AD NUMBER
AD319561
CLASSIFICATION CHANGES
TO: unclassified
FROM: confidential
LIMITATION CHANGES
TO: Approved for public release, distribution unlimited
FROM: Controlling DoD Organization: Department of the Army, Diamond Ordnance Fuze Labs., Washington, DC.
AUTHORITY
Harry Diamond Lab, D/A, ltr dtd 7 Aug 1980; Harry Diamond Lab, D/A, ltr dtd 7 Aug 1980

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REPORT NO. PR-60-3
PERIOD Jan-Mar 1960

PROGRESS IN MINIATURIZATION AND MICROMINIATURIZATION (U)

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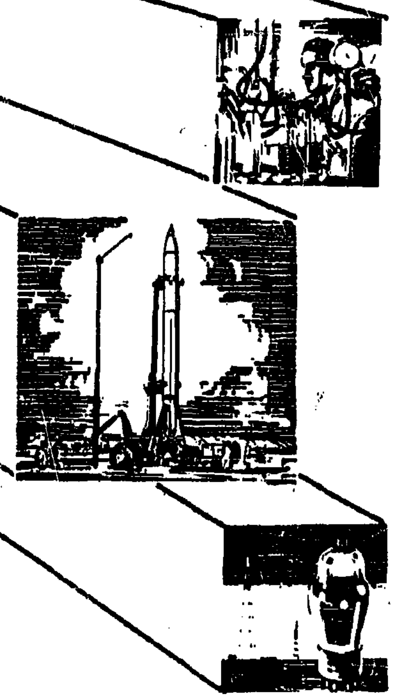

DIAMOND ORDNANCE FUZE LABORATORIES
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WASHINGTON 25, D. C.

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ORDNANCE CORPS WASHINGTON 25, D. C.

DA506-01-010
DA516-01-004

30 June 1960

PR-60-3

PROGRESS IN MINIATURIZATION AND MICROMINIATURIZATION (U)

JANUARY - MARCH 1960

Compiled by N. Doctor

FOR THE COMMANDER
Approved by

Maurice Apstein
Associate Director for
Supporting Research

CONTENTS

ABSTRACT

(U) This report briefly describes the significant accomplishments and progress made in miniaturization work at DOFL during the period January through March 1960. This is the third quarterly report on this subject. Some end items reported in this issue are in themselves not miniature but instead contain miniature elements that may have other applications. Projects are presented under three main headings: (1) systems, (2) components and assemblies, and (3) methods, processes, and techniques.

1. INTRODUCTION

(U) For purposes of orientation, the term "miniaturization" as used in this report implies the design of equipment employing small component parts, such as miniature vacuum tubes or transistors, such parts being commercially available and densely packed to yield equipment appreciably smaller in volume than comparable commercial equipment. The term "microminiaturization" implies the design of equipment employing solid-state devices, such as thin-film resistors and caseless transistors, such devices being experimental items requiring development of special techniques for incorporation in assemblies to yield volume reductions of at least an order of magnitude below those of miniaturization. Examples of microminiaturization are the NOR semiconductor solid circuit (item 3.15) and the 2-D binary counter stages (item 3.12).

(U) Two annual reports (ref 1 and 2) and two quarterly reports (ref 3 and 4) have been published previously on this subject. Except for the Cigarette Fuze (ref 4, item 2.2), which carries a SECRET classification that prohibits detailed discussion in a CONFIDENTIAL report, all items reported in the preceding quarterly report are covered in the present report. One new item entitled "Hawk Missile System" has been added. Some of the previously reported items have been consolidated into a single item or split into several items to enable a clear presentation of related activities.

2. SYSTEMS

2.1 Lightweight GM Fuzing System (Copperhead)

(C) A lightweight GM fuzing system weighing approximately 15 pounds is being developed (ref 4, item 2.1). The fuze will consist of dual channels, each containing: (a) a safety mechanism, arming programmer, and electronic time fuze having an accuracy of 0.1 percent, (b) a UHF Cobra-type FM-radar fuze, and (c) a 32-watt battery supply weighing approximately 0.8 pound. The requirements for the system have been tabulated in a previous report (ref 4, item 2.1).

(U) The electronic programmer is reported separately under item 3.7.

(C) The design of the lightweight FM-radar fuze was achieved by taking the block diagram for the Cobra system and reducing the operating frequency. This design eliminated heavy waveguide hardware, and a klystron with its associated power supply, and allowed substitution of strip-line, co-ax, and lumped-constant circuits. With the exceptions of the oscillator tube and of a gas thyratron in the firing circuit, the entire FM-radar fuze has been transistorized. Because of state-of-the-art limitations in the losses of variable capacitance diodes at high frequency, the oscillator is used with a tripler-amplifier transmitter. The i-f amplifier package is reported separately under item 3.19. The strip-line r-f head is reported separately under item 3.10. A slot-type antenna array consisting of two receiving and two transmitting antennas is employed.

(C) The battery employed with the Copperhead system is of the silver oxide-zinc type described separately under item 3.5.

(C) A single-channel Copperhead fuzing system containing appropriate telemetering circuitry is being readied for flight testing early next quarter.

2.2 Hawk Missile System

(U) The Hawk Missile System was chosen as a vehicle for demonstrating some of the advanced miniaturization techniques currently being pursued at DOFL. Since the Hawk contains vacuum tube circuitry, the miniaturization process will proceed in two steps. First, the system will be transistorized, and then it will be constructed using 2-D techniques. These 2-D techniques involve the fabrication of circuit modules in the form of thin ceramic wafers bearing printed passive parts and caseless semiconductor devices (see items 3.12 and 4.2, this report). Since the Hawk is only the vehicle, the application of these techniques will not await complete transistorization of the equipment but rather will begin as soon as any portion of the equipment is acceptably transistorized.

(C) Preliminary transistorized circuitry was designed for the 30 mc front and side i-f amplifiers in the guidance-and-control portion. Transistorized designs for the elevon servo amplifiers and the 30 mc rear i-f amplifier are in progress.

2.3 Radar Range Finder

(U) This system is a man-portable, battery-powered, radar range finder that should have wide application wherever range accuracy and lightweight are premium requirements. A short pulse radar operates with a pulse of 10 mμsec and 100 w.

(U) In field tests, target separation was a problem and, therefore, a research program was initiated to explore applicable basic separation methods. Techniques such as monopulse (both amplitude and phase), conical scanning, and use of cross polarization and circular polarization are being investigated. Problems of instrument design to allow maximum efficiency in the use of output data by an operator are also being studied.

2.4 Radar Altimeter (Jupiter)

(C) This project has been completed and the hardware components have been delivered to ABMA.

2.5 Radar Altimeter (Pershing Types I and II)

(C) A miniaturized altimeter is being developed for the Pershing Missile System. Originally, two types were under investigation. Type I was intended to provide continuous altitude information from 50,000 ft to below 1000 ft with an accuracy of 15 ft to 30 ft. It was to weigh about 15 lb and occupy a volume of 200 cu in. Type II was intended to weigh only about 8 lb and occupy a volume of 125 cu in. In Type II, unorthodox miniaturization schemes (ref 4, item 2.5) were to be employed. Work on Type II has been discontinued, at least temporarily, and funds have been transferred to Type I.

(C) During the first quarter of 1960, several technical problems have arisen which have dictated some revision in basic system concepts. One of the problems is to maintain proper receiver bandwidth while incorporating sufficient automatic gain control (AGC) to permit separation of the main pulse and the indicator pulse solely on the basis of an amplitude difference. A second problem lies in the difficulty of achieving adequate rise time and recovery time when the same transmitter is used for both pulses.

(C) To circumvent these problems, a dual frequency system was chosen with two transmitters aboard the airborne equipment. The component-and-breadboard work for the airborne unit is essentially complete. Present and future problems are largely those of designing a package which is compatible with allowable space and weight on the reentry vehicle. Most of the circuitry breadboarding for the ground station has also been completed. Construction of two ground stations is expected to begin in the very near future.

2.6 Radar Beacon

(C) The radar beacon miniaturization project for ABMA has been discontinued and the funds which remained in this project have been transferred to the radar altimeter (Pershing) project.

2.7 Ballistic Ranging System

(U) The feasibility of a lightweight ranging system, capable of measuring distance with a high degree of accuracy, was demonstrated. The system consists of an M1C rifle, special spotting ammunition, and an electronic timer which measures the flight-time of the bullet. In field tests, distances were measured up to a range of 5700 feet with accuracies of about ±1 yard at 600 yards.

(U) Since the demonstration of the practicability of such a system was the only requirement of the present program, this project will be considered terminated until it is funded as other than a research activity. A report will be issued next quarter.

3. ASSEMBLIES AND COMPONENTS

3.1 Clock Assembly

(U) The objective of this project is to develop a miniaturized stable source of high-frequency energy having a short-time stability of one part in 10^9 and the ability to withstand missile environment. A preliminary miniaturized solid-state crystal-controlled oscillator with its own temperature-controlled oven was described in the preceding report (ref 4, item 3.1).

(U) During this period tests were made of short-time stability, and a new criteria called phase stability was defined. Contributions of low frequency noise to instability have been reduced. Results will be reported next quarter.

3.2 High-G Telemeter

(U) The high-g telemeter project is intended to develop a telemetering unit for use on nonspin missile models (1 in. to 3 in. in diameter) fired from high-velocity guns through spark photography ranges at APG-EBL. Temperatures up to 1500°C and pressures of several atmospheres will be measured. Launching accelerations above 200,000 g are anticipated (ref 3, item 2.7).

(U) All circuits now being used employ hearing-aid-sized components but would lend themselves to microminiaturization. At present, four units, each consisting of an rf oscillator modulated by a subcarrier relaxation oscillator, have been fired in the transonic range at APG-EBL. Peak acceleration was about 220,000 g and muzzle velocity about 8000 ft/sec. Complete records were not obtained but enough information was received to confirm operation of the circuitry during flight. One missile was recovered intact. This unit remained operable and was fired again.

