the start of FY-60 we will have the tool to enable us to specify the degree of maintainability required of any type equipment, design feature guide-lines for the attainment of the requirement, and the capability of determining the quantitative degree of attainment.

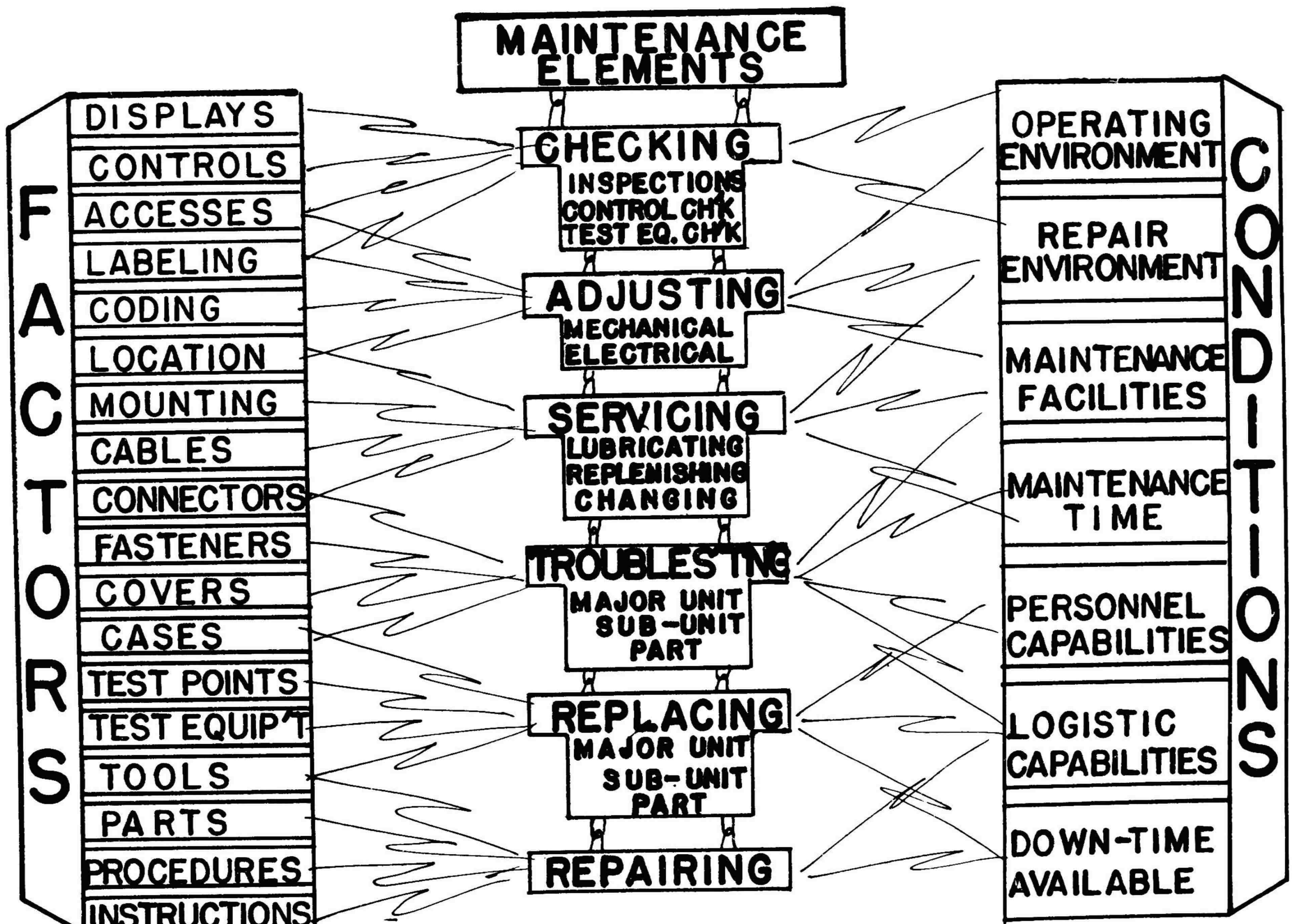

MAINTENANCE ELEMENTS
CHECKING
INSPECTIONS
CONTROL CH'K
TEST EQ. CH'K
ADJUSTING
MECHANICAL
ELECTRICAL
SERVICING
LUBRICATING
REPLENISHING
CHANGING
TROUBLESTING
MAJOR UNIT
SUB-UNIT
PART
REPLACING
MAJOR UNIT
SUB-UNIT
PART
REPAIRING
FACTORS
DISPLAYS
CONTROLS
ACCESSES
LABELING
CODING
LOCATION
MOUNTING
CABLES
CONNECTORS
FASTENERS
COVERS
CASES
TEST POINTS
TEST EQUIP'T
TOOLS
PARTS
PROCEDURES
INSTRUCTIONS
CONDITIONS
OPERATING ENVIRONMENT
REPAIR ENVIRONMENT
MAINTENANCE FACILITIES
MAINTENANCE TIME
PERSONNEL CAPABILITIES
LOGISTIC CAPABILITIES
DOWN-TIME AVAILABLE

Figure 1

DOWN TIME

Is the design feature present in the equipment you are using for your judgments?		Design Features	What is the increase in down time if the design feature is absent?				
Yes	No		Slight increase 1	2	Moderate increase 3	4	Large increase 5
		33. Are units and assemblies mounted so that replacing one unit does not require removal of other units for access?					
		34. Do covers and shields through which mounting screws must pass for attachment to the basic chassis of the unit have large enough holes for passage of the screw without perfect alignment?					
		35. Are parts mounted in an orderly array on a "two-dimensional" surface, and not "stacked" one on another?					
		36. Are the parts mounted on one side of a surface with associated wiring (including printed or soldered circuits) on the other side?					
		37. Are parts located so that other large manufactured parts, such as indicator and magnetron tubes, which are difficult to remove do not prevent access to them?					
		38. Are components placed so that there is sufficient space to use test probes, soldering iron, and other required tools without difficulty?					
		39. Are components placed so that tubes can be replaced without removing assemblies and subassemblies?					
		40. Are components placed so that resistors, capacitors, wiring, etc., do not interfere with tube replacement?					
		41. Are components placed so that structural members of units do not prevent access to components?					

Figure 2

EQUIPMENT DAMAGE

1. 0 10 20 30 40 50 60 70 80 90 100

2. 0 10 20 30 40 50 60 70 80 90 100

3. 0 10 20 30 40 50 60 70 80 90 100

4. 0 10 20 30 40 50 60 70 80 90 100

5. 0 10 20 30 40 50 60 70 80 90 100

6. 0 10 20 30 40 50 60 70 80 90 100

7. 0 10 20 30 40 50 60 70 80 90 100

8. 0 10 20 30 40 50 60 70 80 90 100

9. 0 10 20 30 40 50 60 70 80 90 100

10. 0 10 20 30 40 50 60 70 80 90 100

11. 0 10 20 30 40 50 60 70 80 90 100

12. 0 10 20 30 40 50 60 70 80 90 100

13. 0 10 20 30 40 50 60 70 80 90 100

14. 0 10 20 30 40 50 60 70 80 90 100

15. 0 10 20 30 40 50 60 70 80 90 100

16. 0 10 20 30 40 50 60 70 80 90 100

17. 0 10 20 30 40 50 60 70 80 90 100

18. 0 10 20 30 40 50 60 70 80 90 100

19. 0 10 20 30 40 50 60 70 80 90 100

20. 0 10 20 30 40 50 60 70 80 90 100

21. 0 10 20 30 40 50 60 70 80 90 100

22. 0 10 20 30 40 50 60 70 80 90 100

23. 0 10 20 30 40 50 60 70 80 90 100

24. 0 10 20 30 40 50 60 70 80 90 100

Figure 3

	Yes	No	KO
Test Points (cont.)			
14. (160d) Is an accessible test point supplied at the input and output of each circuit or stage?	___	___	___
15. (90) Are cables "fanned out" in junction boxes for checking if standard test points are not provided?	___	___	___
16. (237) Unless attachment is permanent, do test leads require more than a fraction of a turn for attachment to prime equipment receptacles?	___	___	___
17. (281) Is information provided in the manual about the required signal characteristics and tolerances for each test point?	___	___	___
Cables			
1. (85) Are cables long enough so that each functioning unit can be checked in a convenient place?	___	___	___
2. (88) Can units which are difficult to connect when mounted, be moved to a more convenient position for connecting and disconnecting their cables?	___	___	___
3. (89) Are cable harnesses designed so that they can be fabricated in a shop or factory and installed as a unit?	___	___	___
4. (92) Are cables routed so they cannot be pinched by doors, lids, etc.?	___	___	___
5. (93) Are cables routed so that they are very unlikely to be walked on or used for hand holds?	___	___	___
6. (94) Are cables routed so that they are accessible to the technician and are not under floor boards or behind panels or components that are difficult to remove?	___	___	___
7. (95) Are cables routed so that they need not be bent and unbent sharply when they are connected or disconnected?	___	___	___
8. (219) Has provision been made for easy passage for replacing cables with their attached connectors through walls, bulkheads, etc.?	___	___	___
Connectors			
1. (98) Do plugs and receptacles have painted stripes, arrows, or other indications to show proper position of keys for aligning pins for proper insertion position?	___	___	___
2. (100) Is each plug coded to the receptacle to which it is to to be attached?	___	___	___
3. (101) Are plugs provided which are quickly disconnected?	___	___	___
4. (99) Is each pin on each plug clearly identified?	___	___	___
5. (97) Are plugs designed so that it is impossible to insert any plug in the wrong receptacle?	___	___	___
6. (104) Do aligning pins or keys extend beyond electrical pins?	___	___	___
7. (105) Are unkeyed symmetrical arrangements of aligning pins avoided?	___	___	___

Figure 4

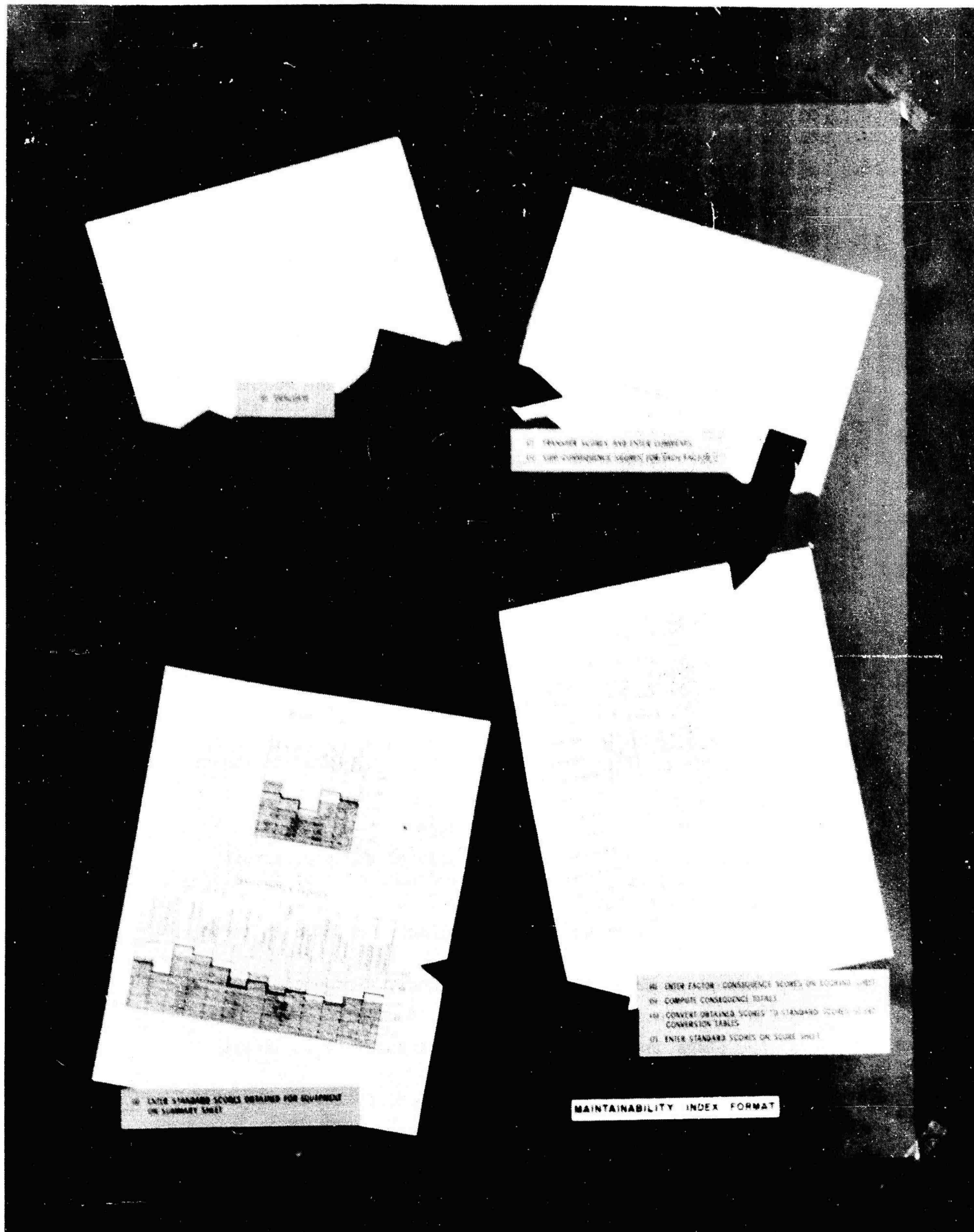


Figure 5 19-16

PRELIMINARY MAINTAINABILITY EVALUATION FORM

INSTRUCTIONS AND MANUALS

	YES	NO	KO
1. (274) ARE STEP-BY-STEP INSTRUCTIONS RATHER THAN PARAGRAPH FORMAT USED TO DESCRIBE MAINTENANCE PROCEDURES IN DETAIL?	X		
2. (277) ARE TABLES AND CHARTS USED WHENEVER DATA ITEMS CAN BE ORGANIZED IN TABULAR FORM?		X	
3. (282) ARE MEASUREMENT DATA REFERENCED TO THE MEASUREMENT PROCEDURES THAT MUST BE USED?	X		
4. (278b) ARE WAVEFORMS AND VOLTAGES SHOWN ON THE DIAGRAM?		X	

(1) EVALUATE

	A	B	C	D	E
1.	1	1	0	0	0
2.	3	3	0	0	0
3.	1	1	0	0	0
4.	2	2	0	0	0

A	B	C	D	E
3	3	0	0	0
2	2	0	0	0
5	5	0	0	0

COMMENTS:

INSTRUCTIONS FOR FIELD REPLACEMENT OF TUBES IS IN PARAGRAPH FORM, p. 32.

SCHEMATIC ON PAGE 63 DOES NOT SHOW WAVEFORMS

(2) TRANSFER SCORES AND ENTER COMMENTS

(3) SUM CONSEQUENCE SCORES FOR EACH FACTOR

Figure 6

	CONSEQUENCES					FACTOR SCORES	
	DOWN TIME	MAINT. TIME	LOG. REQ.	EQUIP. DAMAGE	PERS. INJURY	OBTAINED	STANDARD
FACTORS							
MANUALS	5	5	0	0	0	10	65
DISPLAY-CONTROLS	12						
ACCESSES	11						
TEST EQUIP.	18						
LABELING	10						
LOCATION	20						
TEST POINTS	17						
CONNECTORS	12						
ACCESSIBILITY	9						
FASTENERS	6						
COVERS/CASES	8						
TOOLS/PARTS	12						
MAINT. OPERNS.	10						
CONSEQ. SCORES							
OBTAINED	150						
STANDARD	75						

(4) ENTER FACTOR - CONSEQUENCE SCORES ON SCORING SHEET

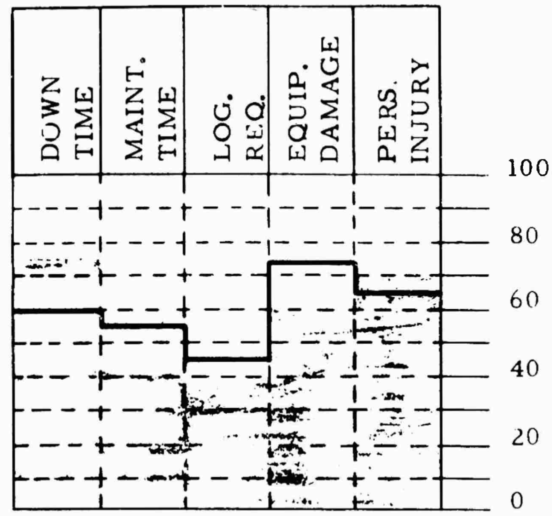
(5) COMPUTE CONSEQUENCE TOTALS

(6) CONVERT OBTAINED SCORES TO STANDARD SCORES USING CONVERSION TABLES

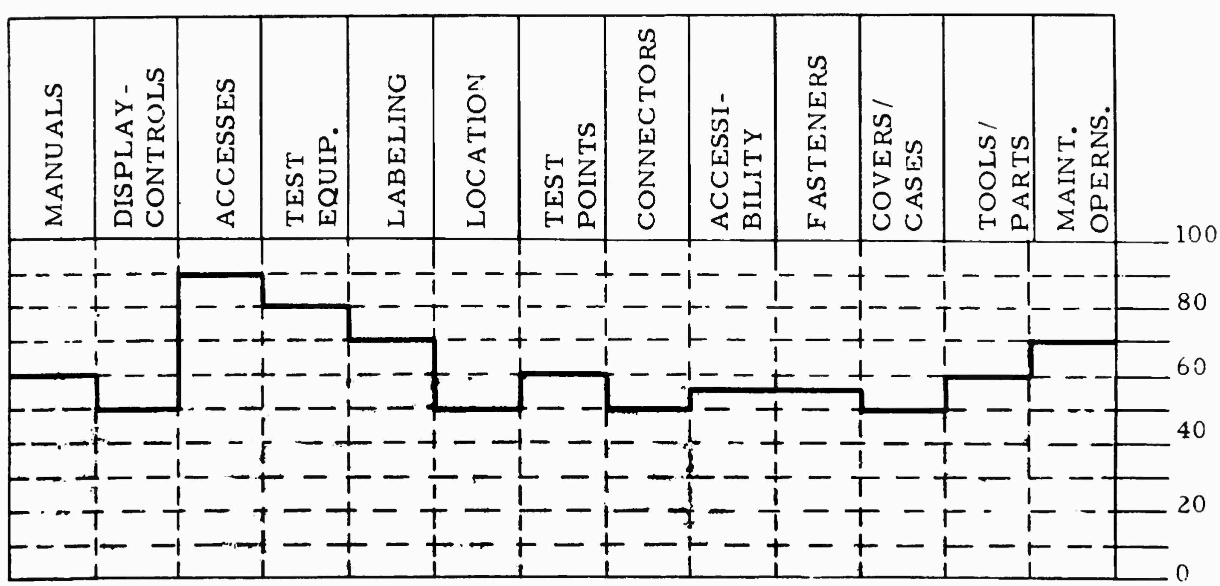
(7) ENTER STANDARD SCORES ON SCORE SHEET

Figure 7

CONSEQUENCE PROFILE



DESIGN FACTOR PROFILE



(8) ENTER STANDARD SCORES OBTAINED FOR EQUIPMENT ON SUMMARY SHEET

Figure 8

COL ROLLA D. POLLOCK, SIGC LOGISTICS EVALUATION GROUP: How long a period of time did it take to acquire the data that you showed in those charts as far as coming up with that much information?

MR. REDFERN: Well, the contact actually started the beginning of this fiscal year. However, a great deal of the material in identifying the 295 design features had already been accomplished by American Institute for Research in previous activities at the institute so that they had a flying start when they went into contract with us.

COL POLLOCK: How long will the contract continue? Or is it still going on?

MR. REDFERN: It's due to be completed at the end of June this fiscal year.

CWO ROY L. ALBRIGHT, HEADQUARTERS COMZEUR: I would like to know (perhaps I missed the point) your total number of equipments evaluated or to be evaluated in the program and the average number of each type evaluated.

MR. REDFERN: Well, there were not a great number of equipments evaluated. Six pieces of equipment representing various types of radio equipments, teletypewriter equipment, and telephone equipment were shipped out to American Institute for Research for their first go around in their own shop; then I think 18 pieces of equipments were used in our own shop here at USASESA, each one being evaluated twice by a team composed first of engineer personnel and second of technician personnel to determine whether or not there was a significant difference in the capability of evaluating in accordance with the procedures established on the same piece of equipment. So actually that is the extent of the numbers of equipment that we used. I might indicate here that we have and are giving serious consideration to a possible follow-through contract, maybe in FY-61, if we can produce that contract at that time to validate the effect of a year's operation of this procedure on actual equipment in the field.

RICHARD M. JACOBS, SYLVANIA ELECTRIC PRODUCTS: This amount of work seems to be quite adequate for evaluating the equipment. How do you propose giving this information to the contractors, such as my company and other companies, in order to ascertain production of the type of equipment that you are looking for prior to the production of that equipment in our pre-bid proposals. This looks like a very excellent second look approach. How do we get the first look?

MR. REDFERN: Well, we are all set for the first part too. As a result of the development of the minimum acceptacle scores for the various types of equipment (these scores are not just one over-all score for the equipment but a score for each design factor and a score for each consequence area), we are able to give you a cross section score as to what the equipment should meet in each of the design factors. In order not to produce too heavy a maintenance load on the field, at the same time, we anticipate producing and making part of the development material the check list data of those features which will give you the score that you are asked to meet if you incorporate them in the equipment. In other words, we are going to tell the contractor what the design features are that build up each design factor and also give him the score as to what those features are worth so that, if he decides that he has to trade off a four-point item, he knows he is losing a possible 4 points on his total score.

MR. JACOBS: This sounds very excellent. The point that bothers me is that this is usually a matter of opinion from what I could see of the questionnaire. There are no quantitative measures which get rid of the bias of personal opinion. This seems to be kind of dangerous, as it is when a contracting agency looks over a quality control system and says you've got a good system or you've got a bad system based on the way you comb your hair.

MR. REDFERN: No. We have actual facts and figures. They were determined originally from weighten estimations but these weighted estimations have come from experienced qualified field personnel, and our analysis of the data indicates they are very practicable. These scores, or these values, will be the same in all instances. In other words, it is not going to vary from one production run to another.

MR. JACOBS: You've answered most of the question but I don't think you've satisfied me regarding the matter of personal bias. If we had a machine to measure, this would do fine -- like measuring the time it takes to get a piece of equipment out of the cabinet. This would be more satisfactory than you or I looking at a piece of equipment and saying it's satisfactory or unsatisfactory regardless of how experienced we might be.

MR. REDFERN: Well, we try to eliminate any degree of judgment in this procedure by the simple method of saying either yes or no when we indicate what the design features are, which will give you maintainability in any one factor area. It's scored either yes or no. It's either in the equipment or it isn't. It isn't half way in; it isn't half way out, even if it is a design feature which may possibly be capable of being in a dozen different places within the equipment. If it is not throughout the equipment, we go whole hog and say it isn't satisfied. Therefore, there is a specific score against that item -- not variable from time to time. It doesn't depend on your guess as to whether it was attained or our guess as to whether you didn't.

MR. R. A. IBSON, GENERAL ELECTRIC COMPANY: With reference to the new proposed MIL spec on maintainability by the Air Force put out by Headquarters, ARDC, and worked over by REDC, and so on, which requires the contractor to justify and to specify in numerical terms the maintainability of equipment he is putting out, do you anticipate that the Army or the Signal Corps will do likewise in anything like the near future --- to place a requirement on the contractor?

MR. REDFERN: Actually, what I can say we will do in the future is purely conjecture because, unfortunately, we at USASESA do not write the development specifications. We hope to influence them. At that time, as I see it, it becomes necessary for the design engineer to qualify his trade offs between reliability, performance, packaging, and so forth, when he does not feel that he can incorporate the full gamut of maintainability features that we have specified are available for the equipment.

New Look in Literature

Col. William Frame
Commanding Officer
U. S. Army Signal Publications Agency

Introduction

I would like to discuss some of the concepts, problems, and improvement areas that are closely associated with the new look in literature. I am sure that these ideas are of particular interest to all of us who are concerned with the maintenance of Army Signal equipment. I am not going to bore you with organization charts and statistics. Statistics always bore me. They are like a bikini bathing suit -- what they reveal is interesting, but what they conceal is vital.

All official Signal Corps technical manuals, field manuals, and other maintenance publications are prepared by the U. S. Army Signal Publications Agency at Fort Monmouth. This literature is utilized for many purposes. The principal use of equipment technical manuals is for operation and maintenance of the equipment. These manuals also form a basis from which training publications and lesson plans are prepared by school instructors.

The New Multipart Technical Manual

The new multipart book plan decreed by AR 310-3 has caused the biggest change in maintenance literature since the inception of the equipment technical manual. This new book plan is vigorously supported by DCSLOG and the Army Maintenance Board and is designed to ease the job of the equipment operator and repairman. This new look in literature already has resulted in simplified presentation of material, more use of picture stories, terse writing, and down-to-earth maintenance data.

Many of you recall, I am sure, the detailed discussion at the last maintenance symposium of this multipart plan by Lt Colonel Curtis of the Army Maintenance Board. Let me briefly outline its features. The major change is the conversion from a one-volume book and separate supply information to a multipart book, with the supply information as an appendix or as a separate part of the technical manual. Technical manuals are published in from one to five volumes to facilitate distribution to, and use by, personnel at each echelon of responsibility. Each part is numbered according to the echelon to which it pertains; for example, a type -10 manual is for first echelon, or an operator's use; a type -20 manual is for second echelon or organizational maintenance use; and so on through the five echelons. Under certain conditions two or more parts of manuals may be combined. For example, a -12 manual is for the first and second echelons; a -34 is for the third and fourth echelons; a -15 is for all echelons, first through fifth. Each echelon is issued its own manual and also the ones pertaining to the lower echelons. Thus, the excessive duplication of data is eliminated and each organization receives only the information necessary for the accomplishment of its mission. For example, the operator will receive the -10 book and no information that applies to a higher echelon for which he has no use. Thus, he can concentrate on his own responsibility.

Each technical manual also includes, either as an integral part or as an appendix, a list of repair parts and special tools authorized to be carried or stocked at that echelon. This list replaces the Sig 7&8 series with which we are all familiar. In the type -20 manuals (second echelon) there is a "maintenance allocation chart" showing the repair operations authorized to be performed by each echelon of maintenance. By putting the appropriate parts of the technical manual for any component equipment with the literature for the major end item, the operation, maintenance, and supply personnel can maintain all the publications applicable to them in one reference file. A "Repair Parts Source, Maintenance and Recoverability Code" column in each parts list shows the availability of material having unusual characteristics.

Implementing this program has required an extensive period of operational adjustment.

Today, we at Publications Agency are presently preparing equipment technical manuals and revisions under the multipart book plan.

New Numbering System

There has been another major change in the technical manual business. The publication numbering system has been completely revised. This new numbering system adds the Federal Supply Classification number to each equipment manual. For example, let us take a look at this chart (fig. 1). This represents a typical breakout of an equipment TM for Radar Set AN/MPQ-4A. The original publication numbers assigned for this equipment were TM 11-1367 and TM 11-1567. You will note that the TM 11-1367 has been changed to TM 11-5840-208-10 and TM 11-5840-208-20. (Incidentally, this chart also demonstrates the multipart book broken out into appropriate echelons.) We note that the first number indicates the technical service which is responsible for literature; in this case, "11" represents Signal Corps. The second number indicates the Federal Supply Classification code; thus, 5840 for radar equipment, as illustrated. The number would be 5820 for radio sets. The third number designates the numerical sequence of the TM. This is an arbitrary control number assigned by the Publications Agency. The last number of -10, -20, -30 and so forth indicates the applicable echelons. The letter "P" designates the repair parts and special tools list.

This new numbering system has been in effect for approximately one year. The changeover is a continuing process; during the transition period, it will be necessary for the man in the field to understand both the new and the old system. All technical bulletins, modification work orders, and lubrication orders on each equipment carry the same numbers as the parent TM for that equipment. This simplifies the filing of the TM and the associated literature in one group and avoids the old problem of not knowing which TM was associated with the other publications. A more detailed explanation of this numbering system, with examples, is covered in a recent issue of TEC-TAC (Number 86).

Avionics

Now a word about literature support of the very important Avionics program (aviation electronics program). Here we have two separate areas of TM preparation to assure adequate and accurate operational and maintenance literature. One is the typical new-look TM on each major component of electronic equipment installed in the aircraft. The other is brand new -- the preparation of a TM on the operation and maintenance of the whole electronic configuration in each aircraft.

Since the individual navigation, communication, and stabilization equipment components are, for the most part, used in more than one aircraft, the typical publications plan is for separate TM coverage of components as follows: the combination of the first and second echelon information into a -12 manual; the combination of the third, fourth, and fifth echelon information into a -35 manual. Sometimes, these equipments are procured from the Navy or the Air Force; in these instances, the initial TM coverage is an authentication of the existing Navy or Air Force publication. However, once these authenticated publications are included in the Department of the Army family they can be changed or even revised to insure their adequacy and accuracy for Army use. In general, we feel that these component equipment TM's do not pose any particular problems.

Our immediate concern in this avionics area is in the field of electronic configuration TM coverage. The electronic configuration may be considered as an approved specific hookup of basic equipments (such as radio sets, navigation gear, and compass systems) and installation items (such as wiring harnesses, junction boxes, and switches). Because the operational requirements vary in different geographical areas, one type of aircraft may have any one of several possible electronic configurations. The aircraft flight personnel are primarily interested in the first (operational) and second (organizational) echelon information; the Signal Corps repair and maintenance personnel are interested from third echelon and up. The Transportation Corps has overall responsibility in requirements, budgeting, and logistics for Army aircraft, including the publications for these aircraft. Thus, the present publication planning for electronic configurations in Army aircraft includes:

1. Integration of the first echelon and the second echelon configuration information within the Transportation Corps -10 manual and -20 manual, respectively. In the -10 manual, the aircraft pilot will find simplified preflight and operating instructions.

2. The preparation of a separate -35 manual for use by the Army Signal repair personnel.

This approach is consistent with the current thinking in other fields - notably in the missile field - where all data required by the operator and organizational man, regardless of technical service origin, is integrated into the one manual prepared for that man. For this avionics configuration literature, our first priority is manuals for the new aircraft being procured by the Department of the Army. We also must cover the various existing configurations for the in-service aircraft.

Service-test Literature

"The new look" in literature includes a longer range look at the overall publications cycle for an item of equipment. Briefly, we can group the equipment literature coverage into the phases of development, service test, production, and upkeep. The provisions of AR 750-6 directly affect the literature coverage in the service-test phase. Many of you recall the recent detailed discussion of this regulation by Colonel Pritchard of the U. S. Army Maintenance Board. From a literature point of view, this regulation requires that the Signal Corps -- as well as the other technical services -- insure that preliminary drafts of parts I and II of the TM (the -10 and -20 manuals) accompany the service-test model of the equipment. These drafts are prepared in accordance with AR 310-3. The purpose is a good one -- to service test the literature at the same time that we service test the actual equipment. Although the AR requires drafts of only the -10 and -20 manuals, we also include additional "technical instructions" -- actually the most pertinent higher echelon maintenance data, such as schematics, wiring diagrams, voltage and resistance charts, and necessary disassembly procedures. To complete the service-test phase, there is a literature portion of the questionnaire that accompanies each equipment forwarded for service test.

What is a Technical Manual?

I consider that a TM is many things to many people; but it cannot be all things to all people. A TM is a source of information on the equipment while the student is learning; then the TM becomes a reference and guide for installation, operation, theory, troubleshooting, and repair. The supply man uses it to identify piece parts and as an authorized basis of repair parts issue. The logistics officer uses the TM for overseas logistics planning; he wants weights and dimensions for shipment and storage. The inspector of repaired equipment at any echelon is concerned with the technical procedures and technical standards outlined in the higher echelon portions of the book.

However, there are some things that the TM cannot be. For example, it cannot be arranged as a daily lesson plan in teaching sequence, for the scope and sequence change too often. It cannot replace the training of men or be a substitute for common sense or experience. There are some things that I feel are basic in what you expect to read in your TM; such items as correct and complete information (our concept of accuracy and adequacy). Also, we look for simplified and to-the-point type of presentation with adequate functional illustrations. There are some things we would like to include in a equipment TM. These items include such things as frills, text and illustrations in the "nice-to-have" category, detailed, profuse illustrations, extensive use of color printing, but most of these items are specifically prohibited by the AR's that guide us in our publications planning.

New Areas of Work

There are some current aspects of publications work that I feel are of particular interest to this symposium. For example, we have just completed a new fundamentals manual covering transistors and their use - TM 11-690. This transistor manual is written for the electronic technician who has a limited mathematical background but who understands AC, DC, and electronic tube theory. This book presents elementary molecular and nuclear theory in a new way, using illustrations of a 3-dimensional crystal structure to explain the concept of transistor conduction. This presentation permits the reader with a limited education to understand how a signal is amplified without having to learn involved mathematical formulas.

However, there are some readers whose understanding can be aided by having a mathematical explanation. A separate chapter has been prepared, based on a knowledge of high school algebra, to provide the formula and equivalent circuit theory. This chapter may be omitted by those with a non-mathematical education without disturbing the continuity of the presentation.

The coverage in this manual is very detailed and includes a non-mathematical treatment of a wide variety of audio, radio, radar and data processing circuit applications. Such subjects as parameters, characteristic curves, amplifier analysis and biasing methods are covered. This manual becomes important because it is a basic manual in a new and vast field. When can you requisition this TM? When TAG and GPO get it printed. We hope that will be within the next month or two. Watch for its listing in DA Pam 310-4.

Also in the fundamentals field, we are preparing a new low-level mathematics manual slanted specifically at the Signal user. We expect that this manual will be completed and forwarded for printing this year.

In the publication standards field, we have a continuing workload in effecting better methods of presentation, more appropriate writing levels, and specific coverage of the maintenance information required. For example, we recently conducted a world-wide literature survey slanted specifically at a typical equipment TM. The results of this survey plus the comments included in the individual questionnaires have been screened, and the raw data tabulated on EAM cards. We hope that the detailed analysis and interpretation of these data will help us improve future TM's.

At present, we are working on suitable methods of presenting schematic and wiring diagram information for printed circuits. The existing drafting standards are not completely satisfactory in this area.

A very important area in the standards field is the pressing problem of loose-leaf format. As many of you may recall, this was a subject of discussion and comment at the last maintenance symposium. Generally, loose-leaf format is not favored by the existing Department of the Army printing and publications regulations. We have had some success in justifying an occasional loose-leaf format; however, we have not been successful up to now in getting loose-leaf across the board. Since the cost of present day printing is high, economy is still the watchword in the whole Department of the Army printing program -- although sometimes we may feel that the printing control tail is wagging the publications dog. However, here is a compromise plan we hope to work out to gain the major benefits of loose-leaf manuals and still overcome the existing objections to them. The most common breakout of a typical equipment TM is a -10 manual for the operator, a -20 for the organizational maintenance man, and a combined -35 manual for the third through fifth echelon maintenance man. We are proposing that the third, fourth and fifth echelon TM's (or any combinations thereof) be printed loose-leaf. The lower echelon books, the -10's and the -20's, would continue to be printed as bound publications. This procedure would not only greatly simplify the use of the higher echelon book but would make it much easier to keep manuals up to date.

Submission of Comments

As a final word, I want to admit that in the literature business we have many problems and not enough solutions. This is a load which we cannot bear alone. We need your help. Though we strive with every facility at our command to produce as perfect a book as possible, we know that errors and omissions occur. For this reason, we conduct a continuing review of all our manuals, and, whenever justified, we prepare changes or revisions. In each one of our manuals (figure 2), we solicit comments from the TM user, and I can assure you that when we receive them, we give them close attention.

We do receive all kinds of advice, guidance, and suggestions from the various interested Agencies and staff activities of the Department of the Army, sometimes too much. But from the user - particularly the maintenance personnel, we hear--practically nothing. I want each of you to take this plea back to your units and organizations. Send in your comments or suggestions, even if you think they are inconsequential or unimportant; it is only through your recommendations that we will know how to serve you better. So write to us, telephone us, or talk to us, but tell us how we can improve our product, Signal Corps Literature. You can use the DA Form 468, the DA Form 2028, or any variety of written correspondence.

We are particularly interested in specific comments on operating procedures, schematics, wiring diagrams, voltage and resistance charts, and differences between the actual equipment and the coverage in the particular TM. In fact, we want to hear about anything you think will improve the TM. I previously discussed loose-leaf format. I hope you will tell us the reasons why you need loose-leaf manuals. The physical evidence of your written comments will help us justify a change in this major printing policy.

I hope we hear from you.

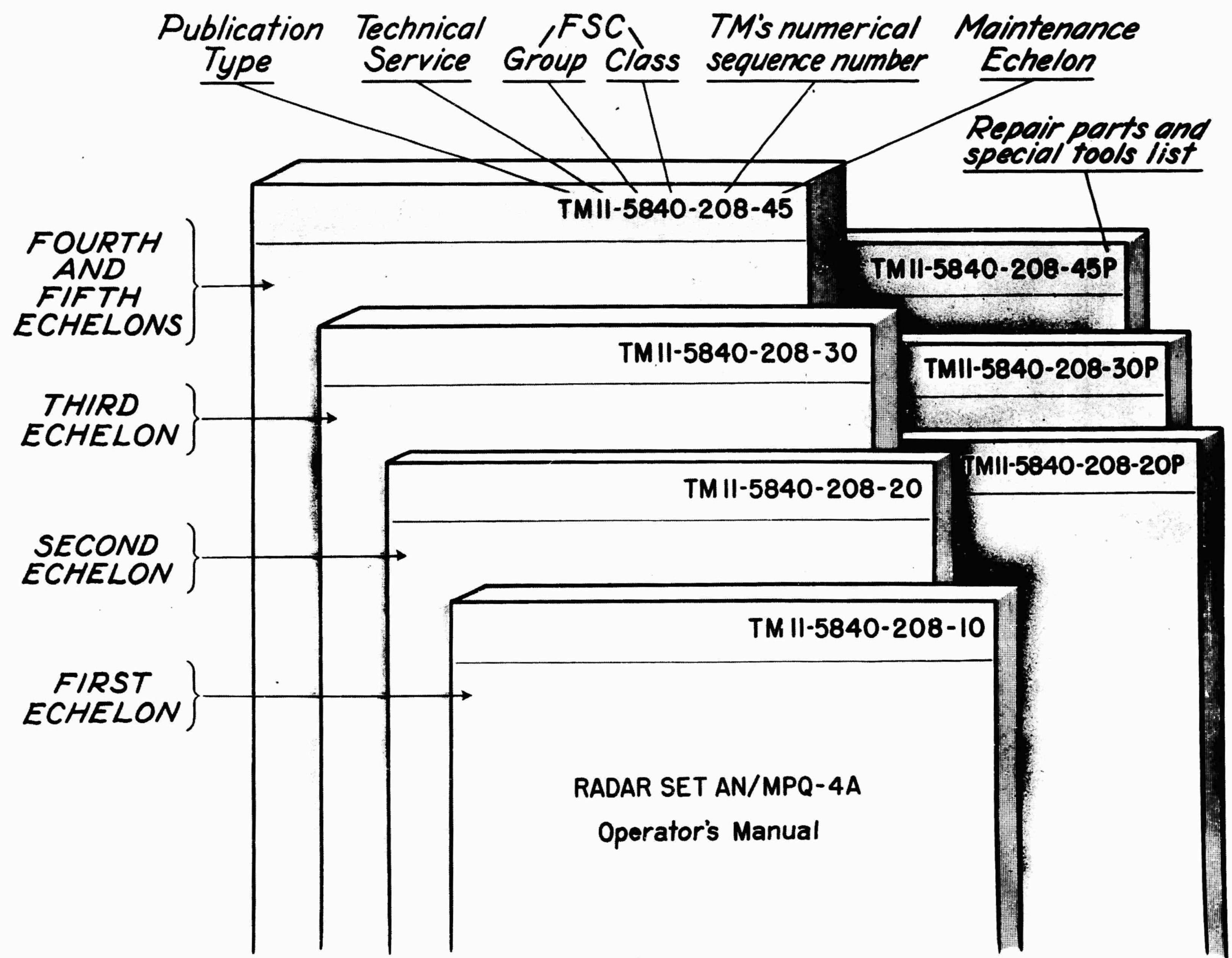

Publication Type
Technical Service
FSC Group
FSC Class
TM's numerical sequence number
Maintenance Echelon
Repair parts and special tools list
FOURTH AND FIFTH ECHELONS
THIRD ECHELON
SECOND ECHELON
FIRST ECHELON
TM11-5840-208-45
TM11-5840-208-45P
TM11-5840-208-30
TM11-5840-208-30P
TM11-5840-208-20
TM11-5840-208-20P
TM11-5840-208-10
RADAR SET AN/MPQ-4A
Operator's Manual

Figure 1

CHAPTER 1
THEORY

Section I. GENERAL

1. Scope

a. This manual covers field and depot maintenance for Telephone Signal Converter TA-187/U. It includes instructions appropriate to third, fourth, and fifth echelons for troubleshooting, testing, repairing the equipment, and general instructions for maintenance parts replacement. It also lists tools, materials, test jigs, and test equipment used for third, fourth, and fifth echelon maintenance. Detailed functions of the equipment are covered in sections II, III, and IV of this chapter.

b. The complete technical instructions for this equipment includes TM 11-5805-212-12, Telephone Signal Converter TA-187/U, Operator's and Organizational Maintenance Manual. The repair parts and special tools list will be published separately.

***c.* Forward all comments concerning this manual to the Commanding Officer, United States Army Signal Publications Agency, Fort Monmouth, N. J.**

[illegible] app [illegible] par [illegible] 5, TM 11-5805-212-1[illegible]

2. System Theory
(fig. 1)

Telephone Signal Converter TA-187/U provides a means for signaling and supervision between central offices over trunk circuits which will not pass direct current (dc) but are operating into switchboards using dc for signaling and supervision (fig. 2, TM 11-5805-212-12). A TA-187/U contains the four-wire terminating and signaling facilities for four trunk circuits. It includes four channel units and an oscillator-power supply. Two channel units are designated *group* 1 units and two are designated *group* 2 units. The channel units operate identically except that the *group* 1 units transmit signaling tones of 2,600 cycles per second (cps) and receive 2,400 cps; *group* 2 units transmit 2,400 cps and receive 2,600 cps. A *group* 1 unit at one end of a system must connect to a *group* 2 unit at the other end of the system. The removal or restoration of tone on the four-wire side provides the required signaling indications. Figure 1 is a simplified block diagram of the various circuit conditions in a typical system. The circuit conditions are described below.

a. During the idle circuit condition (A, fig. 1), the oscillator output (2,400 cps or 2,600 cps) is transmitted from both TA-187/U units.

b. When the switchboard B operator initiates a call (B, fig. 1), the converter B oscillator tone is removed from the circuit and the outgoing speech path is completed toward switchboard A. The signal receiving circuit at converter A closes the incoming speech path to the hybrid. The line signal at switchboard A then indicates an incoming call.

c. When switchboard A operator answers (C, fig. 1), the converter A oscillator tone is removed from the circuit and the outgoing speech path is completed toward converter B. The incoming speech path at converter B is completed to the hybrid and the talking circuit is completed between the two switchboards.

d. When switchboard A operator disconnects (D, fig. 1), the converter A oscillator tone is reapplied and the outgoing speech path is opened toward switchboard B. The incoming speech path at B is opened to the hybrid and the line signal at switchboard B indicates that the circuit has been disconnected at switchboard A.

e. Switchboard B operator then disconnects; the converter B oscillator tone is reapplied and the outgoing speech path is opened toward switchboard A. The incoming speech path at A

COL ROLLA D. POLLOCK, SIGNAL CORPS LOGISTICS EVALUATION GROUP: This new TM -- Which one is packed and shipped out with the equipment? I assume that it is the -10. Is that correct?

COL FRAME: That is correct.

COL POLLOCK: Then how is the distribution made of the other copies? -- through the normal distribution of the past?

COL FRAME: We determine the distribution when the book is sent forward for printing, and that original distribution is made by the AG.

COL POLLOCK: Does the contractor actually print some of these first copies as they did in the old days?

COL FRAME: They are all printed by the Government Printing Office.

COL POLLOCK: And they are made in time to go out with initial shipment from the contractor -- is that correct?

COL FRAME: That is correct.

DR. JAMES P. ROGERS, JR., US ARMY AIR DEFENSE HUMAN RESEARCH UNIT: As I recall, AR 310-3 includes a paragraph which authorizes the procuring agency to omit the production of TM's along the line that you've outlined and to substitute instead manufacturers' manuals or handbooks. Do you have any idea as to what extent this is going to defeat the objectives of AR 310?

COL FRAME: No, I can't give you any answer on that.

DR. ROGERS: How does the new look in literature affect the ability of the agencies to provide up-to-date manuals on time? In the past, that has been a problem.

COL FRAME: We in the Signal Corps have not missed a dead line date as yet.

DR. ROGERS: Congratulations!

COL FRAME: Thank you.

COL ROBERT P. TABB, JR., OFFICE OF CHIEF OF ENGINEERS: I gathered in your support of the Avionics group of end items that you put out -10 and -20 on this grouping of items. Is that right?

COL FRAME: The 10 and 20 are part of the operator's manual and appear in the Transportation Corps book. The 3 through 5 would be put out as a Signal publication for the Signal maintenance personnel.

COL TABB: Right. Now the question is, have you incorporated in the actual making up of your 35 (or 3, 4, and 5, depending on how you make it up) maintenance allocation charts, because this would normally appear in the 20, and I presume that your signal maintenance echelons will not always have a -10 and -20.

COL FRAME: Could you answer that, Joe Osgood?

MR. JOSEPH OSGOOD, USA SIGNAL PUBLICATIONS AGENCY: Our present plans are to have the Signal portions of the MAC -- maintenance allocation chart -- in the Transportation Corps -20 book and duplicate it in the 35 book.

COL TABB: Good answer. That's what I was looking for, because this thing is coming up in systems manuals in other areas --- 10 and 20 support systems manuals. Do you have authority to incorporate the MAC in the 35 already approved?

MR. OSGOOD: Yes we do, and we intend to.

COL TABB: What about information which is normally 20 level TM information? Is this duplicated in the 35?

MR. OSGOOD: No, it will not. But actually we have a working arrangement with the Transportation Corps to provide distribution of their aircraft books to whoever needs them, and that will include higher echelon Signal repairmen.

MR. JOHN THOMPSON, P & D DIVISION, OCSIGO: I don't have a question, Colonel. I just wanted to make one little statement which I think will be of interest to the people here at the Symposium. That is that our office has been working with you and with USASESA in the preparation of fourth echelon field maintenance repair standards. This has been going on for some little time, and it is my understanding now that the first 14 of these repair standards have been completed, are in the hands of AG for publication, and will be ready for distribution in the field in the very near future. This project is going to continue for some time until we have all the repair standards written. They will be put out as changes to the present technical manuals and in the future manuals. I believe it is going to be included as a part of the 5-part manual. I am sure this will be of great interest to the people here in the field, and we have a lot of them here today.

