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OPERATION SANDSTONE

NUCLEAR EXPLOSIONS

1948

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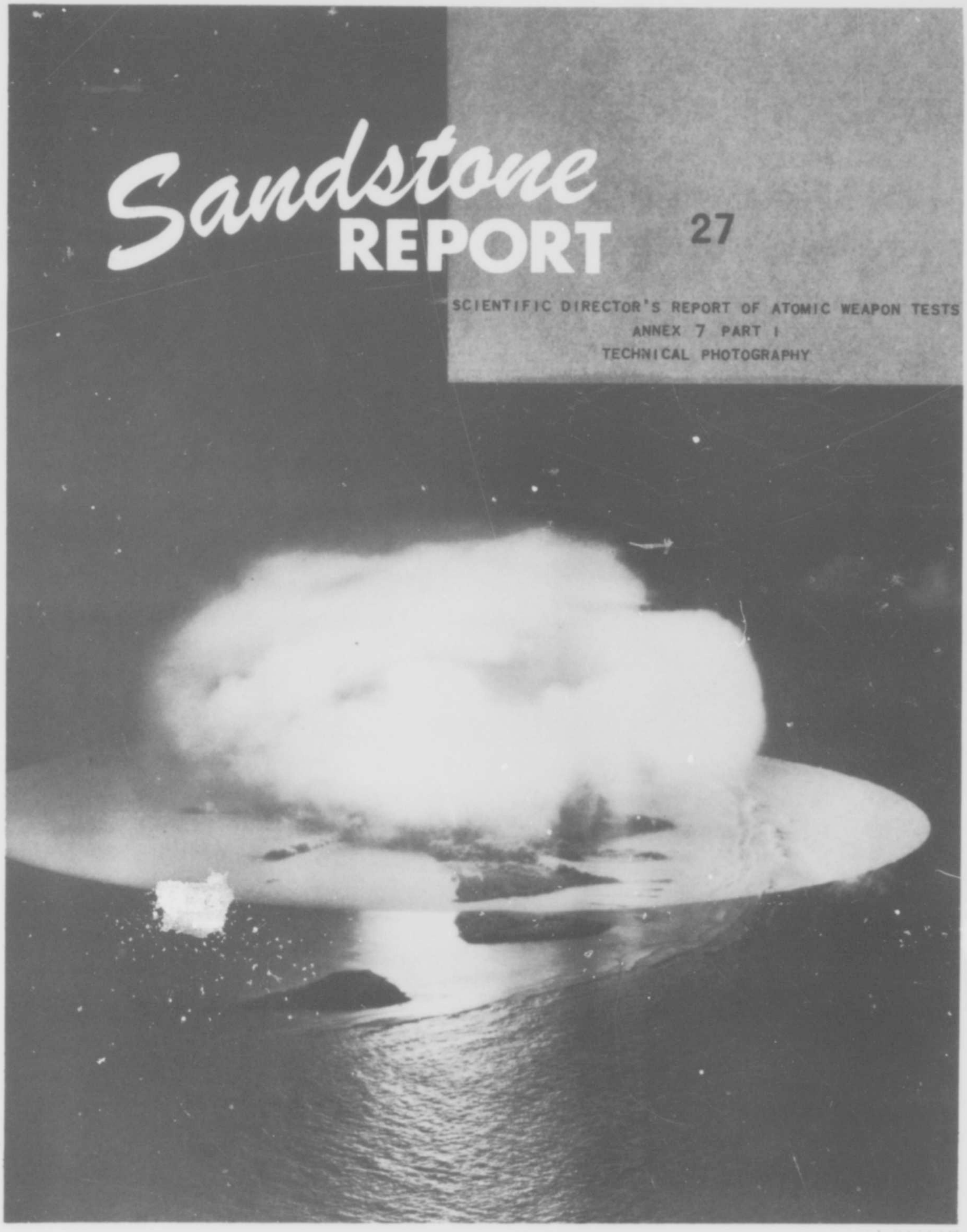

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SCIENTIFIC DIRECTOR'S REPORT
OF ATOMIC WEAPON TESTS
AT ENIWETOK, 1948

Annex 7

TECHNICAL PHOTOGRAPHY

Section 1

TOWER PHOTOGRAPHY INSTRUMENTATION REPORT

[redacted]