3.3 Millimeter Magnetron

(C) A program leading to the design of a beacon-type low power, millimeter wave magnetron is being pursued. The design is based on low-field operation first reported by Columbia University. Because of the low voltage, it should be possible to short pulse the 70 KMc source. Hence, this magnetron represents the first step toward a highly accurate, portable range finder and battlefield surveillance system having sufficient angular resolution (less than 0.5 degree) for radar presentations of television-type definition.

(C) Successful utilization of a reduced-diameter moly-rhenium heater structure has allowed an increase in wall thickness of the nickel matrix cathode from 3 mils to nearly 4.5 mils. This has greatly increased the life and reproducibility of the miniature millimeter magnetron. Performance data presently being taken show increases in power output, rise-time, and moding characteristics. (ref. 5).

3.4 Voltage Tunable Magnetron

(C) Since late 1958, DOFL with the General Electric Co. as contractor, has had under development a miniature voltage tunable magnetron (VTM) suitable for use in missile systems. The effort has provided a high efficiency transmitter package weighing 1.3 pounds and consisting of a magnet mounting structure and a tube and its r-f circuit. (Figure 1). Using the same magnet mounting structure, units are being designed to operate at frequencies within L, S, and C band.

(C) During the past quarter, 60 sets of parts for the fabrication of S-band units were completed. After some difficulties with contacts between tube and circuit, five units were completed and tested. They performed well under normal missile test conditions of shock, vibration and temperature. The output power was nominally 5 watts at over 25% efficiency.

(C) Two L-band units were completed and found to operate well, except at vibration frequencies near 2000 cps. This difficulty is expected to be corrected by a minor modification in the circuit mounting. The output power was nominally 2 watts at over 35% efficiency.

(C) Parts were completed for the construction of five C-band units.

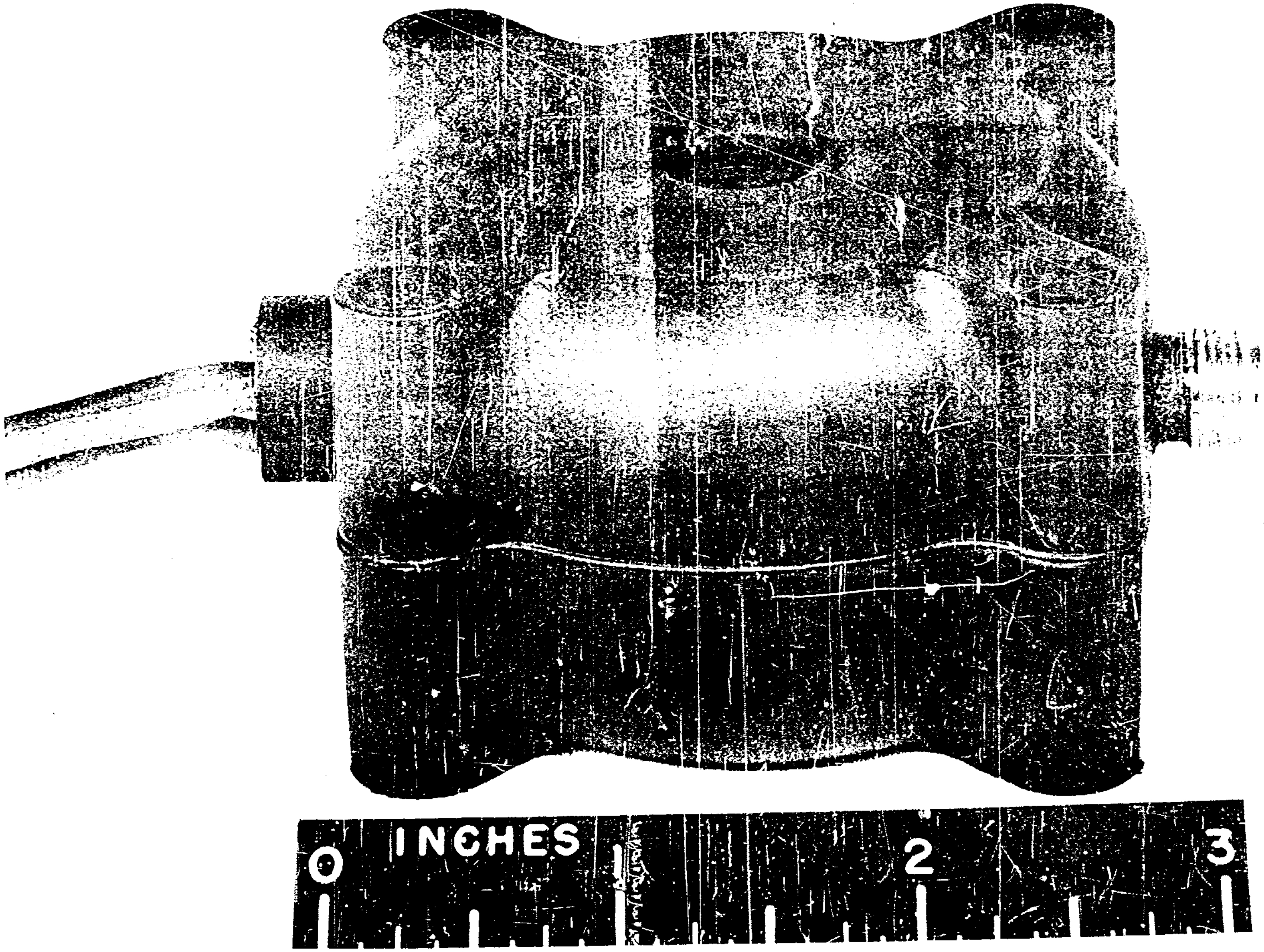

Figure 1. Miniature voltage tunable magnetron weighs only 1.3 pounds.

3.5 Power Supply

(U) Electrolytes composed of cesium and rubidium hydroxides are being considered for miniature silver oxide-zinc batteries capable of low temperature operation without supplemental heating. Conductivity measurements and phase diagrams of various mixtures of potassium, cesium, and rubidium hydroxides are being made. Preliminary results indicate that pure cesium hydroxide has the highest conductivity at -65°F.

(U) A miniature gas generating squib has been developed for DOFL by the Hercules Powder Co., for activating the silver oxide-zinc battery mentioned above. These squibs are 0.19 inch in diameter and 0.42 inch in length and produce 40 cc of gas (excluding water) at 75°F and 1 atmosphere.

(U) The development of miniature thermostatic switches for batteries of the PS-502 type is being considered. They will operate on expansion, or change of conductivity, of freezing liquids.

3.6 Pure Pneumatic Computer Elements

(U) In the pneumatic computer program, none of the work performed this quarter was directed toward miniaturization. It is expected, however, that development of miniaturized elements will become increasingly important as the program progresses.

3.7 Electronic Programmers

(U) Eight additional models of the miniature programmer have been built. These have been redesigned in order to: (1) operate on 0 to -6 volts and hence require only one power line, in addition to the ground line, to connect with the power supply, (2) draw less power (less than 0.1 amp at 6 v), and (3) be temperature compensated to extend their temperature capabilities. One unit was scheduled for flight test on 1 April 1960. Units for two dual-channel flights are being tested and readied for flights late next quarter.

(U) Fabrication of the miniaturized field ground control box for the electronic programmer has been completed. The box is now undergoing laboratory tests and is to be used in later test flights. The preset counter of this unit starts at 1136 and counts toward zero. At the end of precounting, the time remaining in the programmer is displayed by indicator lights on the box. A photograph of the ground control box is shown in Figure 2.

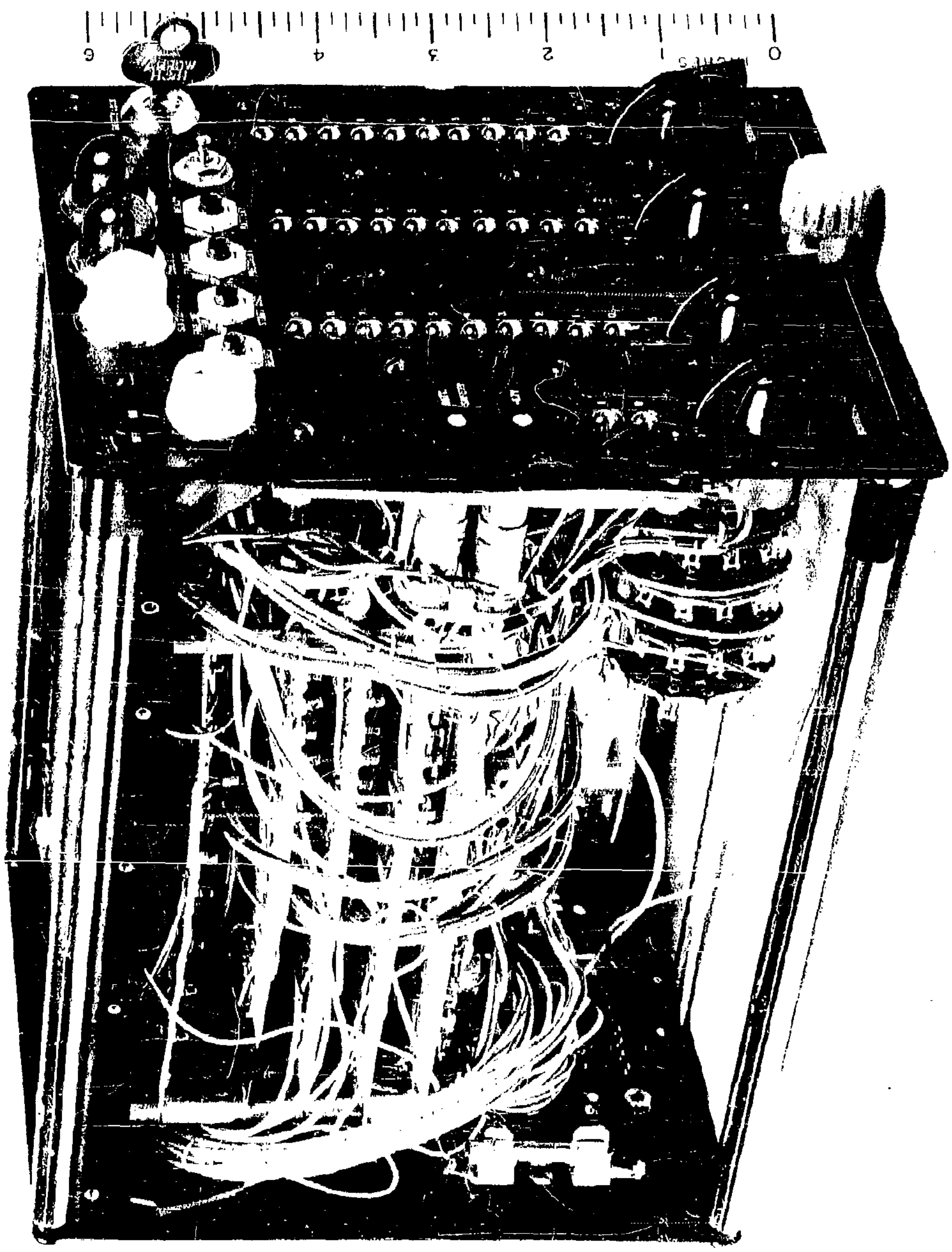

Figure 2. Copperhead ground control box.