MR. MAURICE O'DWYER, USASESA: Is there a current regulation against using a standard three-hole punch on the equipment TM's. Could TM's be supplied pre-punched so that they could be mounted in a notebook of some sort.

MR. OSGOOD: Yes, they can be. They would be bound, but they would still be punched.

CONTRACT MAINTENANCE
OF
SIGNAL EQUIPMENT

P. A. Fritschel
General Electric Company

As a representative of the Electronics Industry with a great interest in the field maintenance problems of military electronic weapons, I am very happy to participate in this Symposium.

First, I would like to establish a frame of reference for my remarks today. The tremendous mobility of the potential enemy, the increase of his effective firepower and the wide choice of weapons in his inventory bring all of us to a realization that our very existence is being threatened. The development of countering weapons, whether offensive, defensive or passive, may demand a Military-Industrial cooperation or relationship that is unique in history. I believe that Industry as a whole feels that the Military must develop a capability for weapon deployment, use and support at the earliest practicable date.

The increasing complexity of our weapons is placing an ever greater demand for highly skilled technical operational and support personnel in our Military Forces. The transition to newer and more modern weapons requires a higher level of training. The problem of the field commander to keep a force trained to combat the newest weapons and strategy that may be deployed against him is causing more and more concern. He is getting electronic aids and data processing capabilities that were not considered realistic a few short years ago.

The industrialist is concerned that the efforts he is expending in use of his capital, facilities and engineering skills are producing weapons that are not or will not be utilized, should the occasion demand, to their fullest capability, which he believes is necessary to counter todays threat. The military man feels that the weapons leave much to be desired; they are too complex, too difficult to use, and too difficult to maintain. The taxpayer, sometimes confused by it all, sincerely hopes the right thing is being done and done efficiently so as to minimize his burden and yet give him the necessary protection. The more astute in these three groups realize that economic factors are a form of weapon in todays total problem.

The staggering cost of maintaining our military inventory is of concern not only to Congressional and Military leaders but also to responsible leaders in Industry. A need for better understanding and communications is at times quite apparent. Today, I would like to comment on some Military-Industrial relationships that have resulted in understandings and communications that I believe have furthered the objectives of all three.

Ten years ago, the General Electric Company, more specifically the Heavy Military Equipment Department, entered into an agreement to provide contract maintenance on what was then considered a complex ground environment radar. Later, other equipments were added to the program. While many factors were involved in the decision, at that time, the lack of skilled technical manpower in the Military was certainly one of the reasons for launching the program.

Contract maintenance as used here includes technical assistance on site, annual overhauls from a central point, emergency team assistance when the requirement exceeds the on-site capability, continuous availability of technical supplies such as parts and test equipment, depot type modifications and rebuilds and a continuing training effort at the using elements. These were fairly large equipments and the quantity to be produced was small. It was hoped the inventory would be minimized by having the manufacturer contractually bound to provide certain logistic support. Since a device of this character was pushing the technological frontiers, it was hoped that modifications and experimental programs could be conducted more expeditiously. Controlled experiments would be possible to determine the effect of employing various personnel skills, the effect of redundancy could be studied, and the effect of pipeline times and repair cycles on provisioning could be examined. It was intended to bridge the gap we all know exists between the development and the tactical field operational use.

This equipment had about 4,000 tubes and provided search, height and fighter director capabilities and certain data handling capabilities simultaneously. Approximately 30 of these systems were to be installed in the 49 states. The contractor maintenance, it was hoped, would result in improved reliability of the equipment. With almost a million parts in the device, the reliability problem indeed seemed formidable.

Since the production was relatively small, only a minimum of equipment could be diverted to training status. Initially, the main training concern was for maintenance personnel.

This program was somewhat revolutionary in character in the Electronics Industry. I mentioned that a good understanding between the two parties was necessary. In viewing it in this light, both parties agreed to certain ground rules some of which in todays light were unnecessary. Others have been proven to be sound business and sound military decisions.

Perhaps a statement I made earlier should be repeated in a different form. That is, that the basic responsibility for military operations vests with the Military. Though maintenance is contracted to Industry, the Military must retain the responsibility of having a usable weapon. In the Industry-Military relationships that were established, this precept was followed throughout. The contract maintenance of this device was in no way to relieve the field commander of his responsibility but was intended to supplement his efforts, and it was hoped that his objectives could be achieved more quickly and more efficiently.

The contractor, on the other hand, was to be held accountable for and measured by his performance in the management area, time on the air, economy of operation and similar factors. A responsible manufacturer has certain management tools and skills that he will apply to his portion of the operation. An interesting study can be made on the actual costs of a contract maintenance operation. Direct labor costs can be misleading unless other costs are also included, such as the overhead burden of social benefits, training, cost of parts, facilities, rentals, etc.

One of the concerns of both parties was the effect of labor or contractual disputes. The possible contractual problems could be ironed out by two parties dealing in good faith with certain protective clauses in the form of options for contract renewal during phase-over.

The usual funding problems existed almost since the inception, and frequently several millions of dollars were "on the cuff," but these problems were all resolved in due course without a single case of service interruption.

In the area of labor disputes over this span of years, there have been several major industry strikes and some Company strikes, but the using Commands, I believe, were not even aware of these difficulties since service was rendered continually without interruption.

Other complex equipments were added into the program and its geographical dispersion broadened. Support is also being rendered to our Military Forces and to Military Aid Programs abroad. Depot activities were established both in Europe and the Orient.

Perhaps the term "contract maintenance" as used in this discussion needs some definition. The refurbishing of old, used electronic equipment could conceivably be included in my definition, but a broad view with the resulting direct benefits as it pertains to new complex modern equipment to be integrated into the military inventory is really what I have in mind.

The contractual maintenance embraced the following:

- Installation Assistance
- Check-out and Calibration Assistance
- On-Site Operator Training Assistance
- On-Site Maintenance (initial)
- On-Site Overhaul (annual)
- On-Site Emergency Assistance
- Depot Support:
  - Technical Supplies
  - Overhauls & Modifications
  - Re-provisioning Data
  - Technical Literature

The objective was to support the military mission by providing these support functions as an adjunct to existing services rather than to supplant them. Speed and economy were goals to be achieved. Various goals were established and success measured against these scales.

In a device so complex (and by todays standards it is not particularly complex) failures initially were frequent. The degree of seriousness of the outages or malfunctions was attacked. Certain failures such as transmitting magnetrons are of course much more serious than the loss of a pilot lamp. Hence, measurement techniques had to be refined and, after a time, effort could be expended on what appeared to be random failures.

Feeding back these failure data continuously resulted in corrective action which led to a fairly high reliability or time on the air. The reliability data generated is today still some of the most valid information available. These data, coupled with information that is currently being collected, will result in savings that may be exceedingly large. The savings to the taxpayer may actually be much greater in the long term than the entire cost of the contract maintenance over a ten-year period.

Initially, the human factors of personal skills and training were not recorded. However, in controlled maintenance, the time to get back on the air, the time to diagnose, the time to affect the repair, the time to get the part and so on must be considered in arriving at the more difficult goals we are striving to reach. In complex missile guidance equipment or vital data processing equipment, the maintenance criteria of even a few years ago are today completely obsolete.

Testing while operating, tape programmed sequential automatic circuit checks, or special exercise and solution checking equipment are becoming commonplace. Now we have problems in the maintenance area by having to have special equipment to check our test equipment. However, in the final analysis, maintenance is still done by people or the action is directed by people. And people, unless they produce, are expensive, in terms of time, money, and sometimes even in materials improperly applied or purchased.

One of the precepts established was that the majority of parts utilized should come from bulk procurement in military channels rather than small quantity procurement. Thus, the price advantage of bulk buying could be utilized. A procedure was set up whereby military stocks could be utilized to obtain such supplies. On the other hand, there are certain non-stock-listed items or non-provisioned items that are required which the contractor must obtain on short notice from whatever sources may be available. It is understood that in true emergencies midnight "over the fence" requisitions may even have been resorted to. The problem of source inspection and the like were worked out without difficulty.

On another contract, an exceedingly large and complex device was completely installed with its associated equipments and placed into operation in three months elapsed time. This equipment, never before assembled as a complete unit, under contractor maintenance operated for the first six months, 24 hours per day, seven days per week, with a total of 1% time off the air.

Over a two-year period, under contractor maintenance, the time off the air has been less than 1%. In this case, the contractor is responsible for the entire support inventory. These reliability figures include failures for all causes. One of the causes of outage time is the main primary power plant.

The initial installations were enlarged considerably and many additional tons of electronic equipment that push the state of the art were added later. A surprising statistic is that the operational reliability of the greatly expanded system, that is the ratio of operational availability time to non-available time, has remained essentially constant. The reason, at least in part, lies in the career type manpower assigned to the project. The contractor also has training problems when new devices with many innovations are added to existing installations. The planning and scheduling of such training is a critical item in a compressed timetable.

The less complex equipments, such as simple test equipment or certain high density items in the data handling areas, which have been maintained by this contractor, are handled more or less as ancillary equipments to other contracts. For example, about 500 items of test equipment are overhauled and recalibrated monthly in one repair facility. Some contributions based on industrial experience can be made in these areas; however, the largest benefits probably accrue in the introductory phases of new complex equipments. The monetary cost of contract maintenance versus service personnel maintenance on this type of equipment could be the subject of an interesting study. Assumptions that Government personnel will be on the payroll whether assigned to this project or not, that parts are free, that storage and shop space is free, that capital facilities need not be amortized, and that annual vacation, retirement and other social benefits are not directly applicable will make such studies meaningless, however.

From my previous remarks, it may be inferred that most of the contract maintenance has been done in shops or on the site. Sometimes, mobile repair vans or trucks with packaged repair facilities are used. In general, it is more economical to do the work on base or at a central shop, but when down time during overhauls must be kept at a minimum or other special conditions prevail, moving overhaul teams or calibration and repair units may be the most satisfactory solution.

Looking back over the last ten years of contract maintenance (both commercial and military) perhaps a few observations as to results may be of interest.

It is difficult to provide skilled technical personnel early in the introductory phases of a weapon. Each product or weapon should be considered on an individual basis to determine the most expeditious and economical method of integrating the weapon into the inventory. In some cases, a depot system may be required; perhaps an existing military depot or special one should be utilized. In other cases, mobile teams with workshop vans may be the answer. In some cases, the support is limited to the weapon site itself. It is perhaps dangerous to draw general conclusions but on large low density equipments the on-site capability may prove the best solution. In small high density portable equipments various echelon schemes will probably be the best answer.

I believe a support program of this nature greatly speeds the day to a more reliable equipment. An interesting by-product of this program was data collected by the contractor's representatives at the site during the overhauls and during the shop work. These data can be plowed back into the reprovisioning. This is especially true if the contractor has a stake in it. Also, the data collected was a carefully controlled sample which has resulted in reliability forecasts for similar applications and this has been used in several designs of new equipment, especially in the missile area. The day is not far off when we will be able to predict failure rates on almost any component in stated environments. The more complex our equipment becomes, the more vital this information becomes. The increasing complexity of our equipment must be matched by an increasing reliability of our devices lest the economics of maintenance forces us to our knees.

Modifications for equipment improvements or modifications to correct malfunctions can be made many times quicker than with any other procedure that we have had experience with. In most cases, the approvals to provide a change took longer than the design, fabrication, installation and check-out of the modifications.

Contractor maintenance should result in useful by-products in the reliability area.

Contractor maintenance cannot solve many of the supply problems if military supply sources are used.

Contractor maintenance should have certain established goals that can be measured and understood by supervisory personnel.

Contractor maintenance can be utilized in achieving military training goals but this should be planned as carefully as work flow or supplies.

Contract maintenance will be most effective and economical if it is not hampered by needless red tape, specifications and myriads of unused reports.

Contract maintenance with incentives should be investigated.

Price alone as a criteria may not result in achieving good contract maintenance.

If the timetable or development to field use is important, contract maintenance has many advantages.

The dangers of contractor maintenance in times of contractual dispute or labor strife appear to be exaggerated or they can be minimized.

Contractor maintenance is not the answer to all maintenance problems -- far from it.

In time of war, workmanship and performance standards should be high but "appearance" standards should be carefully examined. Quality Control procedures are necessary but they should be realistic and contribute to the objectives of economy and a satisfactory end product.

Maintenance experience, especially on early production units should be utilized by designers, manufacturers, trainers, technical writers and supply people.

Maintenance personnel on complex devices should have a reasonable tenure and incentives should be considered.

Preventive maintenance can be overdone. Run to failure (or to destruction) can also be overdone. Cost models should be analyzed.

Test equipment requirements should be analyzed, weighing unit cost, skills required, frequency of use, shortage penalties.

Loss of capability in wartime is probably overstated. Two parties of integrity, dealing in good faith, each understanding the objectives, can solve all contract maintenance problems that are likely to arise.

In summary, I would like to say that it is my opinion that with new and complex electronic weapons or sub-systems much can be gained from contract maintenance on the part of the producer. Both parties and the taxpayer benefit. The time saved in integrating a weapon into our inventory may, at a future date, spell the difference between our survival or our destruction.

PG Fritschel
2/26/59

DISCUSSION

COL SELMER J. ESPELUND, USA LOGISTICS MANAGEMENT CENTER: My question has to do with contract technicians. Do you feel that the present controls -- I'm speaking of the military -- are satisfactory, or do you feel that we should have a more centralized control of contract technicians.

MR. FRITCHEL: I don't know that it makes a great deal of difference to us contractors. I think most contractors who manufacture equipment are interested primarily in getting their equipment to function satisfactorily at the earliest possible date, and the contractual means and procedures, I believe, are really secondary to the average manufacturer. I realize that there are some other people in this business who might be in a little better position to answer your question than I am. I am, this morning, referring to an overall program here. Now, whether the contract technician is controlled from a central point or by the commands -- Would this really be the intent of your question? -- I know to us it doesn't make a bit of difference as long as the service rendered is satisfactory.

AVAILABILITY OF TEST EQUIPMENT FOR CONCURRENT DELIVERY WITH NEW EQUIPMENT

Samuel Kirschner
U. S. Army Signal Equipment Support Agency

When offered the opportunity to prepare a presentation on test equipment availability concurrent with new equipment delivery, many thoughts come to mind. At the outset, the broad area covered by this subject was clearly apparent. Furthermore, a review of presentations offered at last year's maintenance symposium distinctly indicated the timeliness of the subject.

At the 1958 Signal Maintenance Symposium a good deal of the discussions seemed to center around a hidden agenda item, availability. Col. Copeland noted the necessity of purchasing many nonstandard items of test equipment because standard equipments were not available through normal supply channels. He went on further to mention the maintenance problems associated with these nonstandard equipments. Mr. Williams of Ft. McPherson, Ga. discussed the problem of planning and acquiring the shop test equipment for the maintenance support of new equipment prior to its introduction date. Mr. Haas of Presidio, San Francisco, expanded on this, in terms of availability of information and test equipment for the support of new items. Col. Pritchard, Pres. of the U. S. Army Maintenance Board defined a segment of AR 750-6 "Maintenance Planning, Allocation and Coordination" as providing guidance for test equipment planning, and among other areas, for better provisioning criteria; and as Col. Pritchard so capably equated the factor of time as basic and vital to all aspects of maintenance training, I similarly (with the Colonel's permission) would like to equate this same factor with the subject of this presentation. Time as underscored and unquestionably recognized as that element required to perform a series of related actions, following in programmed sequence which will assure the availability of test equipment for concurrent delivery with the new equipment. Test equipment for the field technician at all echelons, for the training instructor in the technical service school, for the Service Test Board evaluation of the new item, yes, even for the new equipment contractor for the development of the technical maintenance literature and repair standards. The best conceived maintenance planning program, using all the expert technological skills, loses its real value if adequate timing is not applied. At this point, the concept of availability should be defined. Availability means many things to many people. To the field technician, it is synonomous with "does the item appear on his TO&E or TA as authorized equipment." To stock control or Supply Agency personnel, availability is recognized as an item either in procurement or in the supply system. The availability of procurement data identifies certain items as available, notably to procurement personnel. To the maintenance engineer at our Support Agency, the question invariably is: "Has the item been successfully procured, and is it available as a commercial off-the-shelf item or is development required?" From the foregoing, it would appear that the term availability has a definite ring of many meanings, all, I might add, having real significance. Obviously the ultimate objective of all these definitions can be summed up in "is the test instrument located where the user can flip the switches and manipulate the controls to perform his operational test and maintenance functions."

It is apparent therefore that the programmed sequence of actions in developing a maintenance plan which will assure the availability of test equipment must be triggered at the earliest practical stage in the development of the prime item.

The first step down this long path is the formulation of a maintenance concept which will assure adequate support and a minimum of down time of the equipment. This concept must envision the maintenance procedures which will be required at all echelons and the skill of the field technician who will be required to perform these functions. Above all, the Department of Defense and Department of the Army directives govern the scope of this equipment design review and, therefore, essentially form the basis for determining requirements for:

a. Built-in Test Equipment -- as an integral part of the prime equipment to perform a specific test or measurement considered vital to an adequate evaluation of the operational readiness of the prime equipment. In some instances, this type of test equipment is provided to perform periodic adjustments as may be required by the operator or forward echelon technician. One thing we can say for sure, this equipment enjoys the highest probability of being available for concurrent delivery with the new equipment. (Figure 1).

b. Go-No-Go Test Equipment -- for rapid fault location using predetermined parameters or tolerances for quality appraisal. This type of test equipment is most often provided at organizational and, sometimes, field levels of maintenance for a simple but positive determination of the component circuitry's condition and for other relative requirements. In most cases, no real challenge to availability is posed by this type of equipment since these items are generally not of a complex nature. They may be built-in or separate equipments. (Figure 2).

c. Automatic Test Equipment -- for accelerated fault isolation of a malfunction or performance deterioration through a programmed sequence of test measurements. Considerable effort is now being expended to develop this type of equipment for use at all echelons of maintenance to meet the urgent need of some of the highly complex military systems now in development. The impetus of the military development programs for greater use of module construction techniques coupled with the more intricate design of electronic circuitry in the new equipments has created requirements for this type equipment not heretofore encountered in military history. The electronics industry, as well as the military programs, has undertaken extensive studies and has made considerable progress. With all this effort, only the surface has been scratched and a great deal of work lies ahead. Much of the military policy and doctrine needs to be established to equate automatic test equipment with maintenance concepts. Therefore, in this area there are no good examples of standard military items and hence no pictures. However, some available module test sets now in development and production seriously lend themselves to automation techniques. Several commercial automatic test equipments have been carefully reviewed for Signal Corps adoption, but no nomenclature or standardization action on these has been taken to date. (Figure 3).

d. General Purpose Test Equipment -- in common field use for the maintenance support of many prime equipments and successfully procured one or more times. These draw first attention in this initial maintenance planning effort since they are recognized as offering immediate availability for delivery concurrent with the new equipment and in many instances are most familiar to the field technician. In this category we find such items as the TS-505/U Multimeter, the AN/URM-25 and AN/URM-48 Signal Generators, the TS-382/U Audio Signal Generator, the OS-8/U and AN/USM-50 Oscilloscopes, and many others of a similar nature (figure 4). Military and industrial development projects are now being processed to supplement this impressive array of general purpose equipments which reflect the technological progress in the state of the art. These will be made available for the maintenance support of the new equipments at the earliest practicable date.

e. Special Test Equipment -- comprising individual or an integrated group of items capable of adequately testing a special or proprietary characteristic of the prime equipment to a given specification, for all criteria of operation or maintenance unique to the system under test. This equipment is further defined as an individual or integrated assemblage of items required to perform a specific test which does not exist either in the Department of Defense supply system or is readily available on the commercial market. This is the area of test equipment which poses the real problem and challenge to timely availability. Typical examples of these types are shown in figure 5. To assure availability and issue of support items such as these in time to meet new equipment delivery, an early determination is made of the detail technical characteristics the items must possess and the most expeditious course of action which will assure success. In this regard, several approaches are considered. First, the items can be developed concurrent with the prime equipment by the development contractor; thus the technical skills and intimate experiences of the contractor with the prime equipment are fully utilized, thereby assuring not only timely delivery but also satisfactory performance. This has a further advantage in that the development of adequate maintenance literature, to be provided concurrent with new equipment delivery, can be more easily realized. This will be discussed more fully later in this presentation. Second, military characteristics can be prepared for processing Signal Corps Technical Committee action to initiate a development program for the items required. This has the obvious advantage of resulting in a fully militarized item representing a high standard of quality. On the other hand, a full-scale development project generally results in the test equipment lagging the new equipment delivery which in many instances poses a serious maintenance problem. Further, with the numerous design changes that take place during the course of the new equipment development, the test equipment effort could prove woefully deficient. Other problems are inherent in this method of approach.

In some instances, serious consideration is given to the possibility of providing timely availability of test equipment by means of modifications of existing items where possible. This includes not only Signal Corps equipments but also those in the supply system of the other military services, as well as standard commercial instruments essentially possessing the desired technical characteristics but lacking in some minor respects. The success of this approach is demonstrated by many items of test equipment now in use in the field and many more will be seen as time goes on.

It might be appropriate at this time to take a closer look at the detail considerations which make up the Maintenance Planning Data Sheet, since this represents the initial effort towards timely availability of the test equipment.

Within 15 days after the acceptance of the development or service test models (when development models have been waived), the test measurements and tool requirements for the maintenance support of the new equipment are determined. This analysis, to be applied to all echelons of maintenance, includes such factors as:

a. Voltage, resistance, and current measurements.

b. Available test points.

c. Built-in test facilities provided.

d. Alignment and adjustment requirements.

e. Trouble shooting and fault isolation.

f. Testing for combat serviceability.

g. Testing for field and depot repair standards.

h. Lubrication requirements.

i. Tools for servicing.

j. Special tests unique to the new equipment.

For the resolution of these factors, many avenues are explored. As previously noted in this presentation, the general purpose items of tool and test equipment in the Signal Corps Supply System are given first consideration because of their availability prospects. However, if no suitable Signal Corps or Army items exist, the preferred test instruments in the Air Force or Navy supply channels are reviewed for possible application. Adoption of these items afford a comparatively short lead time to assure availability. One serious deficiency in this process is the present lack of an up-to-date listing of all test equipment now in the Department of Defense supply system. This eventually will be corrected when the present program to up-date Handbook H-172 is completed. An additional effort is now being made to compile a listing of all items in the Federal Supply Class 6625. Both publications will be extremely useful in this maintenance planning program.

In the absence of such Department of Defense test equipment standards, the commercial field is surveyed for an off-the-shelf item and action is initiated for nomenclature, standardization, and the development of procurement data. This serves a two-fold purpose, first by stretching the tax dollar in avoiding an unnecessary development effort and, equally important, the time-consuming development is avoided which is so essential to timely availability.

As is no doubt apparent, the maintenance process described up till now is generally not applicable to special test equipments. Availability of these items can only be in time if their design, development, and production are processed practically concurrent with the new equipment. To repeat, these represent the ever-present challenge and each new system and equipment introduces its specific problems. As a rule of thumb, the more complex the new equipment, the greater the challenge.

To illustrate a few typical cases, consider a surveillance system in which highly complex coded pulse signals are fed from the antenna system to computer and indicator segments. To test effectively the performance of the computer and indicator when removed from the antenna for maintenance, a test instrument which simulates the pulse conditions encountered in operation must be made available. This item must be specifically designed to be compatible with its intended maintenance functions. Obviously it will not be found on some dealer's shelf or be tucked away in some depot. It must be developed from "the ground floor up" and generally no short cuts.

This is the sort of thing we try hard to avoid, where possible. We lean heavily on developing measurement techniques which would utilize standard general purpose type test equipments and thereby promote availability.

To further illustrate our availability race with time, consider this. The Digital Element Tester TS-1209/MSG was designed and developed by Hughes Aircraft Co., the contractor for the AN/MSG-4 Missile Monitor, specifically to test the standard digital element cards used in Operations Control AN/MSQ-18 and Coder Decoder Group OA-1593/MSQ-18, both part of the AN/MSG-4 system. This was accomplished concurrent with the prime system. There are approximately 13 type cards involved; in addition, the TS-1209/MSG is capable of testing the transistors and diodes used in these cards as separate components. The tests performed provide isolation of the faulty circuits and the individual components of these cards. No one item now exists in the military supply system of a comparable nature which would provide this functional maintenance capability. The use of existing test equipments would be time-consuming, expensive, and extremely difficult to perform. Action was initiated for the adoption of the TS-1209/MSG as standard.

Subsequent action was started to develop a Universal Card Tester based upon the design of the item now in use by the Hughes Aircraft Co. on their production assembly line. This card tester would be capable of testing all the standard and special digital element cards, totaling 138 different types which represent a population of 259 module packages. It is anticipated that the Universal Card Tester, when repackaged for military application, will eventually replace the TS-1209/MSG because of its more versatile capabilities.

A module package tester for the AN/TSQ-36 Coordinate Data Set, which is also a part of the AN/MSG-4 Missile Monitor, is now being investigated. The AN/TSQ-36 now uses 25 different types of module cards for a total population of 170 cards in each Operations Central AN/MSQ-18 and Coder Decoder Group OA-1593/MSQ-18.

Let's look at another system, Radar Set AN/MPQ-4A. Approximately 120 types of tool and test equipment will be required to provide the operational and maintenance support for this system at organizational, field and depot level. Nomenclature and standardization actions have been processed on these items to assure timely development and availability for this system. Several peculiar equipments are worthy of special attention.

The Antenna Pattern Recorder RD-185/U is unusual in that, normally, antenna patterns are plotted by using a long and laborious method of manual measurements and then transcribed on to graph paper to correlate over-all results. The RD-185/U is designed to record the antenna pattern automatically and in a short period of time, facilitating antenna adjustments quickly and accurately.

Measurement of high voltages, in the order of 14 kilovolts, without loading of circuitry, is performed by Electrostatic Voltmeter ME-147/U. The instrument provides the maximum safety to the user and precludes a false voltage reading.

To maintain this radar set in a high state of readiness and to perform the many tests and measurements to achieve the full military effectiveness of this system, practically every conceivable type of general purpose test equipment was provisioned. The somewhat complex nature of the system demanded this approach. As a matter of fact, one maintenance kit alone, Test Facilities Kit MK-387/MPQ-4, consists of 37 cable assemblies, two power supplies, and other miscellaneous items, each essential for proper maintenance support.

I could go on to describe the maintenance effort being applied to timely production and delivery of test equipments for new radio, wire, and radar systems for combat surveillance, target acquisition and others for present concepts of weapons system. Incidentally, this is not limited to individual items of test equipment but also applies to complete bench mock-ups, test facility kits, maintenance kits and maintenance support vans and trucks.

A brief glimpse of the size of this program is demonstrated by the approximately 250 Maintenance Planning Data projects which have been prepared and processed during the past year, with many more in various stages of formulation. This represents maintenance planning on not only prime systems but also on the items of test equipment required to support these systems. Coupled with this we have approximately 368 nomenclature and 72 Signal Corps Technical Committee actions completed or awaiting finalization for this same period.

Only the time limitation scheduled for this presentation prevents me from discussing the availability problems associated with the avionic systems, photographic equipments, radiac instruments, special test equipment for training purposes, and for service test with the new equipments. I would, therefore, like to turn to only one other aspect of test equipment availability, the requirement for technical literature.

In the development of adequate and timely technical literature by the contractor for the new equipment, military field type test equipment must be made available to him. This is essential to assure compatibility of the test procedures with the test equipment which will be authorized and available to the Tactical Army Units. Failing this, substitution or guesswork would only lead to error and confusion. How can this best be accomplished? Standard Procedure P&D-USASSA 11-5.2 adopted 20 July 1956 was established for the principal purpose of realizing this objective. This Standard Procedure required the furnishing of a list of standard test equipments, necessary for the maintenance support of the new equipment, as a part of the procurement clearance processed by the U. S. Army Signal Equipment Support Agency to the U. S. Army Signal Supply Agency. This list would be reviewed by the Signal Supply Agency to determine the availability of the test equipments from stock and, prior to the award of the contract, reserve those items available for GFE to the contractor. Those unavailable items of test equipment would be replaced with alternate or substitute items, where possible, or completely deleted from the list. Such deletion tends to defeat, at least in part, the intent of the Standard Procedure. Several deficiencies are apparent in this procedure, which in the main are contingent upon that all-important factor, availability. In the first place, the stock reservation for the test equipments must be accomplished within 60 days following the clearance of the procurement data by USASESA; however, it is apparent that unless prior planning for these test equipments has been effected to include these new needs in the test equipment procurement program, they will not be available when required. In general, the procurement processes requires a minimum of 12 months lead time. Recognizing these factors, it was determined that certain action was necessary to assure test equipment availability. It was considered mandatory that advanced planning is absolutely essential, planning that would allow a lead time well in excess of the minimum 12 months. The present program involves a screening of the fiscal year procurement program for new equipments immediately following the publication of the list of proposed procurements. This will result in an early determination of the test equipments required and in what quantitites. Information on acceptable alternates or substitutes will be furnished only on those items possessing functional interchangeability and satisfying the optimum objective of providing adequate technical maintenance literature. Further experience with this program will demonstrate its effectiveness and gratifying results.

In summary, from the rather brief discussion of this presentation, it should be apparent that many considerations are associated with timely availability of test equipment.

First, each new equipment generally has its own specific challenge which must be met early in the development stage and must change in concept in conformance with the design of the new equipment.

Second, the development of special test equipments concurrent with the new equipment and under the same contract offers the most realistic approach of attaining timely production and availability.

What can we anticipate in the foreseeable future?

The accelerated micro-module program of the Department of the Army offers a distinct possibility of a major reduction of over-all maintenance and logistic requirements.

The automation study now being conducted by USASRDL to be followed by the development of equipments may result in decrease in the number and types of test equipment required for maintenance support of the new equipments thereby easing the availability problem.

The functional circuit standardization program, described by Mr. Frederick Everhard of the RCA Service Co. in the 1958 Maintenance Symposium, for test equipment may provide the versatility for a reduction in new design to enable timely availability. The need for certain types of special test equipments could be satisfied with standard type modules with the addition of a limited number of special modules.

The promulgation and up-to-date maintenance of a Department of Defense Test Equipment publication from which standard test equipments can be selected will offer real value for a minimum delay to timely availability. This publication is now in preparation.

The standardization of test procedures will promote maximum use of general purpose test equipments and substantially reduce the requirements for special test equipments. This area is now being explored and promising results are indicated.

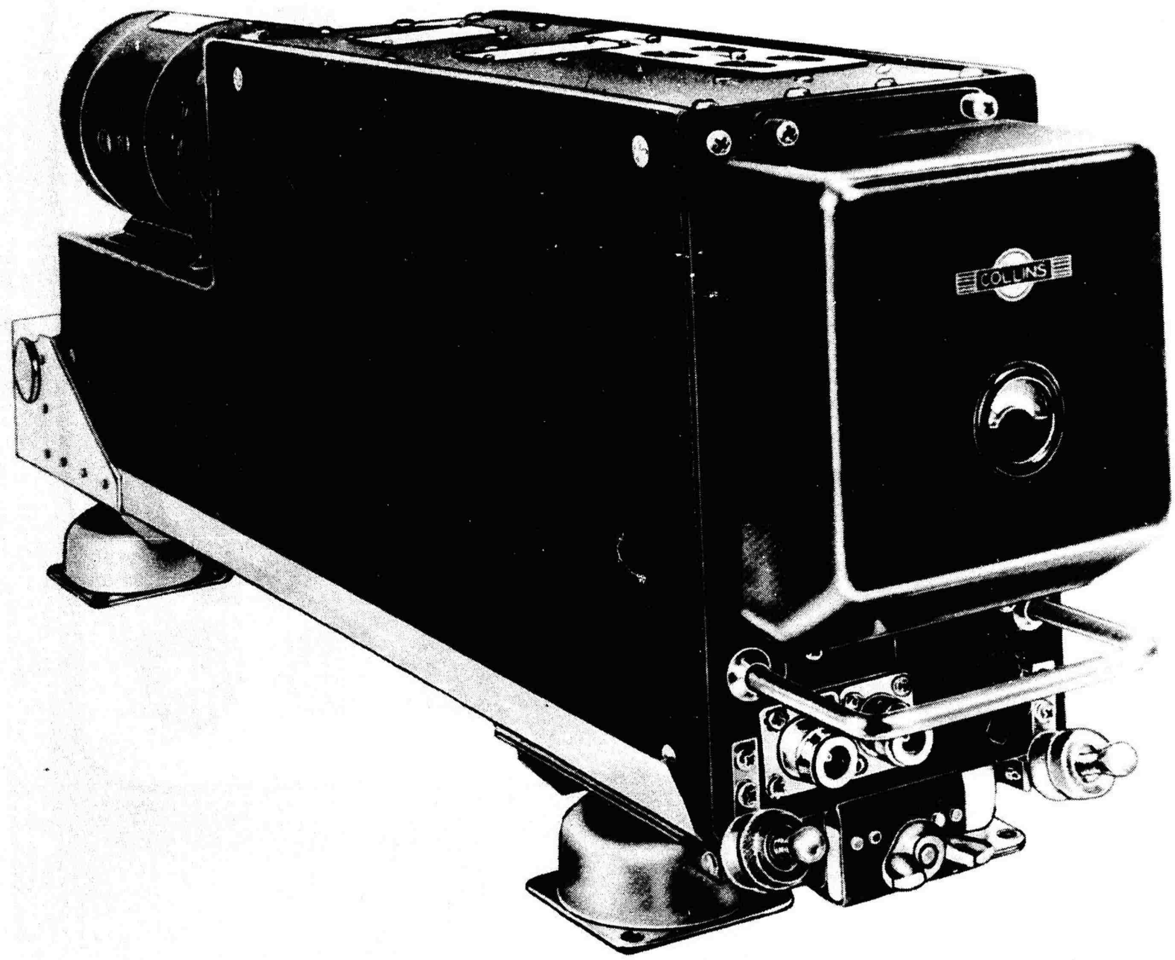


Figure 1

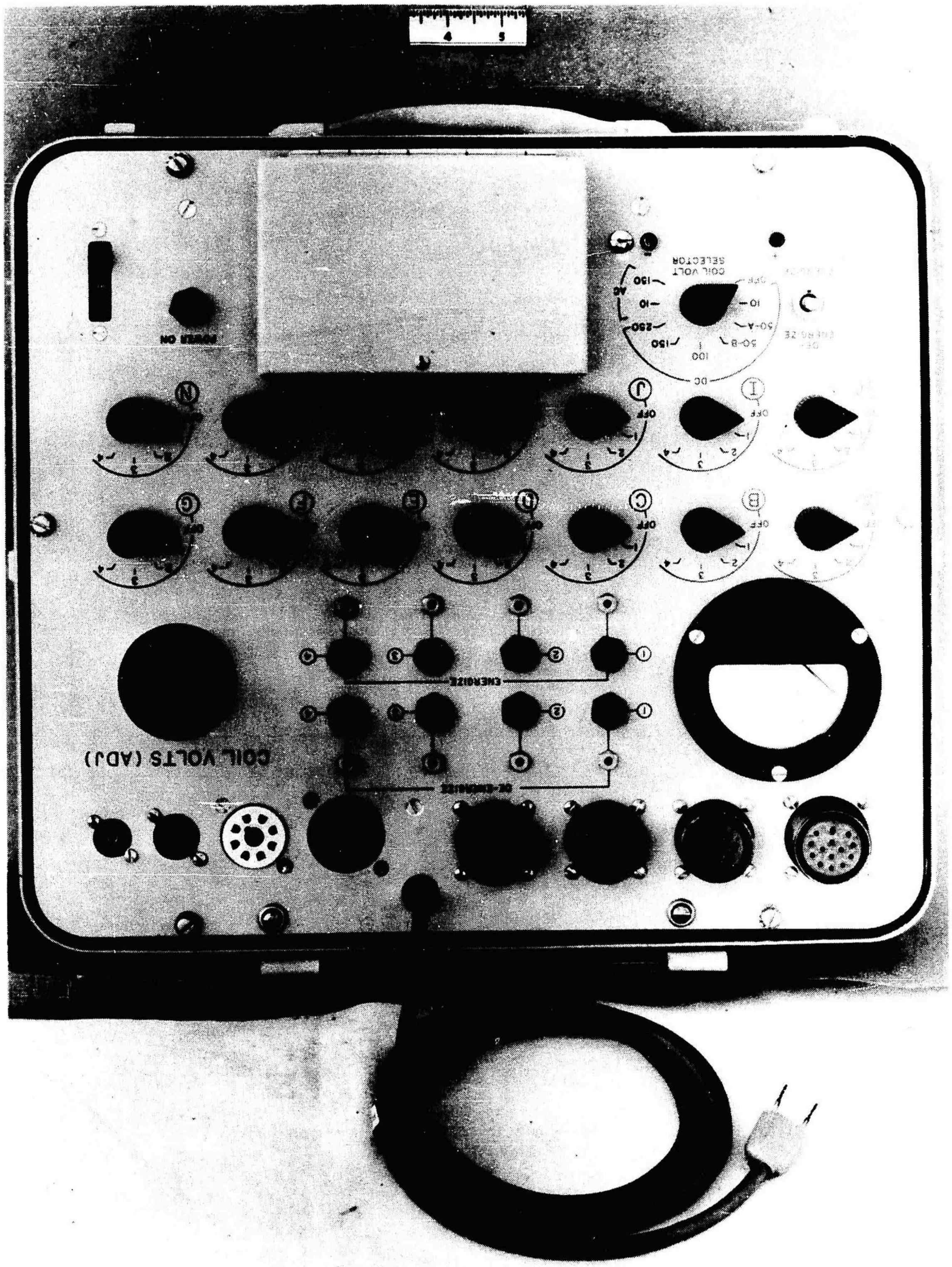

COIL VOLTS (ADJ)
POWER ON
COIL VOLT SELECTOR
ENERGIZE
DE-ENERGIZE

Figure 2

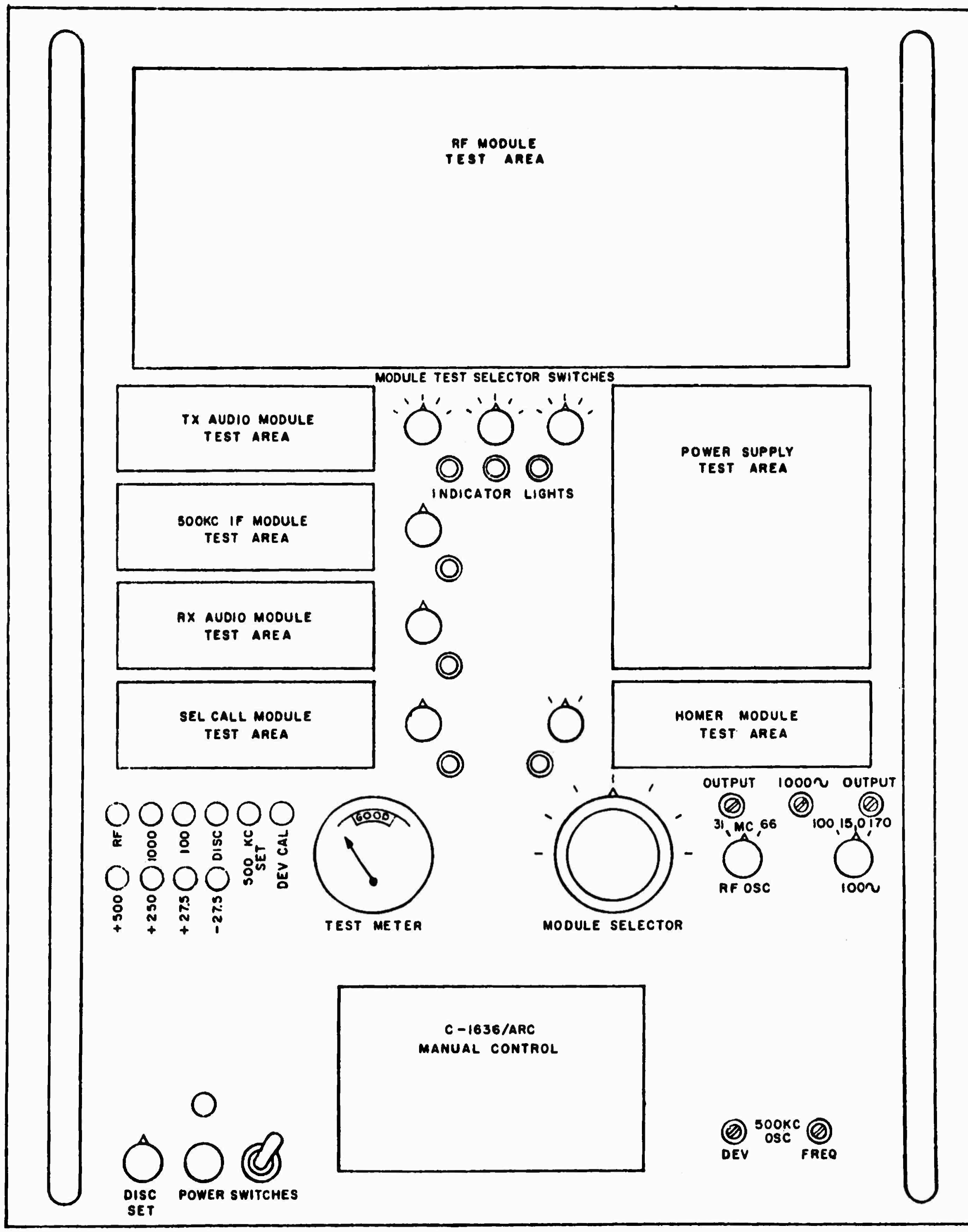

RF MODULE
TEST AREA
MODULE TEST SELECTOR SWITCHES
TX AUDIO MODULE
TEST AREA
500KC IF MODULE
TEST AREA
RX AUDIO MODULE
TEST AREA
SEL CALL MODULE
TEST AREA
INDICATOR LIGHTS
POWER SUPPLY
TEST AREA
HOMER MODULE
TEST AREA
OUTPUT
1000∿
OUTPUT
31 MC 66
100 150 170
RF OSC
100∿
RF
1000
100
DISC
500 KC SET
DEV CAL
+500
+250
+27.5
-27.5
TEST METER
MODULE SELECTOR
C-1636/ARC
MANUAL CONTROL
500KC OSC
DEV
FREQ
DISC SET
POWER SWITCHES