THIS DOCUMENT CONSISTS OF 362 PAGE(S)
NO. 7 OF 20 COPIES, SERIES A

SANDSTONE TECHNICAL INSTRUMENTATION REPORT

TOWER PHOTOGRAPHY

By

Berlyn Brixner

December 6, 1948

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SANDSTONE TECHNICAL INSTRUMENTATION REPORT

TOWER PHOTOGRAPHY

I. INTRODUCTION

Colonel P. T. Cullen, USAF, took a contract to obtain the photographic coverage of OPERATION SANDSTONE. The major programs involved in this were: tower photography, aero photography, and general documentation. Only the first of these will be described in detail, though there was considerable interlocking of the three programs.

The tower photography program had, as its primary objective, the problem of securing data for the ball of fire expansion rate determination from which the equivalent TNT tonnage of each explosion could be obtained. Secondary objectives were data for shock wave velocity determination at later stages and a good documentation of the explosion.

The conditions necessary for obtaining a photographic data record for expansion rate determination are:

1. A motion picture film record with a time resolution on the order of 0.1 millisecond.
2. A negative in the density range of 0.5 to 1.5, so that reliable measurements can be made.
3. An object to film image scale of reduction known accurately to about 0.5% or better. The factors here are camera to object distance, and effective

focal length of camera lens.

4. A film velocity known, at the time the film was exposed, to an accuracy of 0.2% or better.

5. An elevated camera position so that good visibility is obtained at the long distances used and also to avoid the irregular atmospheric refraction which occurs near the ground level.

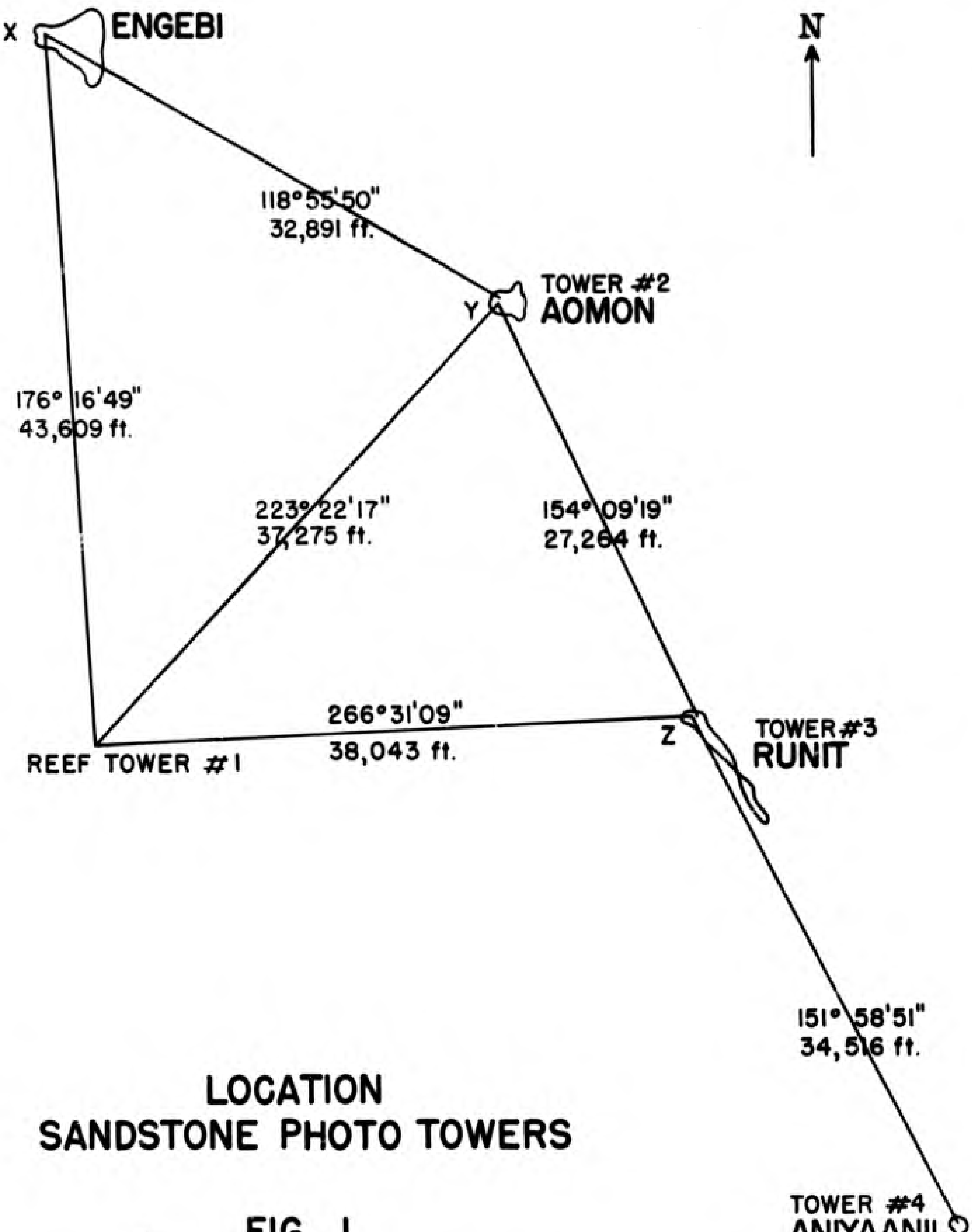
Some of these conditions were relaxed considerably for the secondary objectives because of the difficulty in controlling them in the short preparation time available, and also because of the much longer time scales involved.