3.8 Cavity Antennas

(U) If the functions of an rf oscillator (or power amplifier), transmission line, and antenna could be combined into a single unit, considerable saving of space, weight, and complexity could be achieved. In missile applications, the necessity of maintaining a smooth, unbroken surface contour has led to the almost exclusive use of cavity antennas. Since the space inside these antennas is now largely wasted, attempts are being made to place high power rf components directly inside these cavities. Potential application lies in the upper VHF and lower UHF ranges.

(U) A cavity slot antenna, in which a type 4X250B power tetrode was installed transversely across the narrow part of the slot, had a broad, uniform pattern in the forward direction. Radiated power, however, was disappointing when compared with a reference dipole antenna (ref 4, item 3.8).

(U) Increasing the size of the ground plane greatly improved performance. Laboratory tests indicated that good power output was obtained with an anode voltage of 1500, a screen voltage of 230 volts, and a grid drive of 25 volts (12 KΩ grid resistor and self bias) which yielded 250 ma anode current. An efficiency of 48% was obtained at these optimum settings.

(U) Field test measurements of radiated power confirmed the above efficiency and, hence, demonstrated the equivalence of the power amplifier-cavity antenna combination to the usual power amplifier-transmission line-antenna combination.

3.9 Loop Antennas

(U) Efforts in loop antennas in the past quarter have been mainly concerned with research into the phenomenon of broad-band antennas. The investigation of the possibilities of miniaturizing these antennas has been temporarily suspended.

3.10 Microwave Strip-Line

(C) The first model of a strip-line, L-band rf head has been constructed for inclusion in the Pershing Altimeter Package (ref item 2.5). Satisfactory performance was achieved in the specified frequency region. The head consists of four hybrid ring sections which couple two transmitters, a receiver, and one telemetering point to four antennas. The de-coupling between the transmitters and the receiver exceeds 25 db and is a function of the antenna match. The unit, when shielded, weighs less than seven ounces and measures 4-1/2 in. in diameter and 3/4 in. in thickness. A photograph of the unit is shown in Figure 3.

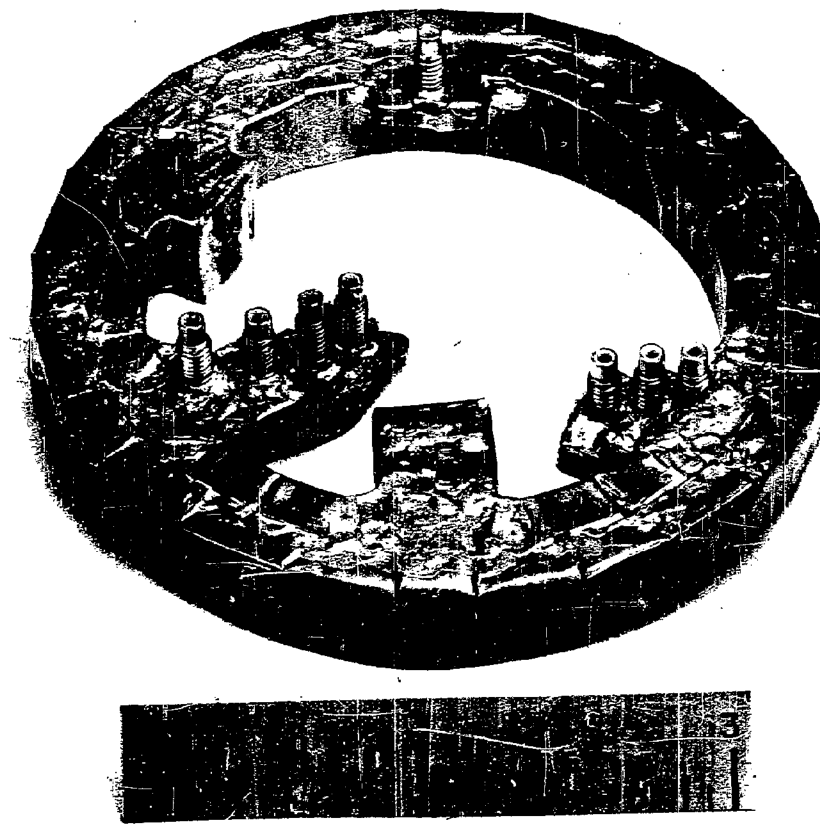

Figure 3. First model of strip-line, L-band, rf head for Pershing Altimeter Package.

(C) A stripline, S-band rf head is now under construction for inclusion in the Coral Fuzing Package. It provides for one transmitter, the output from a balanced mixer-receiver, a servo output, two transmitter antenna terminals, and two receiver antenna terminals. It measures 10 in. x 6-1/2 in. x 1/8 in.

(C) Strip-line development in the X-band region has been discontinued. It was concluded that the involved fabrication procedures required to suppress rf leakage paths discounted any advantages gained in the size of the package compared with the size of conventional waveguides.

(C) A strip-line rf head which operates in L-band with a usable bandwidth of 10% has been constructed for the Copperhead System. It contains two directional couplers, two antenna diplexers, and a balanced mixer. Descriptive data over the required band are as follows:

1. Diplexer balance: ±0.2 db
2. Directional couplers: -21±0.4 db
3. Mixer balance (L. O. noise rejection): >30 db
4. Mixer conversion loss: 8.2 db
5. VSWR: 1.08 - 1.22 (depending on terminal measured; median 1.15).
6. Size: Roughly circular, ca. 9 in. diameter by 1/4 in. in thickness.
7. Weight: 22 oz.

(C) Figure 4 is a schematic of the rf head. Figure 5 shows an exploded view of the transmitter deck of this single channel unit. Work on a dual-system version is underway.

3.11 2-D I-F Amplifier

(U) An investigation is being conducted to determine the practicability of constructing i-f amplifiers in 2-D form (ref 3, item 3.12). The design objectives are: (1) a gain of 100 db, (2) a center frequency of about 30 Mc, and (3) a volume of a fraction of an inch. The circuit under study employs 2N700 transistors in a common-emitter configuration. The stages are not neutralized and simple fixed-tuned transformers are employed as interstage coupling elements.

(U) The individual stages are fabricated on 0.6 in. by 0.6 in. by 0.020 in. ceramic plates. The basic electronic single stage is potted to a thickness of 0.060 in. and then copper-plated for shielding.

(U) Two stages giving a gain of 40 db have been fabricated but instability arises when three stages are interconnected. A change in the location of a ground is expected to alleviate this situation. Extreme difficulty has been experienced in fabricating enough