Figure 3A

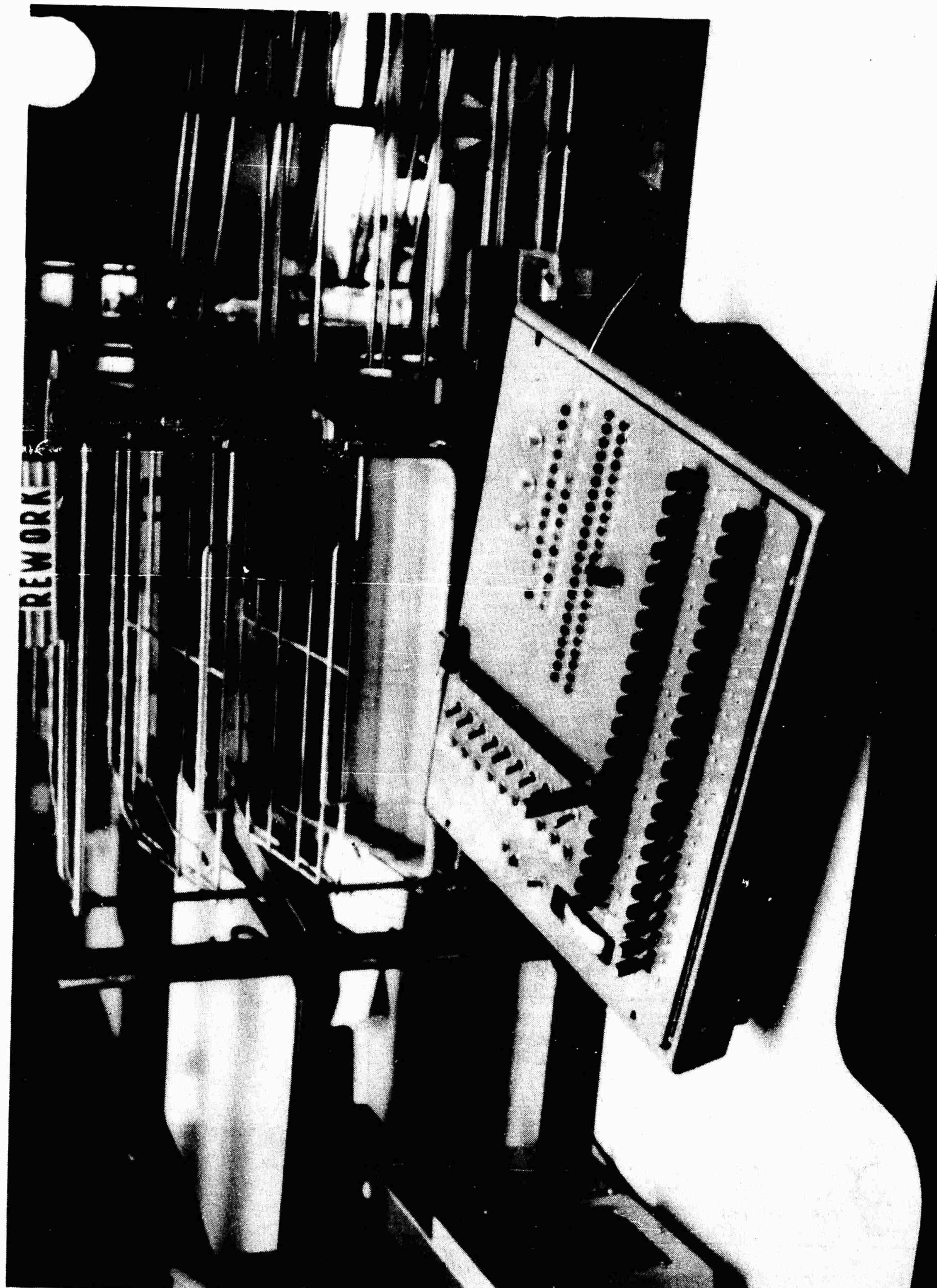


Figure 3B

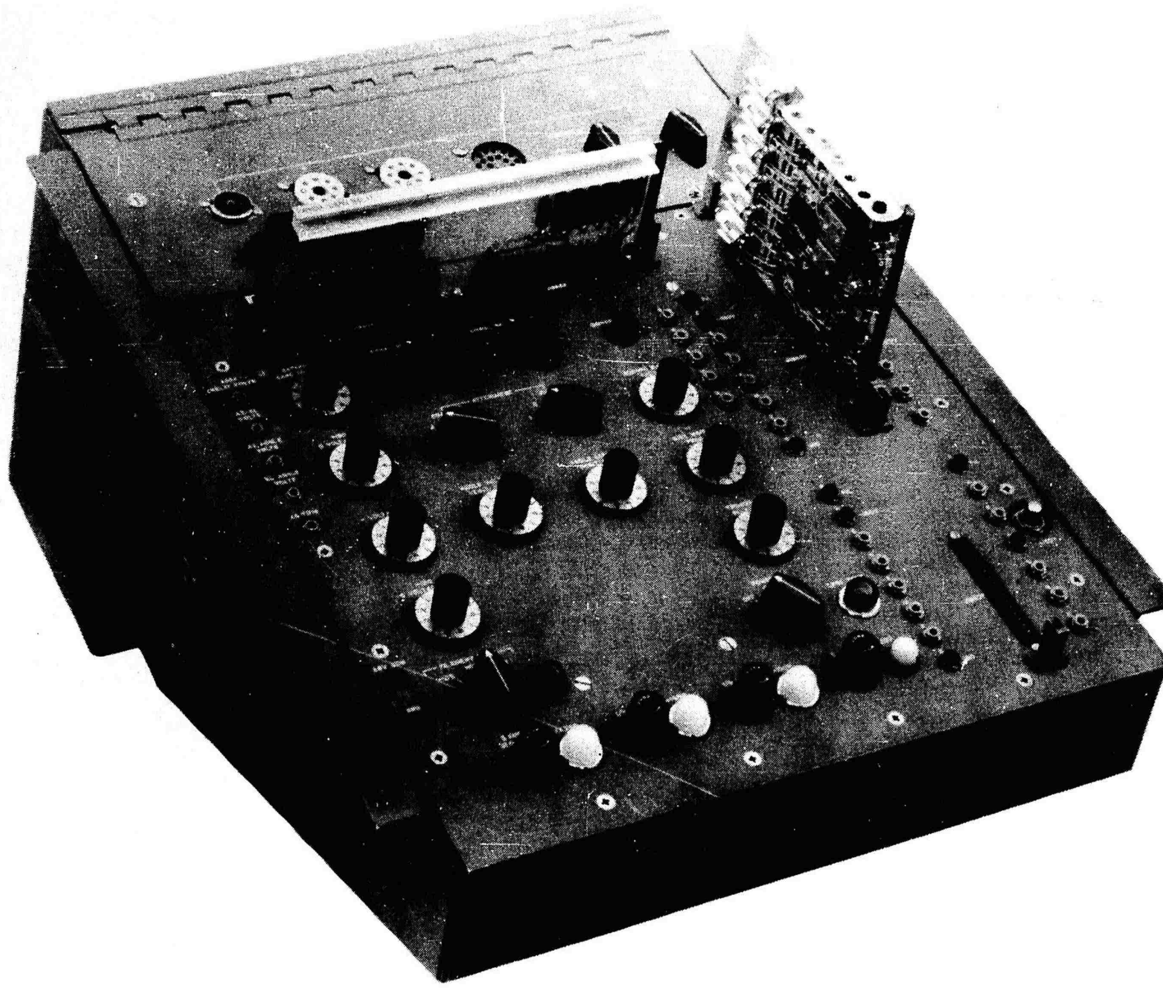


Figure 3C

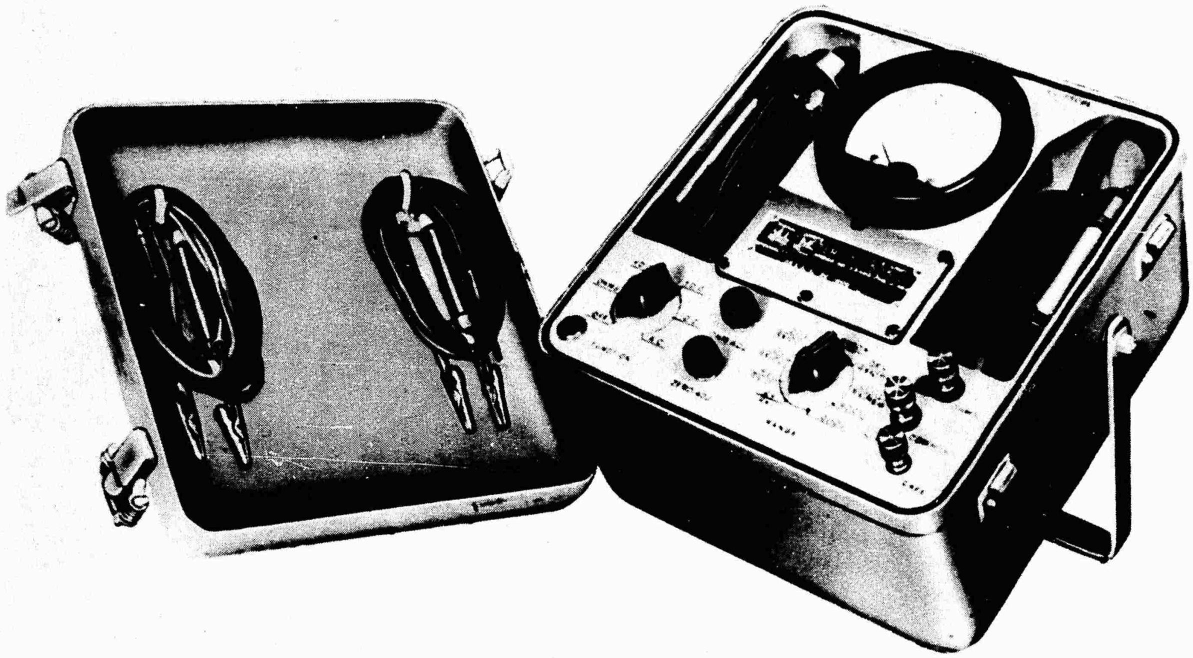


Figure 4A

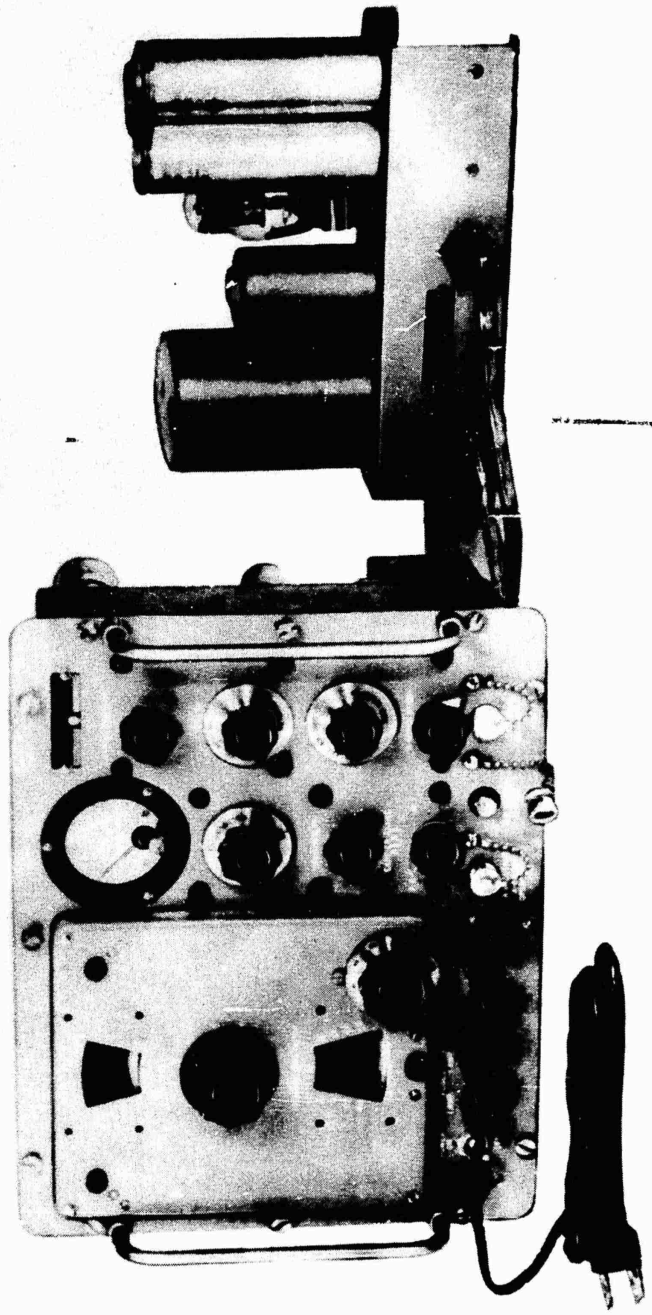


Figure 4B

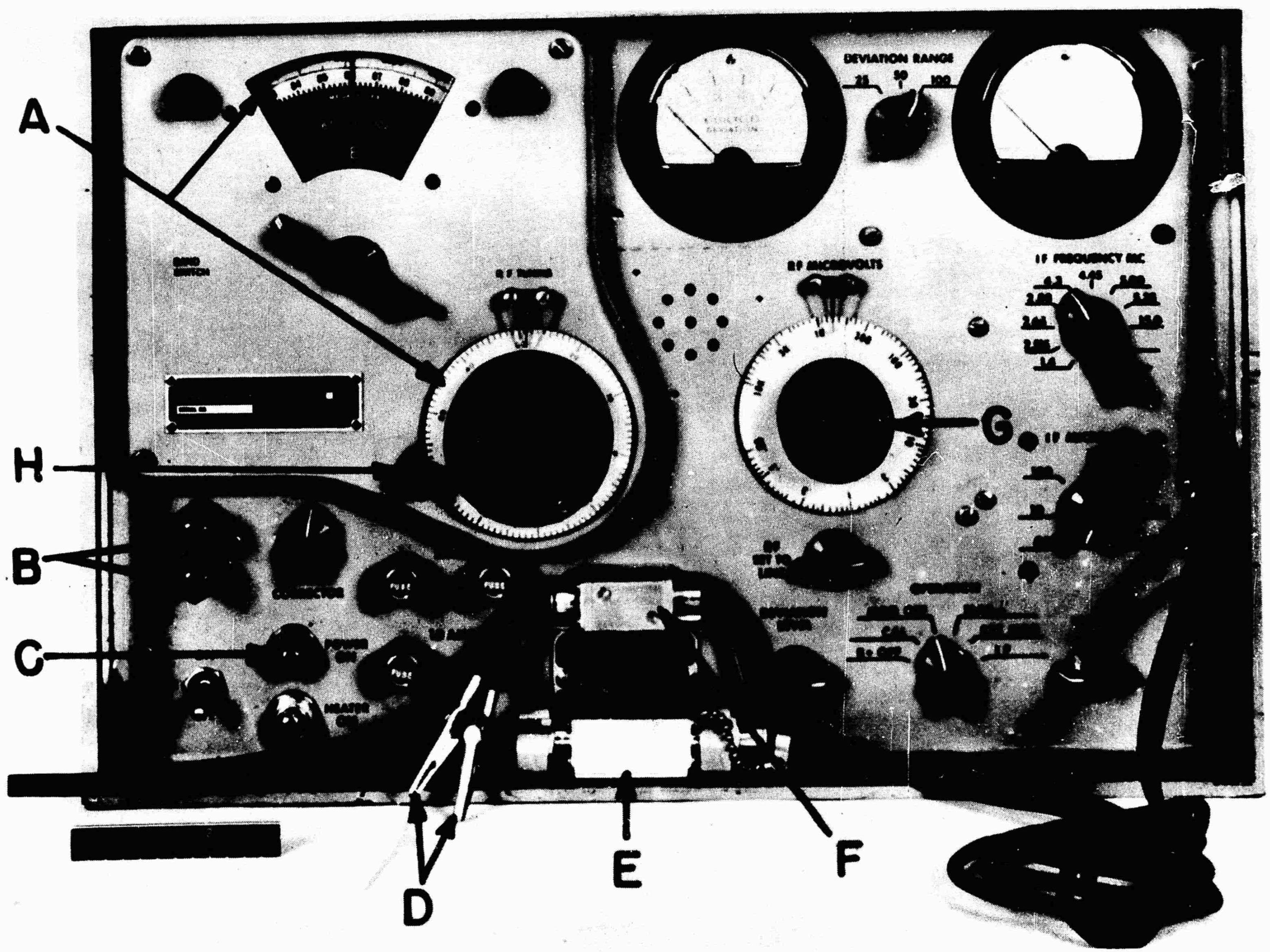

A
H
B
C
D
E
F
G
DEVIATION RANGE
25
50
100
RF MICROVOLTS
IF FREQUENCY MC
FUSE

Figure 4C

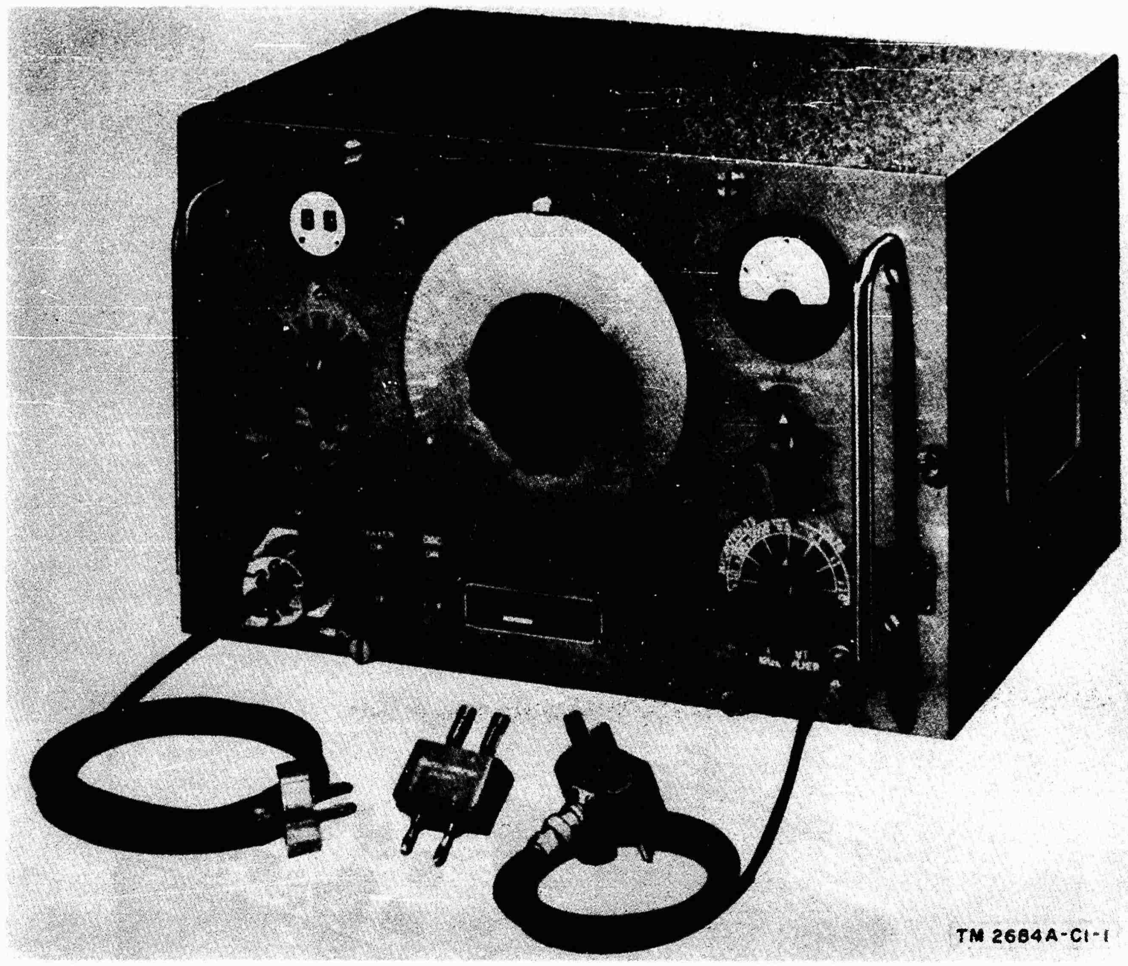


Figure 1.1 (Added) *Audio Oscillator TS-382D/U.*

43. Trouble-shooting Data

Take advantage of * * * trouble-shooting data.

Fig. or par. No.	Description
* * *	* * *
Fig. 15.1	Audio Oscillator TS-382D/U, location of parts, top view.
Fig. 16.1	Audio Oscillator TS-382D/U, location of parts, bottom view.
	Note. Figures 15.1 and 16.1 also apply for Audio Oscillator TS-382B/U.

43.1 Tube Socket Voltages and Resistances (Added)

The voltage table gives the normal ac and dc voltages for Audio Oscillator TS-382B/U and for Audio Oscillator TS-382D/U. The resistance table also indicates the correct resistance for both models when operating properly. The voltages and resistances listed in the tables are based on the following operating conditions:

Line voltage	115 volts
Power frequency	60 cps
OSC. ON-OFF switch	On
HEATER ON-OFF switch	Off
RANGE switch	X10
ATTENUATOR switch	X10
OUTPUT LEVEL control	To produce 10 volts
FREQ. METER switch	On
MAIN TUNING dial	40

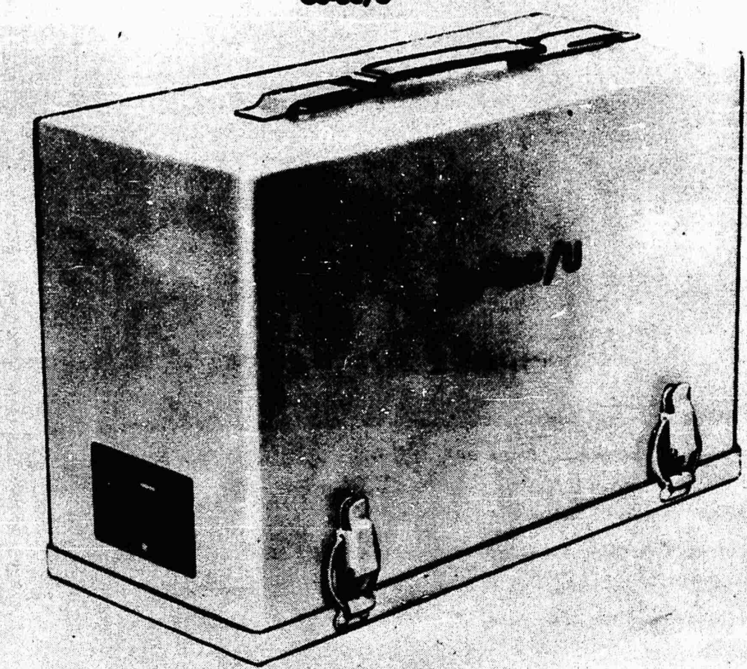


Figure 1-1. Oscilloscope OS-8C/U with Cover in Place

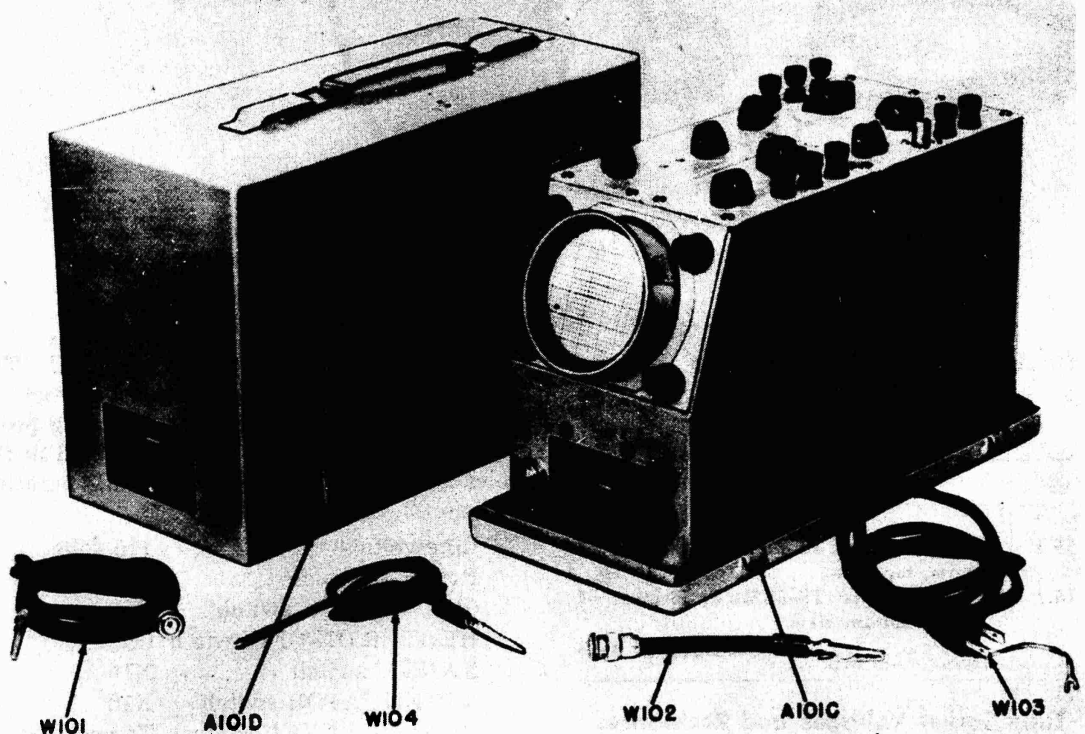
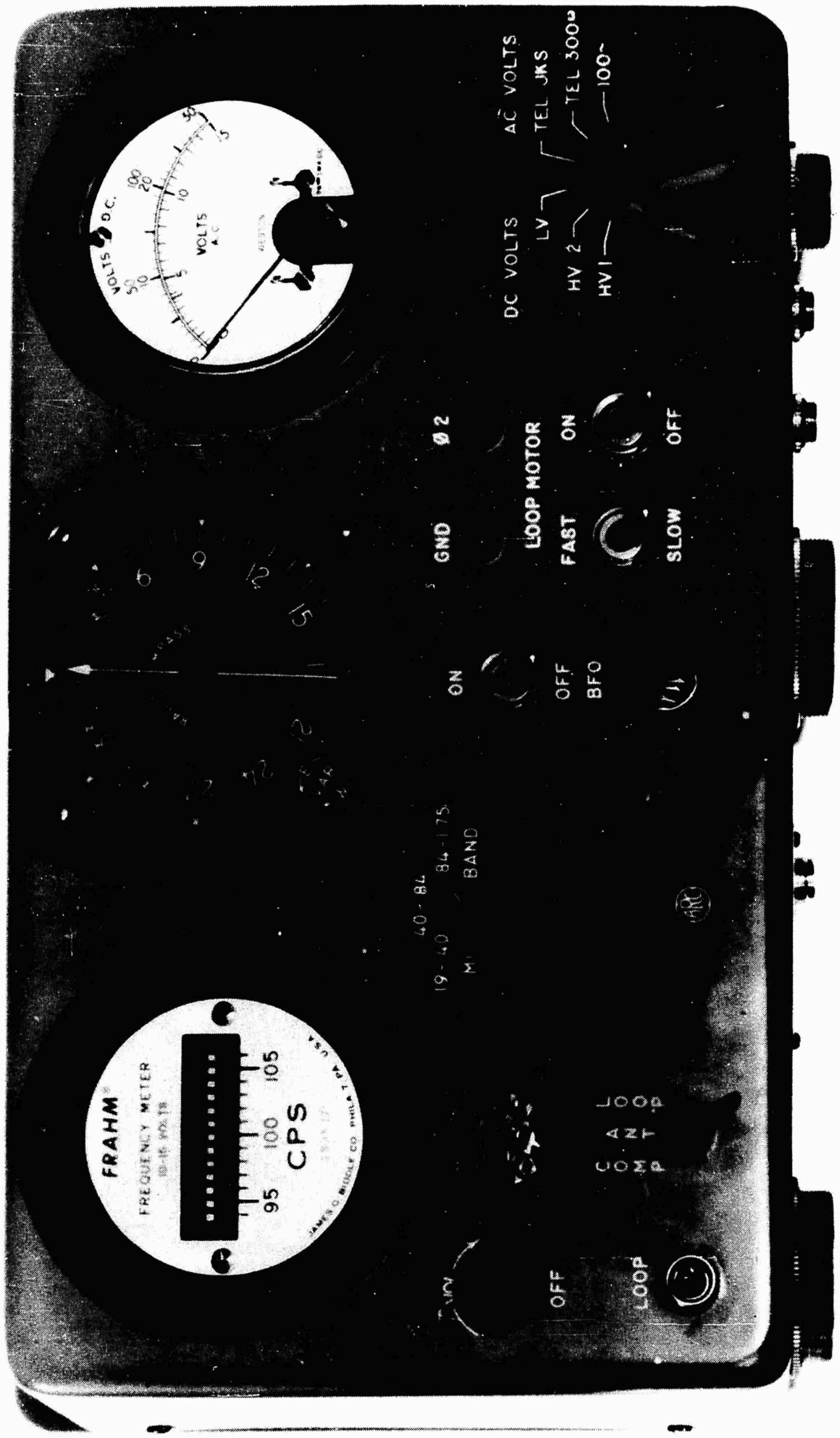


Figure 1-2. Oscilloscope OS-8C/U and Accessories, Cover Removed

Figure 4E 22-18


FRAHM
FREQUENCY METER
95
100
105
CPS
VOLTS D.C.
VOLTS A.C.
19-40
40-84
84-175
BAND
ON
OFF
BFO
GND
LOOP MOTOR
FAST
SLOW
ON
OFF
DC VOLTS
LV
HV 2
HV 1
AC VOLTS
TEL JKS
TEL 300
100~
OFF
LOOP
COMP
ANT
LOOP

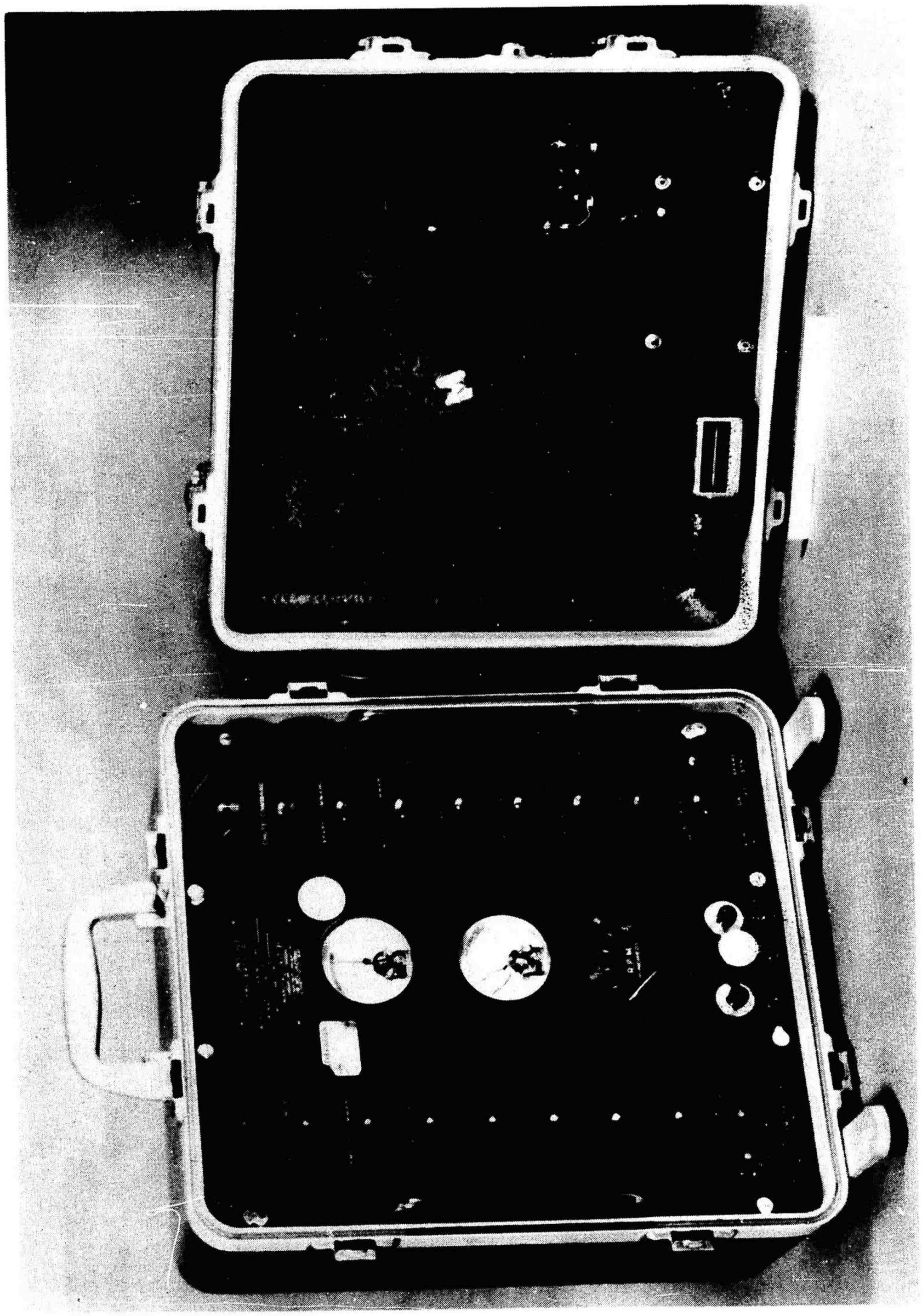


Figure 5B

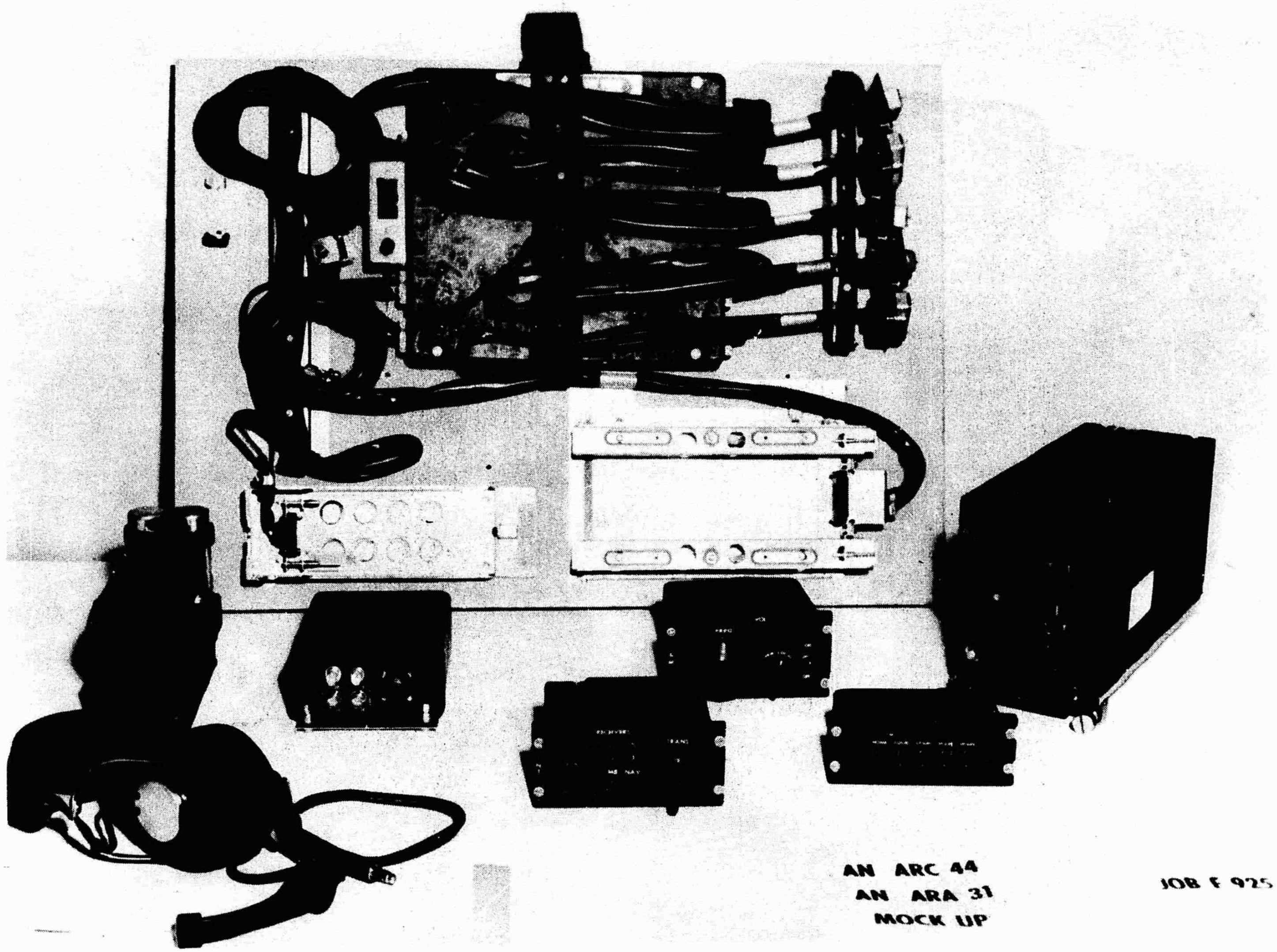


Figure 5C

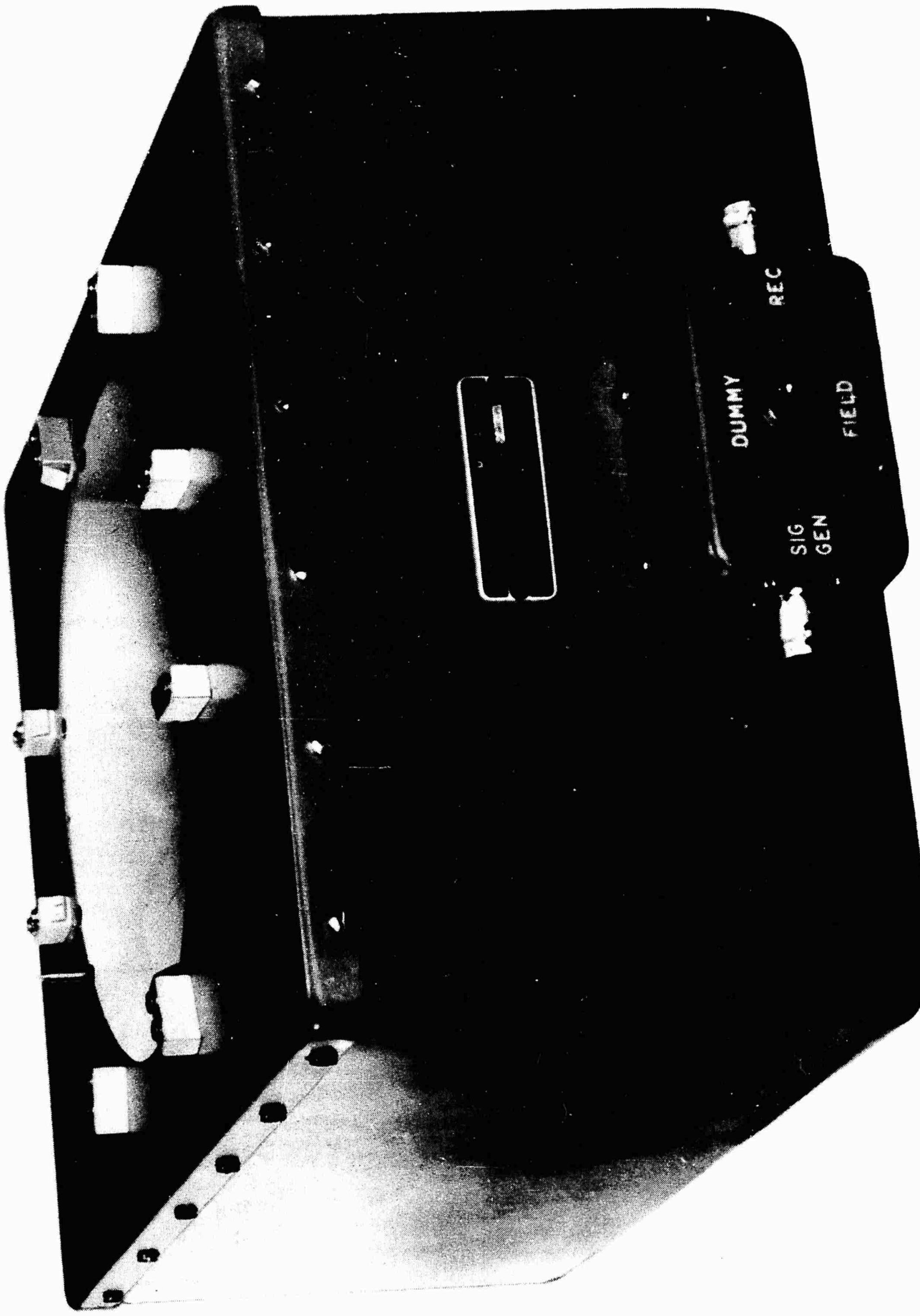


Figure 5D

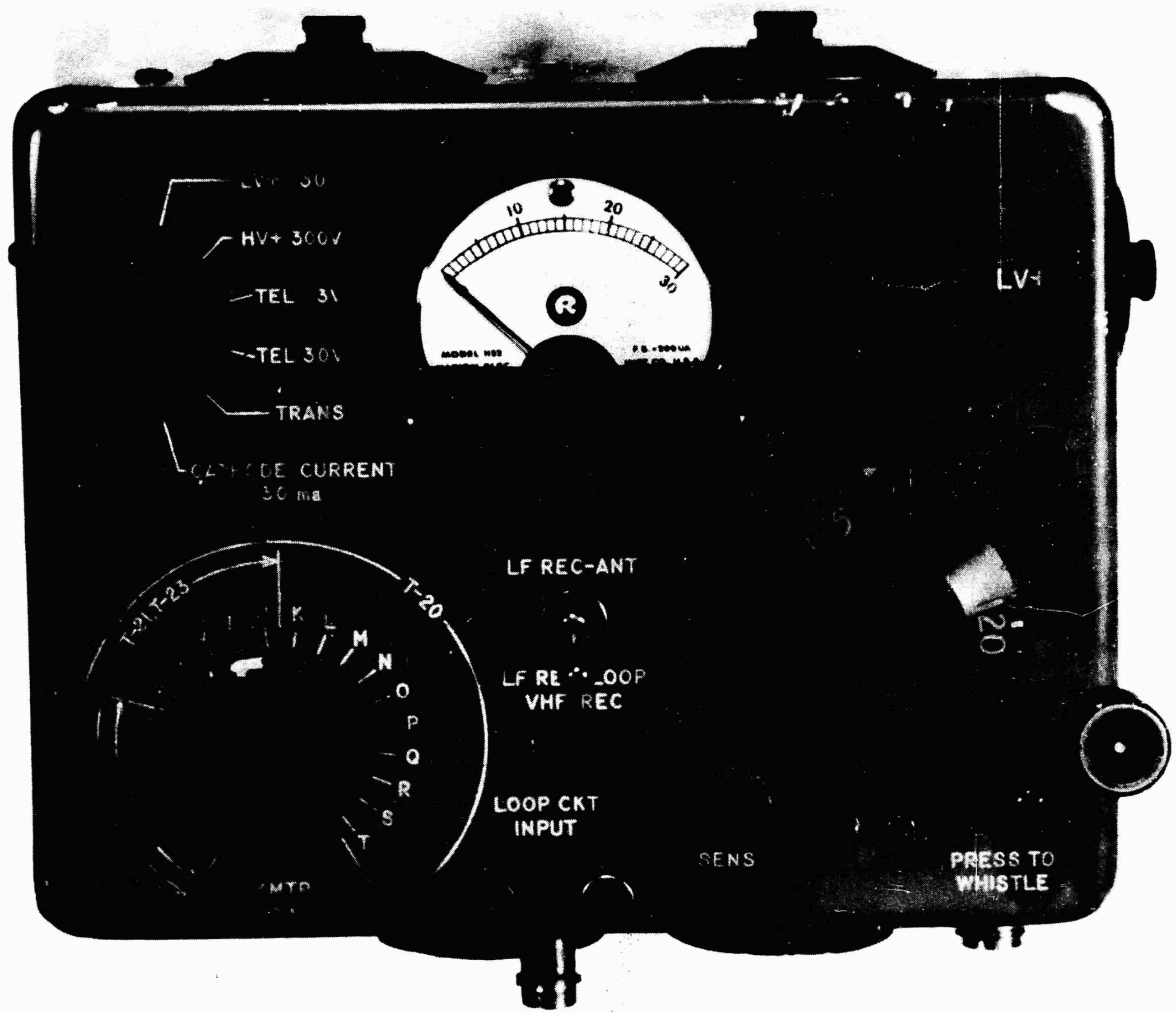

HV+ 300V
TRANS
LF REC-ANT
VHF REC
LOOP CKT
INPUT
SENS
PRESS TO
WHISTLE
LV+
T-20
10
20
30

Figure 5E

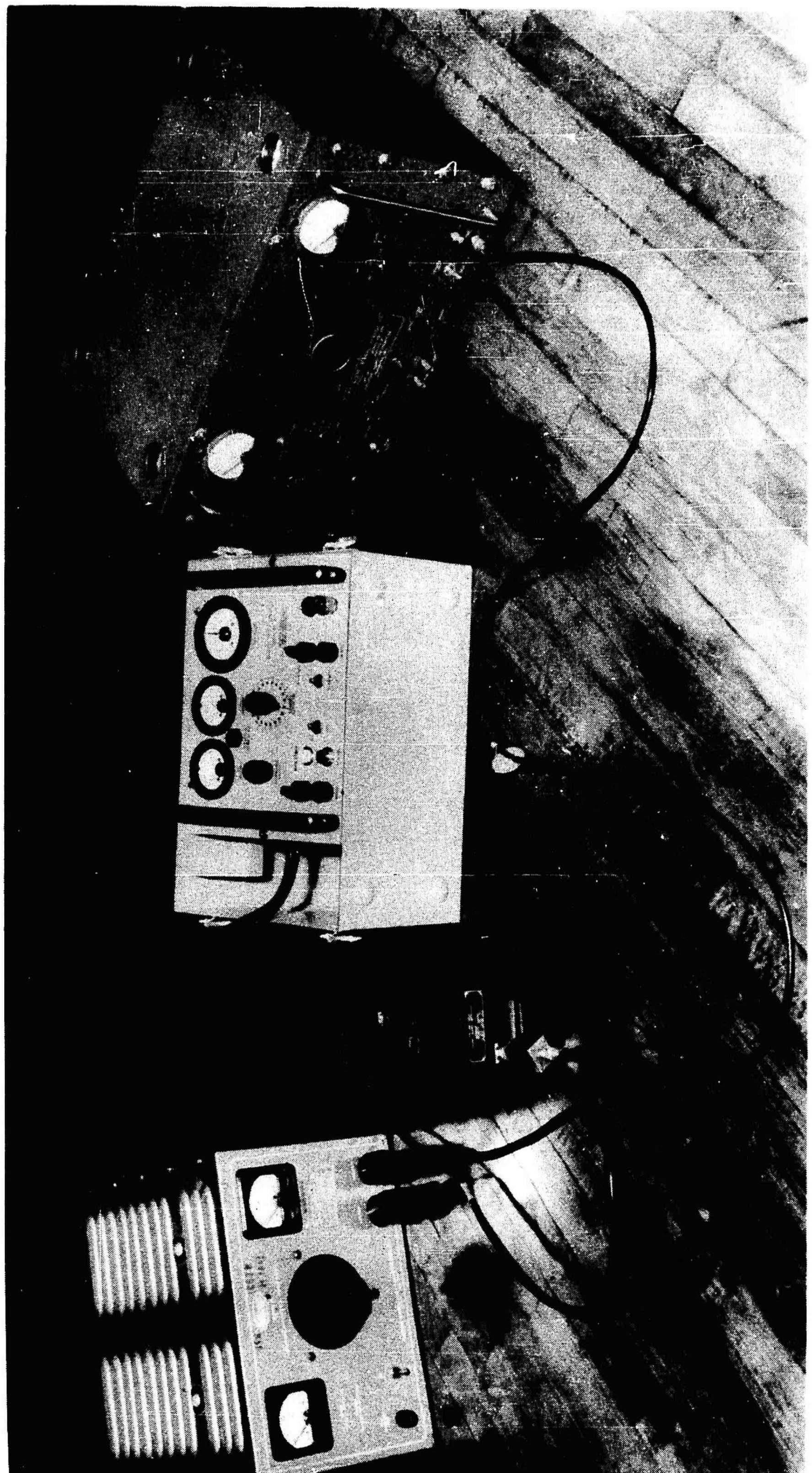
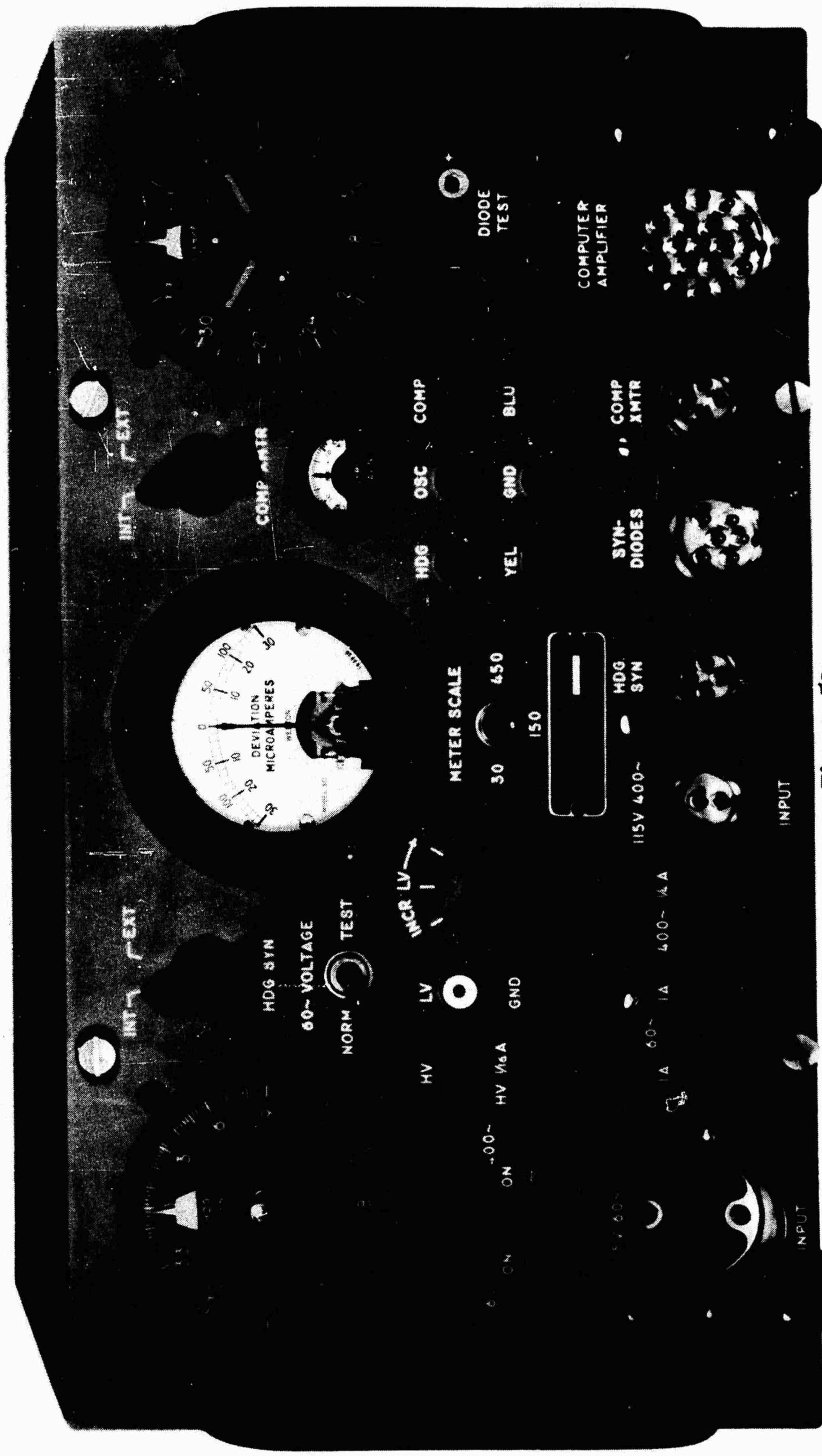