Colonel Cullen assigned Mr. R. M. Davis as director of tower photography and provided him with a crew of twenty-seven officers and enlisted men. Headquarters were established at Eglin Field, Florida for preparation and testing of the equipment to be used. The equipment and personnel were subsequently moved to Eniwetok by air lift and established headquarters on the USS Curtiss. The crews lived at or near their tower operation and were evacuated for about three days at the time of each of the three explosions. After completion of the work, all of the personnel and most of the equipment were returned by air lift to MacDill Field, Florida.

II. SITES AND TOWERS

A decision was made at an early date to establish two, 75 foot tower camera positions for each explosion and to locate these at a distance of five miles or more from the zero point. Figure 1 shows photo tower locations. The towers were established so that their lines of view would be at about 90°. This arrangement provided a clear view, would record two aspects of each explosion, and avoided or reduced the hazards of shock, direct radiation, and radioactive contamination. Remote control operation was accomplished by timing signals, from a central control point, conducted to the station by submarine cables. Duplicate power plants were installed at each station to provide a reliable electric power supply. The load was carried by one generator, but in the event of its failure the load was automatically tranferred to the standby.

The towers (Figure 2) were provided with a twelve foot square cab to house the cameras and control equipment. One side of the cab, (Figure 3) was open to allow a clear field of view for the cameras, but had the disadvantage that the equipment was then exposed to the frequent rainstorms common to the area. A small hand-powered freight elevator (Figure 4) was provided to lift equipment from the tower base to the cab, but it was of such poor design that it could not



LOCATION
SANDSTONE PHOTO TOWERS

FIG. 1

Figure 2
General aspect of tower with power plant in adjacent housing. Landing dock is in foreground.

Figure 3
Camera cab ports covered with a light canvas curtain, cameras in place. Fastax at upper left, motion picture cameras near center, aero cameras on floor, and dissector camera in the foreground.

be relied upon to function properly. It should have been electric-power driven. A personnel stairway (Figure 5) was provided on the tower sides. An additional storage platform about ten feet below the cab floor should have been provided to avoid excessive crowding in the cab.

III. TRANSPORTATION AND COMMUNICATION

Transportation of personnel and equipment to and from Eniwetok Island, the headquarter ships, and the site of operations was accomplished by the combined use of small open boats and L-5 aircraft. All the islands used had suitable landing fields. The use of slow speed open boats was wasteful of time and detrimental to equipment because of the ever-present salt spray. Fast boats equipped with water- and spray-proof storage compartments and suitable loading hatches would have been a marked improvement.

A radio communication network was established between the tower stations and the various headquarters. This is an essential part of the operation, and it was made quite effective in use.