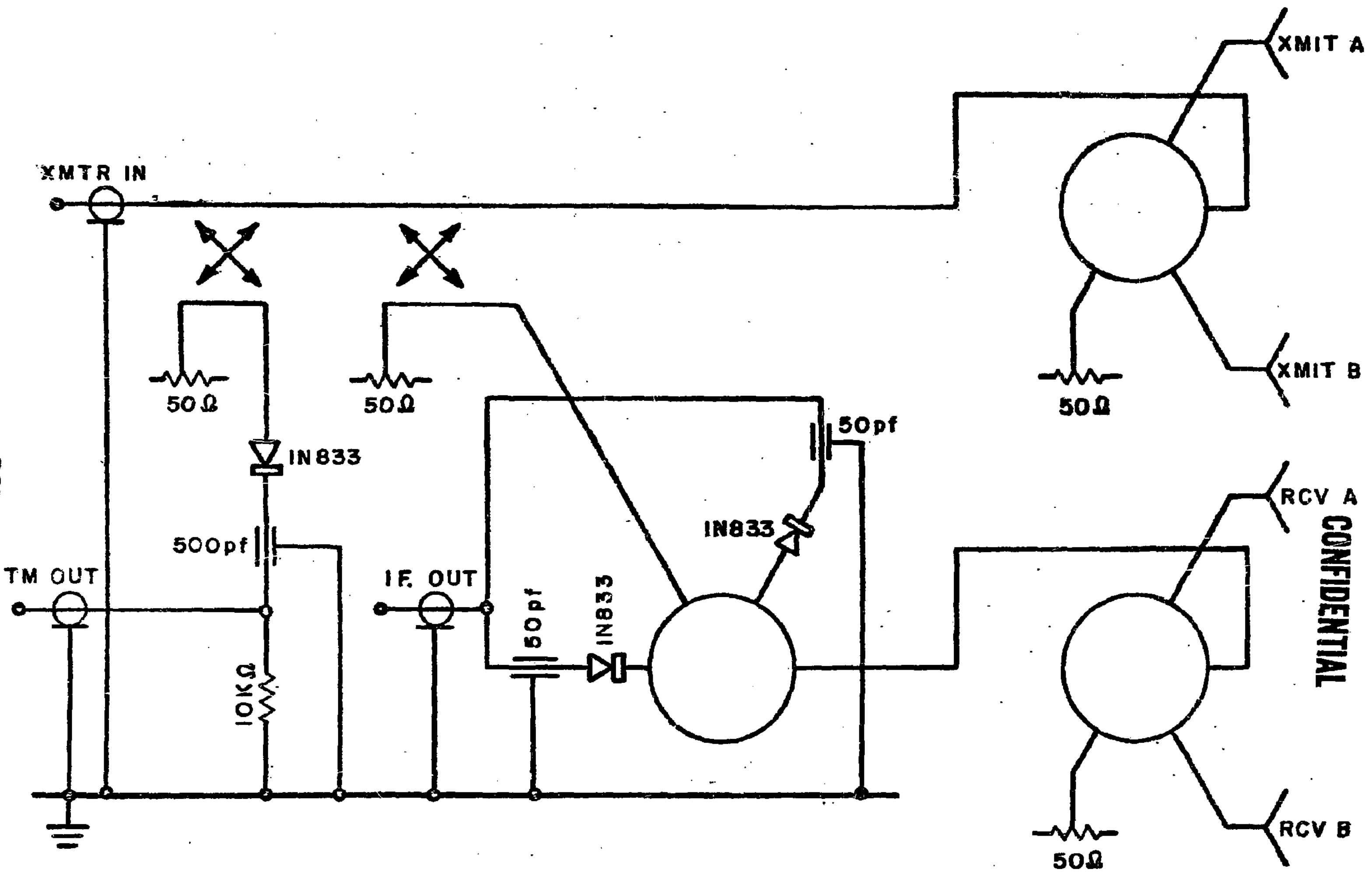

FIGURE 4. SCHEMATIC DIAGRAM OF RF HEAD FOR SINGLE COPPERHEAD SYSTEM

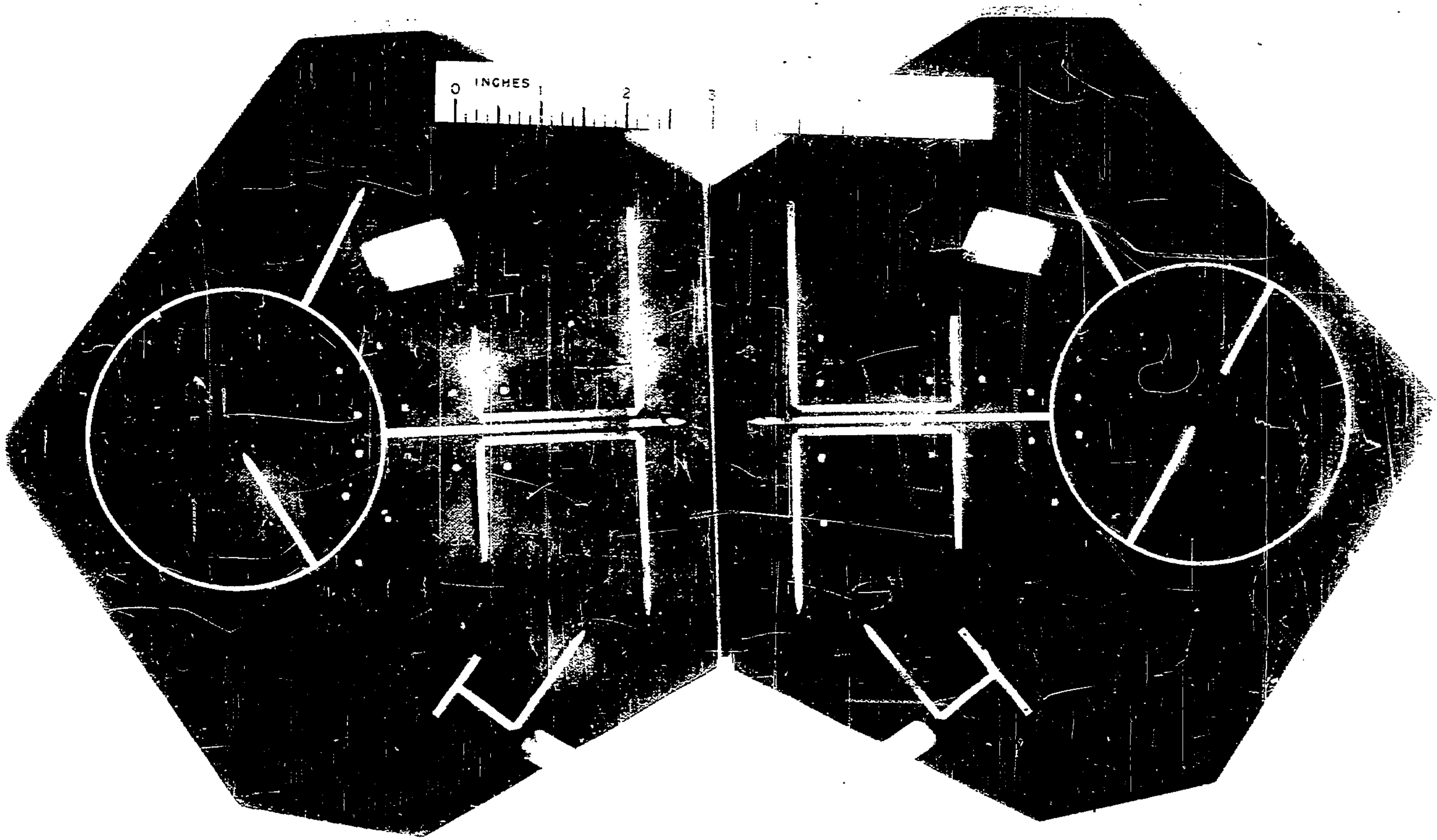

Figure 5. Exploded view of the transmitter deck of an L-band, strip-line rf head which was constructed for the Copperhead.

plates to perform electrical evaluations. The difficulties reside in two areas: (1) high resistance of painted connections and (2) transistor failures during fabrication and processing. Silver-filled epoxy resin is used to form the painted connections and connections less than 1/4 in. in length have shown resistances of over 100 ohms. This problem is simply one of proper mixing of the silver-epoxy formulation and it is aggravated by the difficulty of accurately weighing the small amounts of constituents used to make up the mixture for the individual plates. However, a new two-part mixture, and additional evaluation of these effects during the processing, will help solve this problem.

(U) The difficulties of modifying a commercial transistor to the needs of the program are more serious and causes of failure more obscure. Transistors which have been uncased, incorporated in a wafer, potted, copper plated and then checked electrically, have failed when raised to a temperature of 65°C in an oven. Failure of a transistor in a completed wafer requires a very tedious and delicate operation to salvage the wafer. It is not known whether the failures are due to contamination from the oven or to a failure-prone mechanism resulting from the initial modification of the transistor.

(U) A small metal box 0.3 x 0.65 x 0.65 in. with metal stage dividers is being fabricated in order to permit the electrical testing of five unpotted stages, thus avoiding the need for complete processing of the individual stages prior to testing.

3.12 Contract for Pilot Lot Production of 2-D Binary Counter Stages

(U) On 25 June 1959, a contract (DA-49-186-502-ORD-807) was let to the Sprague Electric Company for the manufacture and delivery of 200 2-D binary counter stages. In the past quarter, 91 units were delivered in six shipments, bringing the total so far delivered to 94. Figure 6 shows the cumulative total of units delivered at any given time after October 1959.

(U) Acceptance tests were performed at DOFL on all units. In addition to a simple check for operation at nominal voltages, a determination was made of performance endpoints for such parameters as minimum collector supply voltage, minimum bias supply voltage, maximum frequency, maximum input series resistance, minimum load resistance, and maximum load capacitance. These parameters will be used in checking effects of time and environment on the 2-D stages.

(U) To date, four failures have been noted. All failures occurred subsequent to the initial acceptance tests which showed no waveform abnormalities. Two failures were connective failures; one occurred in a conductive adhesive connection and the second in an "around the edge of the wafer" fired-silver connection. A third failure was due to poor diode back resistance and the fourth was due to both a poor diode and a