Figure 5F



INT
EXT
HDG SYN
60~ VOLTAGE
NORM
TEST
HV
LV
GND
INCR LV
DEVIATION
MICROAMPERES
METER SCALE
30
150
450
HDG
SYN
115V 400~
INPUT
COMP XMTR
HDG
OSC
COMP
YEL
GND
BLU
SYN-
DIODES
COMP
XMTR
DIODE
TEST
COMPUTER
AMPLIFIER

Figure 50

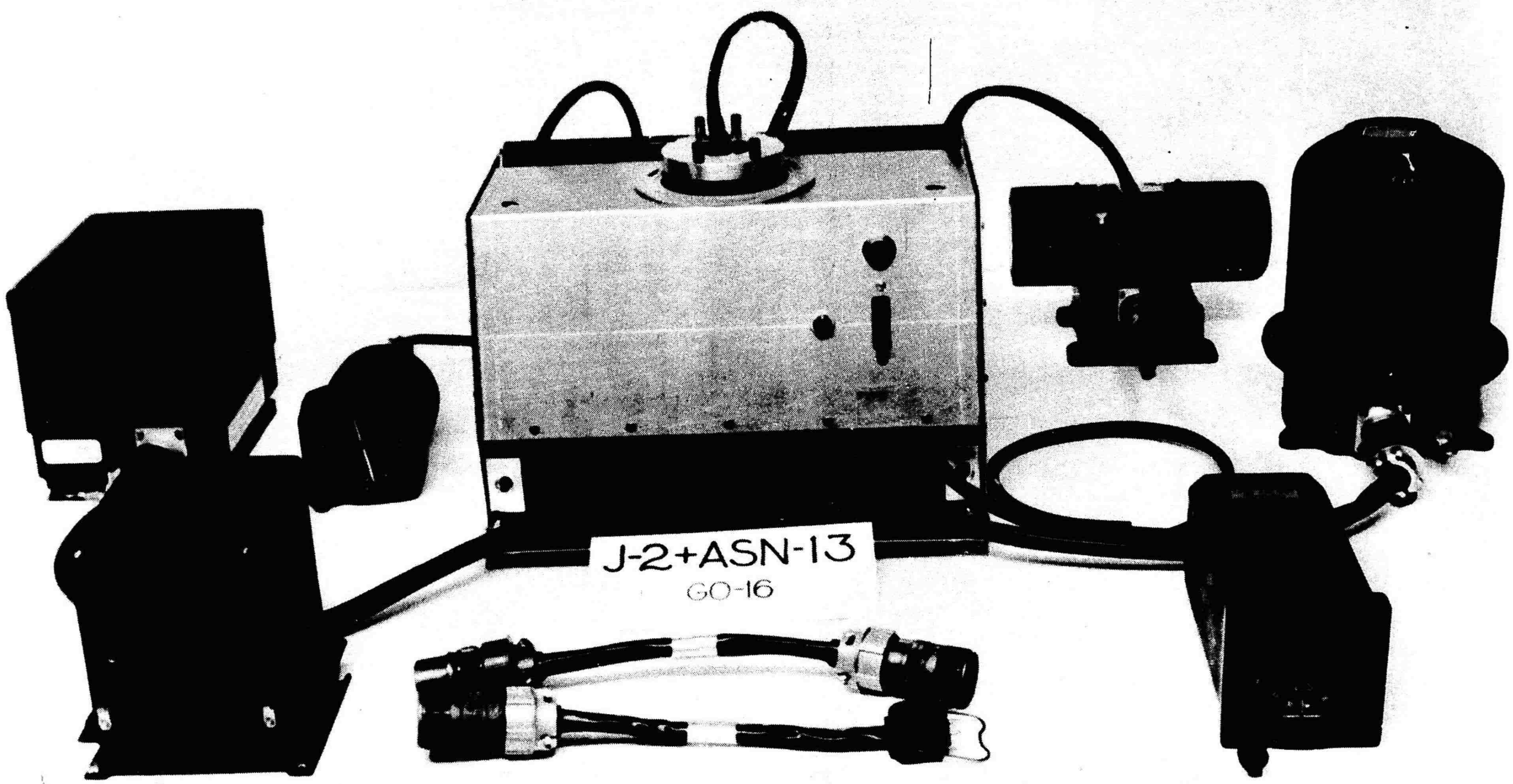
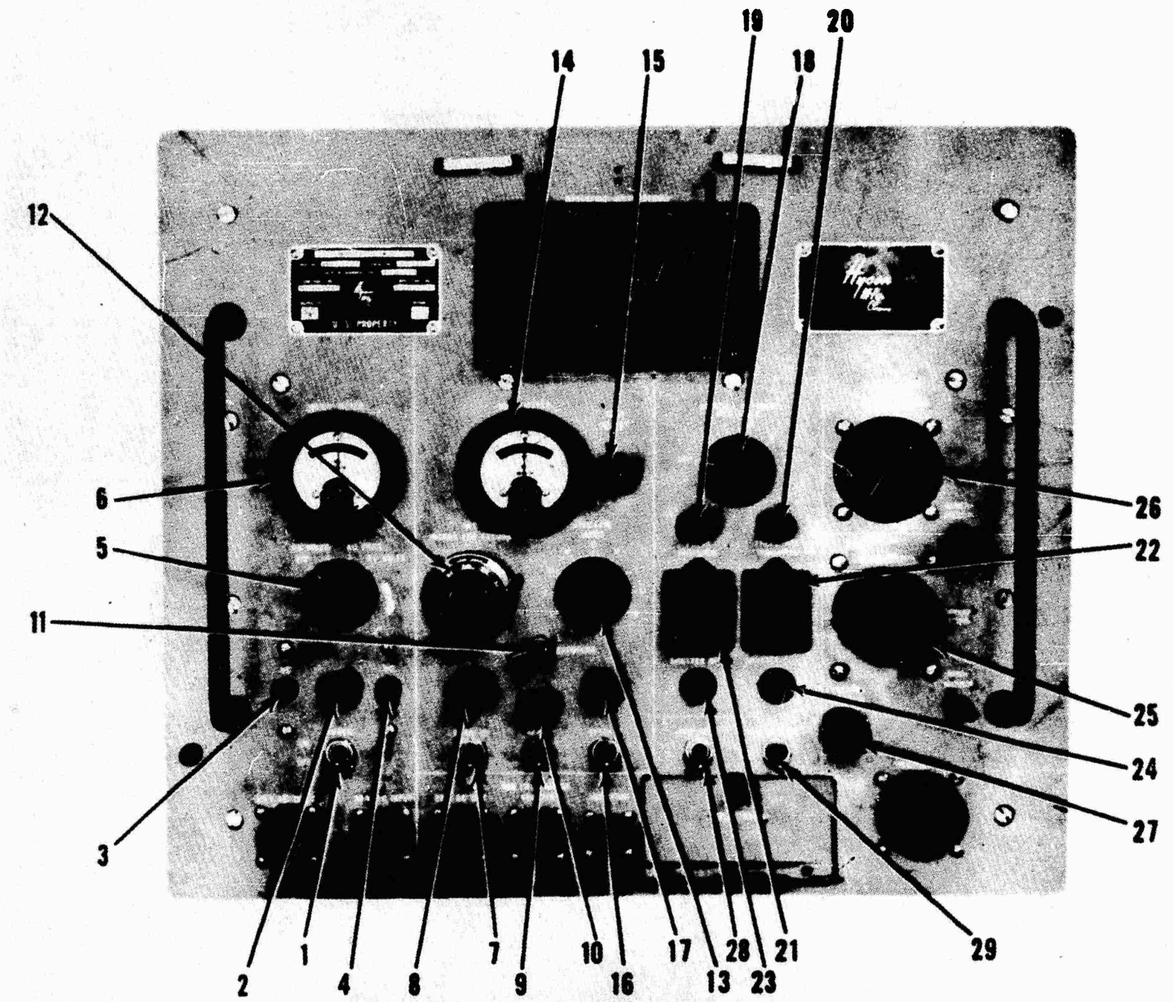


Figure 5H

1-6. Sections I through VII of this handbook apply to the LM-22 Aerial Camera Test Set, Model No. 230200, and Contract No. AF33(600)26964. Additional models will be covered in Section VIII by the use of Difference data sheets.

1-7. Service instructions for models included in Section VIII are the same as the procedures given in Sections I through VII, except for the specific differences noted by the applicable Difference data sheets.



KEY
1. POWER Switch
2. Light Indicator
3. AC Circuit Breaker
4. DC Circuit Breaker
5. Selector Switch
6. INPUT METER
7. WARM UP Switch
8. Light Indicator
9. READY Switch
10. Light Indicator
11. IMC-EXPOSURE Switch
12. IMC Control
13. EXPOSURE INDEX
14. NULL METER
15. ZERO ADJUST
16. OPERATE Switch
17. Light Indicator
18. INTERVAL Switch
19. Light Indicator
20. Light Indicator
21. PULSE INDICATOR
22. TRANSPORT INDICATOR
23. SHUTTER OPEN Switch
24. SHUTTER CLOSE Switch
25. INPUT VACUUM Knob
26. VACUUM Gage
27. VACUUM REGULATOR
28. IMC AMPS Switch
29. NON IMC AMPS Switch

Figure 1-2. LM-22 Aerial Camera Test Set Operating Controls

Figure 51

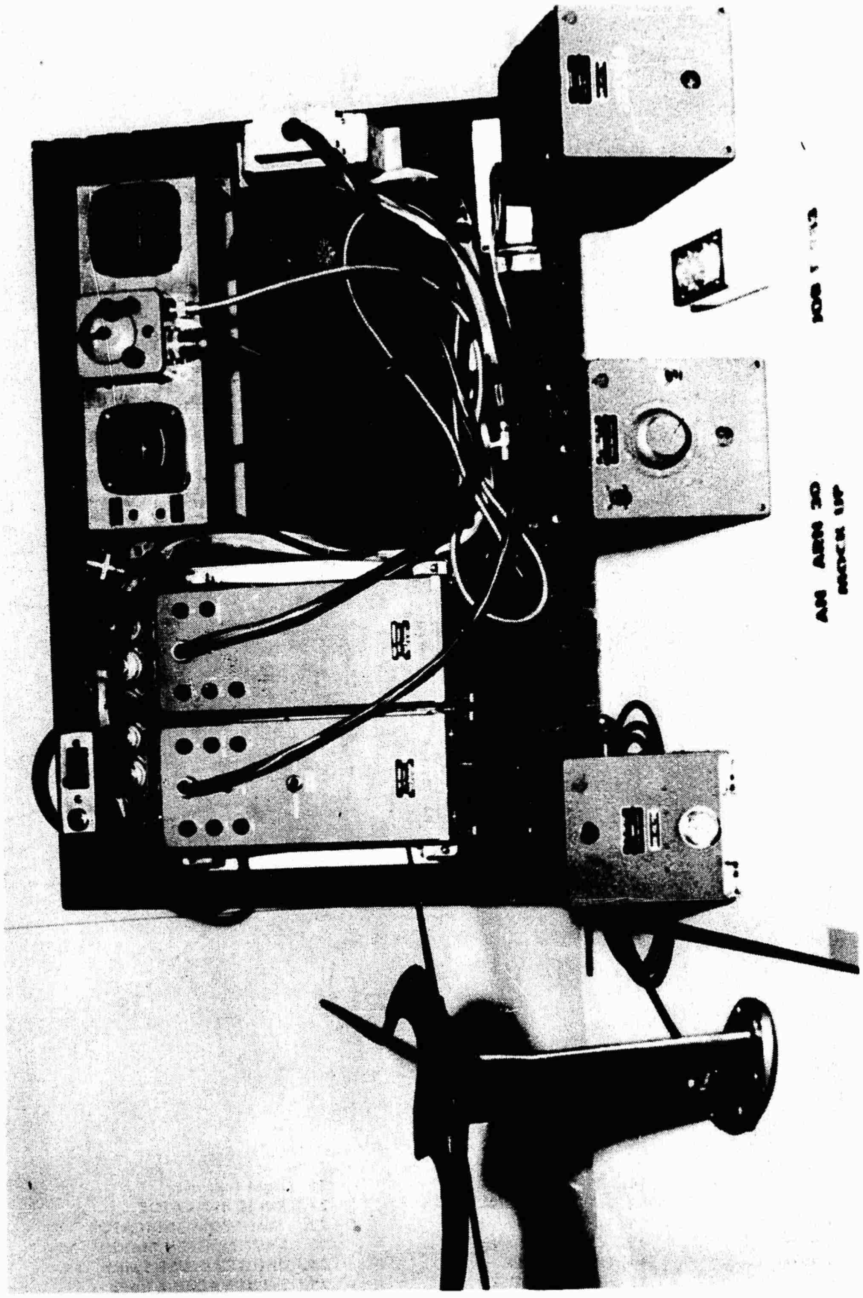


Figure 5J

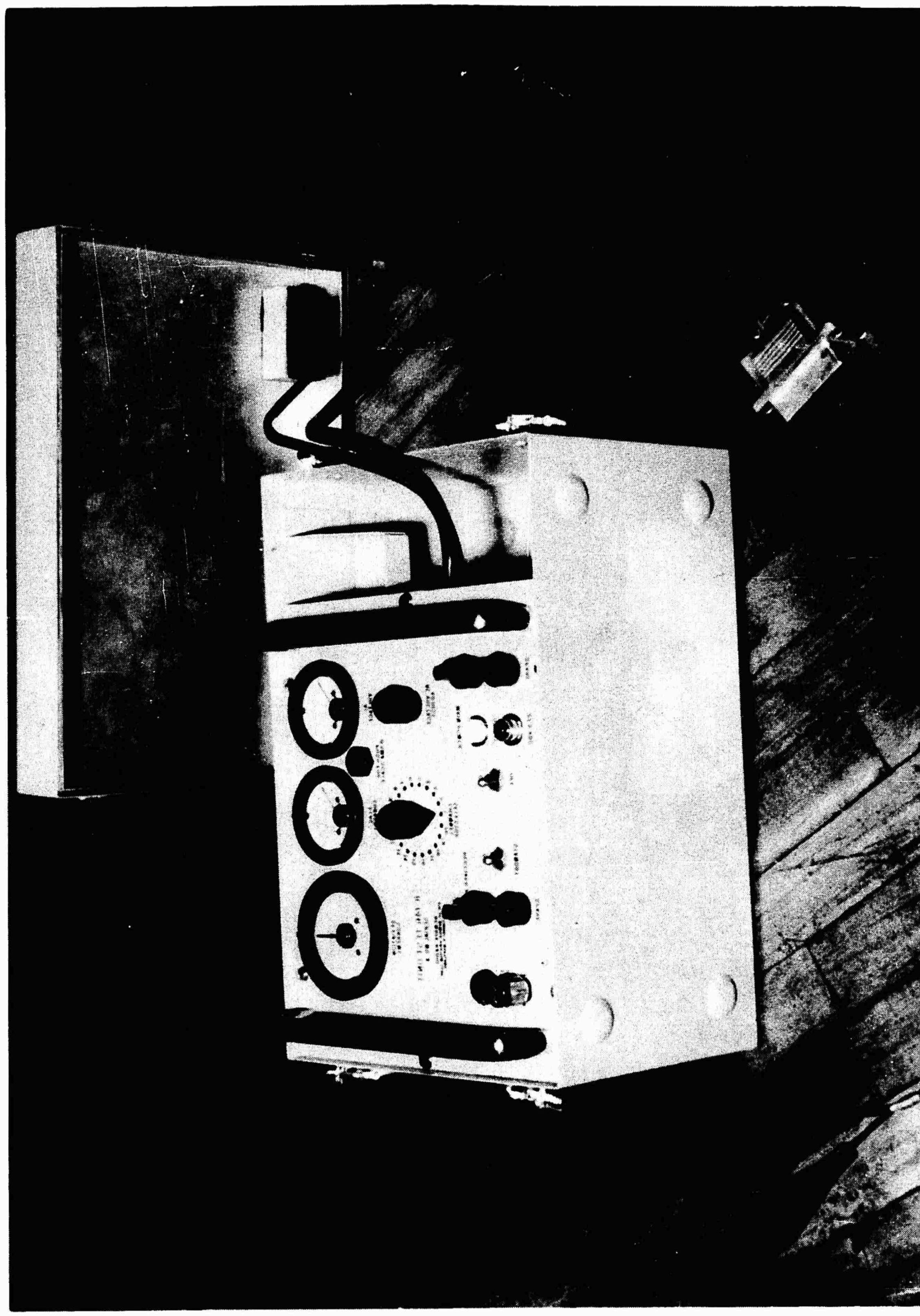


Figure 5K

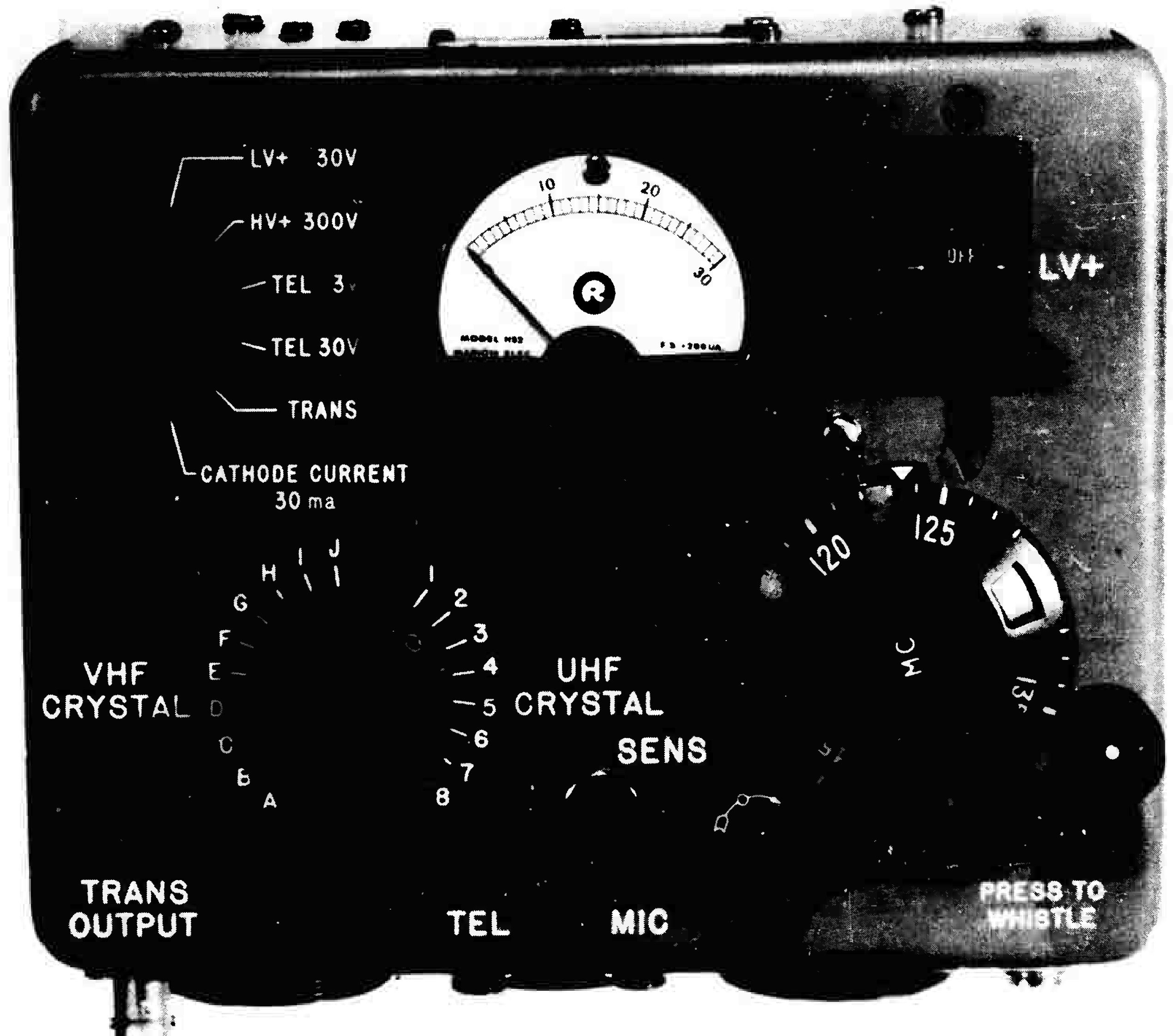

LV+ 30V
HV+ 300V
TEL 30V
TRANS
CATHODE CURRENT
30 ma
10
20
30
LV+
VHF
CRYSTAL
A
B
C
D
E
F
G
H
I
J
1
2
3
4
5
6
7
8
UHF
CRYSTAL
SENS
120
125
MC
TRANS
OUTPUT
TEL
MIC
PRESS TO
WHISTLE

Figure 5L

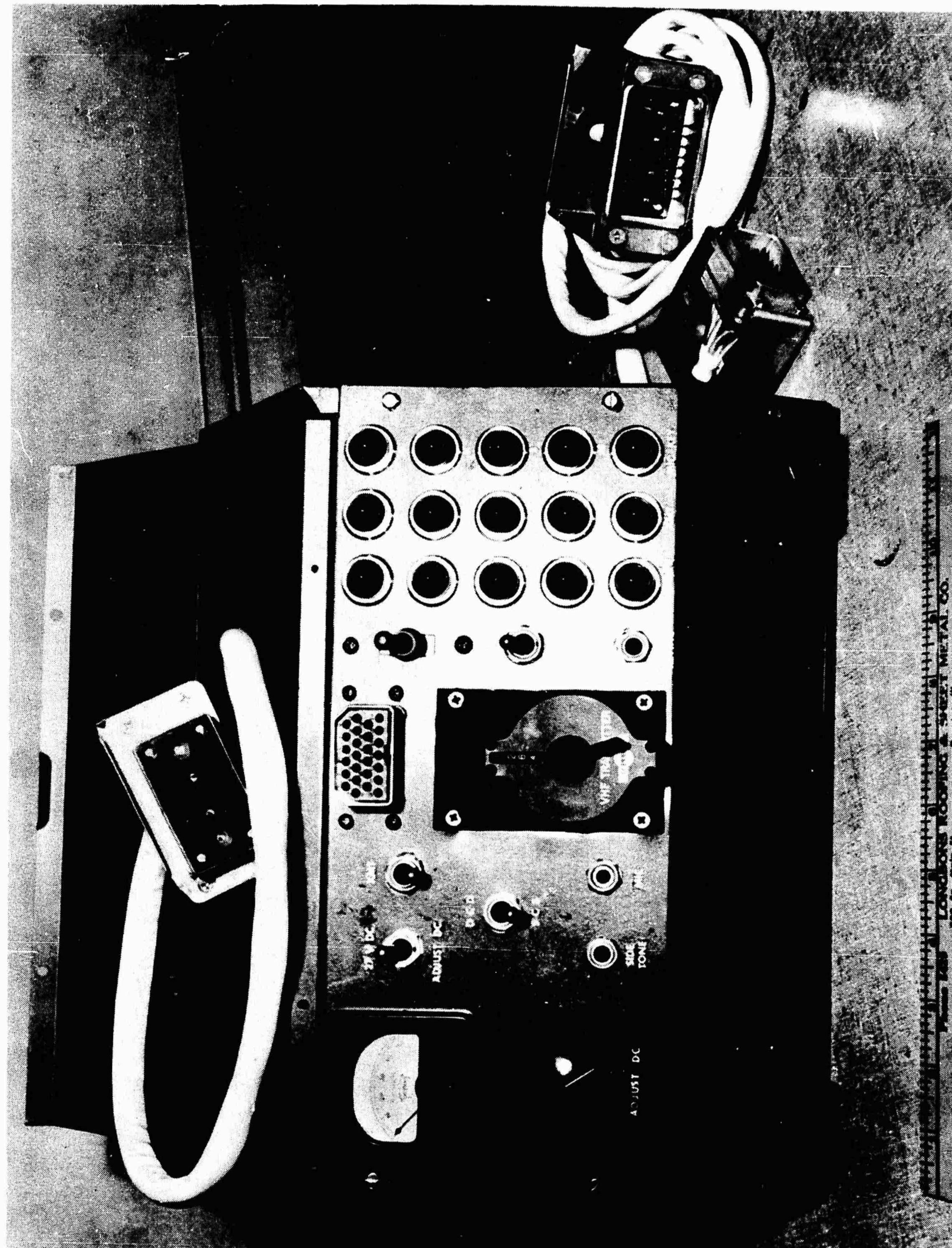
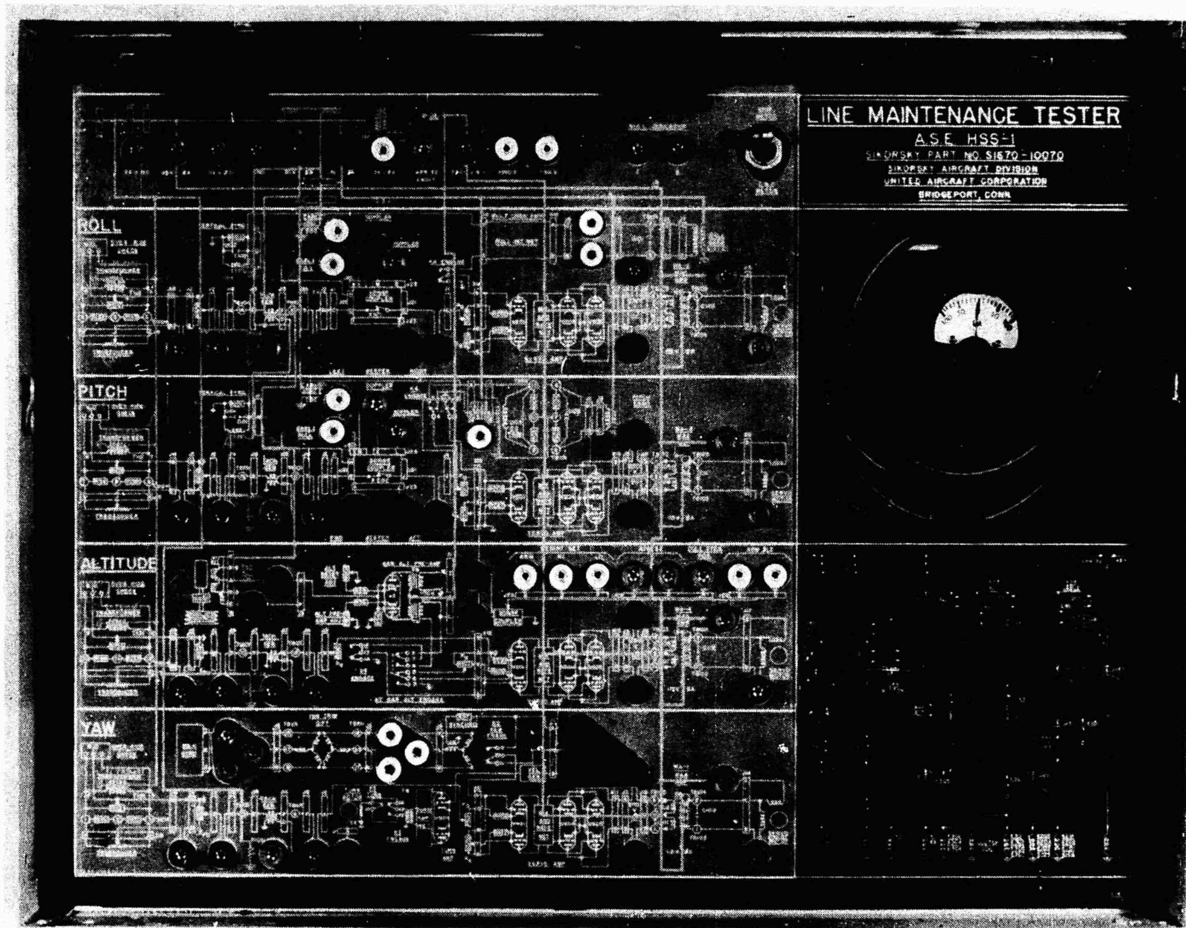


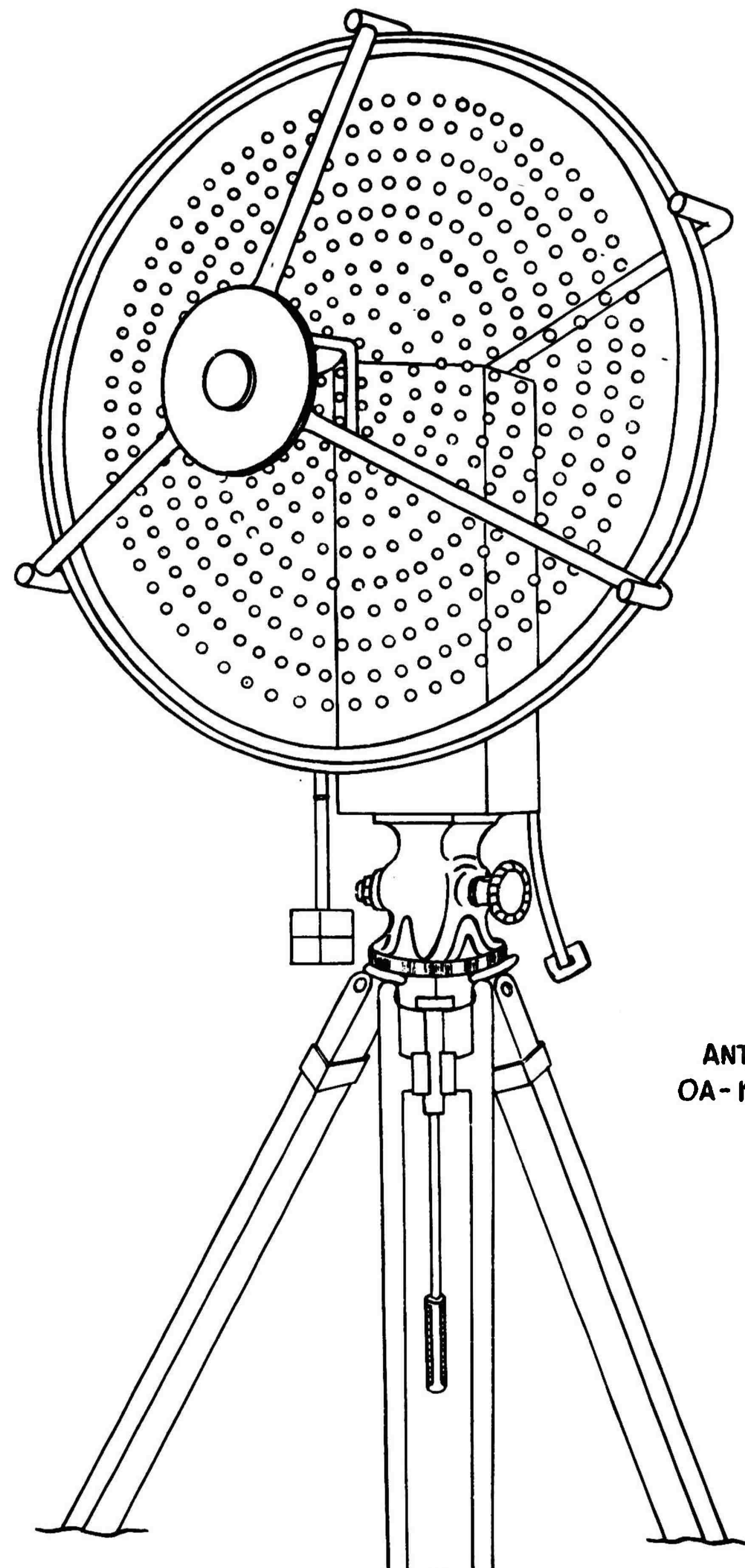
Figure 5M



USASEL-SIGFM-57-634 U. S. ARMY SIGNAL ENGINEERING LABORATORIES FORT MONMOUTH, N. J.

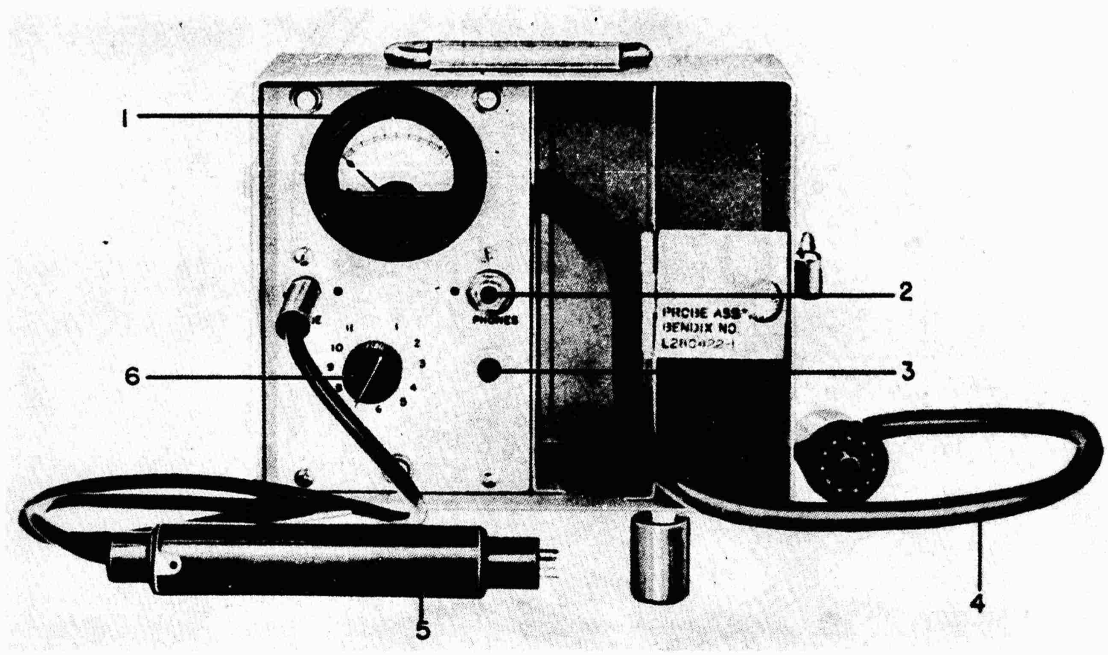
HELICOPTER STABILIZATION EQUIPMENT, ARMY HELICOPTER H-34 . (Service-Test Model)
Mfr. Sikorsky Aircraft Div., United Aircraft Corp., Bridgeport, Conn.
Close-up Front View . LINE MAINTENANCE TESTER, Part #S1670-10070 . Showing Front Panel

Figure 5N



ANTENNA GROUP
OA-1967/MPQ-49

Figure 5-0



1 Meter
2 PHONES jack
3 Sensitivity switch
4 Eleven-pin probe
5 Seven-pin probe
6 Meter selector switch

Figure 1-6. Radio Test Set TS-777/URD-4, Identification of Features

lated signals give visual indications. AM signals only produce an aural response.

p. CRYSTALS:

QUANTITY	FREQUENCY (MC)	JAN TYPE NO.
1	0.833333	CR-28/U
1	3.233333	CR-27/U
1	3.400000	CR-27/U
1	3.566667	CR-27/U
1	3.650000	CR-27/U
1	3.666667	CR-27/U
1	3.683333	CR-27/U
1	3.700000	CR-27/U
1	3.716667	CR-27/U
2	3.733333	CR-27/U
1	3.750000	CR-27/U
1	3.766667	CR-27/U
1	3.783333	CR-27/U
1	3.800000	CR-27/U
1	3.900000	CR-27/U
1	5.172917	CR-27/U
1	5.181250	CR-27/U
1	12.5178	CR-18/U

q. SQUELCH CIRCUIT CHARACTERISTICS: Any signal at a level lower than that for which squelch is designed does not pass through the receiver and cannot be heard in the headphones, so that tube noise and other non-signal responses do not become audible. Squelch does not control the video channel. Squelch may be disabled if desired.

r. IMPEDANCES:

Antenna—52 ohms

R-f input—52 ohms

Headphones (audio output impedance)—600 ohms.

s. CHARACTERISTICS OF ANTENNA:—Rotatable Adcock array, two dipoles vertically mounted, rotating capacitance joint.

t. CHARACTERISTICS OF POWER SUPPLY REQUIRED FOR OPERATION:—115 volts, 55 to 65 cycles, single-phase power source.

u. HEAT DISSIPATION OF MAJOR UNITS:

Radio Receiver R-353/URD-4—262 watts

Azimuth Indicator IP-93/URD-4—136 watts

Antenna AS-514/URD-4—120 watts

Figure 5Q 22-35

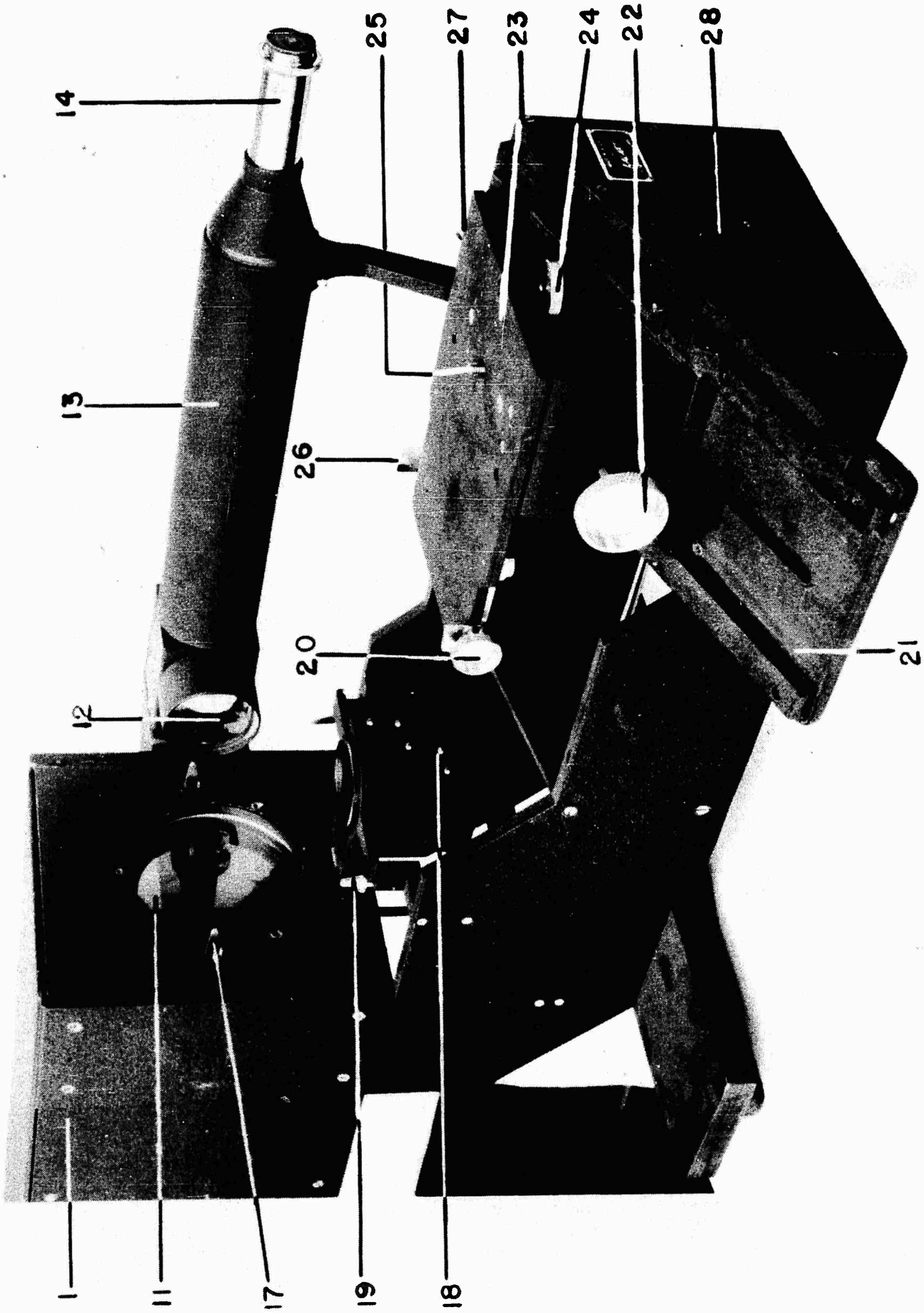
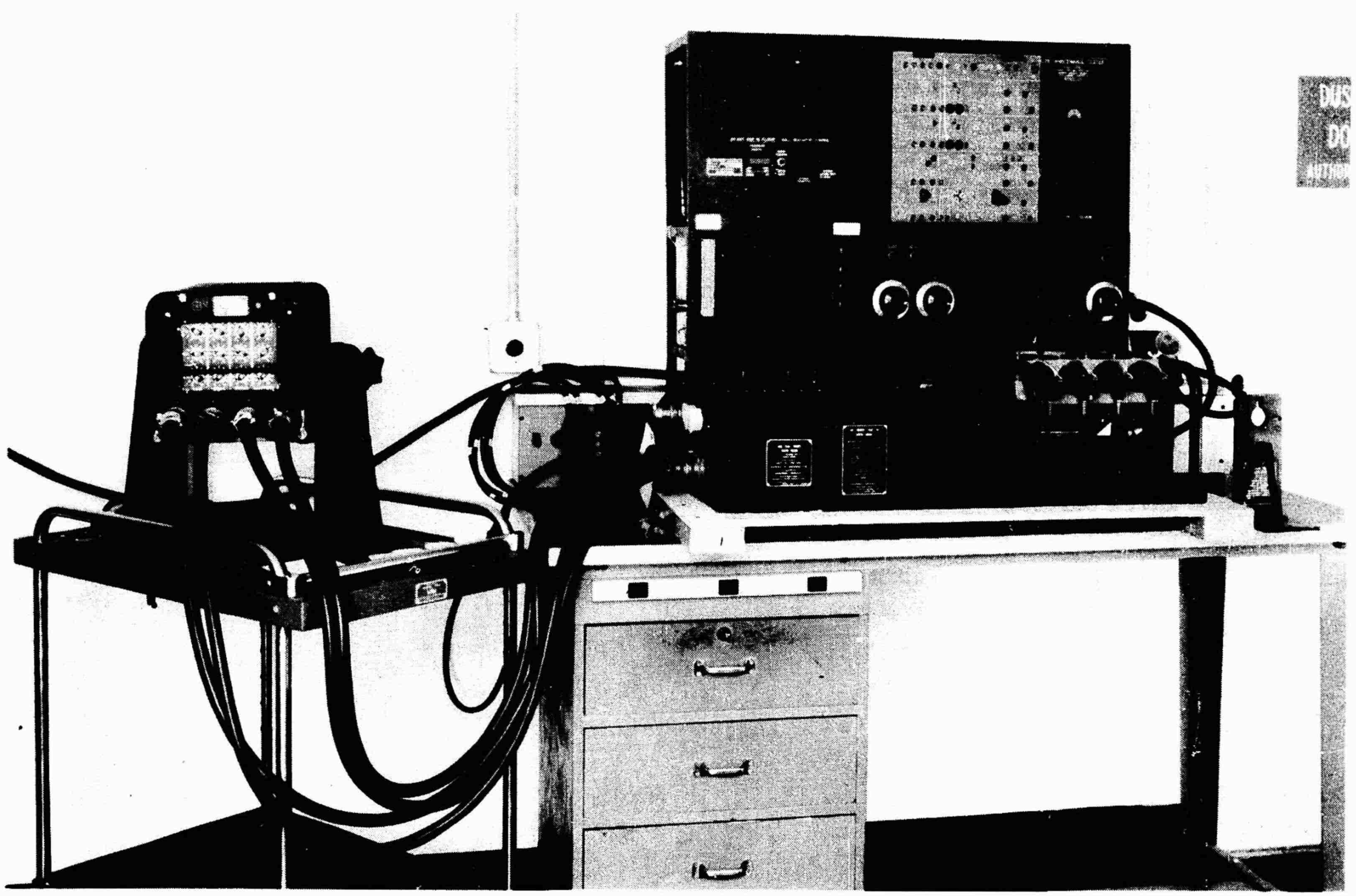


Figure 5R



USASEL-SIGFM-57-633 U. S. ARMY SIGNAL ENGINEERING LABORATORIES FORT MONMOUTH, N. J.