IV. TIMING CONTROL

Timing signals were provided at -1 minute and -1 second. These signals energized relays and started supplementary time delays in the form of Industrial timers, (Figure 6). The starting and stopping time of all cameras was controlled, a necessity for the Fastax. The previously-mentioned generators

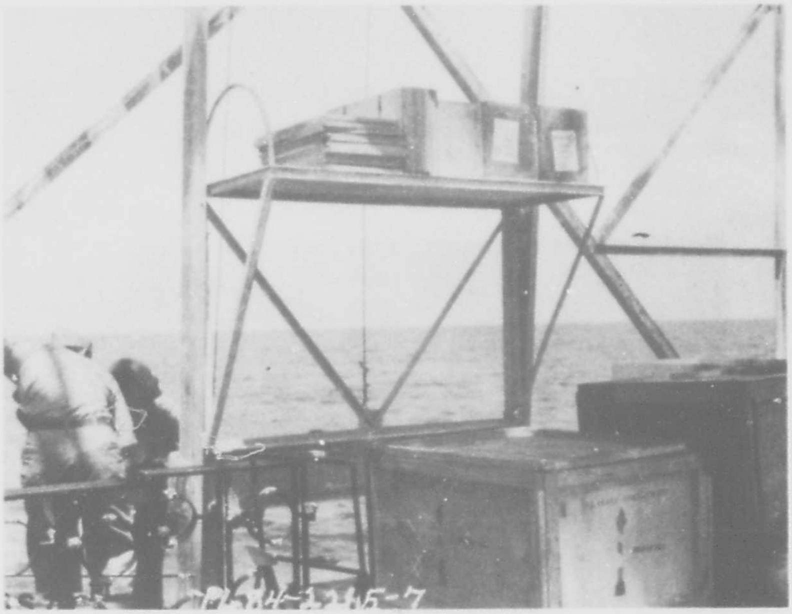


Figure 4
Loaded freight elevator ready for lifting to cab.

Figure 5
Staircase around tower and elevator partly raised.

Figure 6
Relay Racks with Industrial Timers

supplied the AC power, and a storage battery bank the DC power.

V. CAMERAS

A total of thirty cameras were planned for each tower. The summary sheet, Table 1, shows the details of the equipment used. Eleven 8mm Fastax cameras were used to record the ball of fire growth. Three Mitchell 35mm and three Maurer 16mm motion picture cameras were used to record the later stages of the ball of fire development. Eight 5" x 5" and three 9" x 18" aero cameras were used to secure large scale pictures of the explosion. One Sonne moving film camera was installed to secure the minimum acceptable record of the ball of fire expansion. This camera operates for about 25 seconds and has a time resolution of about one millisecond. One O'Brien, image-dissector camera was used for the first time to secure a five-million-frame-per-second motion picture record with rather poor space resolution.

A large number of cameras was used to insure a reasonable record being obtained. Some equipment failure was expected and the exposure range had to be large to cover the event in case the equivalent tonnage of the explosion was much larger or smaller than expected.

VI. FILM AND PROCESSING

Ordinary negative and also color film were used in all of the cameras except the Sonne and dissector. The film was coded with a perforator prior to loading in the cameras. Test film was processed in the photographic laboratory on the USS Curtiss but the explosion film was sent to Consolidated Film Industries, Eastman Kodak Company, or the Bolling Field Laboratory, depending on the film type. Some dificulty was encountered with the proper processing of the 16mm motion picture film at Los Angeles despite the fact that a Los Alamos representative was present.

Three tower camera runs were made for each test. The Queen test was run to secure a set of daylight photographs of the zero area with all cameras. The Peter test was a final rehearsal to determine proper operation of all equipment and made use of a zero tower photo-flash light at zero time to act as a reading fiducial on the film. The final camera run was made at the time of the explosion, with exposures adjusted to properly record an object brightness range of 10^8 cd/cm^2 to 10^{-2} cd/cm^2.

VII. RESULTS

The results obtained from all the tower installations were very good. In all cases the cameras operated at the correct time. There were a few camera operation failures but in no case was there a complete failure for any type of camera. Table 2 contains a preliminary evaluation of the Fastax film quality obtained. The remaining film has not yet been obtained.