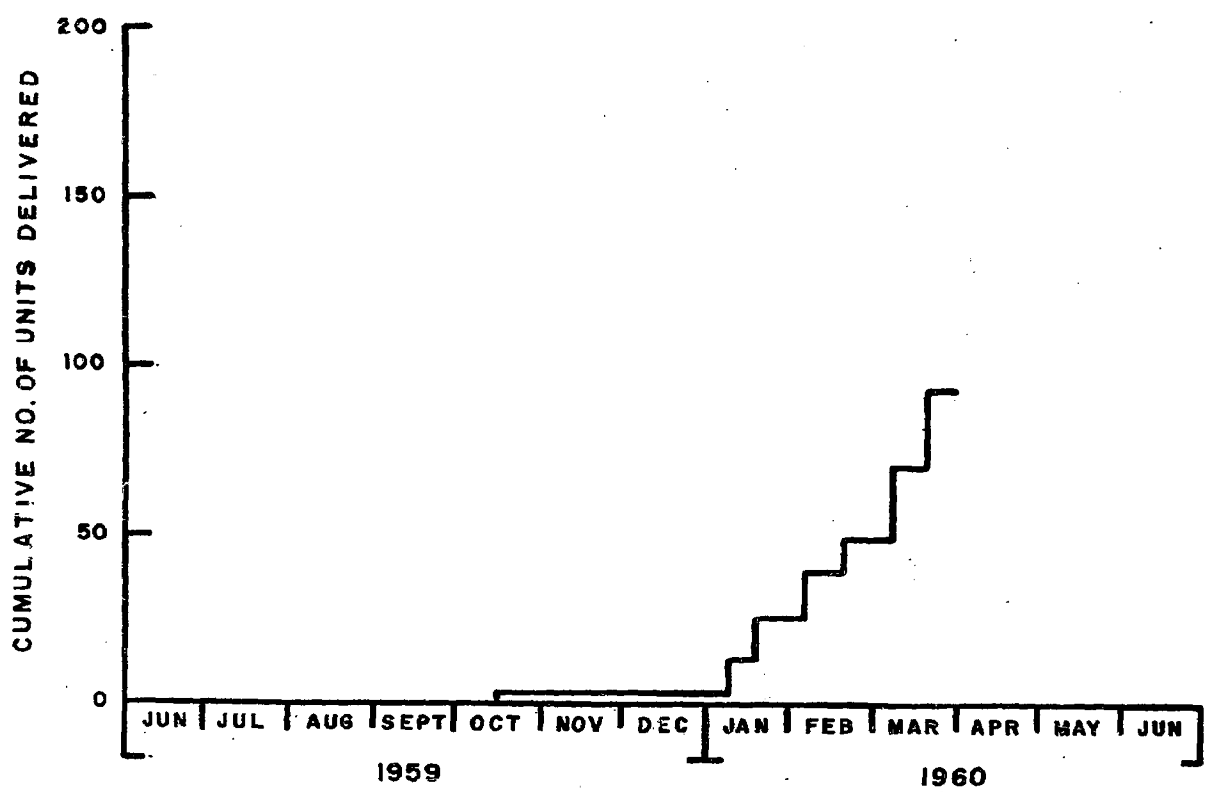

FIGURE 6. DELIVERY RECORD ON 2D–BINARY DIVIDER STAGES FROM SPRAGUE ELECTRIC CO.

defective conductive adhesive connection. It may prove to be pertinent that all failures to date have occurred after a certain amount of handling.

3.13 High-Frequency Diffused Base Transistors

(U) A group of approximately one thousand germanium diffused-base transistors with .002 in. x .006 in. base and emitter bars was fabricated in multiple units of 49 transistors to a 1/4-inch-square wafer. (Fig. 7). At the dicing stage, the yield was 50 percent. A group of these units is being tested in the JETEC 30 header.

(U) A new ceramic package for these transistors has been designed to enable their use in 2-D circuit applications. When the cap is soldered in place to seal the unit, the package has a diameter of .168 in., and a thickness of about .035 in. Two designs of the ceramic header are now being fabricated to determine which is better from the standpoints of ease of fabrication, mechanical strength, and high-frequency electrical characteristics.

(U) Several diffused-base transistors having an interdigital emitter-and-base contact configuration were fabricated. Initial tests showed their performance to be generally comparable to that of transistors having the .002 in. x .006 in. emitter and base contacts. Tests are continuing.

3.14 Tunnel Diode

(U) DOFL-made germanium units that have been tested to date appear to maintain their electrical charatteristics for long periods, provided that they are not subjected to excessive overloads. These devices are insensitive to moderate changes in temperature.

(U) The properties of these diodes suggest the following new uses: (1) as a voltage reference device and (2) as a long-period standby trigger device.

(U) Material is now available for tests of silicon tunnel diodes.

3.15 Semiconductor Solid Circuit

(U) Material has been obtained for solid circuits utilizing double-diffused layers. New patterns have been made for isolation of portions of the NOR circuit on single-diffused material, but difficulty has been encountered in obtaining sharp patterns. The multi-probe micromanipulator for probing the circuit has been completed and tested. A photograph of this instrument is shown in Figure 8, and a close-up of the probe-tips being applied to a solid circuit NOR is shown in Figure 9.

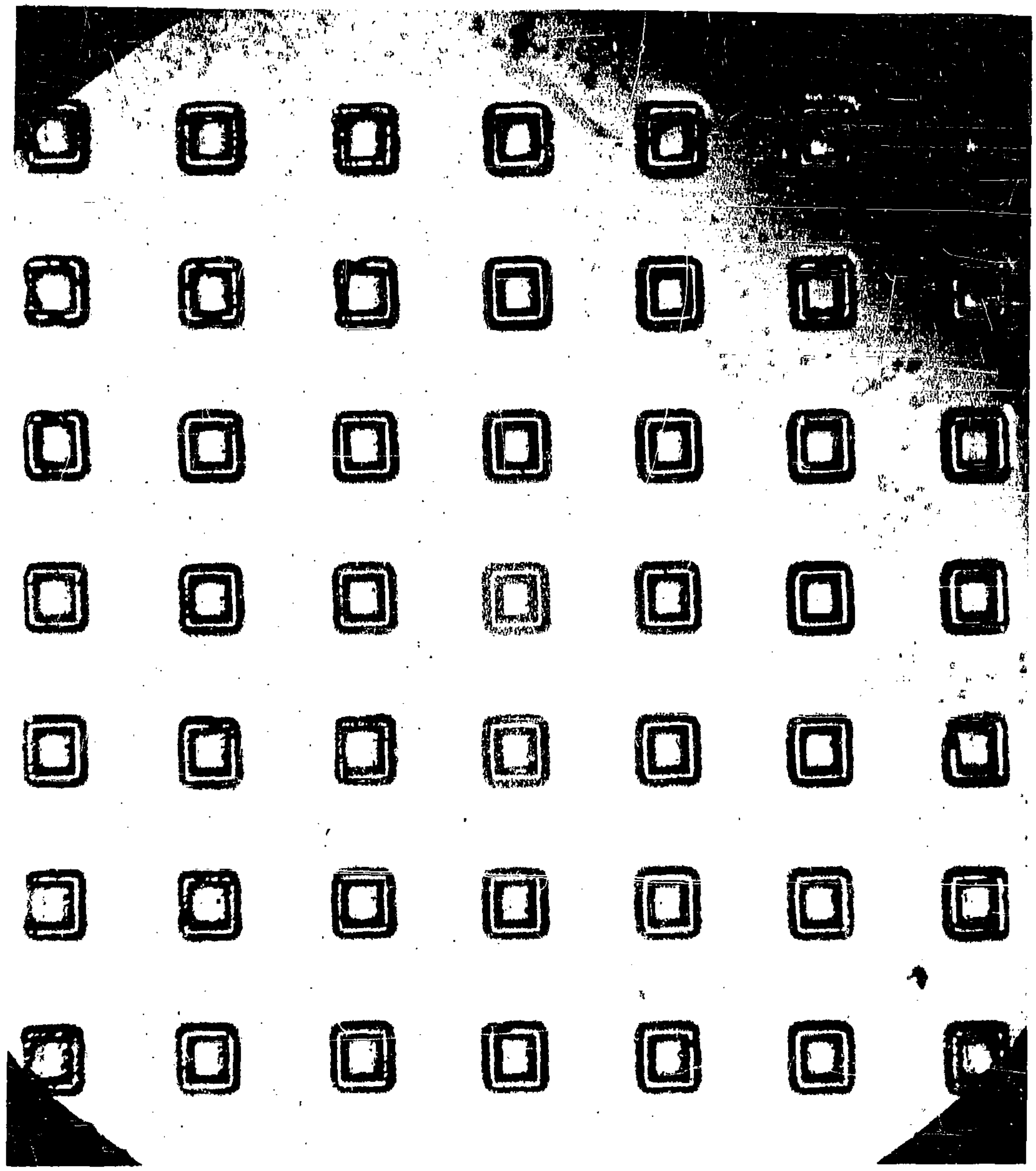

Figure 7. Forty-nine diffused base transistors fabricated on a $1/4$-inch square slab of germanium.

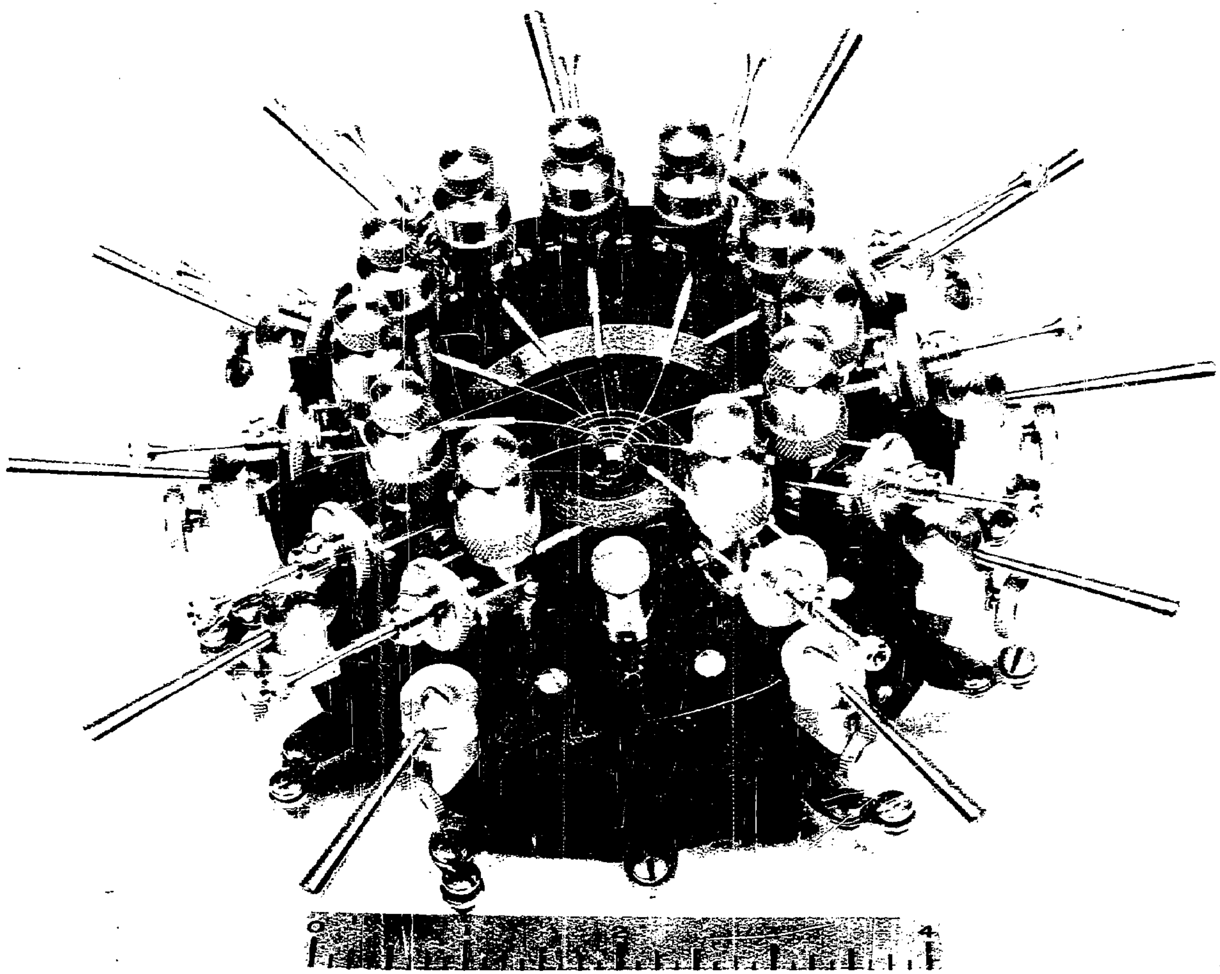

Figure 8. Multi-probe micromanipulator employed in testing of DOFL solid circuits.