HELICOPTER STABILIZATION EQUIPMENT, ARMY HELICOPTER H-34 . (Service-Test Model)
Mfr. Sikorsky Aircraft Div., United Aircraft Corp., Bridgeport, Conn.
Overall Front 3/4 View . BENCH TEST KIT #S1670-10085-1, Serial #1 . Showing
Complete Assembled Equipment

Figure 5S

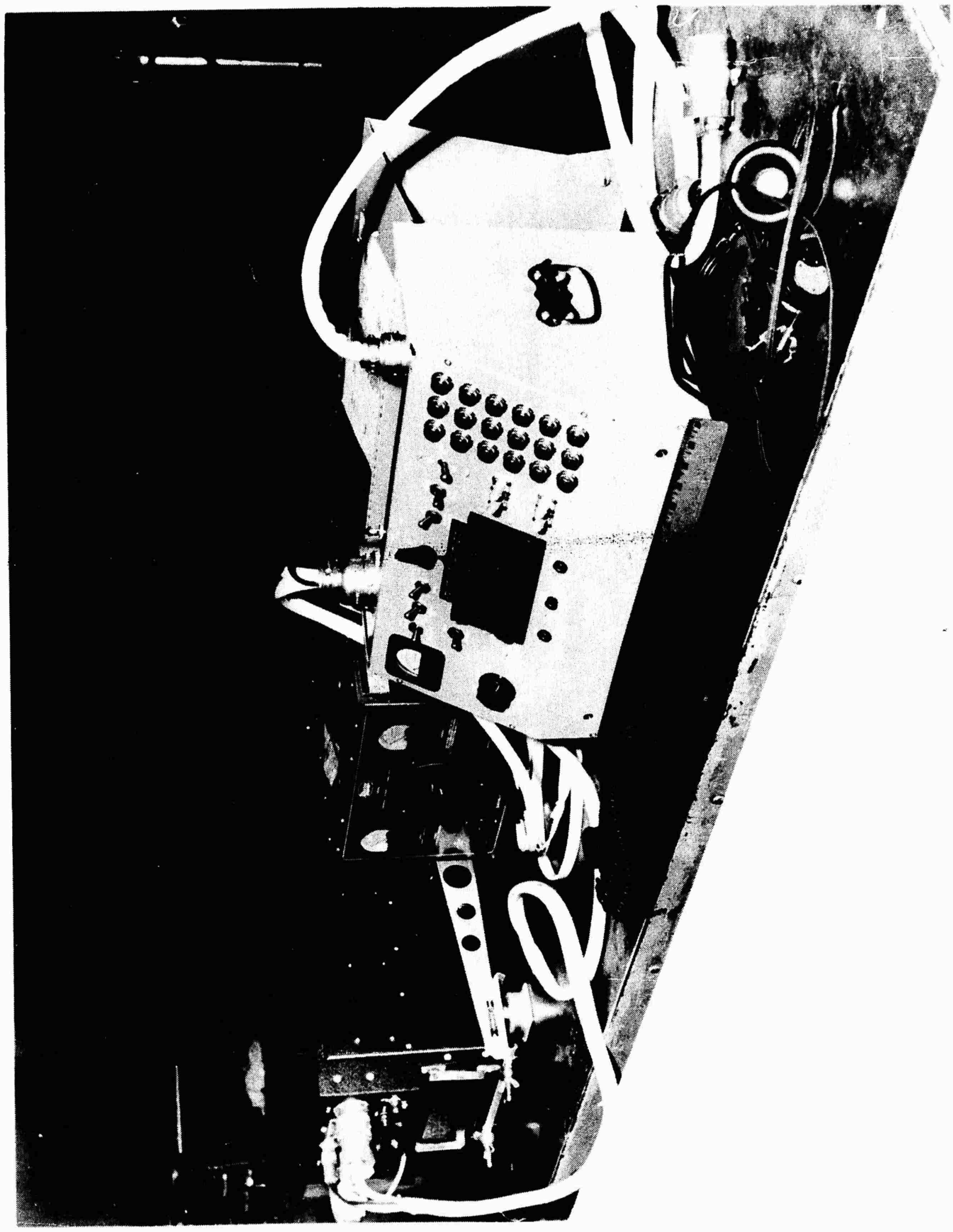


Figure 5T

MR. PAUL K. JOHNSON, USASESA: In your PD, procurement and clearance, how are the particular test equipments arrived at? In other words, you said that commercial gear was crossed off the list, and I can see how for certain things like voltage and resistance measurements you could do that, but how could you go any further than that without knowing all the peculiarities of the equipment itself? The overall ranges, and so forth, might not be adequate. To completely do the job, in order to get that equipment into the TM at the time that the equipment is delivered, I don't see how you can do it in 12 months.

MR. KIRSCHNER: Reference the 12 months that I spoke of -- you're talking in terms of the development of technical literature -- the thought was to plan or to call out the items of test equipment which will be required to be furnished the contractor. In other words, this will be done by looking at the FY procurement program as far in advance as in possible and then take action -- and we have already done this. We have sent the information down to the Supply Agency so that they can procure additional quantities of test equipment and thereby be prepared for these additional demands. In other words, by procuring additional quantities there is reasonable assurance that the test equipment will be available so that it can be furnished the contractor to develop his literature.

MR. JOHNSON: Well, how long does it take if you do not have standard test equipment to do one particular job and you don't have to develop but you have to use commercial gear in order to do the job? How long does it take before the test equipment becomes standard so that we can use it in the TM and also get a procurement clearance data sheet?

MR. KIRSCHNER: Well, the timing for adoption of commercial items where they are required -- that is where they are capable of doing the job -- is a matter of obtaining nomenclature assignment and the time that it takes to process standardization action.

MR. JOHNSON: How long does that take?

MR. KIRSCHNER: Well this varies, actually. I don't know whether I can give you a definite figure -- no more than X number of months. I think it varies with the degree of complexity or nature of equipment. But the point is that the adoption of the equipment itself I don't feel is any real problem, once the need is determined that the item will do the job.

MR. JOHNSON: Well, it is a problem for the engineer who has charge of it in USASESA. In other words, he can't very well tell them to use certain pieces of gear that he knows very well will not do the job and substitute something for a commercial item because he knows very well that it can't do the job; it would be ridiculous for him to go to the manufacturer and even suggest some of those things. So I just wondered. I'm trying to find out how long it takes to get the standardization actions through; that is, how many months or years or whatever does it take?

MR. KIRSCHNER: Standardization actions are processed by the Signal Corps Technical Committee. I don't know whether they adhere to any given schedule. In other words, we can write up an action and send it forward, and it may take 3 or 4 or even 6 or 8 months. This we have no control over. All we can do is prepare the action and send it forward, and from then on timing depends upon it appears on the agenda. It is considered at a meeting of the Committee. the action is taken.

MR. JOHNSON: So for all intents and purposes, it is about an even shake up whether the equipment comes out on time or not. Isn't that about it, sir?

MR. KIRSCHNER: No, the procurement of the equipment ---

MR. JOHNSON: No, I mean the test equipment -- whether the test equipment comes out at the same time as the regular procurement of the prime equipment.

MR. KIRSCHNER: Well, the point is that when the requirements are passed on to us by the equipment engineering group -- and you're familiar with that group I'm sure -- we prepare our maintenance planning data sheet which reflects the items of equipment required to support that given system. From then on in, we take all the necessary actions that we can take in order to move the item into the supply system. Now the items that we can control are the actions that we take. Beyond that, of course, I can't discuss.

MR. JOHNSON: Well that was just the point I was trying to bring forth to show what some of the difficulties were. I know that system just as well as you. I've been there even longer than you and I know all the faults. I just wanted to bring it out into the open more or less. That was all.

PROPOSED AUTOMATIC TEST SYSTEM FOR SIGNAL CORPS EQUIPMENT

Ron Manly
Ramo-Wooldridge

Introduction

Ramo-Wooldridge received a contract from the USASRDL covering the initial phase of their Automatic Test Equipment Program. The contract called for investigations into depot and field maintenance operations; the adaptability of the Signal Corps' maintenance system and of the military equipment design to automatic testing; and automatic testing techniques themselves.

In the course of this investigation numerous visits were made to Signal Corps installations. This included visits to all of the fifth echelon Signal Corps Depots in the Continental United States - Sacramento, Tobyhanna, Lexington, and Decatur and the Pirmassens Depot in Europe.

About half a dozen fixed shops were visited both in the Continental United States and overseas.

Tactical maintenance operations for infantry, armored, and aircraft units were visited both overseas and in the United States. In addition, operations during maneuvers were observed.

Among others, personnel of Army Organizations concerned with Maintenance were interviewed. The U. S. Army Signal Equipment Support Agency, the U. S. Army Signal Supply Agency, the groups in the OCSigO concerned with maintenance, and USCONARC were visited.

In Addition to this detailed study of operational requirements, present standard equipments, and equipments in development were studied to determine how to automatically test them. Also the future design and construction techniques such as micromodular design were studied to determine their effect on proposed methods of automatic testing and to make sure this system would not become obsolete due to new equipments coming in the field. A modular design approach was also developed to permit the proposed automatic tester to keep pace with any new equipments requiring test signals or measurements of a very unusual range of accuracy.

The study of present standard equipments include:

1. A detailed study of how to test about ten different equipments representative of a wide range of the present standard equipments.

2. A survey of the characteristics of most of the present standard equipments.

3. The preparation of extremely detailed test programs and step-by-step usage procedures for a couple of equipments.

As a result of this study it was concluded that it is feasible to automatically test present standard equipment with a "universal" type of tester. Also, a design plan for an automatic testing system designed specifically to test Signal Corps equipment was prepared. This is the one I'm about to describe. Thus, the Thompson-Ramo-Wooldridge Corporation is ready with this design plan and with all of the experience gained from this study to proceed immediately (after the receipt of a contract) to finalize the design and construct Depot and Mobile Field Automatic Testers.

Many of the speakers have pointed out that the unavialability of trained technical personnel was one of the major, if not the major maintenance problem. Accordingly since this proposed automatic tester described here requires what amounts to an untrained operator, it seems to me that this proposed system when completed will provide a solution to the problem of the shortage of trained personnel.

PROPOSED AUTOMATIC TEST SYSTEM FOR SIGNAL CORPS EQUIPMENT

1. General

Figure 1 shows an artist's preliminary conception of an automatic testing system for Signal Corps equipments at the third echelon. The system is shown installed in the S-141-G shelter which will fit on a 2-1/2-ton, 6 by 6 truck.

The purpose of this presentation is to indicate the general method of testing and maintaining equipment which may be available to you in the next few years and to obtain your comments and criticisms.

This system is still in the study stage (under Signal Corps contract) and will probably be modified. The laycuts shown were made to determine whether adequate space was available and to serve as a basis for modification to optimize them.

It is planned to use basically the same equipment at the third to fifth echelon. Thus, for simplicity, only the third echelon application will be described.

2. Description of Shelter Layout

Figure 2 is a view of the right side of the shelter installation.

The man at the right is shown at the test console (Item 3). A detail of the test console will be described later. The man at the left is at the repair bench (Item 1). He does the actual replacement of a defective component on a module, when necessary.

Item (2) contains the instrumentation for testing. This includes signal generators which are under automatic control in both amplitude and frequency. Also, there are signal characteristic measuring devices which measure frequency and amplitude of voltage, current, power, am, fm, etc.

Item (4) is the input-output unit. It contains switching means for connecting the instrumentation to any pin of the standard connectors on the test console, as required by automatic control signals. Also in this unit is the power supply for the test system components (not those for the equipment under test which are in Item (12)).

Item (5) contains the cabinets which will probably be largely used to store spare parts.

Figure 3 shows the left side of the shelter installation.

Item (6) is the air conditioning and heater unit for the shelter. This is a standard GFE unit. The system does not require air conditioning for its operation. However, as most of you well know, the over-all reliability of any equipment will be significantly improved by keeping the average temperature at a nominal value. Also, the functioning of the personnel in the shelter in very hot weather would be considerably improved by air conditioning.

Item (7) contains the magnetic tape unit. The main test program information on the various equipments to be tested may be stored on magnetic tape. This is one of the areas in which the recommendation has not yet been finalized. There seems to be considerable advantage of an alternate means of program storage which is being evaluated.

Item (8) contains the tape unit electronics. This includes power supplies, reading and, perhaps, writing circuiting.

Item (9) is a militarized piece of equipment which functions similar to a Flexowriter. It allows the typing of information such as the identification of equipments which do not have provisions for automatic identification. It also produces a punched paper tape containing logistics and maintenance data such as failure reports. This information can be sent back to higher echelons for machine processing since it is in machine compatible form. Also, various information can be provided to the shelter personnel on the Flexowriter.

Item (10) contains the decision making components of the system. This includes the comparator and control functions of the system. The comparator would determine whether some characteristic of the equipment were out of tolerance. It would also perform various functions during failure isolation.

Item (11) is the magnetic drum unit. It is the main quick access storage and is used in close conjunction with the comparator and control unit.

Item (12) contains the units which are to furnish the power supply voltages needed to operate the equipment under test. These are under the automatic control.

3. Detailed Description of Console

Figure 4 shows the console in more detail.

At the center (A) the EUT (equipment under test) is placed.

At (B) are "standard connectors." It is planned that future equipments will generally have only a standard type of connector on them. Present estimates indicate that an EUT may have as many as five connectors which must be attached to it. Also, since an equipment may have each of these connectors in one of a variety of sizes, the tester might need as many as 30 of the standard connectors (assuming up to 5 each of 6 sizes). However, it is hoped that the largest sized standard connector will be able to be designed in such a manner as to allow it to be directly connected to all of the smaller sizes also. This would reduce the number of standard connectors required to 5 instead of 30.

At (C) are stored the adapters for connecting to equipments which do not have standard connectors.

At (D) are connectors for r-f signals which, of course, require special handling.

At (E) is the pictorial display which is used in conjunction with the talker at (F) to give directions to the operator (who is untrained) on how and where to attach the various connectors to the equipment to locate the pertinent controls, and to disassemble and assemble the equipments. The pictorial display will generally show pictures of the equipment similar to those shown in the technical manual. The talker will give aural directions somewhat analogous to the general printed material in the TM. An automatic pointer (an arrow) will be part of the pictorial display to locate the particular item being mentioned.

At (G) are servos for manipulating the controls of the EUT. These servos are manually attached to the controls by the operator prior to the actual testing. The talker and pictorial display give the directions for attaching the servos to the operator.

Similar procedures are used for solenoids (H) to manipulate switches and (I) "balanced arm servos to manipulate adjustments." The latter must be used instead of the servos for manipulating the controls because the adjustments are very delicate and cannot stand very much weight pressing on them.

The desirability of using (G), (H) and (I) will be marginal for some equipments but probably desirable for others in which the test procedures require much manipulation of controls, adjustments, and switches. An example of this would be when an equipment had many different modes of operation and quite a few functions in each.

However, because many equipments have a very large number of adjustments for aligning, a hand-held servo (J) is also provided.

In the drawer (K), adapters for attaching (G), (H), (I) and (J) to equipments which have nonstandard controls, switches, or adjustments are kept.

At (L) are female connectors for plugging in a module for testing and failure isolation of it.

At (M) are male module connectors for replacing a module in the equipment. This is done in order to isolate failures in the wiring or components associated with a module and to indicate whether or not the connector might have been at fault.

At (N) and (O) are female and male connectors, respectively, for performing a similar function for tubes as is done for modules by (L) and (M).

At (P) are probes used for failure isolation down at the level of components and their wiring and connections. This type of operation is kept to an absolute minimum. Whatever is necessary is done under the aural and pictorial direction of the displays.

At (Q) is a component test area for verifying that a component is defective, for checking a new component before putting it in a circuit, or for testing components received for stock.

At (R) is shown a bumper and guide rail for a drop table which if future equipment were designed to utilize it might be used to detect incipient catastrophic failures by subjecting the equipment to a predetermined shock stress.

At (S) and (T) are a foot switch and a kick bar to allow the operator to indicate to the automatic tester when he has completed a direction or is ready for the next one.

At (U) is a soldering gun to permit the operator to fix a poor connection rather than requiring the repairman to do it.

In the drawer (V) tools used for disassembling or assembling the EUT are stored.

At (W) are miscellaneous meters, lights, and switches. It is important to note that it is not planned to use any meters for the actual automatic testing. They are only used to give the operator confidence when and if he needs it.

4. Discussion of Use of System

Operational, failure isolation, and failure prediction tests will be able to be performed on present standard equipments, equipments now in development, and even micro-modular equipments. The operational tests will be at least as comprehensive as present day Repaired Equipment Specifications. Failure isolation tests will be performed down to the smallest replaceable units. Failure prediction tests will include measurements of the actual margins to failure for tolerance failures and whether the equipment still has satisfactory margins to avoid catastrophic failures.

An advanced model of the system being studied would do all this testing completely automatically. The simpler model described will do operational and failure prediction automatically. But, it will require a few manual operations to be performed by a relatively untrained operator for failure isolation below the module level, i. e., down to single component parts or wiring connections.

The requirements on the operator are good manual dexterity and about two weeks of training to familiarize him with the general procedure of working with the system, teach him to be able to distinguish a resistor from a transistor, and to be able to solder a component into or out of a circuit without damaging the whole equipment very often.

The system will also do aligning of transceivers, complete self-testing including failure isolation, and preparation of failure reports and other paperwork.

An outline of a step-by-step usage procedure is given below.

This outline descirbes the case of the major mission (Third Echelon), the major function (complete testing of a unit), and either developmental or future equipment under test (modularly constructed, and having adequate test points).

1. Identification of the equipment by the operator or the automatic tester.

2. Directions to operator concerning appropriate magnetic tape reel. (This may not be required.)

3. Directions to operator concerning initial setup of tie-ins.

4. Sequency through operational test program.

5. Directions concerning any manual operations required during the test program.

6. Output of results of operational test program.

7. Sequence through failure isolation test program, and/or alignment procedure if necessary.

8. Directions to disassemble the equipment, to replace failed module with a test connector, and to attach another test connector to the failed module.

9. Directions concerning any manual operations required during the failure isolation test program.

10. Directions concerning the failure, repair or replacement, and reassembly of the equipment.

11. Time out for repair.

12. Performance of complete operational test including marginal checking.

13. Print-out of tag for the equipment showing its margins and its due date for further preventive maintenance.

14. Directions for set-down of tie-in to the equipment under test.

As a closing comment which indicates the potential worth of this system, it is estimated that the total time required to completely test and repair a fairly complex equipment will be 5 to 10 minutes (provided the correct spare resistor is readily available and future equipments are designed to allow the necessary disassembly and assembly to be done in a few minutes).

It is evident that such an automatic test system will greatly reduce many of the problems facing the Signal Corps today.

The quantity and quality of the maintenance personnel will be reduced by a factor of at least 10 to 1.

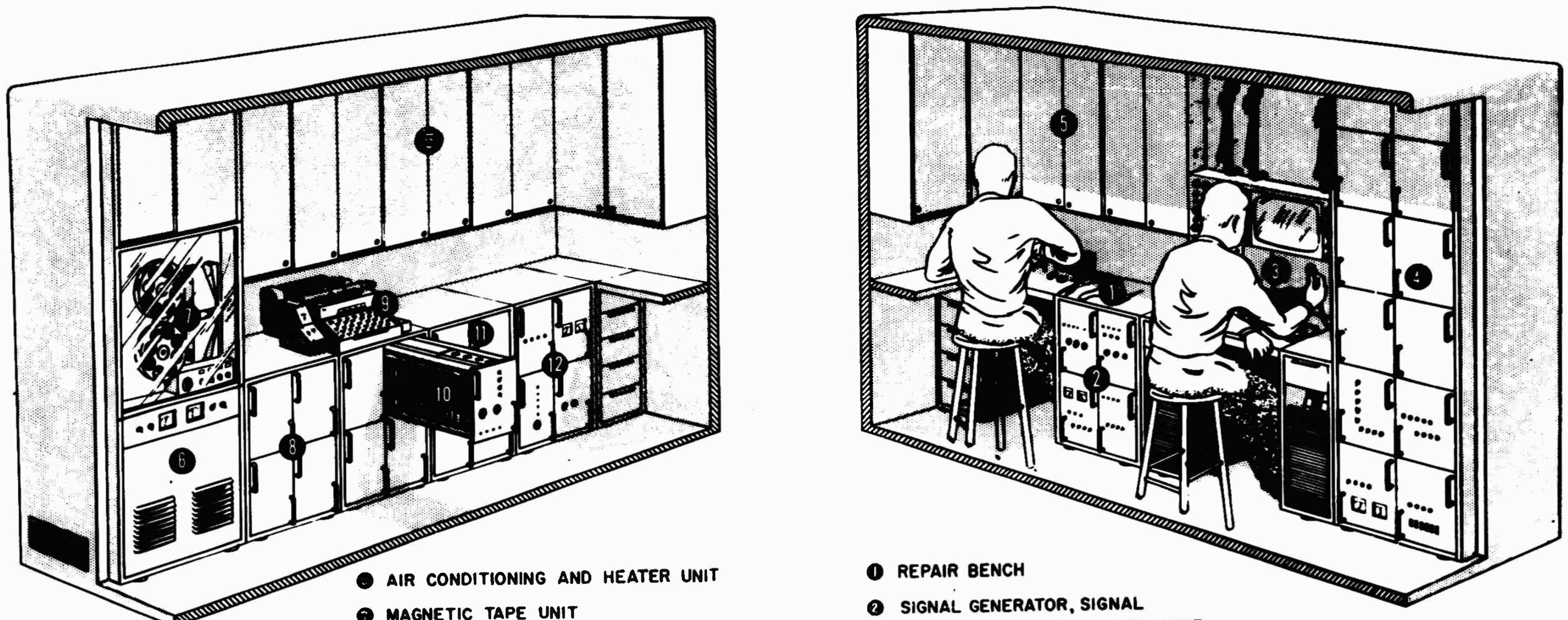
The down time of the equipment will be reduced by as large a factor.

The outputs of the depot type tester will be compatible with the automatic supply system, thus, replacement parts will be automatically requisitioned.

The multiplicity of the "general purpose" type test equipment will be eliminated.

Since the automatic test equipment will be self-checking, the long standing requirement of the test equipment to test test equipment will be eliminated.

The automatic test equipment will be available for field and depot evaluation within 18 months of the contract award.



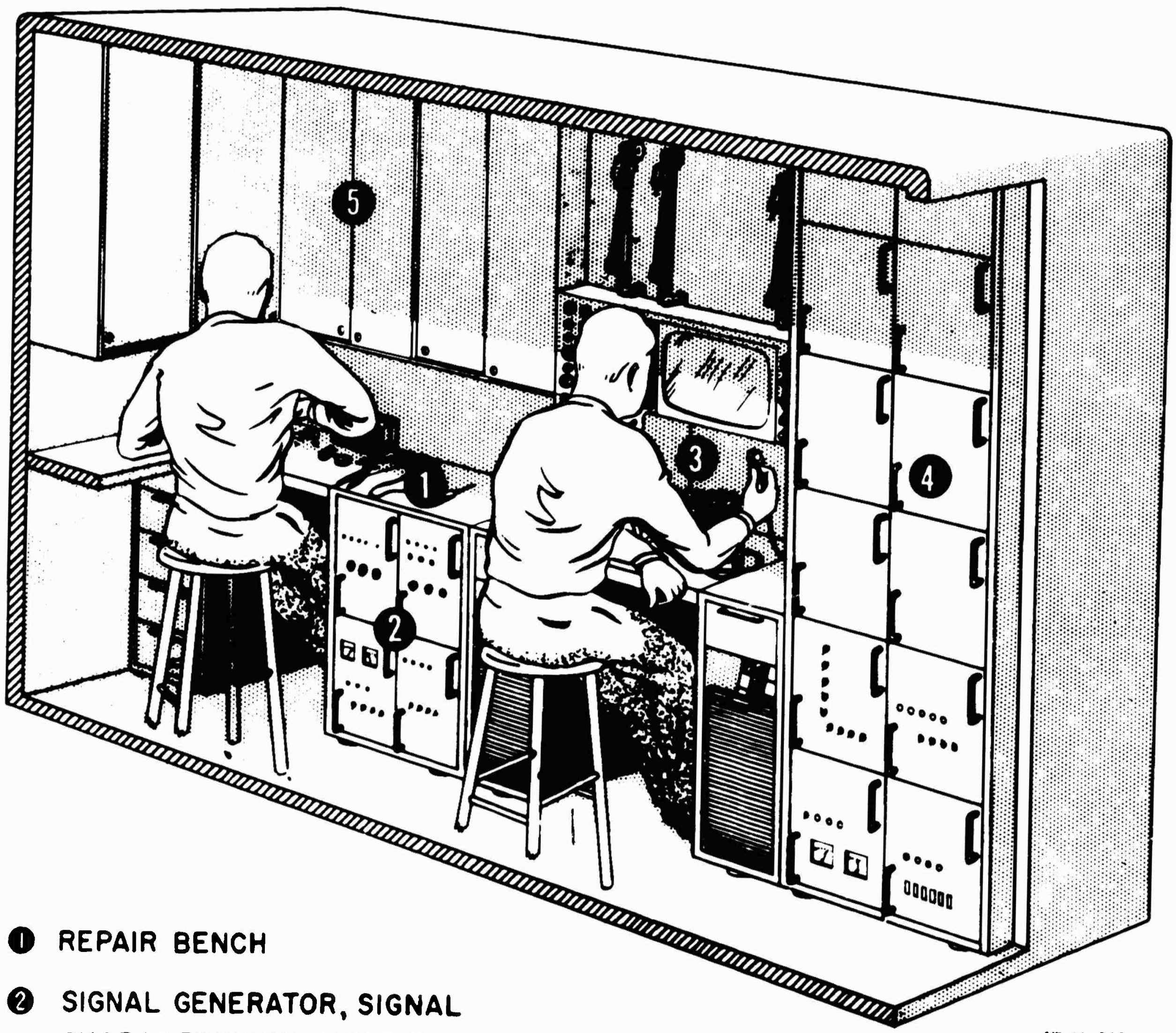
LEFT SIDE

- AIR CONDITIONING AND HEATER UNIT
- MAGNETIC TAPE UNIT
- TAPE UNIT POWER SUPPLY
- FLEXOWRITER
- ARITHMETIC AND CONTROL UNIT
- MAGNETIC MEMORY DRUM
- POWER SUPPLY

1. REPAIR BENCH
2. SIGNAL GENERATOR, SIGNAL CHARACTERISTIC MEASURING UNIT
3. AUTOMATIC TEST CONSOLE
4. INPUT-OUTPUT UNIT
5. CABINETS

RIGHT SIDE

Figure 1



❶ REPAIR BENCH

❷ SIGNAL GENERATOR, SIGNAL CHARACTERISTIC MEASURING UNIT

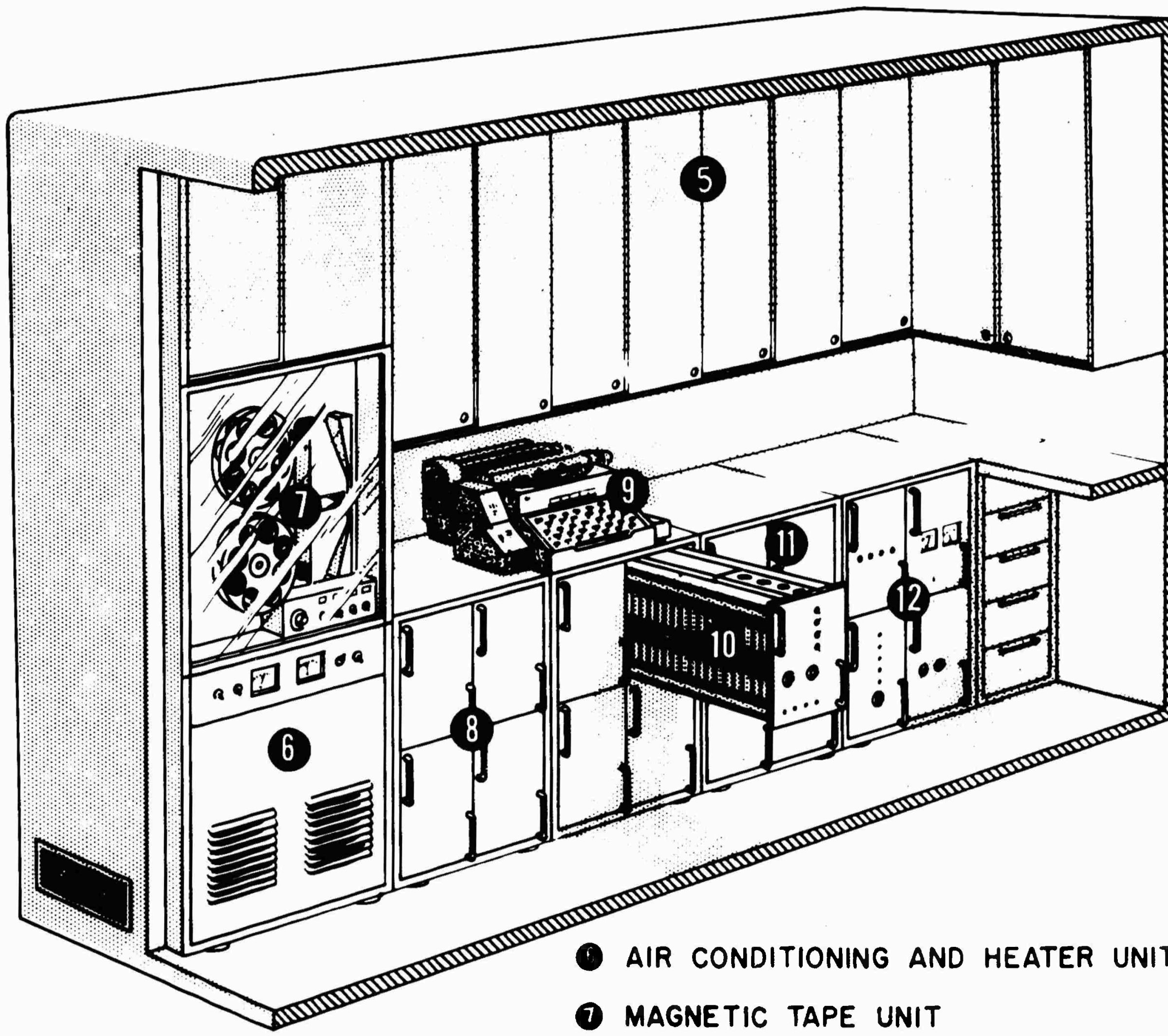
❸ AUTOMATIC TEST CONSOLE

❹ INPUT-OUTPUT UNIT

❺ CABINETS

RIGHT SIDE

Figure 2



LEFT SIDE

6. AIR CONDITIONING AND HEATER UNIT
7. MAGNETIC TAPE UNIT
8. TAPE UNIT POWER SUPPLY
9. FLEXOWRITER
10. ARITHMETIC AND CONTROL UNIT
11. MAGNETIC MEMORY DRUM
12. POWER SUPPLY

Figure 3

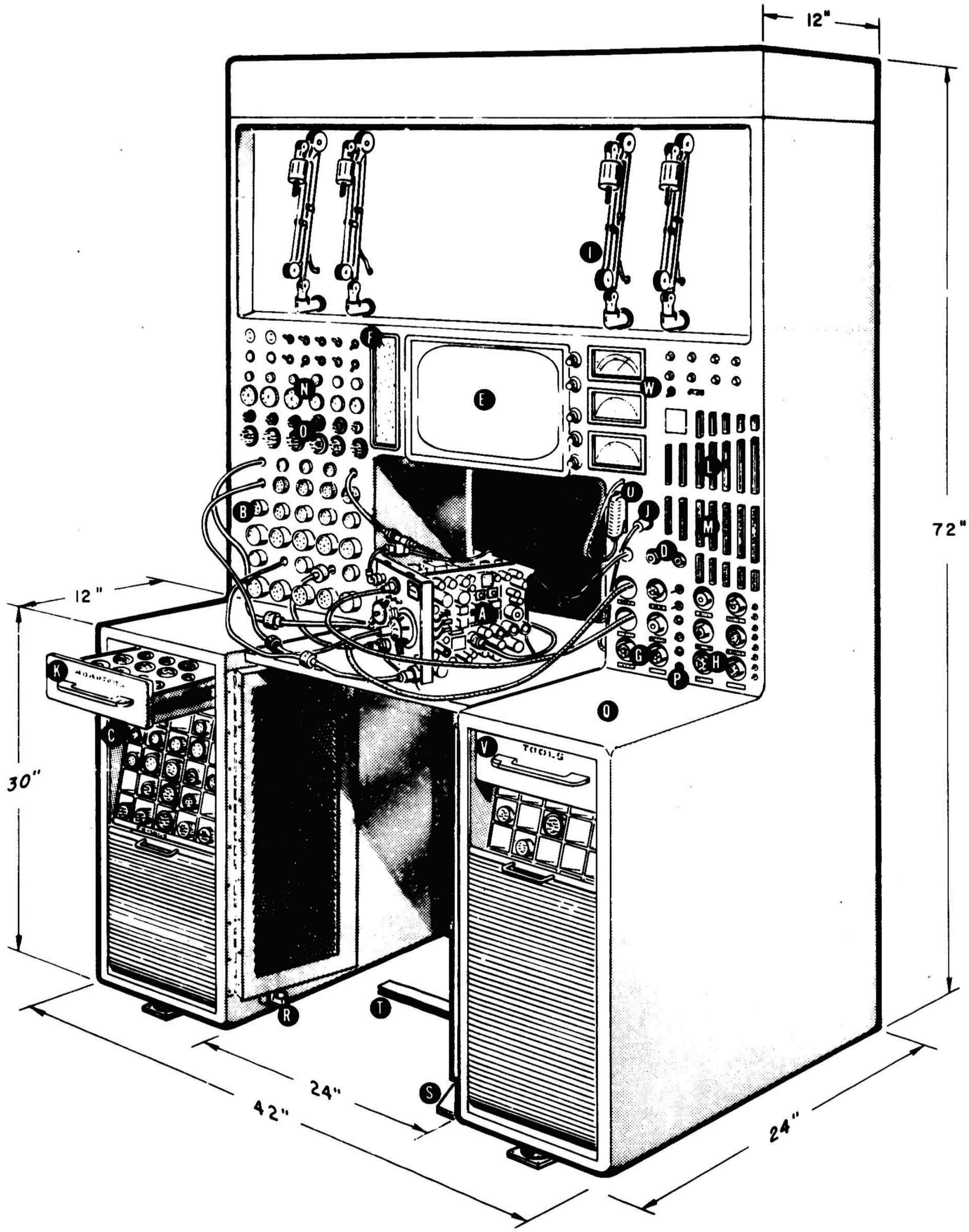


Figure 4

LEGEND FOR FIGURE 4

A. EUT (equipment under test)

B. Standard connectors

C. Adapters for nonstandard connectors

D. R-f connectors

E. Pictorial display

F. Talker

G. Servos to manipulate controls of the EUT

H. Solenoids to manipulate switches

I. "Balanced arm" servos to manipulate adjustments

J. Hand-held servo to manipulate adjustments

K. Adapters for nonstandard controls, switches, and adjustments

L. Female connectors to accept plug-in modules

M. Male connectors toreplace plug-in modules

N. Female connectors to accept tubes for testing

O. Male connectors to replace tubes

P. Probes used for failure isolation to a component or a connection

Q. Component test area

R. Bumper for drop table for shock-testing equipment (this may be included in future models)

S. Foot switches for the operator to indicate to automatic tester that he is ready

T. Kick bar for the operator to indicate to automatic tester that he is ready

U. Soldering gun to fix a poor connection

V. Tools used in disassembling or assembling

W. Miscellaneous meters, lights and switches (meters are not used for automatic testing -- only to give operator confidence)

MR. M. A. SHERRY, HAYES AIRCRAFT: It seems as if only half of the problem has been approached at third echelon. You are taking care of the black boxes, but at least 50% of your trouble is in the existing connectors, harnesses, relays, and circuit breakers existing in tanks, jeeps, or aircraft. How can this be adapted to help the man at third echelon do the rest of the job when his black boxes work?

MR. MANLY: I didn't discuss it here, but we also have with the shelter a cable that would come out and plug into a connector on an installed system in a tank or in a vehicle that would isolate the failure to a black box or unit and also do an operational test on the equipment to tell how well it was performing. Does this answer your question?

MR. SHERRY: Yes, sir.

MR. MAURICE O'DWYER, USASESA: Based on my experience with Signal troops, it doesn't seem right to me that an essentially untrained operator can work this equipment. Is it feasible to have such a machine down at the third echelon level? Are we going to design future equipment to fit this machine or is this machine going to fit future equipments?

MR. MANLY: One by one. We are presently verifying that an untrained operator (or how untrained an operator, or why) can do this. It is obvious here that he doesn't have to make any decisions. All he need do is to be able to follow directions very specifically and detailed directions that show him the location of a part and how to pull out or get at the part in extreme detail, so that he need know nothing except be able to follow some directions and be able to solder and unsolder, which of course is a major requirement. This, however, is about all and, luckily, we designed it so that there is only one soldering operation that will be done per equipment. He won't be pulling out any failed components only to find its not the one. Let's see, the second is whether this is feasible down at the third echelon. This equipment is of an airborne type; I mean, it's the type that is quite capable of standing shocks and vibration and will meet all military specs concerned with the operation of equipment at that level including all the environmental capabilities. There seems to be no reason why it should not be able to operate down there especially with all of its own failure isolations and self-testing capability and the fact that its all transistorized except for maybe a tube in the power supply or something like that but essentially all transistorized. And, let's see -- what was the third question?

MR. O'DWYER: The third question was as far as future equipments are concerned, are we going to adapt them to fit this machine or will this machine take care of all future equipments?

MR. MANLY: I though I made it clear that this equipment will even be able to take care of present equipment. We will recommend requirements to make future equipments more suitable for testing -- design them to be tested quicker, more efficiently, and easily. I even pointed out that this wouldn't be necessary; if they had any special reason for having a nonstandard knob, connector, or special space or any other requirement, they could avoid the requirement as long as they gave proper emphasis to the maintainability aspect which means that they really consider how this is affecting the time required for maintainability. We recommend specific procedures for this.

MR. FRANK A. HARTSHORNE, RCA: I'm not trying to be factious or put you on the spot with this question. The only comment that I heard you make regarding the reliability of the test equipment is that it would be self-checking. What additional steps have been taken in the design to assure that it does not create more of a reliability and maintainability problem than the equipment that it's been designed to maintain.

MR. MANLY: We've had very extensive experience is building circuitry and components of extremely high reliability using all of the present techniques, all self-modular checking, and the very highest quality components to insure that this system has extremely high reliability. A computer using similar circuitry although not even as ruggedized, had well over 600 hours meantime per failure when it had something over 20,000 parts. This was the very first model that had come off the line without any further improvements. The transistors would be all siliconized and would be able to stand tremendously high variations in temperature. We give reliability extremely important emphasis and, in addition, the maintainability time that we are talking about here on the equipment is, I believe, a maximum of 15 minutes -- completely self-test, failure isolate, and repair, and using self-testing equipment.

MR. HARTSHORNE: So you feel that it wouldn't fail, based upon your experience with this other equipment, any more than once a month on the average under continuous operation and would require only 15 minutes to put back into operation. Is that what you infer?

MR. MANLY: The latter part is correct. As for first part -- the detailed design of the equipment has not progressed to the point of ascertaining the actual number of components, so we can't say exactly what that number will be.

MR. JACK FOLLEY, AMERICAN INSTITUTE FOR RESEARCH: My main interest is human factors, but there are a couple of points I would like to raise. Probably you didn't mention some of these because of time limitations and for the same reason I don't expect you to answer all of these. But I would like to bring them up for the group to consider, particularly those who are going to decide on the purchase of this device. I would like to re-emphasize the point on test equipment reliability of this device. I think that for it to have maximum usefulness it should have at least an order of magnitude of reliability superior to the equipment that it is testing; otherwise you would have the eternal problem of which is incorrect, the test equipment or the equipment it is testing. Second, it is my impression from what you showed us on the slide that you are underestimating the time required to hook up a device to this piece of test equipment, and I think that with this device you have omitted consideration of what is perhaps one of the most serious problems in the maintenance business these days and that is keeping up-to-date with the instructions and manuals. What happens when the item to be trouble shot and repaired is a MOD 3 and the instructions on the visual and military display are MOD 1? And, I guess, another point I would like to make is that I don't think that you have reduced the training requirement as much as you would have us believe, because one can take almost any existing piece of test equipment and describe the operations in the same terms that you describe the operations for this and at the same level of abstraction and it sounds good. All you have to do is make a few connections and use a meter to use a UPM6D; that's all you have to do with this one. You are still requiring a man to find components in the equipment being tested and to make a large number of connections. Have you made any provisions for keeping him from connecting the wrong adjustment servos to the wrong adjustment, or is this thing self-compensating so that it will correct signals? I think these are real problems, and I realize you have a severe time limitation in your presentation and, therefore, can't cover all these things, but I think they are things to be considered.

MR. MANLY: Do you have some more?

MR. FOLLEY: Yes, I have two more.

MR. MANLY: I definitely want to answer all of them because we have considered all of them and I think we have them all quite satisfactorily answered. Don't give me too many -- but go ahead.

MR. FOLLEY: Well, I think that the last one I would like to mention is that you said it was evident that this would reduce the personnel requirements, training requirements, and the down time, I think you said, by a factor of 10. I wondered if you had any data to substantiate this, because, as I have said, my impression from what I have seen and what I do know about maintenance operations and personnel now I would not judge that you have a factor of 10 reduction in either training time, manpower, or equipment down time.

MR. MANLY: First, and one of the most important ones, was whether this made any difference to the operator, with regard to the requirements on the technician. I think that you grossly misstate the case when you say that this doesn't make any difference. First of all, the present operator has to understand the equipment under test in extreme detail. He has to know how it works. This is where all of the difference comes in. It's true, as far as explaining how the test equipment works, that you can say that you can explain it just as easily, but the operator here does not have to be familiar with any of the equipment under test, which can be several hundred equipments, perhaps down in the third echelon and 1,000 or more at a depot; this can make all the difference in the world regarding training. The fellow would have to be able to do nothing but follow directions -- no decision making whatsoever, no knowledge of doing anything except the ability to follow extremely detailed instructions. Concerning test equipment reliability, again I think that one of the extremely important points in here is, as you say," have to be in the order of magnitude better than the equipment under test." One of the important points is, how long is the testing operation going on? This testing operation now is in the order of 5 or 10 minutes instead of a couple of hours or more previously. But nonetheless I think that even without this the equipment would have extremely good reliability. Also the question of availability is extremely important because of the very quick maintenance of this equipment compared to any other. The availability time is the time that you are sure the thing is right; it does all sorts of self-testing continuously every few minutes so you can be quite sure when the thing is operating satisfactorily. Second, concerning the time requirements, we have done time and motion study estimates of the actual time required and we have done actual experimental data on the time required. Reference the question as to whether he connects the wrong thing up. We have various sensing devices and various procedures that will check that the right adjustment to the right adapter is being used, every step of the operation. It is probably better than Mr. Hershey could imagine -- damn foolproof. As for the question of being able to test present and future equipment, -- every different modification would have specific detailed changes required internally in the equipment and would be able to distinguish one from another and would be able to specicially take care of each different MOD type of every equipment. And this is one of the reasons for the drum on there. To be able to make slight modifications to a program. I think that covers about all of them.

MR. SOL SELTZER, FEDERAL ELECTRIC CORPORATION: I've got two questions to ask. One is for a modification on a new equipment introduction. Will the military instead of having electronic technicians to repair equipment have to provide an army of programs? The second question is, what is one of these gimmicks going to cost the taxpayer?

MR. MANLY: With regard to the first question, as part of the original planning of the modification and part of the equipment engineering, there should be some maintainability and test equipment evaluation and test procedure evaluation which would be done, but besides this, we also have in mind the automatic preparation of these programs on other high speed computers with a stationary location. A specific program would be prepared in advance automatically and changes made automatically. As for your second question, I don't feel at liberty to tell you what the development contact that we propose is going to cost -- and it's a little. I'd rather confine my answer to what the equipment costs in production which, of course, is still hard to estimate, because it hasn't been detail designed, but probably it would be in the order of $100,000 or $200,000 dollars. This is very rough though.

CWO GALE L HAGENSICK, WISCONSIN ARMY NATIONAL GUARD: I'm wondering just what the expendability of this item is. I'm the Signal maintenance officer in the infantry division and I'm wondering if this machine is going to be taken down to the level of where the shooting is going on, where I am directly concerned with maintenance. What happens when a stray mortar shell gets this thing. Who does the maintenance then?

MR. MANLY: Well, this is the same question as what happens when the present repair van is knocked out. It's the same thing. This takes the place of the third echelon mobile repair van. If a bomb knocks it out or if a bomb knocks this one out, they are both the same.

CWO HAGENSICK: Along those lines -- I also run a field maintenance shop and it costs approximately $40,000 a year and we repair around 7,000 signal items a year of all types. To me $200,000 dollars for one machine when I can do a whole year's work for $40,000 doesn't seem economical.

MR. MANLY: How much of this are you counting? -- all of your military time and all of the training time and all investments and everything that went into these people that you had to put in there, and all of the general facilities? Also there is the matter of the improvement in capabilities that you get with this: better testing, better performance of the equipment, and also a reduced requirement for spare parts. Are you also including all of your overhead operations and everything with this? Generally most of the military costs are counted separately (that is, the investment and cost of the actual facilities you are using). I think that this would answer the question.

MR. A. J. FINOCCHI, ITT LABORATORIES: I have a question with regard to your pin pointing of components and how you can isolate components in a high frequency IF or any rf application where straight capacity of 2 or 3 micromicrofarads are fatal to the system. How then are you going to program a sophisticated test of this IF and an alignment when even taking the cover off IF today makes them almost inoperable.

MR. MANLY: There are probably some limitations in judging the equipment here and there but, as far as this particular case is discussed, we have special transistors that we have studied and developed and we are able to do this alignment operation and such other things as telling which of two components in parallel has failed without removing them from the set.

ULTIMATE CONCEPT FOR MAINTENANCE

Major Quentin S. Hoshal
and
Bernard Pear

Part I. The Signal Corps Logistics Evaluation Group: Its Activities and Progress (Bernard Pear)

Being practically the last speaker on the Agenda has its advantages. For three days I've been exposed to an avalanche of information. The array of speakers has been very impressive; the discussions of our maintenance problems, the new approaches to their solution, and new concepts of maintenance have been most informative and stimulating.

This is the first appearance of the Signal Corps Logistics Evaluation Group as an official participant in a Maintenance Symposium conducted by the Signal Corps. We participated in the first and second ones, but only in the role of observers. Perhaps quite vocal observers. The fact that we insisted on being heard, as well as seen, is evidence of our vitality as a young and uninhibited organization still on fire with the zeal for progress and growth. It is fitting that our formal entry on the scene of a Maintenance Symposium would be preceded by a brief introduction.

Signal Corps commanders have long recognized the need for a group of individuals that could be released from the pressures of day-to-day operations and supervisory duties for the explicit purpose of devoting its entire time, talents, and energies to long-range planning and to the study, reflection, and analysis of logistics problems. In these past few years, there has been a rising tide of urgency for more and better knowledge in the logistics field that would lead to the solution of our present day problems and assist planning wisely for the future.

Uneasy world conditions, changing concepts and patterns in military organizational structures, rapid scientific and technological advances, development of revolutionary weapons systems, and new trends in the application of modern business machines and business techniques to military operations - all brought into sharp focus the paramount need for a logistics research group.

The Signal Corps Logistics Evaluation Group was established on 13 June 1955. Experimentally, it was given a two-year charter. However, before the expiration of the two-year period, a decision was made to continue the Group as a permanent Agency. Its "modus operandi" has been approved by the Chief Signal Officer and recently favorably commented upon by the Assistant Secretary of the Army for Supply and Logistics. The Group's organization and activities have been studied by a number of other research organizations, more recently by the Logistics Research and Doctrine Division at the Army Logistics Management Center, Fort Lee, Virginia, and the Chief of Transportation who is considering the establishment of a similar group.

The mission of the Signal Corps Logistics Evaluation Group is to scan the total effort of the Signal Corps in the discharge of the supply and maintenance as part of the logistics mission of the Chief Signal Officer. The Group is charged with the responsibility of developing concepts and long-range plans and resolving significant problems to insure that the Signal Corps is capable of providing the most effective and efficient logistics support to its customers.