TABLE 1

TOWER CAMERA EQUIPMENT SUMMARY

CODE NUMBER	CAMERA TYPE	LENS FOCAL LENGTH MM	SPEED FRAMES/SEC	FILM TYPE	RUNNING TIME SEC	CAMERA VOLTAGE
F1	Fastax 8	400	10,000	Pan	1	180
F2	Fastax 8	250	10,000	Pan	1	180
F3	Fastax 8	100	10,000	Pan	1	180
F4	Fastax 8	100	10,000	Color	1	180
F5	Fastax 8	100	10,000	Color	1	180
F6	Fastax 8	400	10,000	Pan	1	180
F7	Fastax 8	250	10,000	Pan	1	180
F8	Fastax 8	100	10,000	Pan	1	180
F9	Fastax 8	100	10,000	Infrared	1	180
F10	Fastax 8	100	1,000	Pan	5	35
F11	Fastax 8	100	1,000	Pan	5	35
M12	Mitchell 35	450	96	Pan	80	110
M13	Mitchell 35	100	24	Pan	650	110
M14	Mitchell 35	35	12	Pan	1300	110
N15	Maurer 16	63	64	Color	250	110
N16	Maurer 16	25	24	Color	650	110
K17	Aero 9"X18"	610	0.33	Pan or Color	150	28
K18	Aero 9"X18"	610	0.33	Pan or Color	150	28
K19	Aero 9"X18"	610	0.33	Pan or Color	150	28
L20	Aero 5"X5"	508	0.12	Pan	45	28
L21	Aero 5"X5"	508	0.12	Pan	45	28
L22	Aero 5"X5"	508	0.12	Pan	45	28
L23	Aero 5"X5"	508	0.12	Pan	45	28
L24	Aero 5"X5"	508	0.12	Color	45	28
L25	Aero 5"X5"	508	0.12	Color	45	28
L26	Aero 5"X5"	508	0.12	Color	45	28
L27	Aero 5"X5"	508	0.12	Color	45	28
S28	Sonne	150	1 Meter/sec	Pan	25	28
029	Dissector	40	10^7	Pan	0.005	110
B30	B & H 16	25	128	Color	30	110

TABLE 2

TOWER FILM EXPOSURE QUALITY SUMMARY

CODE NUMBER	X-RAY		YOKE		ZEBRA	
	TOWER 1	TOWER 2	TOWER 1	TOWER 3	TOWER 1	TOWER 4
F1	VG	VG	VG	VG	VG	VG
F2	G	G	G	VG	VG	VG
F3	G	O	VG	VG	VG	O
F4	O	O	VG	VG	G	VG
F5	G	O	VG	G	G	O
F6	G	O	O	G	VG	VG
F7	VO	G	G	O	VG	G
F8	G	G	VG	O	VG	O
F9	O	O	VG	VO	VG	G
F10	O	O	VG	G	VG	VG
F11	G	VO	O	O	VG	O

O — Over Exposed
VO — Very Over Exposed
G — Good Exposure
VG — Very Good Exposure

SCIENTIFIC DIRECTOR'S REPORT

OF ATOMIC WEAPON TESTS

AT ENIWETOK, 1948

Annex 7

TECHNICAL PHOTOGRAPHY

Section 2

TECHNICAL PHOTOGRAPHIC OPERATION

TECHNICAL PHOTOGRAPHIC OPERATION

By

R. N. Davis

November 15, 1948

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ABSTRACT

Photographic recording was used on Project Sandstone for four primary purposes:

1. To afford basic scientific studies and evaluations of nuclear fission explosions and their results.

2. To gather material from which Military meanings and implications may be drawn.

3. To show how this project was accomplished.

4. For indentification photographs and badges.

To accomplish adequately the recording of the first three categories responsibility for photographic recording of the various aspects of Project Sandstone was divided into three main units:

1. Tower photography

2. Air photography

3. Documentary photography

The Photo Tower unit was established to gather the basic scientific photographic material from which efficiency of explosion studies could be made. Secondary purpose was to gather any other pertinent scientific data that could be obtained without compromise of the primary objective. Tertiary objective was to record any phenomena that could be used for military study of the effects and meanings, for

indoctrination of military personnel in the meanings and implications of Atomic bomb warfare, and to gather material for demonstrations of the phenomenon and effects of Atomic bombing.