Figure 9. Close-up showing tips of probes contacting s ..ected points on a solid circuit NOR.

3.16 Thin-Film Capacitors and Resistors

(U) Twenty-eight additional thin film SiO_x-dielectric capacitors of varied dielectric thicknesses and compositions were formed by vaporization of SiO_2 from a BeO crucible. The electrical properties of these capacitors were essentially the same as those obtained for capacitors formed by vaporization of SiO from a Ta boat. It thus appears impossible to vaporize SiO_2 under these conditions without appreciable decomposition. No further work on this material is planned pending installation of electron bombardment equipment which may aid in avoiding decomposition difficulties.

(U) Nichrome film resistors of various resistance values and film thicknesses were stored at 70°C in order to obtain long-term stability data.

(U) Nine additional logic circuit subassemblies, consisting of vacuum-deposited resistors and wiring on 1/2 x 1/2 inch glass plates were fabricated. A photo of one of these plates is shown in Figure 10. Testing is in progress.

(U) A thin-film air-core inductor was deposited, using MgF_2 as the insulating layer. Resistance of the Cu conductors was too high to permit measurements of inductance.

3.17 Printed Cables and Harnesses

(U) Flat flexible multiconductor cables made by two commercial concerns in 500-ft. lengths are undergoing tests to determine conformance to specifications set by ABMA. These cables comprise an 0.008-in-thick polyester matrix in which are embedded 30 flat copper conductors, 0.025 inch in width and spaced 0.045 inch from center to center.

(U) Electrical tests are in process at DOFL. Mechanical tests have been completed by the National Bureau of Standards. The latter tests showed that neither of the cables met all the mechanical requirements. For example, both failed the 700,000 psi minimum required modulus of elasticity in flexure. The cable from IRC also failed the ±0.004 inch tolerance on width and, in general, showed a higher degree of variability of construction than did the cable from Tape Cable Corp. Mechanical test data are summarized in Table I. A photograph of a piece of each of these cables (Figure 11) shows the greater variation of spacing between conductors in the IRC material compared with that in the Tape Cable material; this variation is also apparent to the naked eye.

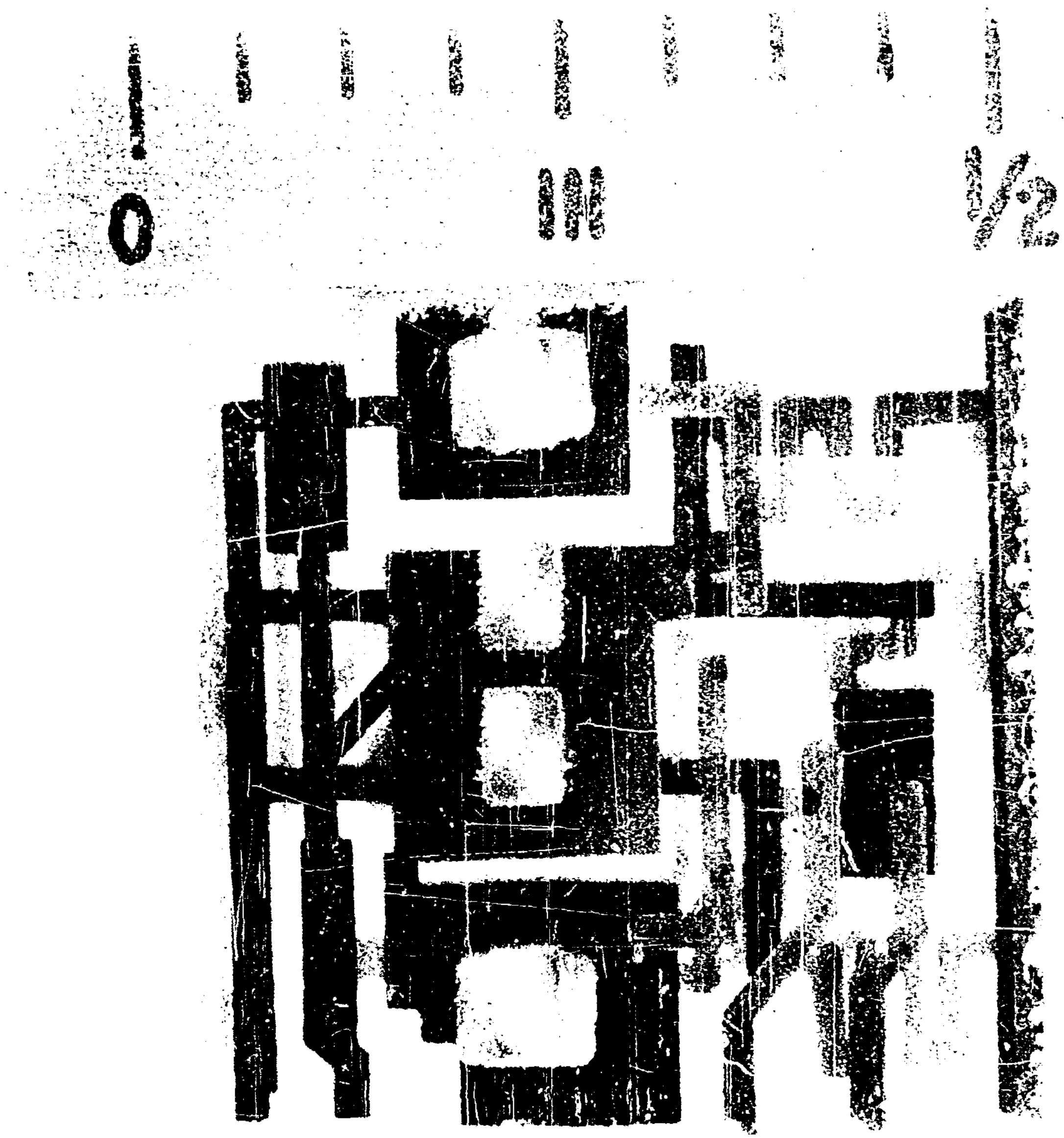

Figure 10. The conductors and resistors for this logic circuit were formed by vacuum depositions on both sides of a glass substrate.

Table I. Mechanical tests[a] on printed cables manufactured by Tape Cable Corp. (TCC) and by International Resistance Company (IRC).

Parameter	ABMA Specification	Av. value		Spread, %	
		TCC[b]	IRC[c]	TCC[b]	IRC[c]
Modulus of elasticity in flex, psi	700,000 min.	450,000	343,000	+3.2 -3.8	+8.8 -7.6
Tensile strength, psi	8,000 min.	15,120	11,020	+5.2 -3.2	+26 -17
Water absorption, %	0.1 max	0.18	0.12	+67 -44	+33 -25
Cable width, in.	±0.004	1.497	1.499	±0.2	+1.1 -0.8
Spacing between conductors (center to center), in.	0.045	0.044	0.043	+0 -4.5	+4.7 -2.3
No. of conductors	30	30	30	0	0
Cable thickness, in.	0.008	0.008	0.008	+0	+0 -11
Copper thickness, in.	0.0027	0.0022	0.0024	+0 -4.5	+0 -4.2

(a) Test work carried out by the National Bureau of Standards.