The Group reports through its Steering Committee directly to the Chief Signal Officer. An integral part of the Group, the Steering Committee, consists of the Chief, Procurement and Distribution Division, OCSigO and the Commander, U. S. Army Signal Supply Agency.

In addition to comprising the membership of the Group's Steering Committee, the Chief, Procurement and Distribution Division exercises staff supervision and the Commander, U. S. Army Signal Supply Agency furnishes the housekeeping and administrative support to the Group.

The Group is located at 225 South 18th Street, Philadelphia, Pa., the building housing the U. S. Army Signal Supply Agency. This is an ideal location since the U. S. Army Signal Supply Agency, the Signal Corps' National Inventory Control Point and central procurement agency, not only generates and stores a wealth of logistics data and information, but also contains the greatest concentration of logistics experience which serves as a source material for many of the Group's projects.

There are six officers assigned to the Group. Although 15 military members, field grade, are authorized, no more than eight have ever been assigned to the Group at any one time. The Chairman is the senior military member assigned on orders. There are three civilian consultants who complement the military members. Our administrative and clerical staff consists of one administrative assistant and four project secretaries.

The chiefs of twelve activities, including the major divisions of the Procurement and Distribution Division, the U. S. Army Signal Board, U. S. Army Electronic Proving Ground, the U. S. Army Signal Research and Development Laboratory, the U. S. Army Signal School, and the U. S. Army Signal Training Center serve as advisory members of the Group.

As required, associate members are selected from various Signal Corps elements. The Group uses associate members when an assigned project requires specialized knowledge and skill in a particular field of logistics. Associate members are usually assigned to the Group on a full-time basis and serve for a minimum of six months to a year.

In March 1958, the Chief Signal Officer established a Steering Committee for Concept Development Planning. The Committee, chaired by the Deputy President of the U. S. Army Signal Board, was activated for the purpose of coordinating all concept development planning in the Signal Corps. The Group, an associate member of the Committee, bids for projects having logistics implications proposed by Committee members as concept development studies. Through active participation in the Committee meetings, the Group maintains close liaison with all other planning agencies of the Signal Corps, thus keeping abreast of the various concept development studies underway in the areas of research and development, communications, surveillance, electronic warfare, personnel, and pictorial service.

In developing long-range plans, new logistics concepts, and new approaches in the solution of operational problems, the Group exploits many paths of research. Close liaison is maintained with the Deputy Chief of Staff for Logistics, Continental Army Command, various operating and research activities of the other Technical Services, Operations Research Office, the Navy, the Air Force, other government agencies, scientific, technical, and professional societies, research institutes, industrial and commercial organizations, and academic institutions.

Projects are assigned to the Group in several ways. The Chief Signal Officer may direct a study in a specific area. The Steering Committee may direct the Group to conduct a study. Any element of the Signal Corps may propose a subject for study. The Group reviews the proposal and if it appears to be within the scope of the Group's mission, it is forwarded to the Steering Committee with a recommendation for approval of the study. The Group itself initiates projects, obtaining approval from the Steering Committee prior to assignment of a project officer.

Dependent upon the project's scope, complexity, the need for specialized skills and experience to carry on the study, and the availability of internal resources, the study may be assigned to any of the following: a project officer, an associate member, a contract technician, a contract consultant, a management consultant firm, a research organization, or a university. Generally speaking, it takes approximately one year to complete a logistics research project.

A month or more is spent on preliminary research to obtain familiarity with the problem area. During this initial exploration, the project officer will arrive at a tentative definition of the problem and determine the scope of the study. When he feels that he can construct the framework for the project, he prepares a Plan of Study. This Plan sets forth the objectives and scope of the study, the problem areas to be investigated, the methods of research to be employed, and the sources of information. The Plan of Study is disseminated to all personnel and activities that may be interested in the problem area or that can contribute their knowledge and experience to the project. The Plan of Study also serves as an announcement that the Group is undertaking a study in a particular area and that visits and meetings will be arranged for the purpose of gathering pertinent material.

After publication of the Plan of Study, the project officer conducts intensive research, gathering all possible factual information and data pertinent to his study. During this research stage, the project officer seeks information from both primary and secondary sources. The principal source of information is personal contact with individuals in the military services, other government agencies, industry, commerce, and academic circles. Approximately 50 percent of the project officer's time is spent in travelling throughout the world to gather factual, on-the-spot information. As many as 150 interviews may be conducted in the research stage of one project.

Secondary sources include current military, quasi-military, technical, and business periodicals. Library research is held to a minimum since library material becomes out-dated very rapidly or is usually inadequate for the type and scope of the problems undertaken for study by the Group.

In many instances, the major contribution of the logistics researcher is the determination as to whether a problem really exists and then to formulate the problem. It is an old proverb that a problem well put is a problem half-solved. Painstaking efforts are taken by the project officer in the formulation of the problem and in defining the objectives of the study.

Throughout the entire life of the project, brainstorming sessions are held to stimulate thinking and encourage the fluency of ideas. At these sessions the team, consisting of the project officer who wishes to explore his problem, several other project officers and one or two civilian consultants, is encouraged to suggest the wildest of ideas, to strive for a quantity of ideas, and to combine and improve on other' ideas. Creative thinking has paid off. It is not unusual to obtain 40 to 50 ideas in a single brainstorming session.

When the project officer feels that he has clearly defined the problem, collected all the pertinent information and data available, and selected the material relevant to the study, he prepares an initial draft of the report, using the staff study format. While the drafting of the report is tedious and time-consuming - as many as five or six drafts may be prepared before the report is finalized - the draft preparation is a necessary part of report writing. The contents of the report and the quality of presentation must meet the high standards established for Group projects.

When the contents of the report fully satisfy the objective of the study and the quality of presentation is considered adequate, a final draft report is prepared.

Prior to final publication, the study is forwarded for review and comments to the advisory members and to those individuals and organizations that have contributed to the study or that have a direct interest in the subject matter. This staffing of the project not only serves to inform personnel and activities of the findings and recommendations, but also insures comprehensive coverage and the inclusion of all meaningful material. The project officer carefully considers all comments received. If he believes that a suggested revision to the study will improve the project, he will make the appropriate changes. All the comments and suggestions that are received are included verbatim under separate annex in the final report, thus giving the Steering Committee the full benefit of all the views expressed.

When the final report is completed, the project is presented orally to each member of the Steering Committee by the Chairman and the Executive Secretary. Upon approval by the Steering Committee, the report is published and distributed to all personnel and agencies, world-wide, that have an interest in the subject material. Implementing action is directed by the Steering Committee, where appropriate. If the Steering Committee decides that the study should be expanded or approached from another point of view, the project is returned to the Group for further study.

During the three and a half years of its existence, the Group has undertaken 35 major projects. Of this number, 22 projects have been completed and 13 are in progress.

To give you an idea of the breadth and scope of the Group's activity, I'll briefly describe, first, several examples of the major projects that are in progress and then several of those that have been completed.

The project entitled, "Application of ADPS to the Field Army," is under the cognizance of the Deputy Chief of Staff for Logistics. The purpose of the study is to apply automatic data processing techniques to a Field Army in the functions of "Requisitioning" and "Item Accounting and Reporting" for Class II and Class IV materiel. These are two of the many functions being studied by the Technical Services. These studies are an outgrowth of prefeasibility studies which indicated that automatic data processing would improve responsiveness on an atomic battlefield and reduce materially requirements for clerical personnel.

The study, when consolidated with other System Analysis Studies, will constitute a master analysis corresponding to a full-scale automatic data processing system projected for the future Field Army. The study is now in the Office of the Deputy Chief of Staff for Logistics. Upon approval of all the studies by the Deputy Chief of Logistics and the Continental Army Command, the initial programming, testing, and debugging of the application will be conducted at the U. S. Army Electronic Proving Ground, Fort Huachuca.

The objective of the study, "Signal Corps Logistics System Concept for CONUS," is to develop an optimum system concept to accomplish the Continental United States logistics missions of the Signal Corps in the 1962-1970 time frame.

This study embraces the areas of supply management, maintenance customer service, and organization. It will run the gamut from top logistics planning and policy levels down to the posts, camps, and stations within the Continental United States.

Because of the breadth and complexity of the project, the Group has decided to approach it in phases; the initial phase to be devoted to the maintenance aspects. It is hoped that improved maintenance concepts will be devised, increasing combat effectiveness.

At the present time the Group is furnishing Signal Corps representation on a committee of the Chiefs of Technical Services dealing with problems of intratheater logistics support as envisioned within the current time frame. The results of the committee effort will provide the "take-off-point" for the Group's study entitled, "Intratheater Logistics Support System," to be projected to the time frame 1965-1975.

The design of a theater maintenance and supply support system that will be completely responsive to both peacetime and wartime demands is the project's objective. The study will concentrate attention on the following areas: logistics effectiveness, supply management, maintenance, expanded use of automation in a theater of operations, development of logistics know-how, and organization. An attempt will be made to improve supply effectiveness compatible with the mobility of using units in the period 1965-1975.

The high cost of Signal equipment and systems is a problem of long standing. Since World War II, increasing attention has been focused on these continual rising costs.

The purpose of the study, "Cost Concepts of Signal Equipments," is to identify and analyze the factors contributing to the costs of Signal materiel and to develop methods that will guarantee maximum equipment capability for every dollar expended. Military characteristics, equipment design, logistics implications, and procurement laws and regulations, singly and collectively, are the major factors contributing to spiraling costs. Efforts are being directed to find a means for evaluating costs, while at the same time, fully recognizing the urgency of military requirements.

The project, "Measuring the Quality of Logistics Activity," is in the preliminary study stage. Aimed at the development of a means for measuring the quality of logistics activity, this project is concerned with devising a tool that will (1) determine the extent to which the Signal Corps is fulfilling its prime mission of providing materiel readiness for combat units, and (2) serve as a planning instrument for future logistics supply and maintenance operations. Our current reports, related to materiel readiness, are inadequate since they fail to distinguish between equipment authorized but not yet issued because of fund shortages, equipment deadlined, and inactive equipment awaiting receipt of installation units. This measure will indicate how well the Signal Corps is performing its role as a combatant supporter, not as a mere issuer of supplies. Through this measure we will be asking our users to grade the quality of our efforts.

I would like to turn now to several major projects completed by the Group. The first of these was concerned with the development of an Economic Inventory Policy. Harbridge House, Inc., a management consultant firm, was awarded a contract by the Office of the Deputy Chief of Staff for Logistics to conduct the project. The Signal Corps Logistics Evaluation Group was appointed Department of the Army monitor and consultant to Harbridge House, Inc.

The objectives of the study were to increase supply effectiveness and reduce administrative costs. The study was directed toward the development of Army-wide inventory control policies for repair parts and minor secondary items. It embodied the areas of requirements determination, cost elements, and the effects at posts, camps, stations, units, depots, and national inventory control points.

The Economic Inventory Policy Test was implemented in the Signal account at Fort Devens, Mass., and the Ordnance account at Fort Meade, Maryland, in February 1958. The test was instituted at the U. S. Army Signal Supply Agency, selected as the National Inventory Control Point. The study developed stockage levels, safety levels, and reorder policies on the basis of the economic order principle.

The Economic Inventory Policy Test is still underway. The results of the test will not be known for some time.

A very important study was made with regard to training Signal Corps logistics enlisted personnel. As a result of this study, there emerged a new dimension in the training of noncommissioned officers. A Signal Corps Logistics Noncommissioned Officer Career Development Program was formulated for developing and using professionally equipped and capable noncommissioned officers in the top three grades in key positions in overseas logistics operations. It was recommended that 100 Table of Distribution spaces be allocated to the Procurement and Distribution Division and its field activities as follows: Procurement and Distribution Division, 5 spaces; U. S. Army Signal Supply Agency, 20 spaces; U. S. Army Signal Equipment Support Agency, 15 spaces; each Signal branch depot, 15 spaces. It was also recommended that a Logistics Troop Capability Program be established for the purpose of training Signal Corps TO&E units in the various operations of the Continental United States Signal Branch depots.

Since its inception, the Group has been conducting a series of studies on dry batteries. Through these studies, the Group determined that the storage temperature of -30°F prolongs the shelf life of modern military dry battery cells longer than four years. The upper limit of shelf life is still not known. With the development of this information, there are now possible realistic programs for the accumulation of reserves of dry batteries for military operations and for more effective distribution in the military system.

For the past several months the Group, in conjunction with the Packaging Standards Officer, U. S. Army Signal Supply Agency, at Tobyhanna, and a container manufacturer, has been conducting tests involving disposable types of containers for shipment of dry batteries. The purpose of these tests is to determine the best type of container and the insulating material that would provide a "protective period" of sufficient duration to permit a shipment of approximately one ton of dry batteries anywhere in the world. These shipments would have a refrigerator-induced initial temperature at -30°F. They should arrive at destination within 40 days from shipment with a temperature no higher than 70°F.

A container with these capabilities would continue the extension of shelf life of dry batteries initially provided by storage commercially or in depots at -30°F. Further, it would help to insure the issue of factory-fresh batteries to using units.

I have given you a picture of the Signal Corps Logistics Evaluation Group and its major activities. As you have seen, this is a forward looking Group that countenances no complacency. It is not bound in any manner by the way we do things now. We work in an ever-searching and inquiring environment, seeking constantly better and less costly ways of utilizing human and material resources. If you want to know more about the Group, its projects, and other activities, we will be very glad to have you visit us. Major Hoshal will now present a project he is currently engaged in which may well be a fitting climax to this conference.

Part II. Ultimate Concept For Maintenance (Maj. Quentin S. Hoshal)

(Headline) ARMY SIGNAL CORPS ABANDONS MAINTENANCE

NEW EQUIPMENT NEEDS NO MAINTENANCE
SIGNAL CORPS SAYS

Gentlemen: Will this really come true? Frankly, I don't know. Concepts may come and concepts may go, but I would like to believe the "No Maintenance" concept will become an actuality some day. Until such time as we can design and produce equipment that is so reliable, so rugged, and so economical to manufacture that maintenance is totally unnecessary, our maintenance problems will be with us.

I don't wish to infer that these problems are insurmountable. Symposiums, such as this, give all of us concerned with maintenance an excellent opportunity to air our difficulties, to discuss new approaches to old problems, and to try to find ways of coping with new problems.

Advanced technology brings with it new problems and challenges our imagination to the utmost. Equipment design trends such as modularization and micro-modularization draw sharply into focus the immediate need for the development of new maintenance philosophies and concepts.

Miniaturization of equipment has been a Signal Corps goal for several decades. Over the years, the Signal Corps, in redesigning its equipment, has continually reduced its size and weight and, at the same time, increased its performance capabilities. Future wars will demand unprecedented mobility, not only for the tactical units but for our logistics system as well. This demand for mobility points up a greater need for smaller, lighter, and more reliable equipment than ever before. The high priority assigned to the missile and satellite program has given impetus to the necessity for miniaturizing electronic equipment and to the need for incorporating a high degree of reliability into the equipment.

The Signal Corps Logistics Evaluation Group is tremendously interested in all of these developments. We firmly believe they will have a far-reaching impact on the nature and character of our supply system. Because of our profound interest in these developments, the Group has undertaken recently the study entitled, "The Logistics Implications of Modern Equipment Design Trends." This study is still in the early stages of research and analysis. I will discuss the objective of the project, its scope, and some of the preliminary observations. I will then give you a picture of what the Ultimate Concept for Maintenance may well be.

The objective of our study is to determine the long-range impact of electronic equipment design trends such as miniaturization, modularization, and micro-modularization upon logistics concepts and future logistics planning.

In pursuing this study, we intend to carefully scrutinize the Signal Corps P&D system to determine its true magnitude, to examine its characteristics, and to arrive at the overall costs of operating the system. We are exploring both the present and future trends in equipment design.

What do the design engineers and military planners foresee in design changes for the years 1963-1970? How will changes in the military characteristics of Signal equipment affect our logistics philosophies, concepts, and systems planning for the future? Will it be possible to design equipment with a predetermined life span, so that it may be replaced on a cyclical basis? What will the impact of the future design trends be upon requirements, procurement, stock control, stockage, distribution and maintenance? We hope, as a result of the study, to come up with some concrete answers to these questions.

For the next few moments, let us look at the maintenance and supply picture of today. Problems such as repair parts shortages, shortage of maintenance personnel, requirements for extensive test and tool equipments have plagued all of you at one time or another. These were perplexing problems during World War II, staggering during the Korean War, and they are still with us. In fact, instead of their decreasing, these problems are fast multiplying and will continue to grow under the impact of increasing quantities, varieties, and complexities of Signal equipment in the Army of the future. We must find solutions now; we must be very sure that we have the capability of properly maintaining the equipment in the field today as well as in the future.

In our present-day maintenance operations, this capability is largely affected by the supply of maintenance parts. When you requisition a maintenance part, you trigger a huge global supply system. The requisition is processed by hundreds of hands and travels a complex route from your organization to the post property office, then on to Signal Corps depots, passing through thousands of miles of transceiver networks, communication facilities, and automatic data processing equipment. Depending on its availability, you may receive your part in one day, three days, or six months.

Your requisition is but one of more than 150,000 requisitions processed each month in the Signal supply system. The Signal Procurement and Distribution System, with its nerve centers in Washington and the U. S. Army Signal Supply Agency at Philadelphia, supports Signal operations all over the world. The system costs over $100 million a year to operate and carries an inventory of 189,000 different items amounting to nearly $1 billion, of which $184 million represents repair parts.

Its shops in five Continental United States depots annually overhaul and repair equipment with an acquisition value of nearly $40 million. The overhaul and repair operations alone require almost 3,500 repair personnel and cost $35 million a year, exclusive of real estate, buildings, or equipment.

This huge supply system within the Continental United States supports your maintenance operations in both the Continental United States and overseas. The 65 Signal field maintenance shops authorized by AR 750-670 are among its customers. These shops, employing almost 1,400 personnel, cost approximately $9 million to operate, excluding real estate, buildings, or equipment.

Posts, camps, and stations in the Continental United States and depots overseas are served by this system. They have in their stocks $25 million in repair parts.

I don't have to tell you the extent to which our maintenance operations are dependent upon the Signal supply system. This is typified in the following table.

Stock Fund - Repair Parts		138,216	
Stock Fund - Other		46,551	
	Total Stock Fund	184,767	
Major Equipments		2,271	
Plant Items		1,691	
Miscellaneous		203	
	Sub-total Line Items	4,165	
	Total Line Items		188,932

Another way of showing this supply support is in terms of parts stockage. The following table shows the monetary value of parts stockage throughout our supply system.

CONUS Depots	$185,000,000
CONUS Installations	5,000,000
Overseas	25,000,000
	$215,000,000

Parts are being procured at the rate of $50 million each year.

Despite sincere efforts to standardize parts and reduce parts inventories, the parts list continues to grow at the approximate rate of 9,000 items per year. At this rate, by 1970 we will have almost 300,000 parts in the system. The introduction of each new equipment brings new problems of logistics support. The end result -- deadlined equipment for lack of parts. The Group feels that the rate of deadlined equipment in our troop units and maintenance shops is an exceedingly important element in judging the effectiveness of our Signal operations. For this reason, in the summer of 1957 the Group conducted a study to determine the extent of deadlined equipment in the Continental United States Signal field maintenance shops. The situation was again studied in December of 1958. The results of both studies are reflected in the following tables:

	30 Days		45 Days	
	1957	1958	1957	1958
1st Army	367	867	88	94
2nd Army	1,140	2,542	24	127
3rd Army	3,963	3,518	1,308	667
4th Army	2,540	1,845	116	310
5th Army	1,567	1,891	368	840
6th Army	1,432	2,949	183	348
MDW	126	136	29	2
	11,135	13,748	2,116	2,388

I do not mean to infer that all of these equipments were deadlined for lack of parts; however, this was the most repetitious explanation given during the conduct of these studies.

Despite the improvements in supply action brough about by Project MASS, repair parts for deadlined equipment continues to be a problem in the Seventh Army. According to a Report of MASS Activity (ROMA), the number of Code 1 requisitions processed on the dates shown were:

1958	No. of Requisitions
January	467
October	642

Code 1 requisitions serve to supply nonstockage items necessary to remove equipment from deadline. If supplied from the Continental United States, these items are shipped by air.

While we cannot draw specific conclusions from these limited data, it does appear that deadlined equipment continues to be a serious problem. Where these deadlines are caused by repair parts shortages, we must improve our supply operations. Yet, ironically, almost one-half of all items shipped from Signal Corps depots is shipped back to the depots as "Returned Materiel."

Unless our present-day planning provides form new supply and maintenance approaches and concepts, our problems will continue to increase in the years ahead. It is, therefore, imperative that we devote increasing effort to their solution. How shall we reorganize our depots to gain utmost benefit from the reduction in size and weight of electronic equipment, greater reliability, and simplified maintenance? Will smaller size of our equipment mean that we should plan in terms of smaller tonnages, smaller depots, and smaller loads in our distribution pipelines? Can the millions of dollars now being spent on maintenance and parts supply be more profitably spent on the development of maintenance-free equipment?

Scientific and technical advances and the accumulation of new knowledge in the electronic field are bringing us closer to the Ultimate Concept of Maintenance. These, along with the advances being made in automatic data processing, transportation, communications, and weaponry make it necessary that we develop new concepts for logistical support. We must not limit our thinking to conventional patterns as we know them today.

Replacement of parts by modules will surely simply the daily lives of both the user and the maintenance man. But the supply man? His life will be far more complicated than ever more in that period of phasing out standard parts for modular components. Not only will he be harassed with problems of supplying 300,000 repair parts, as projected from 1970, but he will be plagued with supplying thousands of additional modules. This transition period may give rise to larger, not smaller depots, to increased, not decreased, transportation requirements, and to greater, not fewer, problems of supply. Ultimately our "Supply <u>for</u> Maintenance" system may be replaced by a "Maintenance by Supply" system. Instead of a supply system concentrated on repair parts distribution, we may see the emphasis shift to replacement module distribution and, ultimately, equipment replacement distribution.

Troops in the field may be using equipment designed with self-testing modules and plug-in components which can be replaced with on-hand spares by unskilled user operators. Unserviceable modules or equipments may be disposed of, if expendable, or put aside for evacuation.

Replenishment of spares may be made from Continental United States depots, equipped with launching sites. Space cargo missiles may carry replacement modules and equipment for delivery to forward depots both on earth and hovering space platforms. These depots may stock fast moving modules and assemblies. Delivery to field units may be accomplished by both conventional and space vehicles, as required.

To achieve the Ultimate Concept of Maintenance, military planners, design engineers, and logisticians must work hand in hand. Only by this coordinated effort and interchange of ideas can we develop a dependable communications system, maintenance-free, and logistically supportable.


GET THE MESSAGE THROUGH
The Star Gazer
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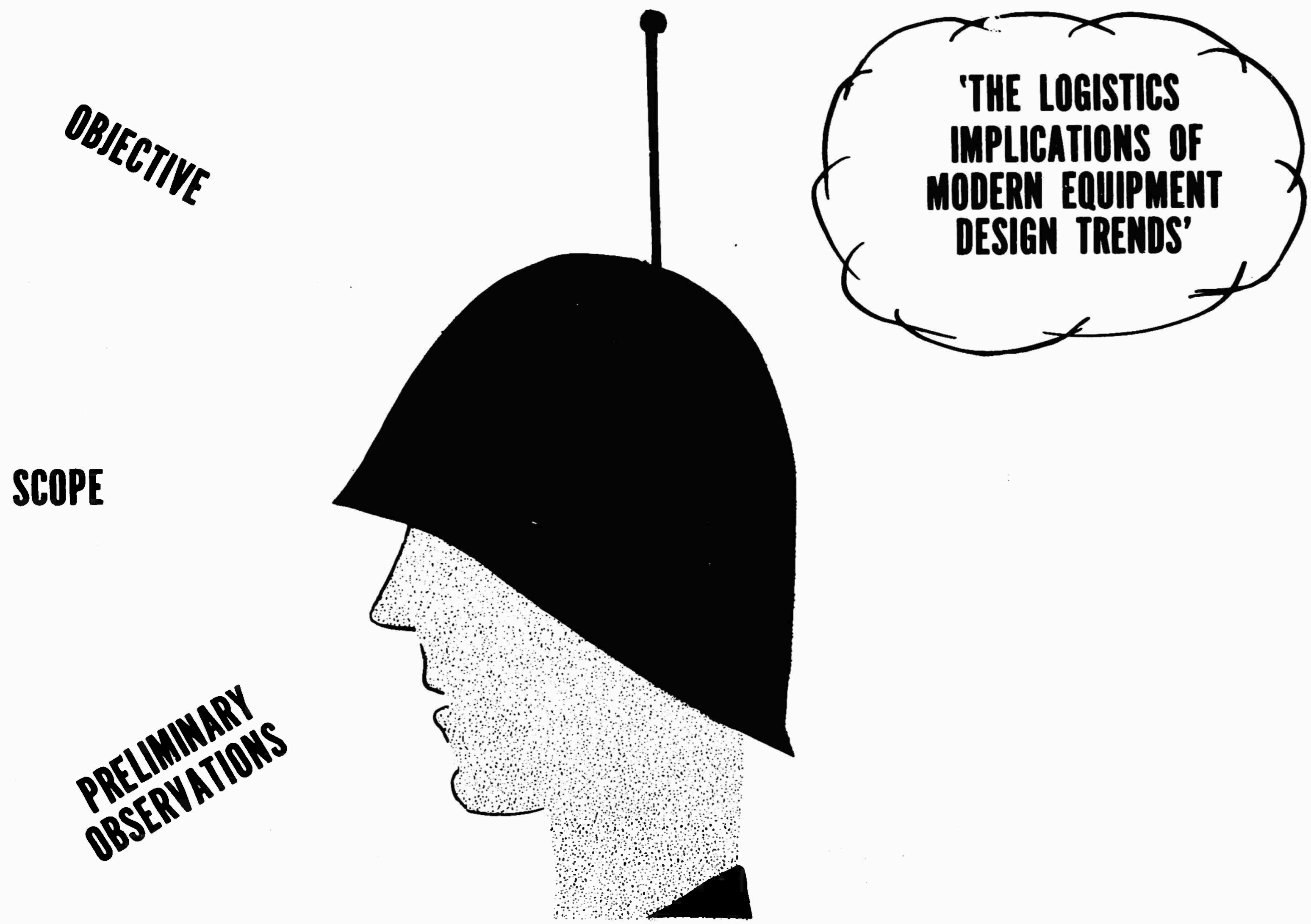
ARMY SIGNAL CORPS
ABANDONS MAINTENANCE
NEW EQUIPMENT NEEDS
NO MAINTENANCE
SIGNAL CORPS SAYS

SIG CORPS GLOBAL SUPPLY SYSTEM


OBJECTIVE
SCOPE
PRELIMINARY OBSERVATIONS
'THE LOGISTICS IMPLICATIONS OF MODERN EQUIPMENT DESIGN TRENDS'

DEADLINED SIGNAL EQUIPMENT

SIG FIELD MAINT SHOPS
CONUS

	1957	1958
30 DAYS	11,135	13,748
45 DAYS	2,116	2,388

7th ARMY

1958	NUMBER OF REQUISITIONS
JAN	467
OCT	642

MAINTENANCE PROBLEMS

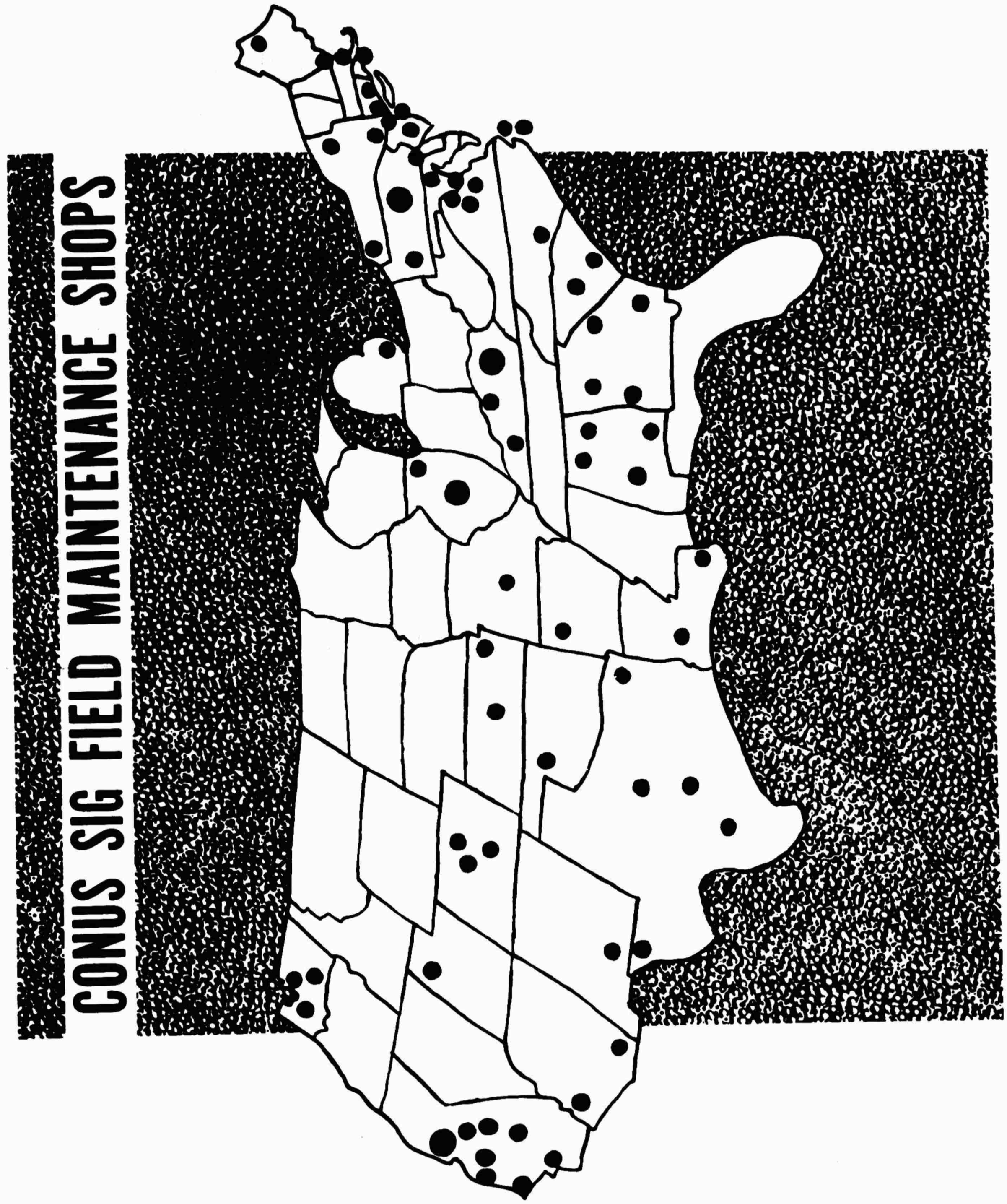
REPAIR PARTS ?

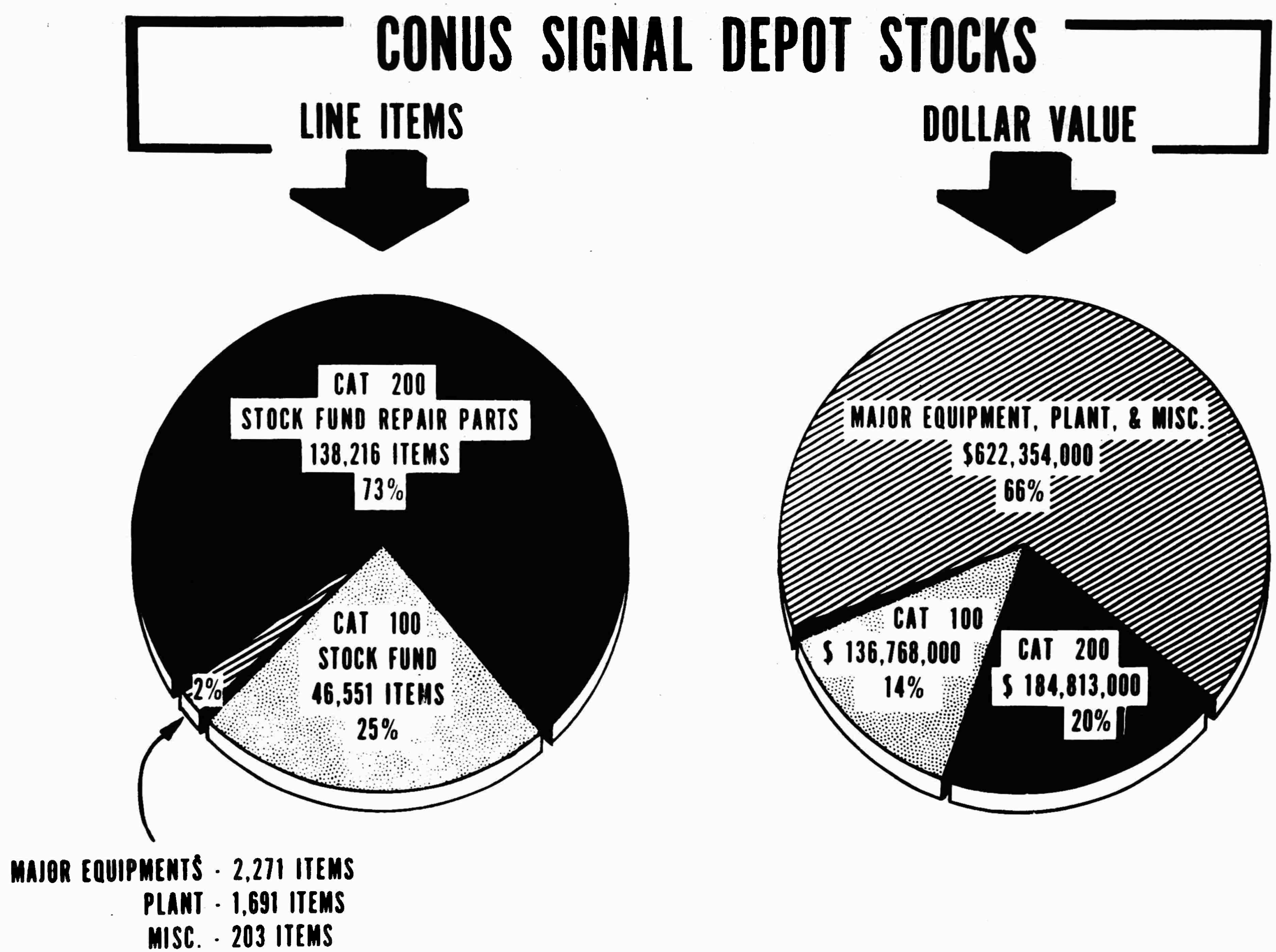
PERSONNEL ?

TOOLS & TEST EQUIP ?

~~SUPPLY FOR MAINTENANCE~~

MAINTENANCE BY SUPPLY


CONUS SIG FIELD MAINTENANCE SHOPS


CONUS SIGNAL DEPOT STOCKS
LINE ITEMS
DOLLAR VALUE
CAT 200
STOCK FUND REPAIR PARTS
138,216 ITEMS
73%
CAT 100
STOCK FUND
46,551 ITEMS
25%
2%
MAJOR EQUIPMENTS - 2,271 ITEMS
PLANT - 1,691 ITEMS
MISC. - 203 ITEMS
MAJOR EQUIPMENT, PLANT, & MISC.
$622,354,000
66%
CAT 100
$ 136,768,000
14%
CAT 200
$ 184,813,000
20%

SIGNAL CORPS LOGISTICS

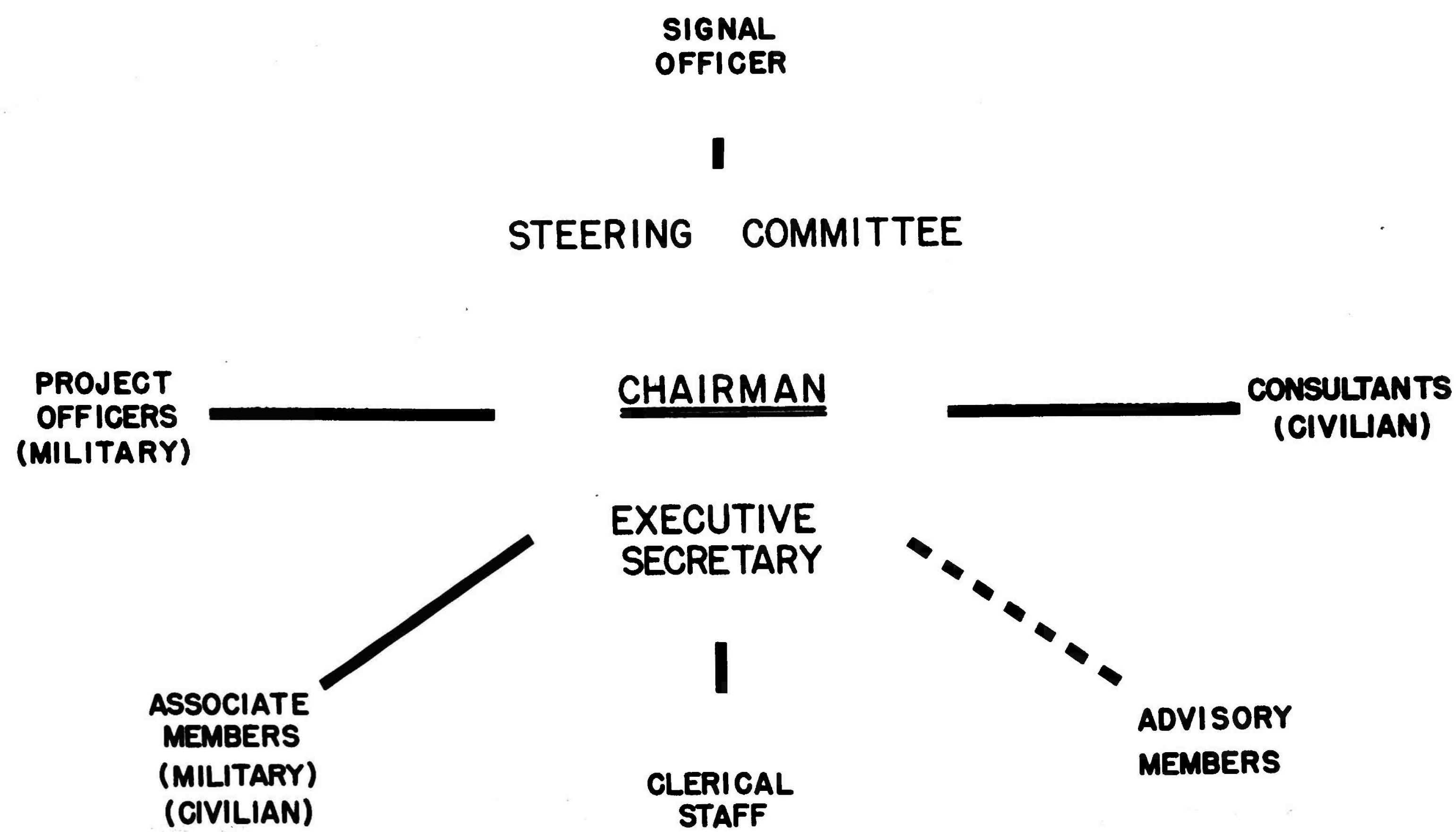
EVALUATION GROUP

MISSION

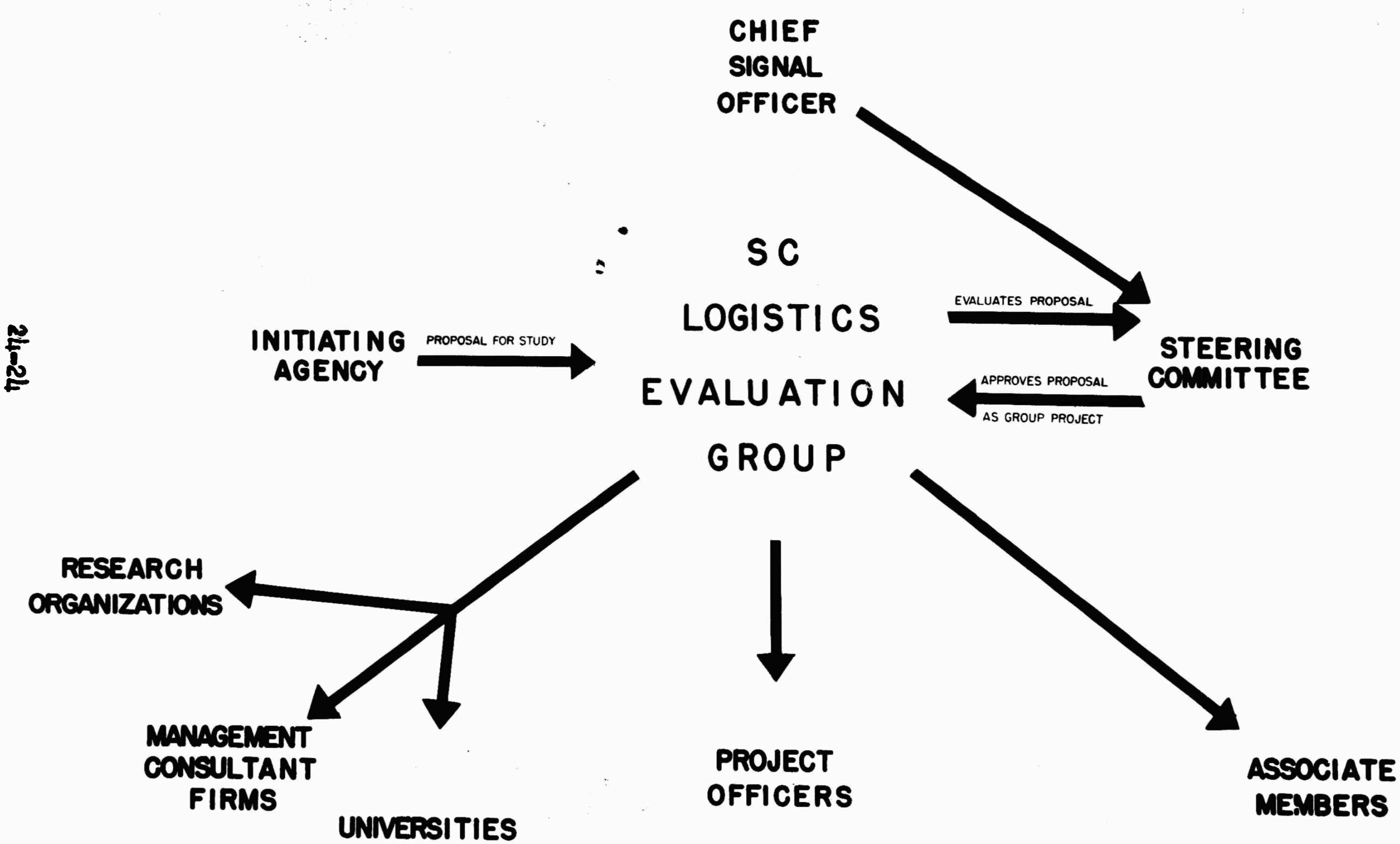
1. TO DEVELOP CONCEPTS AND LONG-RANGE PLANS FOR EFFECTIVE AND EFFICIENT LOGISTICS SUPPORT TO SIGNAL CORPS CUSTOMERS

2. TO IDENTIFY AND DEFINE MAJOR OPERATIONAL PROBLEMS, APPLY SCIENTIFIC METHODS IN THE CONDUCT OF STUDIES, AND RECOMMEND IMPROVEMENTS IN SIGNAL CORPS DOCTRINE, POLICIES, PROCEDURES, OPERATIONS AND ORGANIZATIONS.

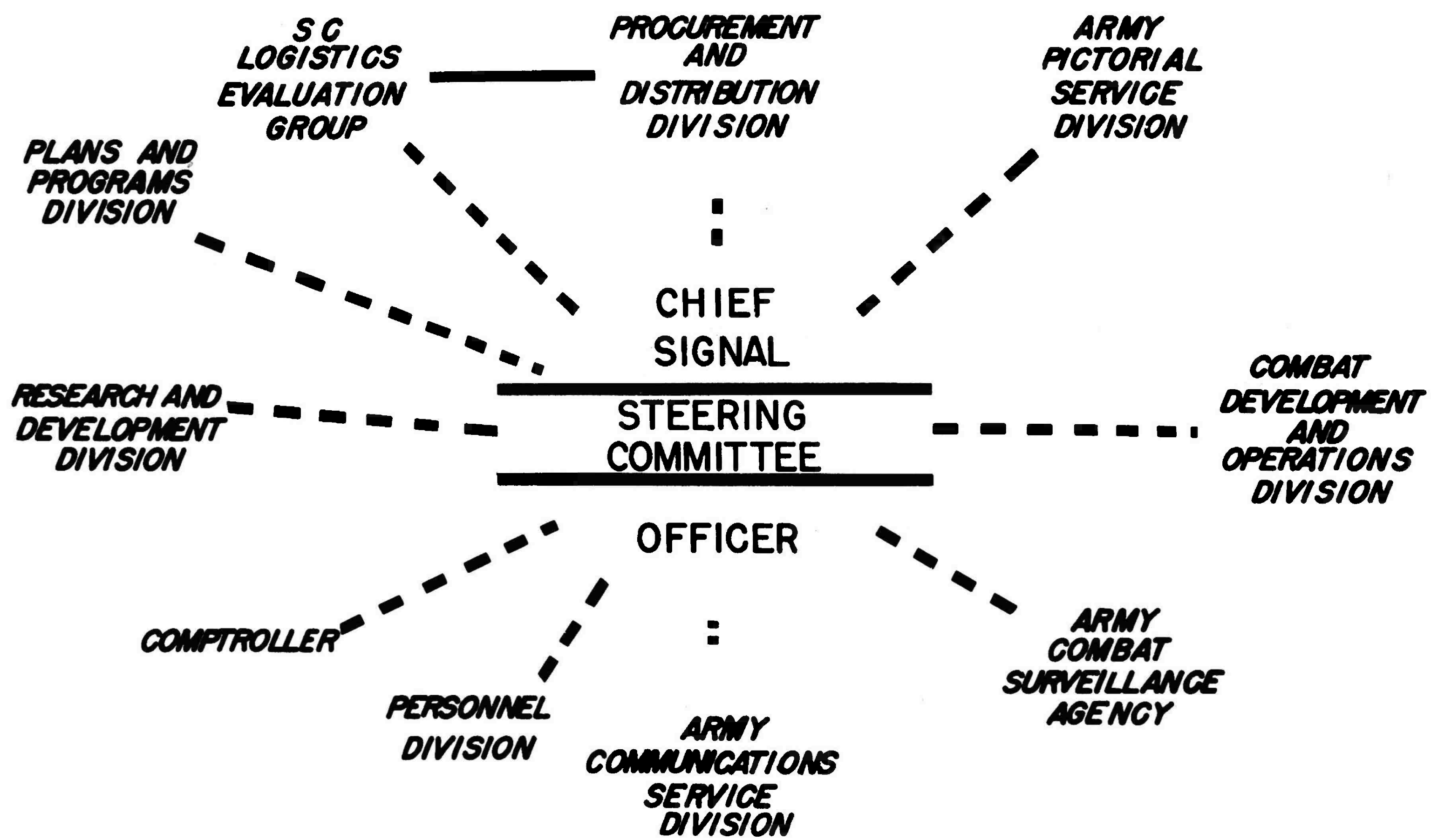
COMPOSITION OF THE GROUP



FLOW OF GROUP PROJECTS



ROLE OF THE GROUP IN SIGNAL CORPS CONCEPT DEVELOPMENT



SIGNAL CORPS LOGISTICS EVALUATION GROUP

COMPLETED ACTIVITIES

FY-1956 - FY-1959

FY	No. Projects	No. Consultant Services
1956	2	8
1957	3	17
1958	12	20
1959 (1st Half)	5	30
Total	22	75

COMPLETED PROJECT

TRAINING OF SIGNAL CORPS LOGISTICS MILITARY PERSONNEL

OBJECTIVE

INCREASE CAPABILITY OF SIGNAL CORPS LOGISTICS TO&E UNITS AND ENLISTED SIGNAL SPECIALISTS TO ACCOMPLISH LOGISTICS MISSION OF SIGNAL CORPS.