(b) 10 determinations

(c) 8 determinations

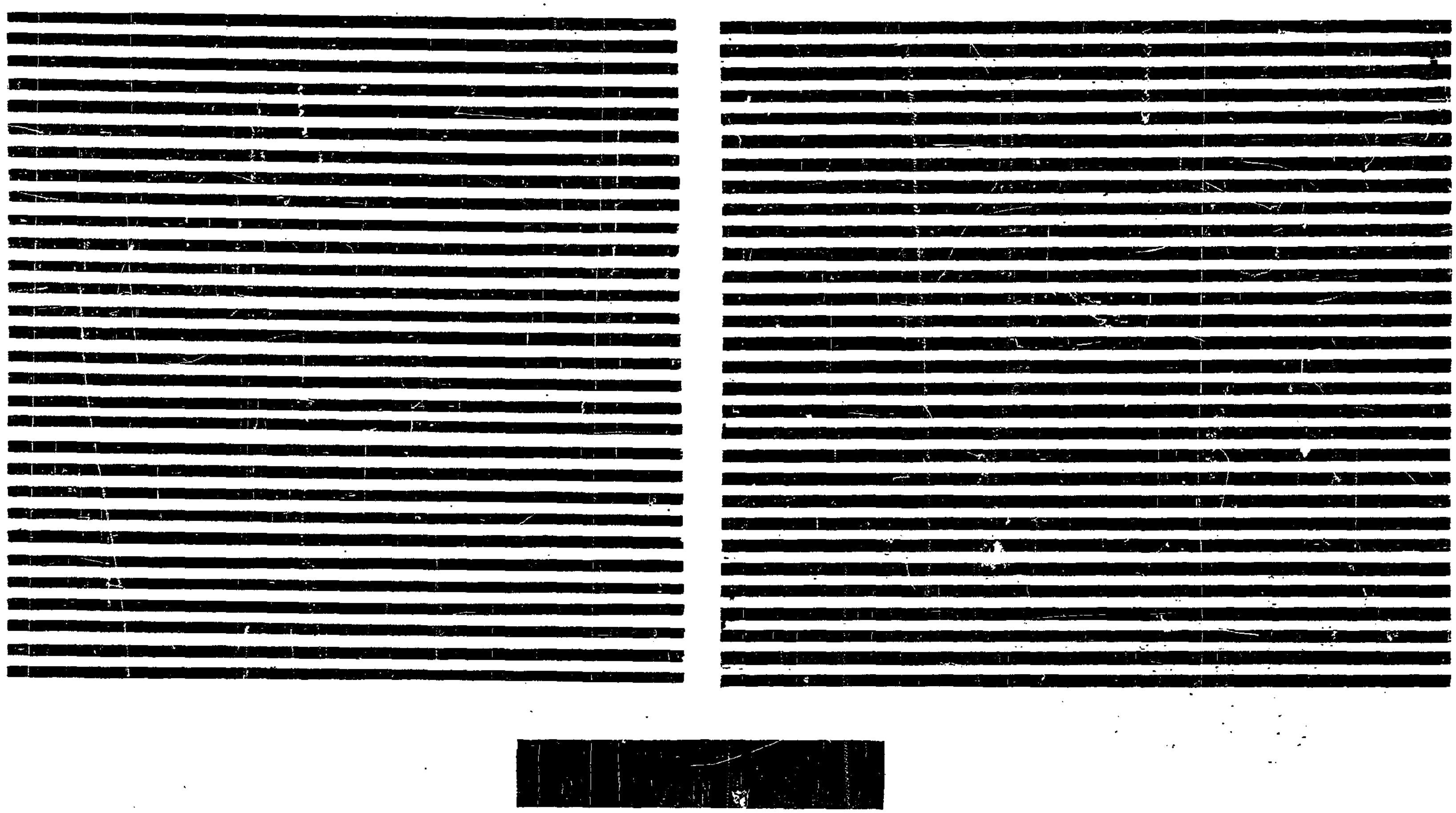

Figure 11. Printed cables from IRC (left) and Tape Cable Corp. (right) have been compared mechanically and electrical tests are now in process.

3.18 Microlamp

(U) Limited time continues to be given to the construction of DOFL Microlamps for specific applications, and to electrical and optical testing of these lamps.

(U) On 17 March Kay Electric Company, Pine Brook, N. J., announced the production of their "Pinlights", measuring 0.015 by 0.062 inches. These Kay Electric Company lamps, as well as Sylvania's "Mite-T-Lights" which were placed in production last November, are industry versions of the DOFL Microlamp.

3.19 I-F Amplifier and Discriminator Package

(C) The schematic diagram of the if amplifier and discriminator package required for the Copperhead System is given in Figure 12. Dashed lines group the parts assigned to each etched wiring board in the package. The miniaturized package is shown in Figure 13. It has a component density of ca. 10^5 parts/ft^3 and operating characteristics as follows:

1. Gain: 105 db
2. Center frequency: 300 Kc
3. Bandwidth: 100 Kc
4. AGC: 50 db dynamic range

4. METHODS, PROCESSES, and TECHNIQUES

4.1 Contract for Research on 2-D Circuits

(U) Philco has been conducting an investigation of thin film techniques for 2-D circuit fabrication. Sputtered tantalum resistors and capacitors and nickel-covered tantalum conductors are used. Active elements (Philco 2N501 transistors) are fixed into a recessed part of the substrate.

(U) Effort during this quarter has been expended in fabricating 2-D circuit plates as reliably as possible with a minimum number of production steps. A telemeter voltage-controlled sub-carrier oscillator is being fabricated to demonstrate these thin-film techniques.

4.2 Interconnection Techniques for 2-D Wafers

(U) Three 10-stage counters were assembled using welded interconnections. Figure 14 shows the housing used for the counters; Figure 15 is a close-up view of the bottom of the assembly showing the welded connections. The welded connections were deliberately made 1/2-inch from the wafers so that, in case a unit failed, the defective unit could be removed and the lead length would still be adequate to enable testing.

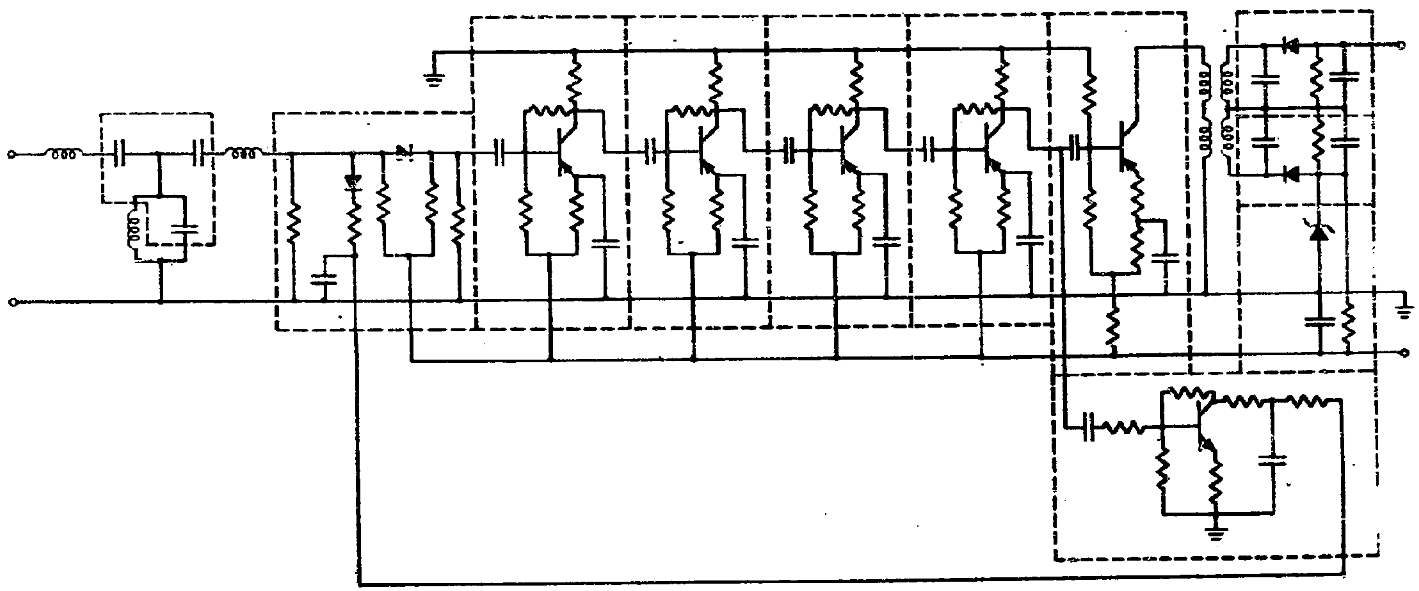

Figure 12. Schematic diagram of i-f amplifier-discriminator package employed in the Copperhead system.

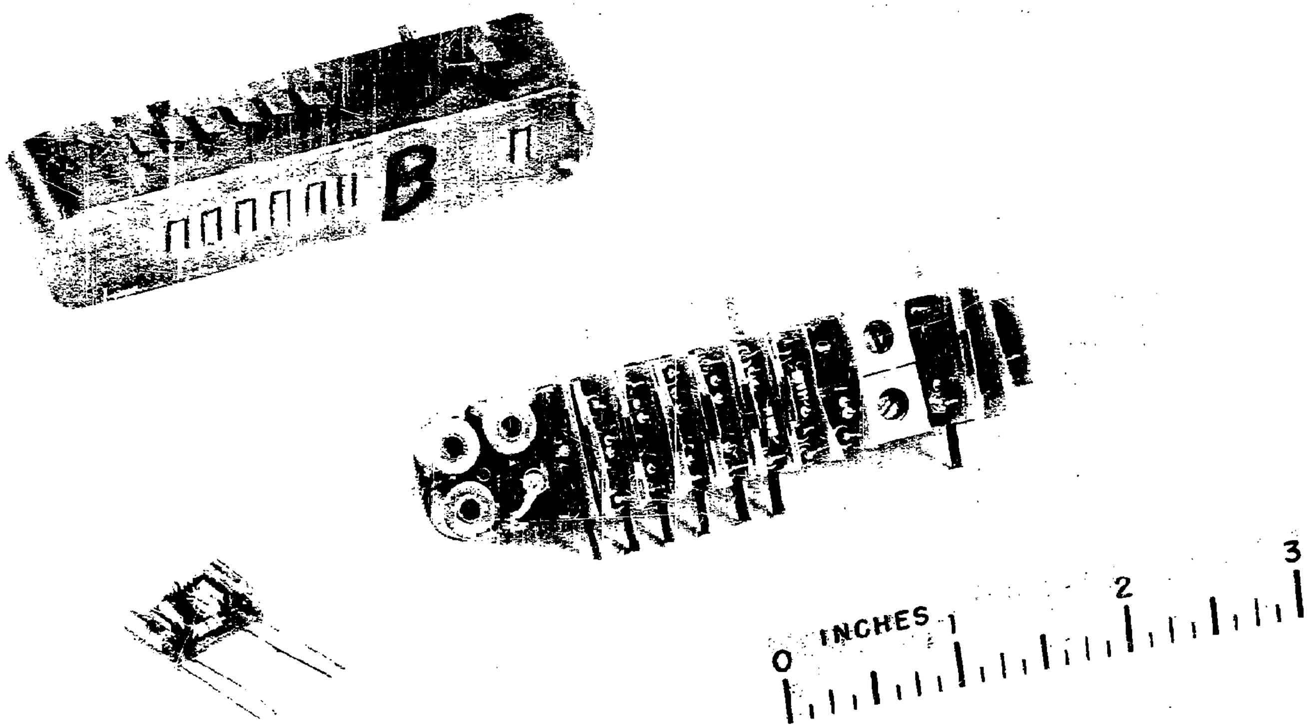

Figure 13. IF amplifier-discriminator package employed in Copperhead System is constructed of miniature commercial parts and has a packaging density of ca. 10^5 parts/ft^3.