RECOMMENDATION

1. **ESTABLISH SIGNAL CORPS NON COMMISSIONED OFFICER CAREER DEVELOPMENT PROGRAM.**
2. **EMPLOY TO&E UNITS IN OPERATIONS OF CONUS SIGNAL BRANCH DEPOTS.**

COMPLETED PROJECT

BATTERIES

STORAGE DISTRIBUTION RESERVES

OBJECTIVE

IMPROVE SUPPLY MANAGEMENT
OF DRY BATTERIES

RECOMMENDATIONS

STORAGE

DISTRIBUTION

MOBILIZATION RESERVES

COMPLETED PROJECT
DEVELOPMENT OF
ECONOMIC INVENTORY POLICY

COGNIZANT ACTIVITY

D C S LOG.

GROUP MISSION

DEPARTMENT OF ARMY EXECUTIVE AGENT
& CONSULTANT TO HARBRIDGE HOUSE.

OBJECTIVE

IMPROVE ARMY-WIDE SUPPLY
MANAGEMENT POLICIES.

COMPLETED PROJECT

FEASIBILITY OF MOBILE SIGNAL CORPS DEPOTS

OBJECTIVE

DETERMINE FEASIBILITY OF MOBILE SIGNAL CORPS REPAIR PARTS DEPOTS.

RECOMMENDATION

1. OUTFIT VANS AS MOBILE REPAIR DEPOTS
2. TEST MOBILE REPAIR PARTS DEPOTS IN MANEUVERS.

CURRENT PROJECT

SIGNAL CORPS LOGISTICS
SYSTEM CONCEPT FOR CONUS

OBJECTIVE

DEVELOP OPTIMUM SYSTEM CONCEPT FOR ACCOMPLISHING CONUS LOGISTICS MISSION OF SIGNAL CORPS.

AREAS UNDER CONSIDERATION

SUPPLY MANAGEMENT
MAINTENANCE
CUSTOMER SERVICE
ORGANIZATION

CURRENT PROJECT

COST CONCEPTS OF SIGNAL EQUIPMENTS

OBJECTIVE

IDENTIFY AND INCREASE CONSIDERATION OF FACTORS CONTRIBUTING TO COSTS OF SIGNAL CORPS EQUIPMENT.

MAJOR CONTRIBUTING FACTORS

MILITARY CHARACTERISTICS
EQUIPMENT DESIGN
LOGISTICS IMPLICATIONS
PROCUREMENT LAWS & REGULATIONS

CURRENT PROJECT

APPLICATION OF ADPS TO THE FIELD ARMY

COGNIZANT ACTIVITY

DSC LOG

OBJECTIVE

APPLICATION OF ADPS IN THE FIELD ARMY TO THE FUNCTIONS OF ITEM ACCOUNTING AND REQUISITIONING OF CLASS II AND CLASS IV MATERIEL

CURRENT PROJECT

INTRA THEATER LOGISTICS
SUPPORT SYSTEM

COGNIZANT ACTIVITY

DSC LOG AND TECHNICAL SERVICE
CHIEF COMMITTEE

OBJECTIVE

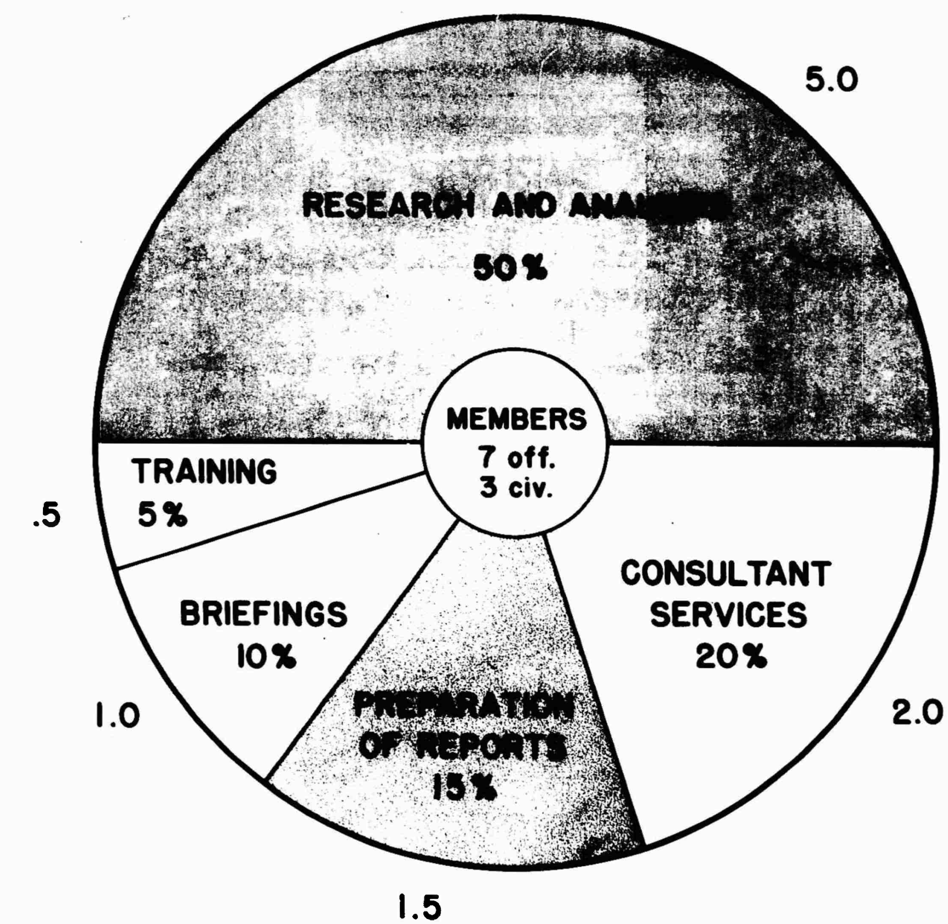
DEVELOP A THEATER MAINTENANCE AND SUPPLY SUPPORT SYSTEM FOR ATOMIC WARFARE.

SIGNAL CORPS LOGISTICS EVALUATION GROUP

DISTRIBUTION OF WORKLOAD

MAN-YEARS

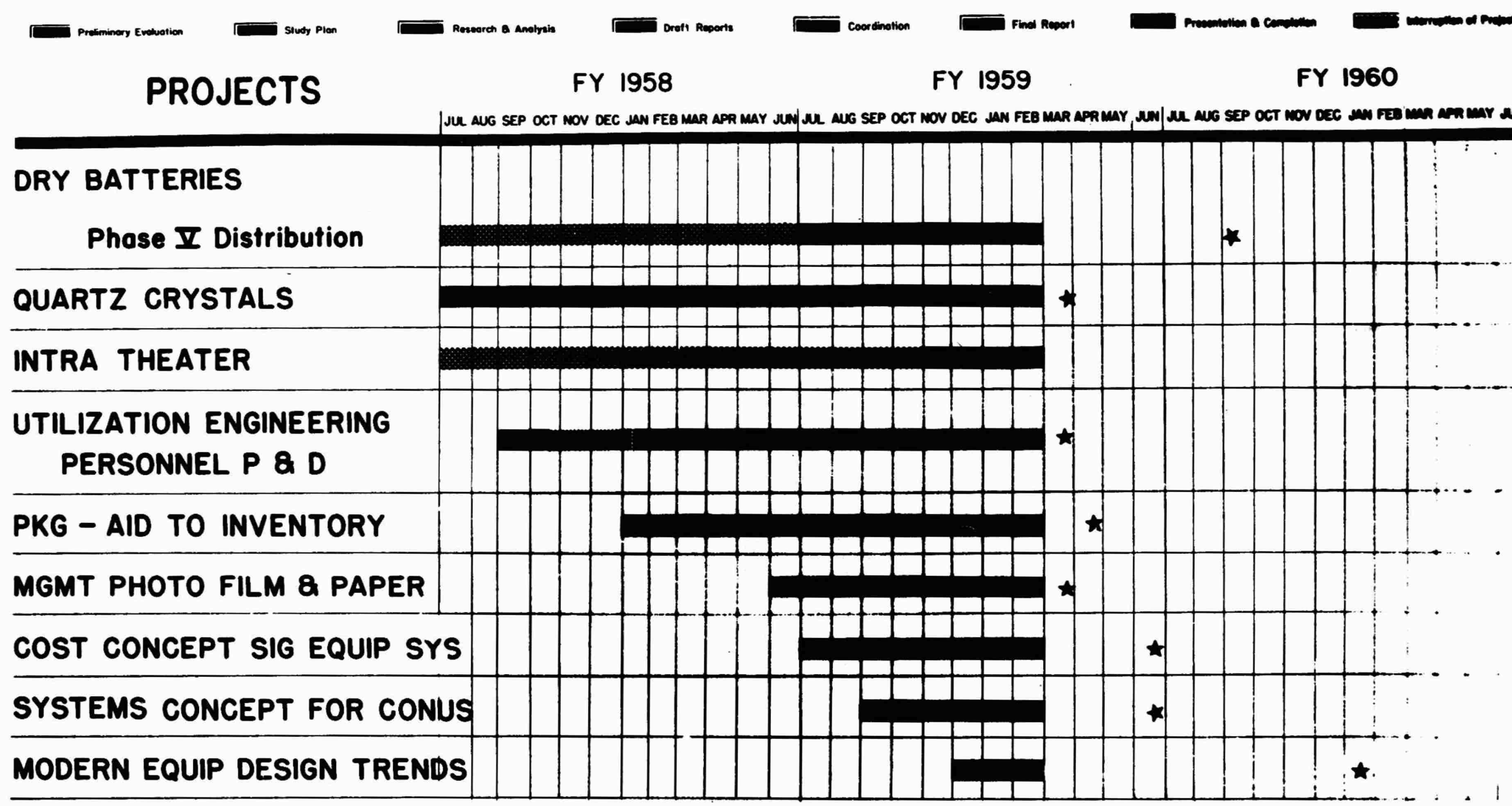
FY 1958



SIGNAL CORPS LOGISTICS EVALUATION GROUP

STATUS OF PROJECTS

FY 1958 — FY 1960



MAINTENANCE SUPPORT PLANNING

Col. Frank G. White
U. S. Army Maintenance Board

The purpose of this briefing is to acquaint you with the successive steps in developing a maintenance plan.

Before getting into the details I should like to relate maintenance planning to the general philosophy of Army Maintenance.

In our Army today maintenance considerations are no longer confined to equipment already in the hands of troops. Neither is it enough to say that an item must be maintainable. Who shall maintain it, how, when and when not, where, how often and for how long are the important questions. Minimum maintenance demands from in-service equipment require long-range planning. Such planning actually begins at the time the item itself is nothing more than a statement of military characteristics. Through successive stages of development, maintenance considerations become increasingly important until finally the item is produced and issued for use. In effect maintenance is a continuing process which parallels and interrelates with the life cycle of an item from its inception to its obsolescence.

In many ways the most effective preventive maintenance is that which is accomplished before an item ever reaches the user. If maintainability is given proper consideration during the development of an item, the learning cycle through which using units must go is shortened and maintenance training and support requirements are reduced. Essentially, two maintenance objectives should be met before an item reaches the field. First, the item should be designed and engineered for easy and economical maintenance and, second, a comprehensive plan for support of the item must be developed. These two objectives are combined into a DCSLOG program, entitled, "Maintenance Support Planning."

This program is now well along in certain areas and results are beginning to be realized.

Now, a step-by-step discussion of maintenance planning.

In 1956 the department of the army published AR 750-1 entitled "concept of maintenance." This regulation directed the developing services to prepare a maintenance support plan concurrently with the development of new equipment, and assigned the correlation of the plan to the Army Maintenance Board.

Subsequently, a second AR 750-6 entitled "Maintenance Planning, Allocation and Coordination" was developed and published. The primary objective of AR 750-6 is to provide guidance for the development of the maintenance support plan (figure 1). It lists certain major functions for inclusion:

1. Ease of maintenance.

2. Standardization of repair parts and components.

3. Allocation of maintenance functions to the appropriate echelon.

4. The development of technical publications for release concurrently with the equipment.

5. Early recognition and execution of an adequate training program.

6. Adequate tools and test equipment.

Any plan to be effective must be easily understood and must result in a tangible product if it is to be checked for timeliness and adequacy. The parts of the plan shown here meet this requirement and I will discuss each separately.

Our first major objective in Maintenance Support Planning must be to insure that the item is designed and engineered for ease and economical maintenance with the human engineering being considered, as well as the mechanical engineering.

Good progress is being made in designing for ease of maintenance using modular construction of electronic portions of signal and guided missile equipment. As depicted in figure 2, many small components -- miniature, subminiature, or micro-miniature -- are often packaged together to form a module designed to facilitate:

a. Easy insertion into the equipment.

b. Rapid isolation of malfunctioning modules.

c. Rapid replacement by the operator.

The day is not far away when by use of this type of construction, together with automatic test equipment, a trained operator can push a button and receive an indication telling him which cabinet contains the faulty chassis, which chassis contains the faulty module, and which module is actually malfunctioning (figure 3).

The operator then simply opens the chassis and removes and replaces the plug-in module, depending on economics, environment, and other factors. The module may be constructed in a manner permitting repair in the field or may be designed for throw away.

Effective maintenance planning requires wide participation, including not only the supplying technical service and the manufacturer but also the users of military equipment.

As figure 4 indicates, user participation must be reflected throughout the whole process of development from the initial drafting of military characteristics and specifications, through design and mock-up down to and including service test, acceptance and production. Coordinated planning will emphasize man-machine compatibility, timely establishment of training requirements, and the preparation of effective technical publications. You may note in our illustration, the presence of the user representatives, a policy maker and a man who is intimately acquainted with the operation of such equipment.

The use of standard parts and components must be considered at all stages of development (figure 5). The maintenance engineer must be constantly alert to prevent new parts or components from creeping into the system, unless they are essential to operational characteristics. For example, rather than design a new squelch module for use in an airborne radio set it may be that, with minor redesign of the radio, a module which is already in service could be utilized. The savings which would result are obvious.

The maintenance evaluation process begins with the very concept of an item of equipment and regardless of the system used it is a continuous process. One of the major problems which has not been fully corrected is the development of an effective procedural relationship between maintenance engineers, design engineers, repair parts and tools specialists, training representatives, technical publications writers, and manufacturer's representatives. The effectiveness of the maintenance evaluation is dependent on the coordination achieved among these specialists (figure 6).

A complete evaluation by physical teardown is conducted on a prototype model and is attended by specialists and technicians shown on this chart, as needed. During this operation the effectiveness of earlier coordination is checked and technical instructions and parts and tools lists are appraised. This evaluation is dependent on the availability of a prototype model or the essential components thereof. This can only be accomplished if planned, budgeted for, and coordinated by research and development.

Maintenance evaluation is specifically required by logistics directive within four stages of development:

1. Initial design.

2. Prototype design.

3. Engineering tests.

4. Preproduction tests.

For each new item of equipment an early decision must be made on what maintenance functions will be performed at each echelon. Such a decision is vital for it determines not only the maintenance responsibilities of using units, direct support, and depot activities but also the allocation of tools, test equipment, repair parts, technical publications, and specialist training requirements. The maintenance allocation results are documented on a Maintenance Allocation Chart (figure 7). This chart shows the echelon required to perform each maintenance operation of an infrared receiver. Based upon the available skills, time required, and the parts, tools, and test equipment available, each maintenance function is allocated to a specific echelon. For example, under Group Number 8000 "Alarm Monitor" the decision was to service the Alarm Monitor at 1st echelon, replace it at 2nd echelon, test and repair it at 3rd echelon, and overhaul it at 5th echelon.

The user receives a copy of such a chart in the organizational maintenance portion of the technical manual and thus knows exactly where each maintenance operation is performed.

Technical publications are a vital part of a sound maintenance plan as they are a necessary standardized guide to correct operating and maintenance practices. Great stride has been made in the direction of adequate publications in the present department of army program of the 5-part manual (figure 8). These technical manuals which include operational and maintenance allocation chart, and lubrication order, where required, comprise the "Maintenance Package" required by the Army Regulations mentioned previously.

This package in preliminary draft must be furnished to the CONARC and Technical Service Boards concerned, prior to completion of the end item service test. Their comments are reflected in the final publication.

It is well to note here that the "Maintenance Package" may be assembled for test by use of manufacturer's notes on material or in the form of special texts. The main consideration must be that it is in a format that permits adequate testing and evaluation.

Prior to completion of development of the end item action must be taken to train key personnel. These personnel are required to support the item during service test, re-examine the TOE's and MOS's, review the training aids, POI's, and facilities in order to determine their adequacy for training the specialist who will support the equipment when issued. Test boards and service schools must request quotas for these schools organized by the technical service agency developing the equipment.

Technical sercices utilize varying methods for training personnel to receive new equipment. As an example, the Chief of Transportation has established contracts for Mobile Assistance Teams. Each team is comprised of two highly skilled contractor-furnished technicians. These teams go to the field units who are to receive the new aircraft and give on-the-job instruction for operators and maintenance personnel. These teams provide the latest technical knowledge relative to organizational maintenance of a specific aircraft manufactured by their firm for the Army. M/SGT John James listed on this chart received instructions by a Beechcraft Team on L-23 Airplane (figure 9).

Test equipment and special tools are especially important in missile systems, electronic and communication equipment (figure 10). They are becoming <u>increasingly</u> important to conventional weapons and automotive maintenance. At <u>times</u> they become as important as the end item itself.

Early decisions on test equipment have a profound effect on the end item. All of the factors which we have considered thus far in the development of the maintenance support plan apply to the test equipment and special tools in the same manner as to the end item.

At present, effort is being directed toward supplying operators with test equipment which, though it may be complicated in itself, gives a simple indication of "Go" or "No-Go." This equipment may be either "Built-in" or may be quickly plugged into the equipment or console under test. Some instruments may be necessary to permit calibration or adjustment of complicated systems. The test equipment being experimented with today will not only tell the operator which module is faulty, as I mentioned a few moments ago, but can automatically check and prove itself.

In addition to the specific parts of maintenance support planning which we have discussed, the AR requires that the developing service consider throughout development two additional factors. These are, first, "Durability and Reliability"; second, "Mission of The Intended User." The design of this radio set must be influenced by the mission of the organization to which it is furnished. Maintenance support must be planned for its employment in unpredictable weather and terrain. Pre-planned maintenance must be accomplished under combat and field conditions. It must be borne in mind at all times that this radio will not be maintained under conditions which exist in the development laboratory (figure 11).

Figure 12 portrays the result of the maintenance support plan prepared by the technical services and coordinated with the user. When the end item is placed in the hands of the user, he has trained people to accept it. It is accompanied by technical instructions, repair parts list, test equipment, adequate tools and the prescribed load of repair parts. The item and the support planned for it will reflect an understanding of the user's peculiar needs, his capabilities, and his primary mission. Of equal importance to the user is support by higher echelons of maintenance.

The U. S. army maintenance board is responsible to DCSLOG for coordination of this program among the various technical services and field commands. Figure 13 will give you an idea of the detailed coverage which we apply to selected end items of equipment in order to insure timely compliance with existing directives.

The areas of interest to the Army Maintenance Board from the detailed work chart (figure 14) are recapped here.

1. Is the review at specified points in development completed?

2. Is the maintenance support plan initiated concurrently with the initiation of development?

3. Is initial provisioning based on findings of an adequate maintenance evaluation?

4. Is the preliminary draft of the maintenance package available for service test?

5. Do tests of equipment include an adequate test of the maintenance support plan?

6. Are the publications finalized and in proper format for release to the user together with the end item?

7. Is adequate training being provided in sufficient time to insure effective maintenance during the entire life of the end item?

The subject matter of this briefing is not new; it is covered in detail in regulations and directives that are as much as two years old.

Our observations to date indicate a general awareness of the problem at the working levels. In fact in some areas we find all, or almost all, of the separate pieces of such a program. But, in order to be effective, each element of the plan must be covered and the various elements must be coordinated. This coordination must be achieved within the developing technical service, between technical services, as applicable, and with the user. It must commence with development and follow through production and operational support phases.

We feel that the DCSLOG Program, which I have described to you, will reduce maintenance planning to a series of logical steps. The coordination of such a plan will focus the attention and knowledge of the developer, support agencies, and user on those features of the end item that tend to reduce operational effectiveness and increase support requirements. This early attention will permit timely, corrective action in the form of changed support plan, as necessary. Initiation of sound maintenance planning concurrently with development will reduce the time required to place a truly effective item in the hands of a combat organization.

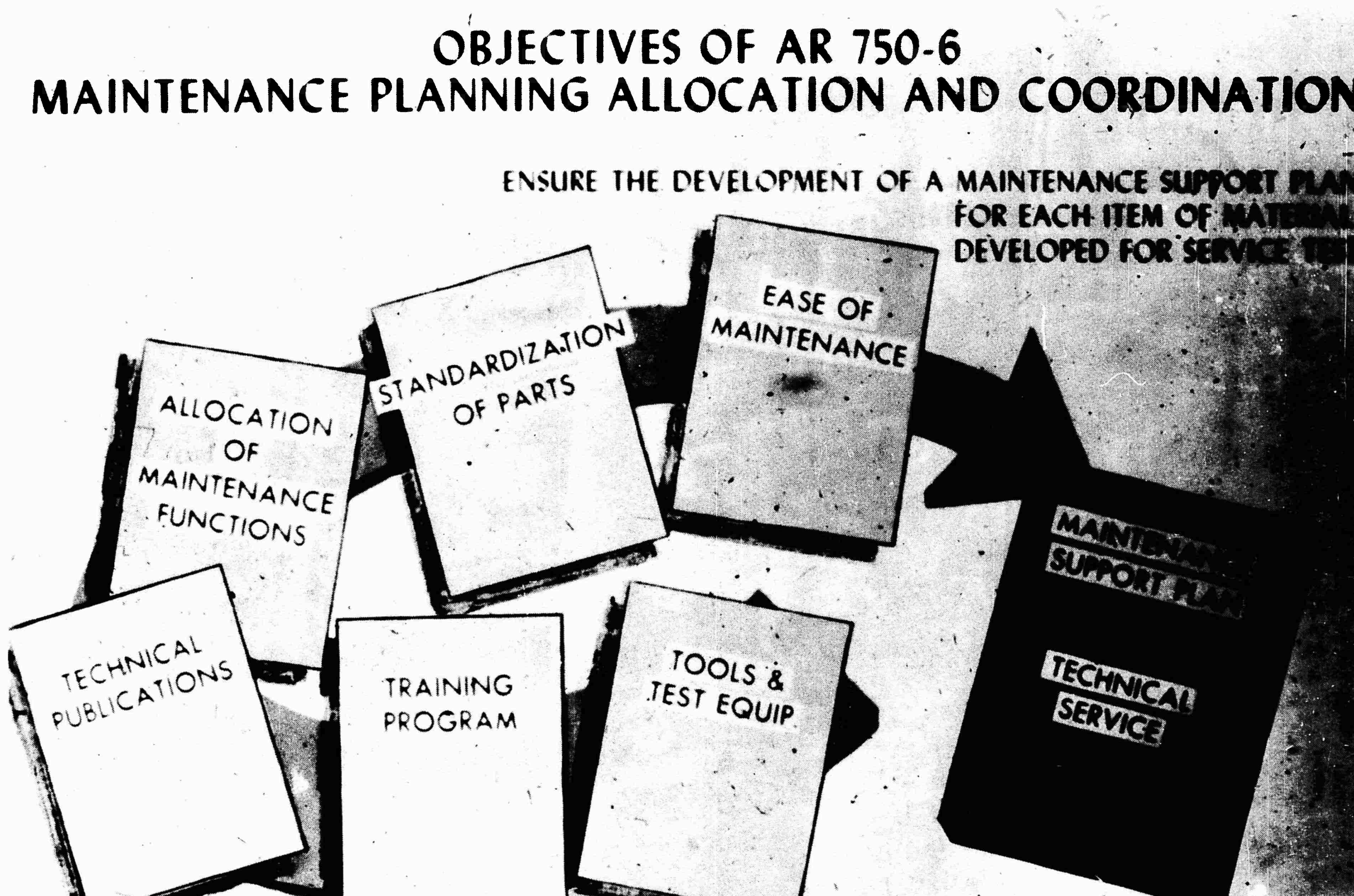

OBJECTIVES OF AR 750-6
MAINTENANCE PLANNING ALLOCATION AND COORDINATION
ENSURE THE DEVELOPMENT OF A MAINTENANCE SUPPORT PLAN
FOR EACH ITEM OF
DEVELOPED FOR
ALLOCATION OF MAINTENANCE FUNCTIONS
STANDARDIZATION OF PARTS
EASE OF MAINTENANCE
TECHNICAL PUBLICATIONS
TRAINING PROGRAM
TOOLS & TEST EQUIP
SUPPORT PLAN
TECHNICAL SERVICE

Figure 1

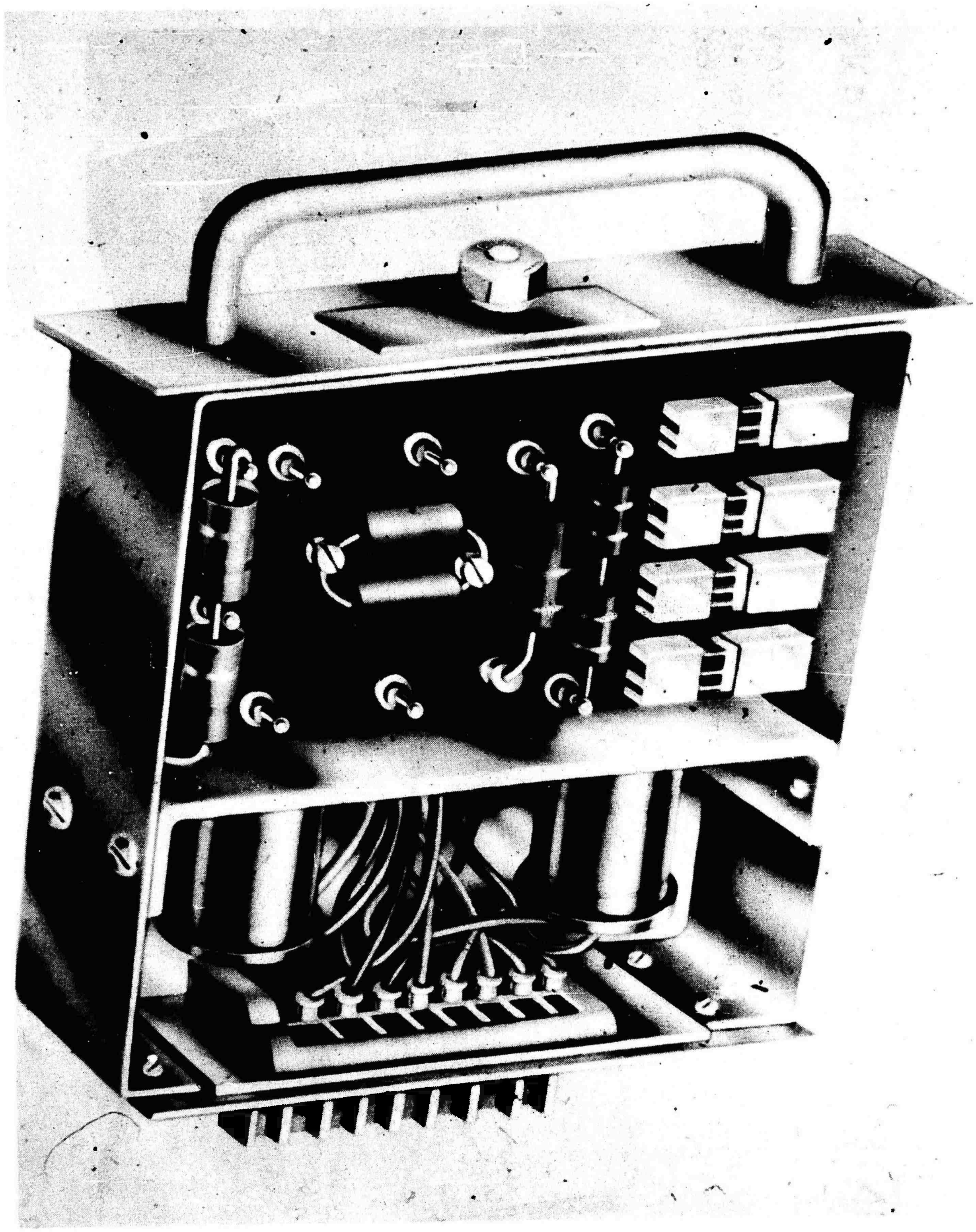


Figure 2

Figure 3


USER PARTICIPATION IN MILITARY
CHARACTERISTICS AND DESIGN

Figure 4

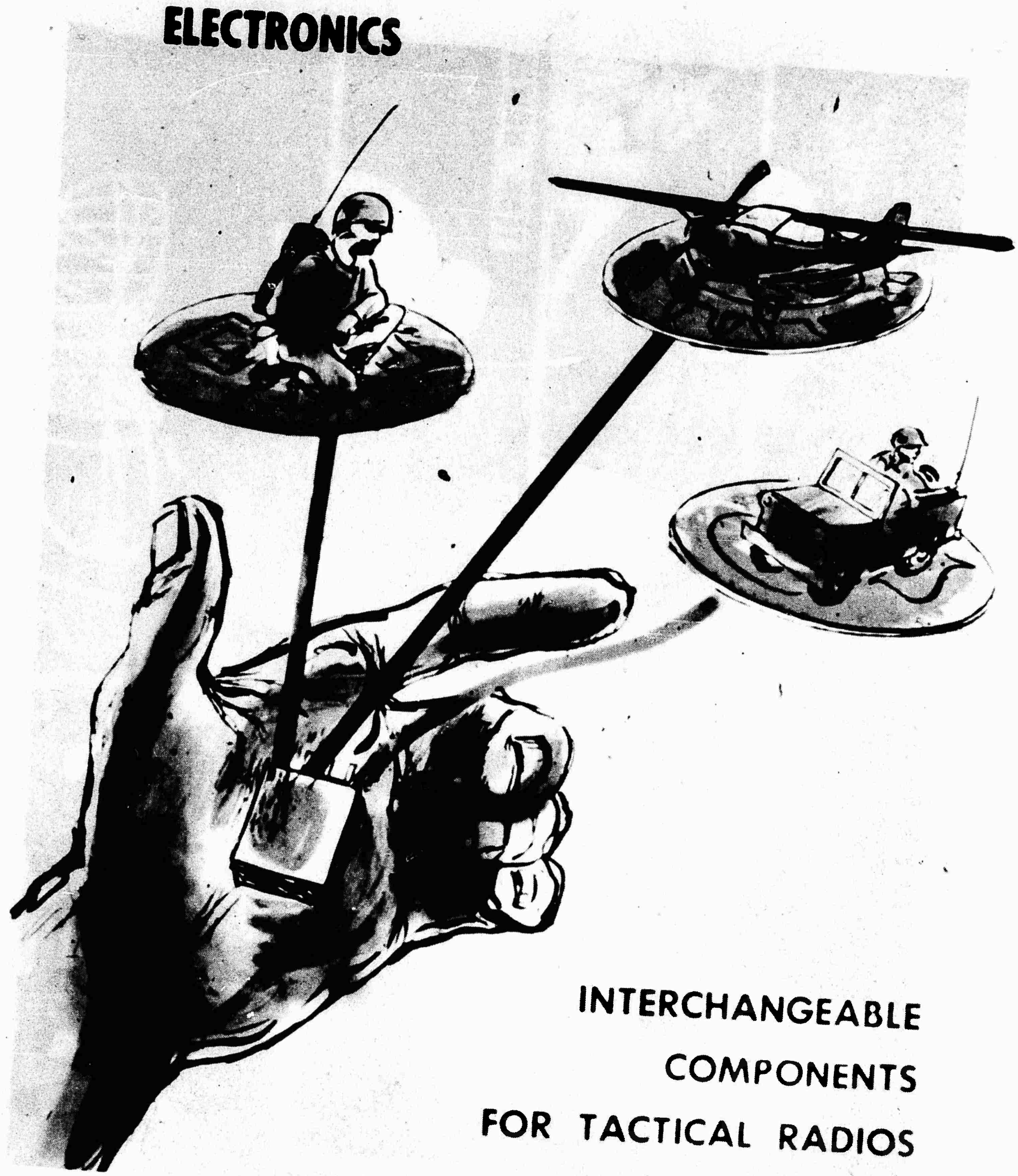

ELECTRONICS
INTERCHANGEABLE
COMPONENTS
FOR TACTICAL RADIOS

Figure 5

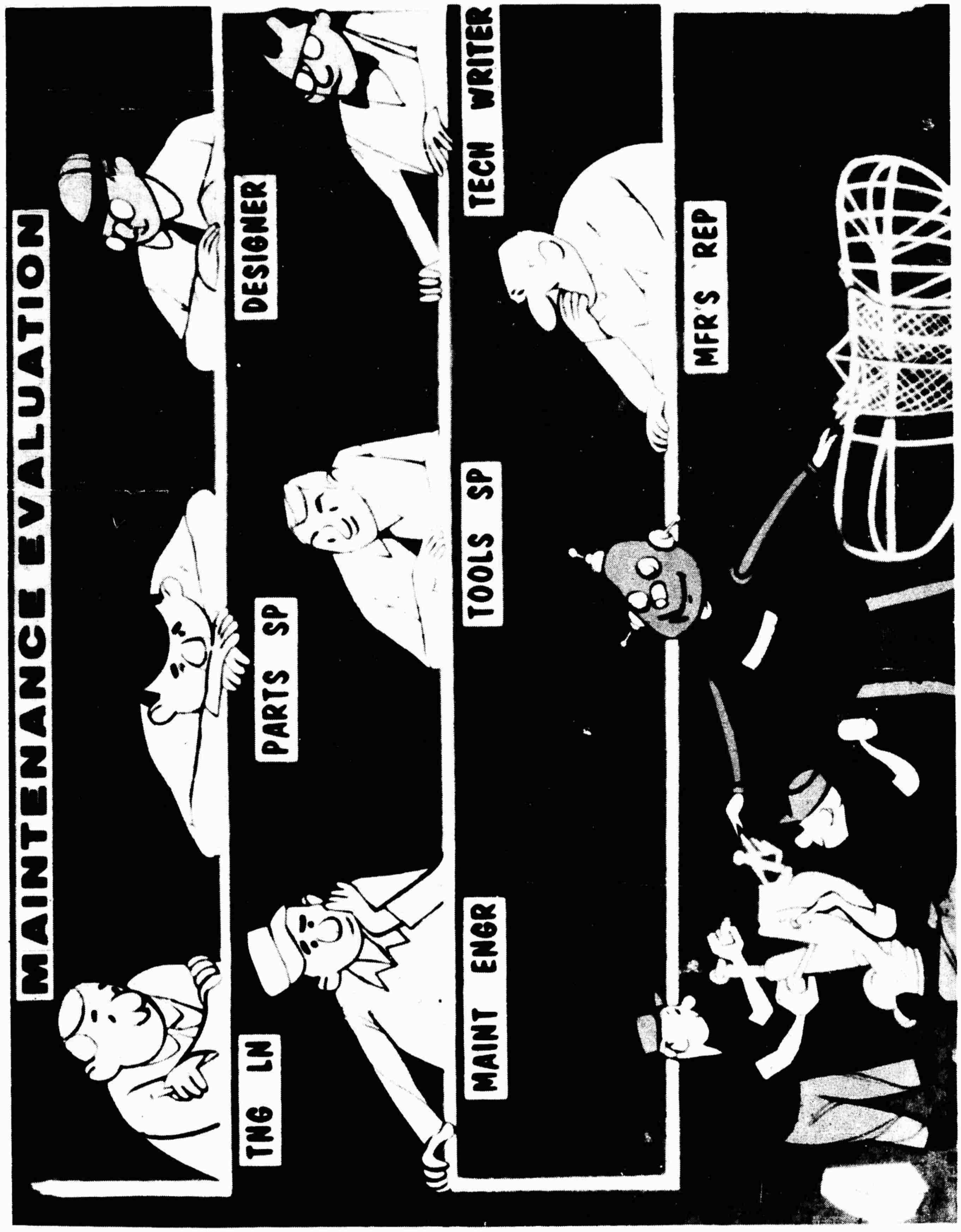

MAINTENANCE EVALUATION
TNG LN
PARTS SP
DESIGNER
MAINT ENGR
TOOLS SP
TECH WRITER
MFR'S REP

Figure 6

APPENDIX II SECTION II MAINTENANCE ALLOCATION CHART

(1) GROUP NUMBER	(2) PART OR COMPONENT	(3) RELATED OPERATION	(4) 1st ECH	(5) 2nd ECH	(6) 3rd ECH	(7) 4th ECH	(8) 5th ECH	(9) REPAIR FACILITIES CODE	(10) REMARKS
	RECEIVER, INFRARED R-718()/PAR								
		SERVICE	X					3	
		ADJUST		X				4	
		INSPECT	X						
		TEST		X				2	
		REPLACE	X						
		REPAIR			X			4	
		REBUILD					X	1,2,4,5	
8000	ALARM MONITOR	SERVICE	X					1	
		INSPECT	X					1	
		TEST			X				
		REPLACE		X					
		REPAIR			X			4	
		REBUILD					X	1,4,5	
8010	BATTERY BOX	REPLACE		X					
		REPAIR			X			1,5	
8011	BATTERIES	REPLACE	X					1	
8012	CONTACTS	REPLACE				X		5	
8020	CASE ASSEMBLY	REPAIR			X			3,4	
		REBUILD					X	1,2,4,5	FABRICATE
8021	BUMPER, RUBBER	REPLACE		X				4	
8022	CAPACITOR	REPLACE			X			4	
8023	CAPS	REPLACE	X					1	
8024	CASE	REPAIR				X		3,4	
8025	COVER	REPAIR				X		3,4	
9000	CARRYING CASE, TRIPOD	REPAIR				X		4,5	
		REBUILD					X	4,5	
9010	BUCKLES	REPLACE				X		1	
9020	CASE	REPAIR				X		4	
9030	COVER	REPAIR				X		4	

Figure 7

TECHNICAL PUBLICATIONS
MAINTENANCE PACKAGE

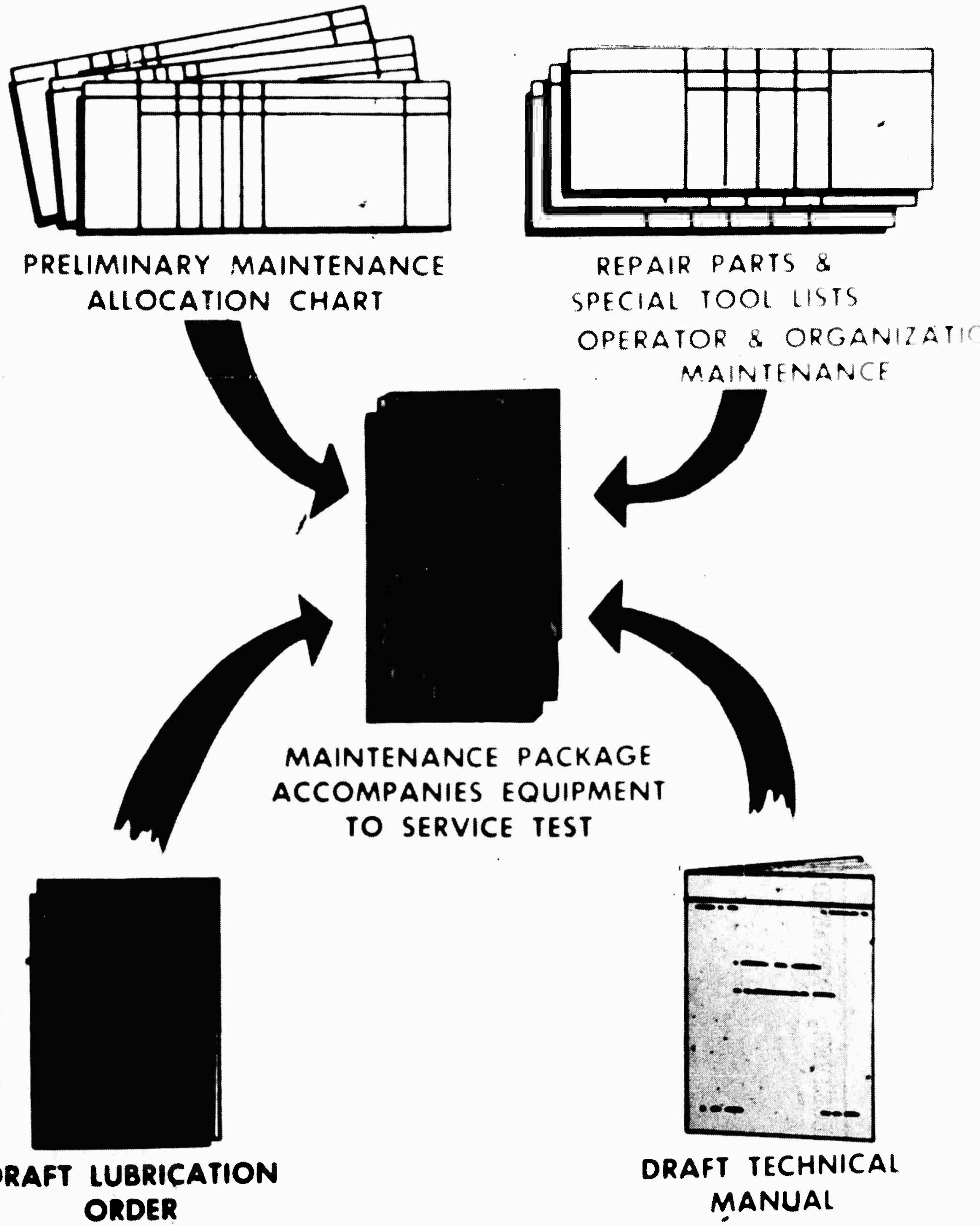


Figure 8

TRAINING REQUIREMENTS

Department of the Army

Certificate of Training

Beech Aircraft
Corporation
SERVICE SCHOOL
DIPLOMA

This is to certify that
SP3 CHARLES G. SMITH RA 17160303
93d TRANSPORTATION COMPANY
has successfully completed
40 HOURS OF L-23 ORGANIZATIONAL
MAINTENANCE TRAINING

This is to certify that
M/Sgt. John James
has completed a course of instruction in
ORGANIZATIONAL MAINTENANCE
on the
Beechcraft *L-23 Airplane*

Figure 9

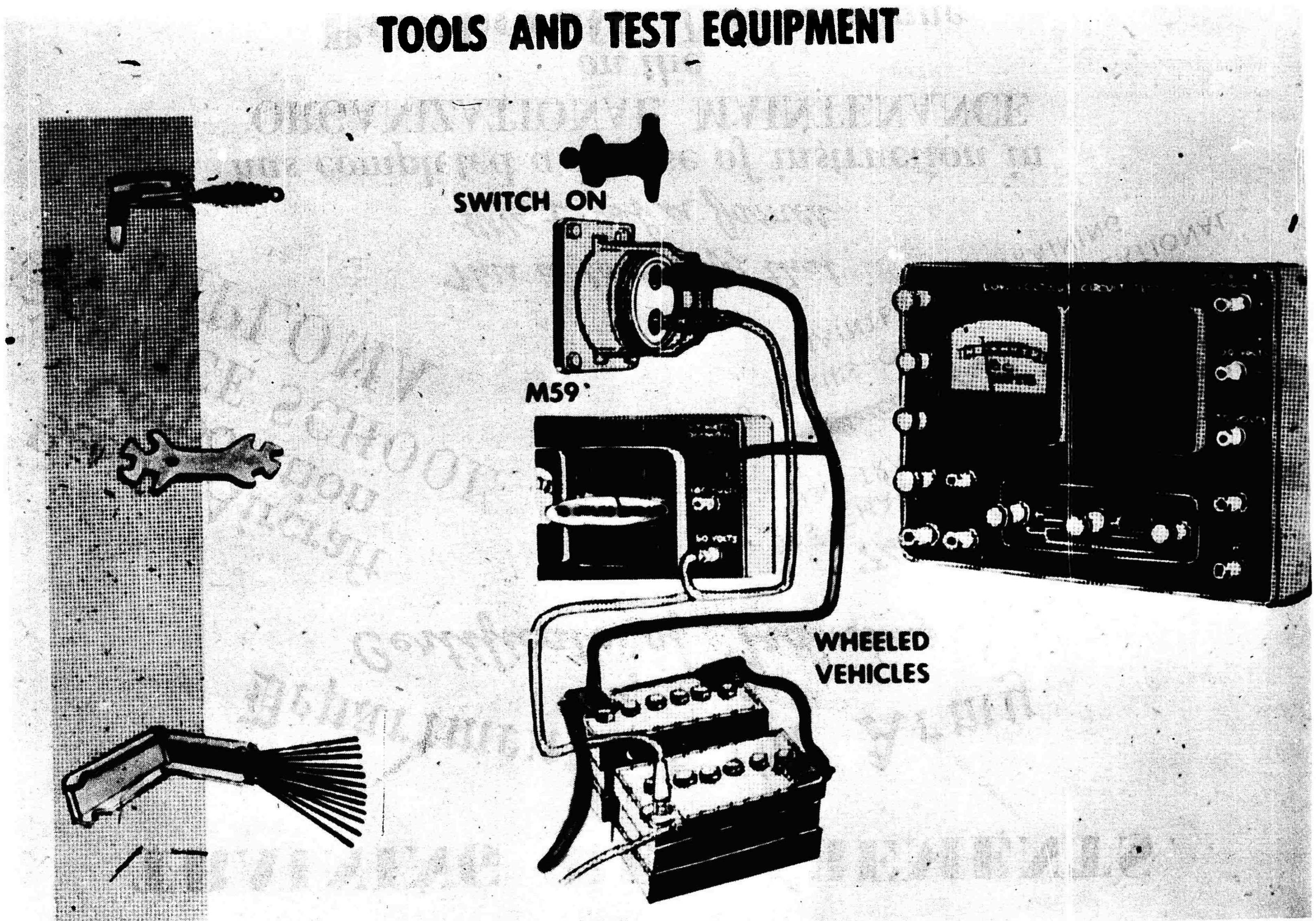


Figure 10

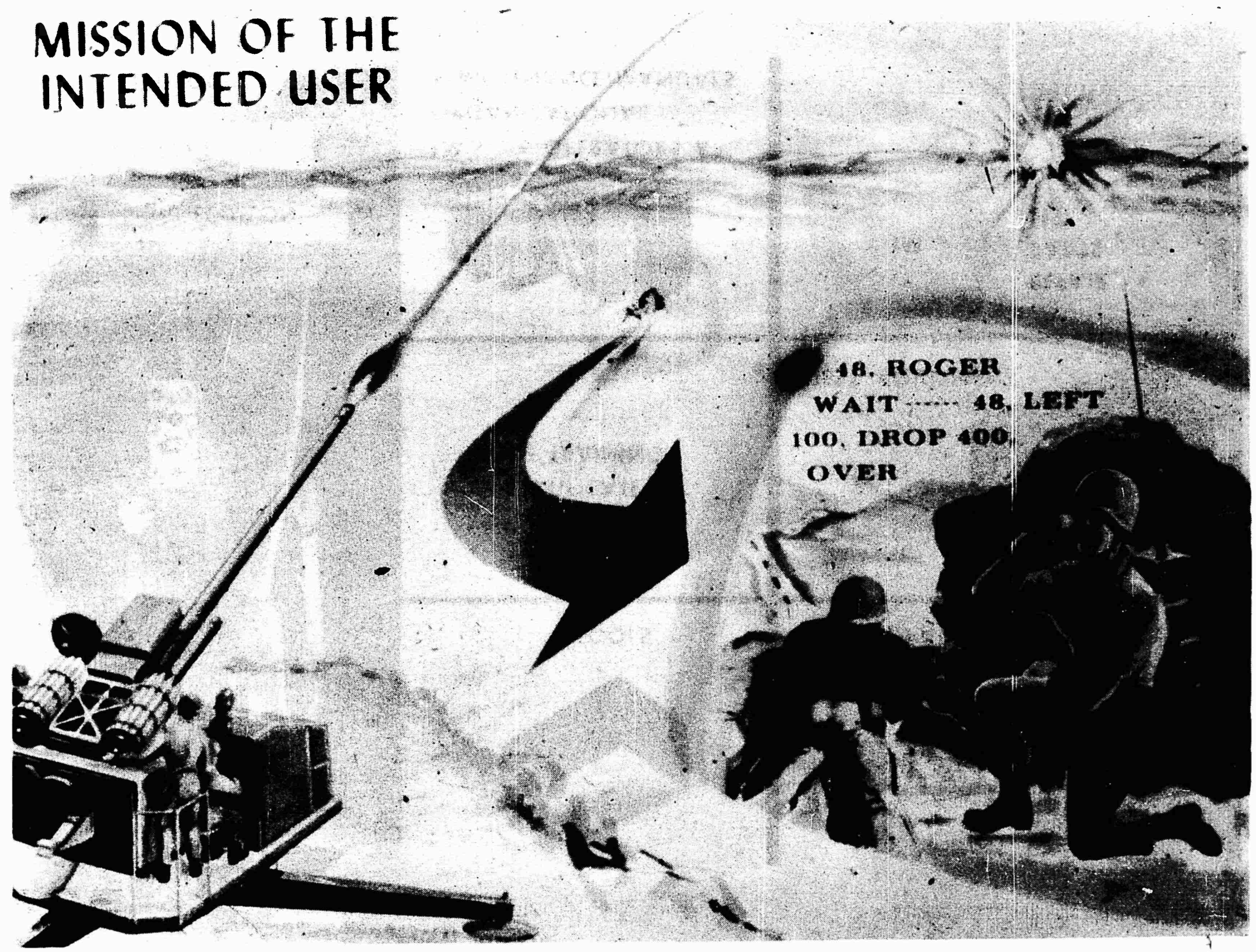

MISSION OF THE
INTENDED USER
48, ROGER
WAIT ------ 48, LEFT
100, DROP 400,
OVER

Figure 11


ISSUE
TO
USER
3rd ECHELON
4th ECHELON
5th ECHELON
TOOLS
PRESCRIBED LOAD
REPAIR PARTS
CERTIFICATE
OF TRAINING
TEST—EQUIPMENT
TM'S --- OPERATORS &
ORGANIZATIONAL
MAINTENANCE MANUALS
TM --

Figure 12

EQUIPMENT DATA CARD

1. ITEM:

2. REFERENCES

3. MILITARY CHARACTERISTICS

4. BRIEF DESCRIPTION

5. APPLICATION

6. GENERAL DATA

DEVELOPING AGENCY ______

CONTRACTOR ______ CONT NO ______

TOTAL COST ______ UNIT COST ______ PRIORITY ______

POPULATION (A) ______ (AF) ______ (N) ______ (MC) ______ (NATO) ______

	R&D MODELS	PEMA MODELS	OTHER
QUANTITY			
COST			

TOE

LN NO ______

BASIS OF ISSUE ______

OTHER INT AGENCIES ______

7. TECHNICAL SERVICE

8. SPECIFIC REVIEW POINTS

PHASE	DATE	PLACE	REMARKS
INITIAL DESIGN			
PROTOTYPE			
ENGINEERING TEST			
PREPRODUCTION			

9. MAINTENANCE CONCEPT(S)

10. MAINTENANCE EVALUATION

TYPE	DATE	PLACE	CHANGES DESIRABLE	CHANGES ESSENTIAL
INITIAL				
INTERMEDIATE				
FINAL				

REFERENCES

11. SPECIAL TOOL & GAGE REQMTS

12. PROVISIONING ACTIONS

13. PUBLICATIONS

ITEM	INITIAL M/S DATE	DATE REVIEWED	DEVELOPING AGENCY	RESPONSIBLE AGENCY

14. TESTS

TYPE	PERIOD FROM	PERIOD TO	LOCATION(S)
ENGINEERING			
USER (SERVICE)			
USER (TROOP)			

15. TYPE CLASSIFICATION

DATE	TYPE	REFERENCE

16. PERSONNEL REQUIRED

DATE	MOS	TITLE	REMARKS

17. COURSE(S) REQUIRED

DATE	LENGTH	TITLE	LOCATION

18. REPORTS

19. READINESS DATE

20. GENERAL REMARKS

FIGURE 13

US ARMY MAINTENANCE BOARDS CHECK LIST FOR MAINTENANCE SUPPORT PLANNING

1. Specific Review Points.
2. Maintenance Support Plan (AR 750-1).
3. Initial Provisioning (AR 750-1).
4. Preparation of Maintenance Package (AR 750-6).
5. Tests of Equipment (AR 705-5).
6. Maintenance Publications (AR 310-3).
7. Program of Instruction on New Equipment.

Figure 14

AERIAL PHOTOGRAPHIC REPRODUCTION SUPPORT

Maj. Fred D. Preuett
Fort Polk, Louisiana

In order to better understand the problems of maintenance and supply which I will bring into the picture in a few minutes, I believe I will spend a couple of minutes at this time explaining the organization of the 1st Air Reconnaissance Support Battalion and the changes which have occurred in the last few months. This will help make the picture clearer.

The 1st Air Reconnaissance Support Battalion was activated in April, 1957, and has the mission of producing and disseminating all available information and intelligence obtained or developed from tactical air reconnaissance units in support of a field army. The Battalion, in order to do this, is authorized a Battalion Headquarters and Headquarters Detachment of 11 officers, 1 warrant officer, and 23 enlisted men; a Photo Interpretation Company of 21 officers and 120 enlisted men; and a Photo Reproduction and Delivery Company of 17 officers and 129 enlisted men.

Currently, we depend upon the Air Force to fly the photographic missions and to furnish the Battalion with one duplicate copy of the negative and two copies of the prints of any approved reconnaissance photo request. The two copies of the prints are sent to the PI Company for interpretation and proper reports to be sent to the requesting units. The duplicate negative goes to the Aerial Photo Reproduction and Delivery Company for reproduction of the desired quantity of prints.

Presently, in the Battalion, we have a Headquarters and Headquarters Detachment of 4 officers and 23 enlisted men and a reduced strength modified Air Photo Reproduction and Delivery Company. The PI Company has never been organized.

The 205th Signal Company (APR&D) was activated in February, 1956, at Fort Bragg, North Carolina. Personnel and equipment for the company came from a provisional unit that was formed for Exercise SAGEBRUSH to test a theory that good, rapid aerial photo reproduction was feasible and practicable by using automatic and semiautomatic equipment. Exercise SAGEBRUSH proved this theory correct and further proved a need for this type of company.

The 205th Signal Company (APR&D) was reorganized at reduced strength modified on 1 June 1958 and reduced from 17 officers and 129 enlisted men to 3 officers and 66 enlisted men. In this reorganization, we lost the delivery capability of the company. We lost the aircraft, mechanisc and pilots, and 19 of the 55 photographic laboratory technicians. However, we retained all of the reproduction equipment.

The equipment of the 205th Signal Company, in 1956, consisted of six prototype photographic laboratories, semitrailer mounted, especially for the test in SAGEBRUSH. These vans were issued without spare parts and without sufficiently identified spare parts lists or catalogues. These photographic laboratories, semitrailer mounted, are equipped with automatic and semiautomatic systems in which a stabilization process of photo printing is utilized. The stabilization process uses a water-resistant paper and the chemicals in the emulsion are stabilized, thus eliminating the need for washing the prints as in the conventional methods. The difference in the time it takes to finish a print is considerable, averaging 70 minutes for the old method and only 36 seconds for the new.

The stabilization process was new to the operators who received their only training on the job. There was a large amount of experimental equipment in the vans. Therefore, repair and replacements of parts for this equipment were critical. These replacements had to be manufactured locally or purchased directly from the factory by using dimensions, drawings, and pictures. In many cases, a factory representative was required to visit the unit and to aid in securing the information needed at the factory. The operators and maintenance men had to be trained on the job, as there were no Army schools teaching how to use this type of equipment. We were fortunate in being able to send a few men to the factories to spend a few days and get first-hand instruction in the maintenance of this equipment.

During 1957 and 1958, we received two new models of the photographic laboratory, ES-22, the first of which was for conducting a test to be supervised by the U. S. Army Airborne and Electronics Board Number 5, Fort Bragg, North Carolina. This laboratory was found to be unacceptable without certain modifications. We have been instructed to return these vans to the laboratory here at Fort Monmouth for modification. In the case of the test model, we did not receive the necessary manuals or spare parts to conduct the test without considerable delay. With the second ES-22, we did receive spare parts and manuals. However, not all of the modifications, recommended following the test of the first ES-22, had been incorporated.

Now, where do we stand? We have a standard photographic laboratory, semitrailer mounted (figures 1 and 2). This van has the capability of producing prints from previously developed aerial film at the rate of approximately 5,000 9-inch by 18-inch prints per 8-hour period. This van is equipped with heating, ventilating, and air-conditioning equipment to enable use under all weather conditions. The equipment in this van is all automatic or semiautomatic, and six men are required to operate it (figures 3 through 8). We are authorized five photographic laboratory vans of this type and one manually operated, "back-up" laboratory van. Twelve men are required to operate the "back-up van", and it has a maximum capability of approximately 4,000 prints in an 8-hour period.

The equipment that we have is capable of handling only 9-inch by 9-inch or 9-inch by eighteen-inch negatives, which we currently receive from the Air Force reconnaissance element responsible for support of the Army element to which we are assigned. We do not have the capability of developing film and we do not have the capability of enlargement.

We have had our share of supply and maintenance problems. These problems have been, for the most part, due to the lack of trained personnel, both operators and maintenance technicians. The equipment is complicated and the men are on-the-job trained. The Army photography schools in being do not teach operation or maintenance of this equipment. It requires approximately 6 weeks of on-the-job training to produce a qualified operator and 6 months to produce a 2d-echelon-level maintenance technician.

The types of supplies and repair parts that we use are largely now to the supply system, and it takes time to get these into the supply channels and to establish usage factors.

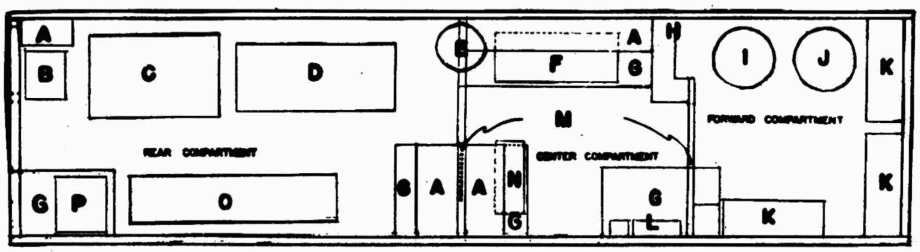
IN SUMMARY: We are equipped with semitrailer mounted photographic labs using a process of development new to most of you -- a stabilization process. This equipment gives the Signal Photo Reproduction Company of this Battalion a capability of producing 75,000 prints in 24 hours.

We are able to produce prints only from 9-inch by 9-inch or 9-inch by eighteen-inch negatives, and we do not have a film developing or an enlargement capability.

Maintenance of this equipment has been, and still is, a problem, since the equipment is of a new type. Our operators and maintenance men are on-the-job trained.

We expect new requirements as the Army develops its own photographic reconnaissance capability.

Figure 1



UPPER: PHOTOGRAPHIC LABORATORY, ES-22

LOWER: FLOOR PLAN & LOCATION OF COMPONENTS

A. WALL TYPE STORAGE CABINETS
B. SINK
C. REPLENISHER
D. PROCESSING MACHINE, PHOTOGRAPHIC PAPER, EH-26
E. LIGHT TIGHT REVOLVING COMPARTMENT
F. AUTOMATIC CHOPPER
G. TABLE TOP, STORAGE CABINETS
H. GASOLINE SPACE HEATER
I. HOT WATER TANK
J. COLD WATER TANK & INTAKE WATER PUMP
K. ONE TON AIR CONDITIONERS
L. POWER SWITCH PANEL
M. LIGHT TIGHT SLIDING DOORS
N. USAF TYPE A-7 FILM PLOTTING TABLE
O. USAF TYPE D-IA PHOTOGRAPHIC CONTACT PRINTER (STEP & REPEAT)
P. USAF TYPE C-IB CONTINUOUS CONTACT PRINTER

Figure 2

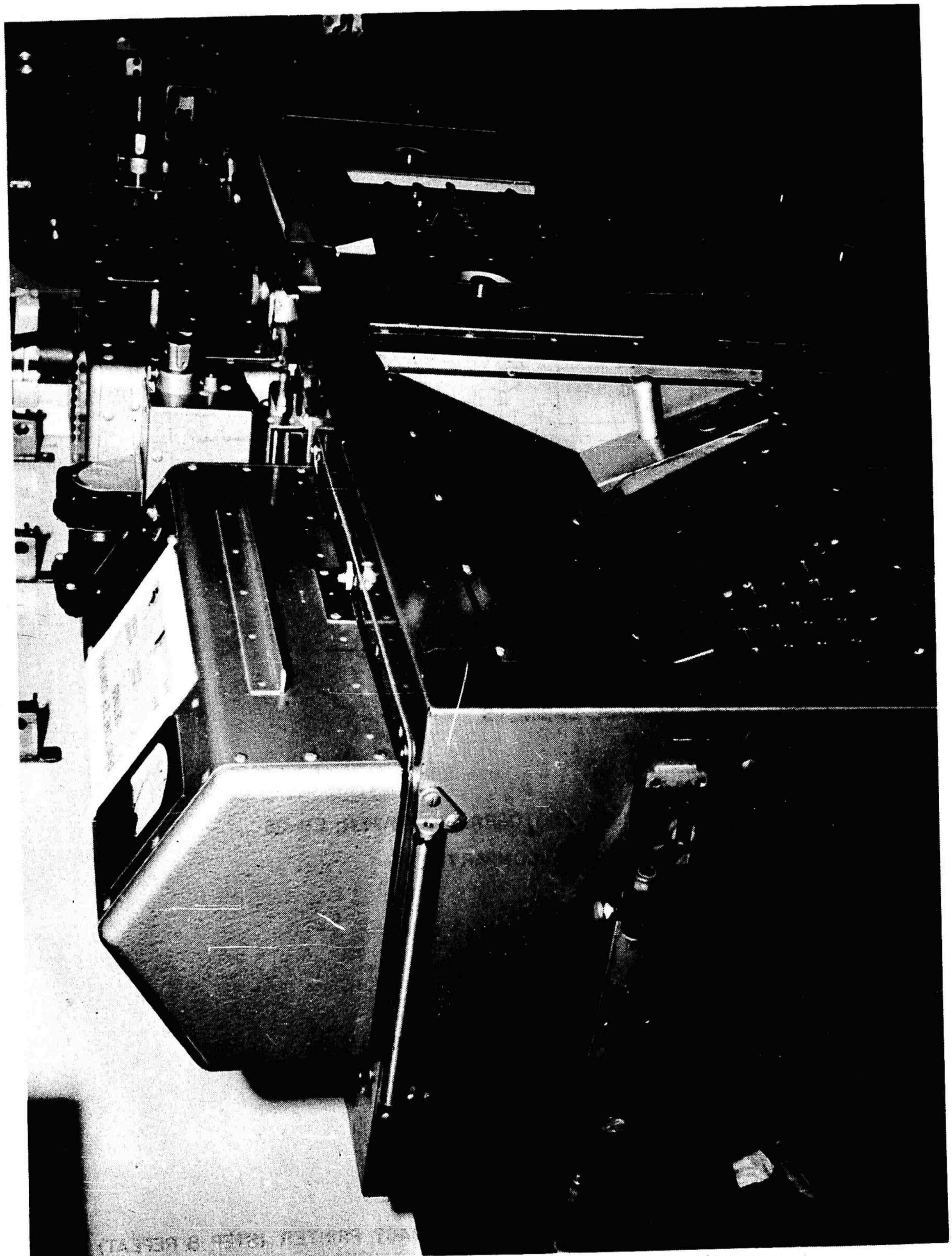


Figure 3

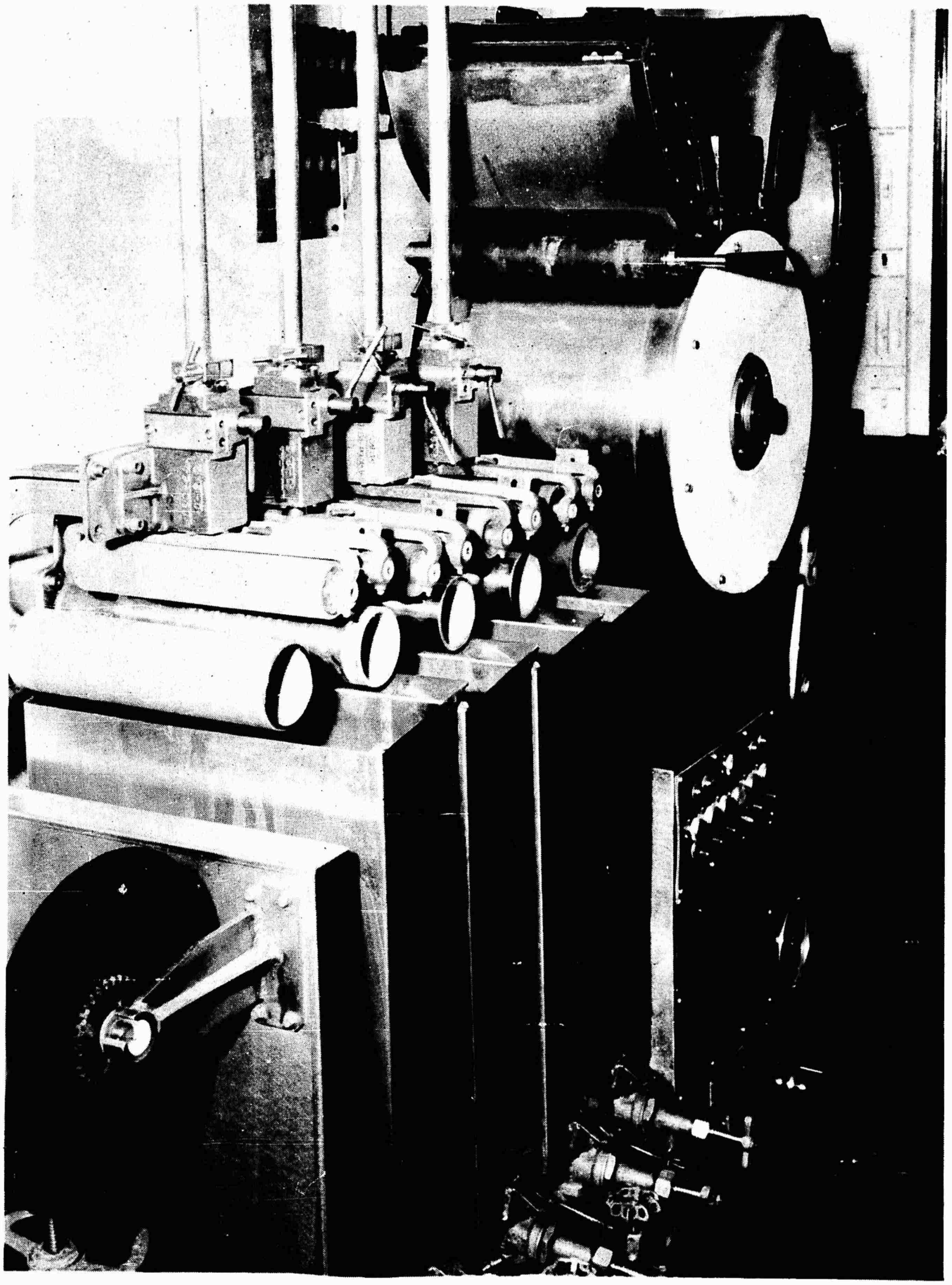


Figure 4

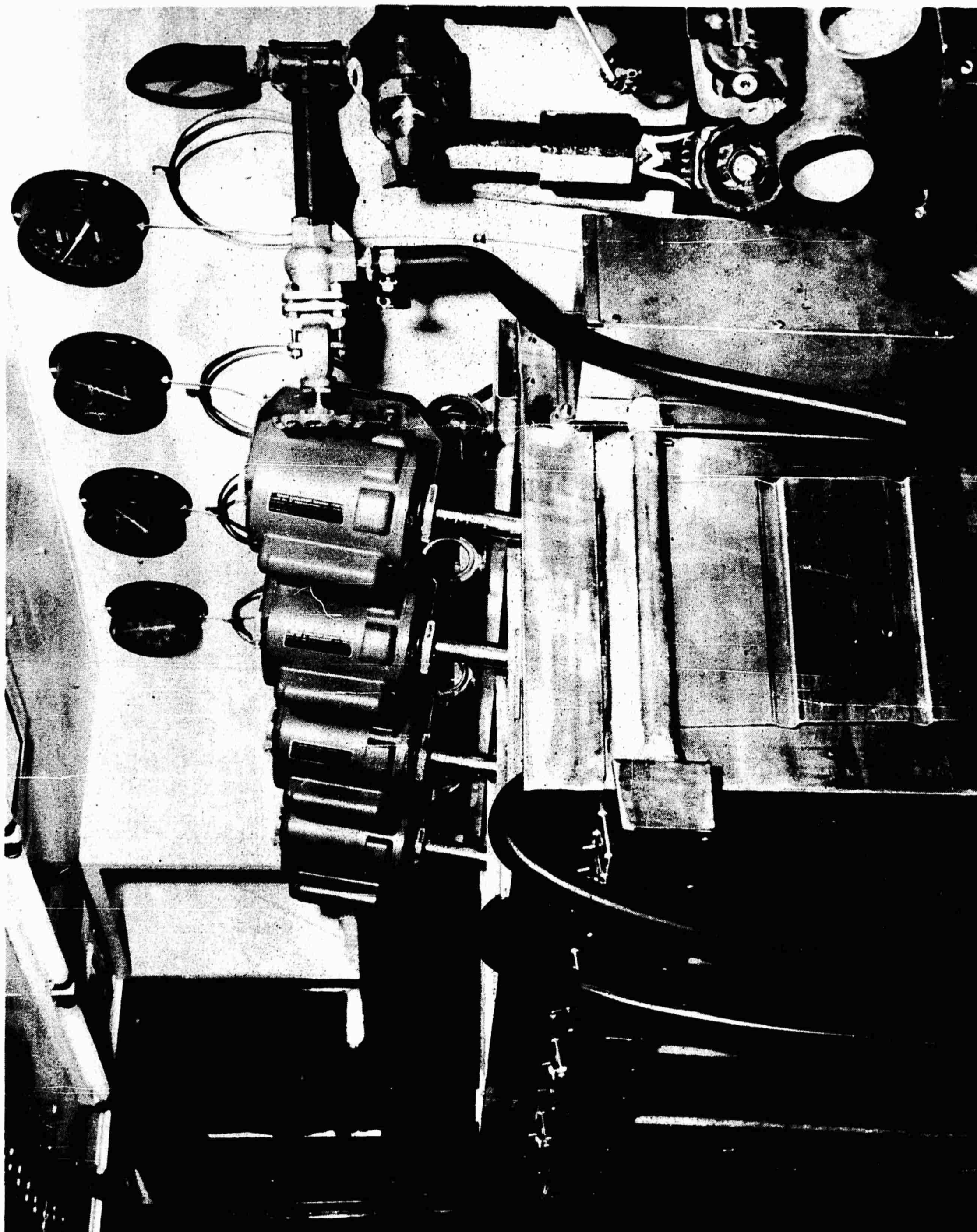


Figure 5

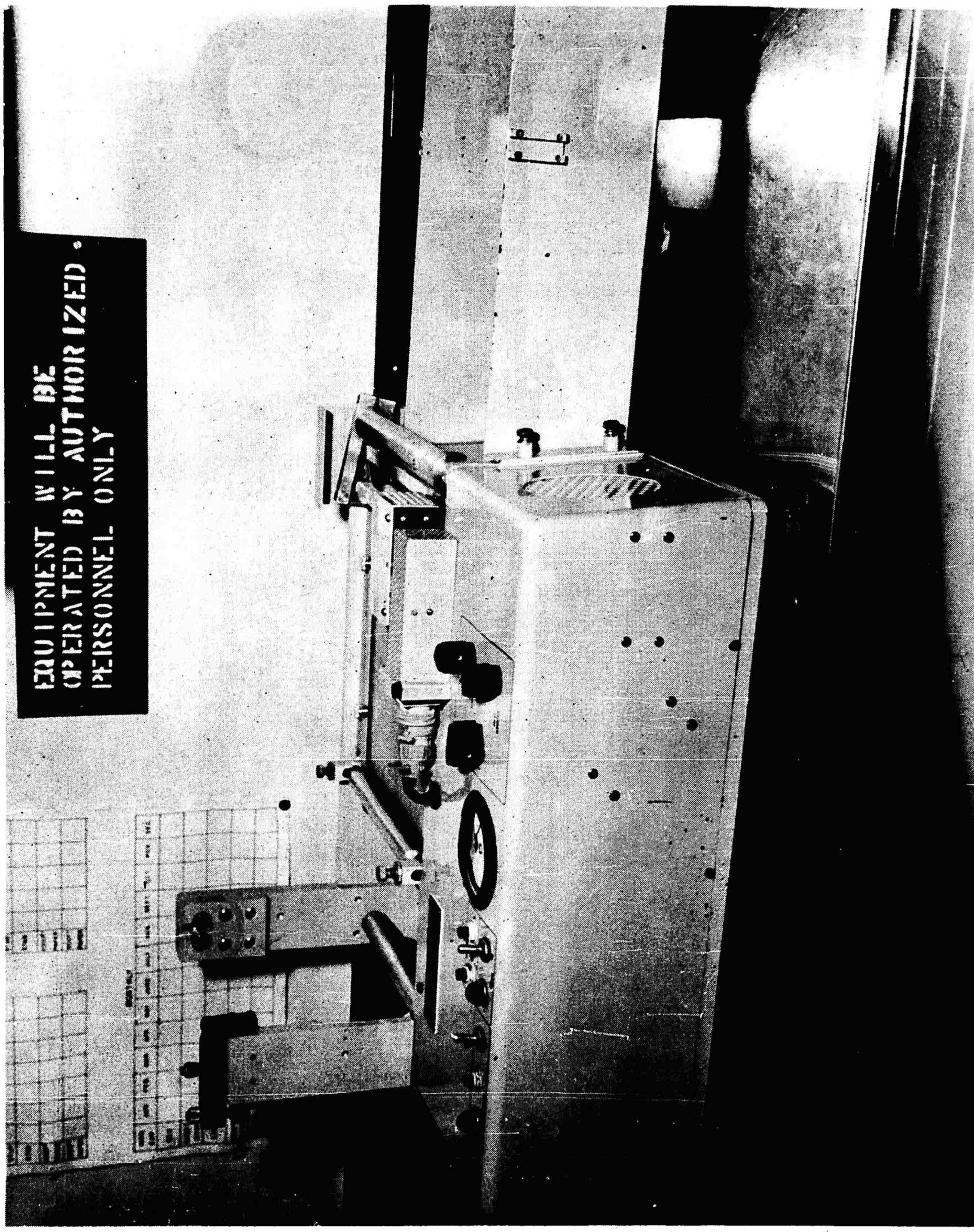


Figure 6

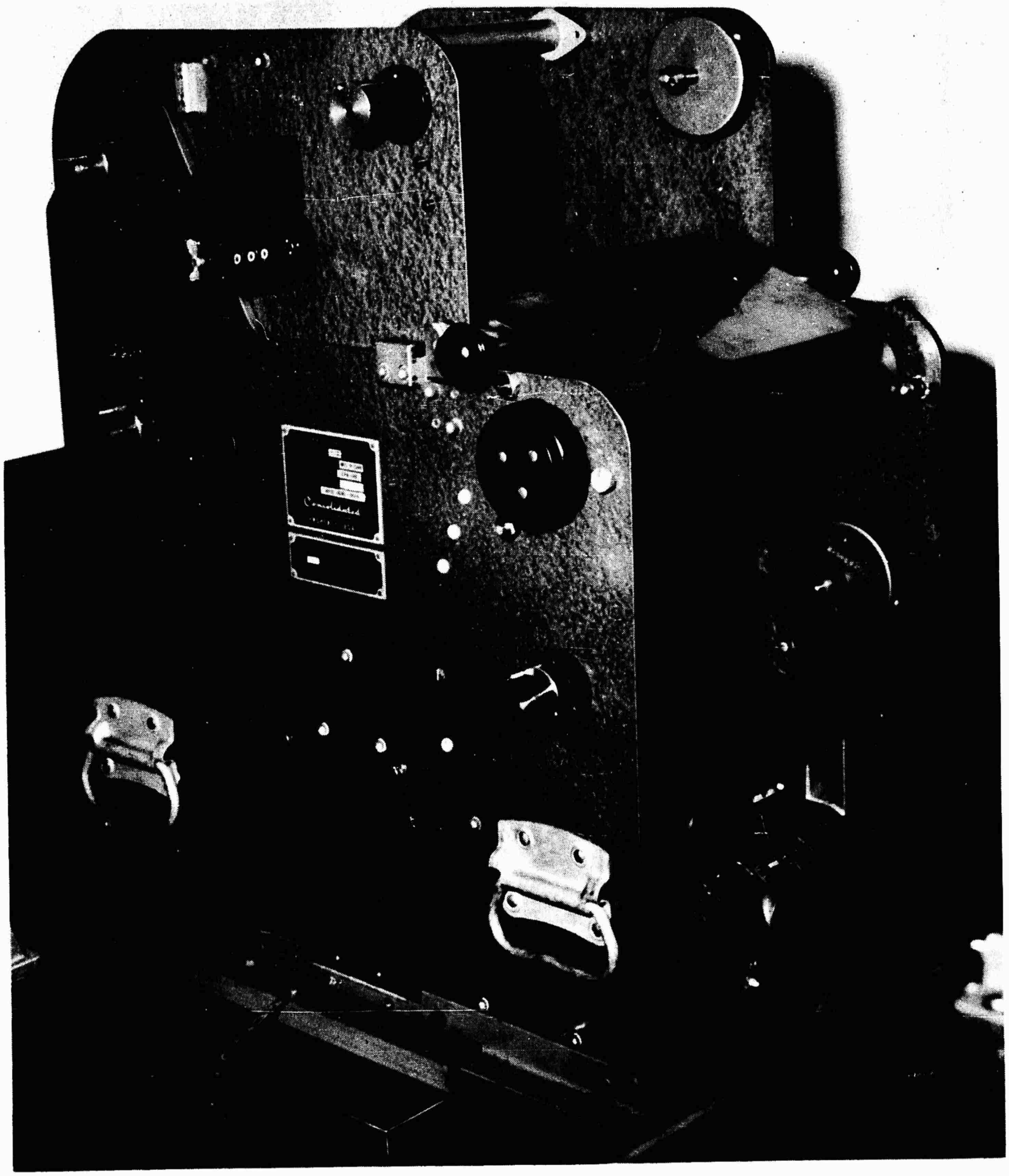


Figure 7 26-10

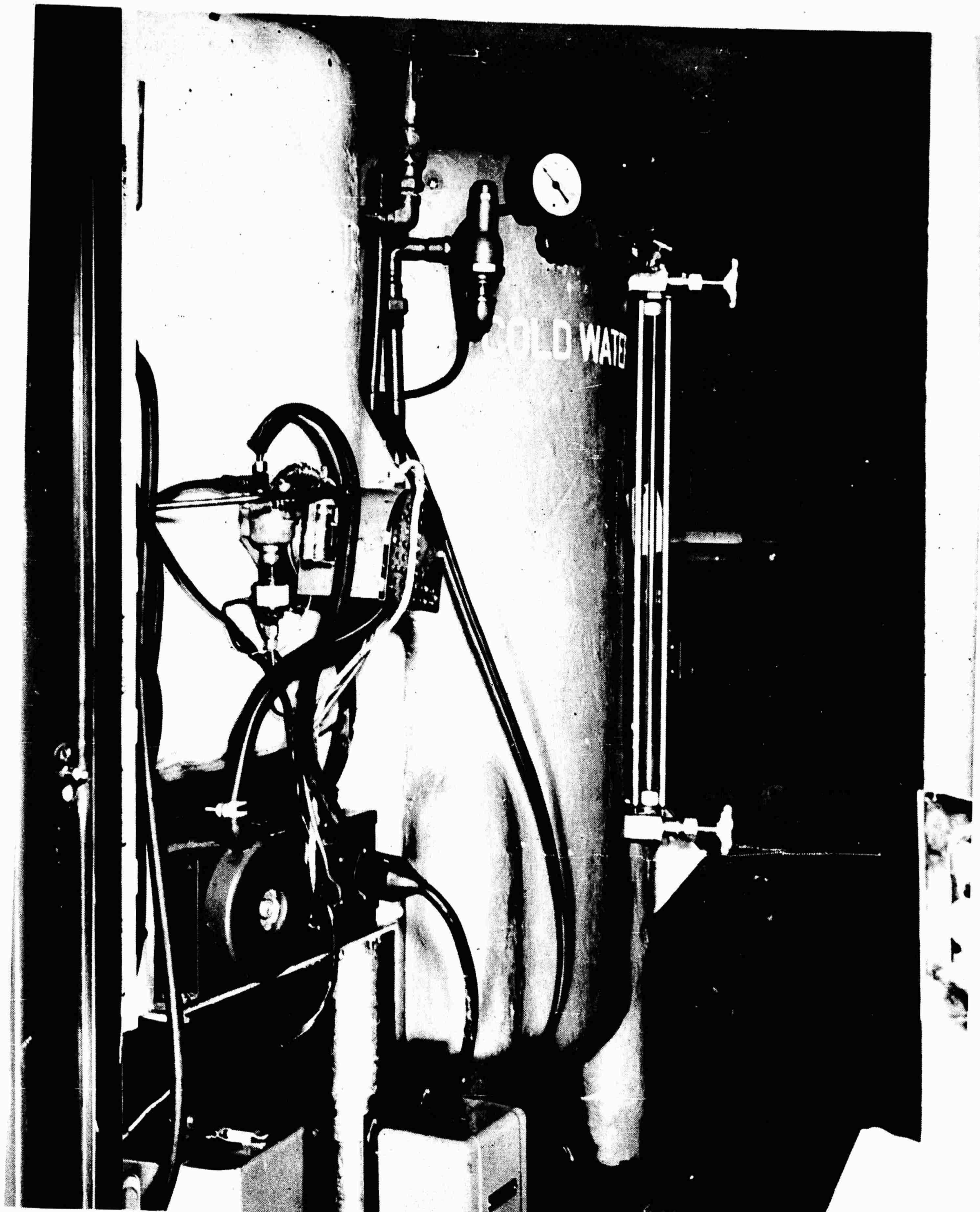


Figure 8

SIGNAL AERIAL PHOTOGRAPHIC SUPPORT

Capt. Charles E. Hulit
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The Signal Corps is responsible for the procurement, installation, operation, and maintenance support of all aircraft cameras and photographic equipment used by the Army. As most of you know, the photographic equipment available in the field at present is not what we would like to have. In the past, we have been supported by the Air Force for much of our photography. At present, we are attempting to do some photography for ourselves. In the future, we may be forced to do most of our photography ourselves. Based on this fact, I would like to discuss some of the implications of modern, up-to-date photography for Army aviation.

First of all, we have the camera with which we will accomplish the photo mission. In the past, that has been little more than a black box with a spool of film, a lens, and a shutter. The equipment required little training to operate and any good mechanic could probably perform 90 per cent of the repair required. Most of you are familiar with the K-20 and similar cameras which have been around for several years. These cameras were small and lightweight but not always usable. It seems that the K-20 would jam every time you pulled the shutter trigger while winding the film advance handle. You are also familiar with the Air Force K-17C, which a few people tried to use as a hand-held camera. The equipment we are now procuring and testing bears little resemblance to these simple cameras. In order to give the Army the best available equipment, we have tested such cameras as the KA-30, KA-20, and some parts of the Air Force KS-21 system, as well as several others. One of the more complicated of these is the KA-30. This camera has the following unusual features:

a. A photocell which measures the available light and automatically gives the operator the correct F stop and shutter speed when he manually centers an indicator needle.

b. A scanner which automatically provides proper image motion compensation (IMC) by scanning the ground and feeding the information obtained through a computer to the camera.

c. A computer which automatically provides 60 per cent overlap at any altitude and speed within the operational characteristics of our aircraft.

These photocells, scanners, computers, etc., are all new items to most of our people and, as a result, will create problems. Additional problems will arise when we start using these new cameras at night. This will involve light sources and additional controls. In addition, serious consideration is being given to several means of air dropping either the camera or the exposed film magazine by parachute to a field processing unit. These systems require additional controls as well as parachutes, etc. As a result, it appears we are finally going to end up with airborne photographic systems which may be more electronic than photographic. We are still experimenting with strip cameras, integral processing equipment, etc. I imagine by 1960-65, we will have available day-night camera systems which will perform the complete photo mission with the exception of flying the plane and loading the camera.

You probably think this is good; maybe it is, and then again, maybe it isn't. It will all depend on how well we can support what we put in the field. In the past when we dealt with camera equipment failure, it was usually a total failure of a part to function. In the newer equipment, there will be a possibility of a partial failure. If the operator or repairman is able to recognize this, he may be able to compensate for the partial failure by proper operation of the controls, thereby allowing the equipment to be used in an emergency until a replacement is available. It would be desirable to have our operators trained so that they will be able to recognize just what are the critical items in the system and what are "nice to have". Many of the new cameras will be of such a nature that they could be operated by a simple push button and a 28-volt power supply if the basic control system was to fail completely.

The present photographic equipment repairman will probably be able to accomplish the repairs required on the basic camera of any of the new systems; however, when we start dealing with scanners, computers, and the associated controls used by some of the newer systems, we have an entirely different problem. This equipment is basically electronic and, as such, could be best maintained by an electronic equipment repairman. It may become necessary to train an electronic specialist in basic photographic repair, rather than to try to train a photographic repairman in electronic repair.

The probable result of the dual training required for this repairman is the establishment of a new MOS. This new MOS will include training in photographic principles, lens systems, mechanical and electrical shutters, electronic iris control systems, and film transport and image motion compensating systems. In addition, it should deal with intervolometer systems, light sensing equipment computers, and control systems. In general, this man must be trained to maintain a photographic system that is more than a simple mechanical camera. If this is done, and we do it soon enought, the Signal Corps will be able to provide the required qualified personnel to support any foreseeable-type camera system which the Army will use in the next few years. If this is not accomplished, we will be faced with the problem of "mechanics working on missiles". This is the first and most important implication -- we must have trained people!!

A second effect that will generated by increased Army aerial photography is the need for supplies. By supplies I mean the necessary spare parts, replacement items, tools, and test equipment which will be required to maintain any new photographic system. Just as the present photographic equipment repairman will need new training, he will also need a new set of tools and test equipment. This equipment will be comprised of items previously belonging to the separate fields of electronics and photography. It will now become necessary to revise the tool set to eliminate the unnecessary items and to add those required for the newer equipment. In addition, the spare parts and replacement items that are required will include resistors, condensers, tubes, and so-called black boxes which contain printed circuits as well as the normal parts, such as shutter springs and lens caps.

A third implication resulting from increased Army aerial photography is the effect on the aircraft. In the past, we have used a standard aircraft and in general let the photographer hang out the side or do anything else to get his picture. No attempt was made to really provide a photographic capability such as will be required with the new systems. Since the Aviation mission includes photography, the aircraft should and must have certain provisions built in to allow this mission to be accomplished.

The Mohawk is the first aircraft we can honestly say we attempted to provide with a photographic capability. Muct of the new camera systems will be easily removed from an aircraft; however, we must plan or retrofit our aircraft so that the necessary power outlet, interconnecting wiring, and necessary mounts or mount provisions are available when required.

You can readily see that we have a lot to do and a lot to look forward to in this field of photography.

CLOSING REMARKS

COL ALLEN T. STANWIX-HAY DEPUTY CHIEF, P&D DIVISION, OCSIGO: By now you have seen, I'm sure, the script upon which this Maintenance Symposium was based. It opened with General Scofield giving you the approach today as he sees it -- the approach to which we must go -- and it has closed by Major Hoshal giving you the end and the ultimate to which we must be going. In between that -- those two points -- the script was the effort to get there, and that was the design of this Maintenance Symposium. Now in looking at Major Hoshal's presentation, either you agree or you do not agree. It hasn't left us much of a middle ground. On the other hand, if you tie it in with the necessities that were placed upon you when the envelope was opened by the keynote address on Tuesday morning, certainly the pathway that you went over on Tuesday, Wednesday, and today couldn't lead much place else except to where Major Hoshal took you this afternoon. To those of you who look upon maintenance as a support of a career, and by a career I mean any career, be it industry or military, certainly the changing elements that go hand and glove with this are obvious to us in this year of 1959. The things that we have heard here in the past 3 days we could not possibly have heard in 1948. We could not possibly have heard in 1949 -- just a short 10 years ago. There are many who will question that we could not have heard them as late as 1955, just a short 4 years ago. What will the next 4 years bring? What will the next 5 years bring? -- or the next 10 years? The envelope that was placed around this year's Maintenance Symposium I do not believe, in my own simple sort of way, was fantastic. I do not consider fantastic some of the things that we have seen here in the past 3 days, for example -- the U. S. in a throwaway concept, and the U. S. with reliability built into its equipment. The operational concepts that were placed before you this morning by the Combat operational and development division should give you some example of the way in which the equipment is being steered. New techniques that we heard yesterday afternoon on engineers' design of a testing unit -- a universal testing unit -- whether or not you believed in it makes the fact no different: that it will undoubtedly, within your lifetime and mine, God willing, by some manufacturer or by many manufacturers be a successful piece of equipment within the time span that we are speaking about. Publications, people, and skills -- we do tie people, skills, and the equipment. You can think very carefully back to one sentence that was given by one of the speakers in the past 3 days, and it is peculiar how one sentence will stick in the mind; this one stuck in mine -- that much of this we could blame on Eli Whitney. And there is a great deal of truth in it. I couldn't help but think about that for the past 2 days -- that much of this can be blamed upon Eli Whitney. Maybe the headline which Major Hoshal put upon the screen -- certainly it will not read the Army Signal Corps abandons maintenance but it may be that the Army abandons maintenance. It may be that we can't afford maintenance. These are the things that the years and only the years will bring to us. This was the reason that this Symposium for maintenance was started; this was the reason that it has been carried forward in an effort to expand it slowly, if you will, but certainly in an effort to expand it. Now, for a brief moment, I would like to look at next year's Symposium which already we of the committee have been in conversations about. We propose to expand the Symposium next year to include at least one sister service -- preferably the Air Force and its maintenance concepts if we can obtain participation and I'm certain that we can. We intend to expand it to include an invitation to our Canadian confreres for their presentations. And we intend to expand it to at least one other technical service. We intend to continue with the major commands of the U. S. Army throughout the world, and we intend to continue the participation of industry which was instituted this year. To those of you who participated from industry, in speaking for General Scofield and for the Chief Signal Officer, I would like to extend our deepest appreciation and sincere thanks for your help in making this Symposium as interesting and as effective as it has been this year. In one note, I might tell you that occasionally, as I get along in the 50 year mark, I think I'll learn but I don't believe seriously that I ever shall. When we requested Mr. Pear to prepare his paper for us, Bernie presented two papers -- one of which was an expose of the Signal Logistics Evaluation Group and the other was our closing speech by Major Hoshal. We talked to Bernie about this expose of the Signal Logistics Evaluation Group and said, "Bernie, It just doesn't fit. We'd like this to be the closing speech by Major Hoshal." "Fine," Bernie says, "We'll give you one paper." Well he gave us one paper and you heard the one paper that we got. I'll never learn, and he will always be one step ahead of me. In closing, Gentlemen, as your overpaid stagehand for the week, it has been a pleasure being with you. Some of you will consider that the question periods have been too strictly handled. If you consider this, please believe that I have military people with me here that must make a schedule -- that I have military command papers that had to be presented for the benefit of the military and have to considered by the military, and it was always our hope that we would hever have to cut one of the industrial papers. With the group that we had, we handled the time the very best that we could. I hope that we satisfied at least most of you. To those of you who have stayed with us until the last moment, may I wish you all safe trips home. God's blessings upon all of you, and this Third Symposium is closed. Thank you very much.

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*USASESA:	U. S. Army Signal Equip. Support Agency
*USASCS:	U. S. Army Signal School
*USASRDL:	U. S. Army Signal Research & Devel. Lab.
*USASSA:	U. S. Army Signal Supply Agency
*USASPA:	U. S. Army Signal Publ. Agency

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