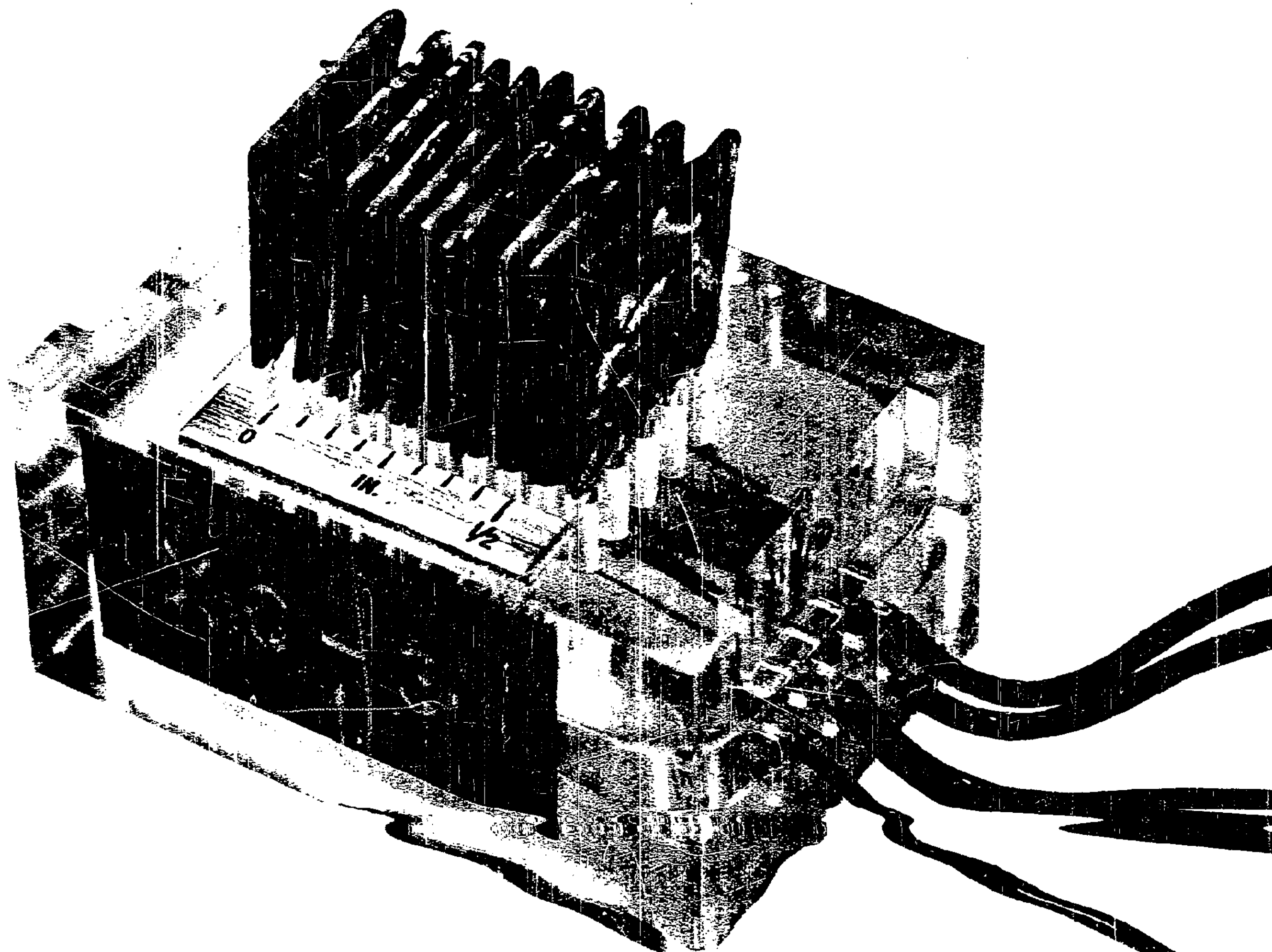

Figure 14. 10-stage binary counter employing welded interconnections is mounted in a fixture allowing uncomplicated replacement of defective stages.

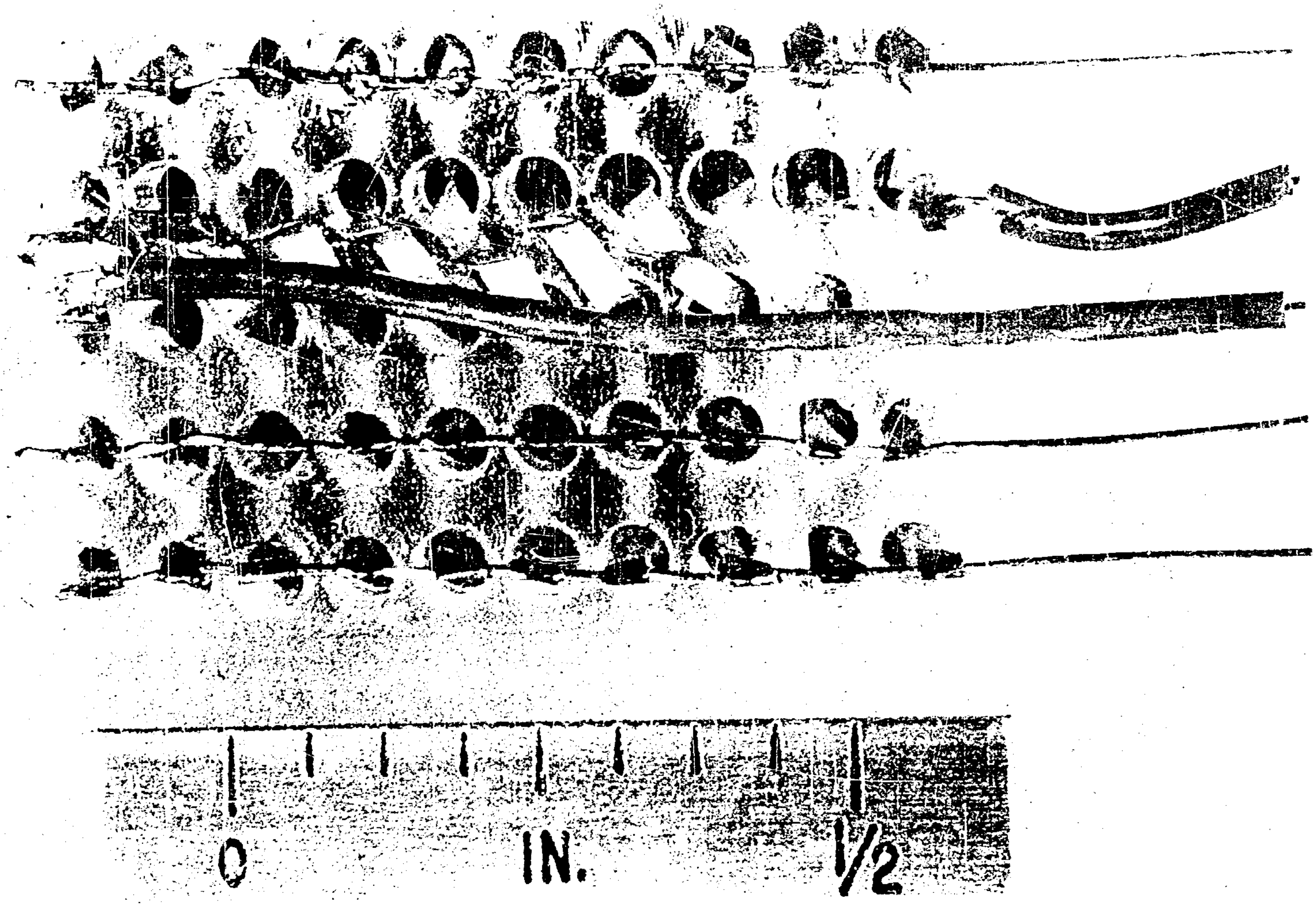

Figure 15. Bottom view of fixture pictured in Figure 14 shows welded inter connections.

(U) Plans were made to fabricate a nine-stage encapsulated counter employing deposited metal interconnections.

4.3 Trouble-shooting the DOFL 2-D Binary Counter

(U) Waveforms obtained by deliberately causing failures on a typical binary counter circuit on a part-by-part, connection-by-connection basis were employed in analyzing failure waveforms from actual 2-D binary dividers. It was discovered that many actual failures were caused by connection breaks that isolated more than one part at a time and some extension of the initial waveforms to include these situations is warranted. Additional information on 2-D-binary counters will be found in sections 3.12 and 4.2 of this report.

4.4 Environmental Control by Thermoelectric Techniques

(U) Exploratory work is being conducted in thermoelectric techniques to provide controlled temperature chambers for electronic modules. These chambers may be used to increase the allowable packing density of components, to make circuitry operable over a wider than normal ambient temperature range, and to provide low-temperature environments for special applications, e.g. for infrared detectors.

(U) In the past quarter, theoretical and experimental investigations were made of methods of achieving environments as low in temperature as the temperature of liquid nitrogen. It was found to be impractical at the present time to cool from room temperature to -196°C entirely by Peltier cooling. Using the best currently available materials, a temperature differential of about 100°C from room temperature is practical with a cascaded cooler and low thermal load. With an extremely low temperature heat sink, e.g. liquid nitrogen, and the newly developed silver telluride-selenide compounds, a few additional degrees of cooling may be obtained.

5. REFERENCES

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