A USAF Air unit was established to supplement the tower scientific findings, to use their elevation for gathering data and recordings unobtainable from the towers, and to gather early period documentation of the blast and its repercussions. Eight documentary photographic teams were active during the project to record the various ways in which each phase of the entire project was conducted.

This paper is the report of the Director of Tower Photography.

I. PLANNING OF THE PHOTO TOWER OPERATION

A. RECOGNIZED VARIABLES

1. Positioning of Towers

Early resolution of the problems surrounding the following variables was necessary in order to have a realistic approach to the accomplishment of the mission. The positions of three "Zero" towers had been chosen on the various Islands of the Eniwetok Atoll (as shown in Appendix I, Photo Tower Physical Relations). It was decided to use two self-contained automatically operating, remotely-timed photographic towers for each of the test bombs, X, Y, and Z. (See Appendix II, Description of Photo Towers.) The towers were to be spaced well away from the blasts so that Gamma shielding would be unnecessary and so that special precautions against blast damage would not be required. The towers were to be automatic so that men would not be required for their operation nor to be in attendance during the twenty hours previous to each of the explosions, this to preclude the possibility of radio-active poisoning to any personnel. The positions of the Photo Towers were determined on the basis of ease of construction and access as a first requirement, and on the basis of photographic characteristics secondarily. To obtain approximately right angle views for each pair of towers on each explosion it was decided to place one tower on a Coral Head in the Lagoon, this tower to be used for each of the explosions. Three other towers were to be established, each to be used only once. Therefore, towers were constructed near the Aomon and Runit Zero towers while the third one was placed on Aniyaanii. The distances of each of these towers from the blasts, the direction of view, and their relative positions are shown in Appendix I.

2. Time Signals

Time signals were to be supplied via submarine cable to assure dependability of time operation of the photographic equipment. The time required to develop dependable radio links for this was greater than the time available. The need for late changes in time of explosion precluded the use of automatic pre-set time control mechanisms. Two predetonation signals were decided upon for the control of the cameras: a one-minute signal and a one-second signal. The one-minute signal was to start electronic and motor driven equipment that required time to come up to speed or to warm up for stable operation. This signal needed only a five-second accuracy. The one-second signal was to activate the timing units which would then control the cameras. The decisions about time control were made concurrently with the selection of the cameras to accomplish the necessary photography. See Appendix VIII, Time and Sequence Controls.

3. <u>Brilliance Latitude</u>

The Curve giving Brilliance with respect to time of a Nuclear Fission explosion (Appendix III, <u>Brilliance versus Time</u>), demonstrates two phases of Atomic Bomb explosion analysis that are greatly different from most other types of photographic recording: (1) the brilliance latitude is very great and (2) the time latitude is great. It was necessary to choose cameras to cover brilliance from approximately 500 Suns (best pre-X guess obtained) down to less than first magnitude stars. A great number of important phenomena are manifest in the first few microseconds of the explosion, and yet some of these continue for several minutes. It must also be appreciated that some of the photographic ability must be reserved for unusual events including low order fissioning and detonating malfunctions. The accompanying list (Appendix IV, <u>Camera Selection</u>), shows the choice of the cameras and their settings to cover the time, brilliance, and unusual event latitudes.

4. <u>Timing Latitude</u>

The short time periods encountered in this type of recording usually suggest high speed motion photography. In addition, series of still pictures can give valuable scientific and documentary evidence. The most valuable feature of large scale still original pictures is their photographic quality and ease of analysis. It was therefore decided to use controlled cycled banks of aerial cameras to produce series of pictures from which could be extracted exacting analysis. By placing millisecond time marks on the Fastax films from which phenomena relations could be determined, the time sequence of the still series can be determined. It was therefore decided not to attempt to develop an absolute or relative time system for the aerial stills at that time because of the short period remaining for that development.

5. Military Indoctrination

One of the more important aspects of Atomic explosion photography is the accumulation of pictorial evidence for indoctrination of Military organizations and personnel, the people who must intelligently use these weapons if they are to be worth developing. Additional cycled sequences of Aero Color cameras were added to supply dramatic quality photographs for indoctrination. Appendix IV shows these sequences and their settings.

B. EQUIPMENT SELECTION AND DESIGN

1. Camera Selection, High Speed

The primary function of the Photo Tower mission was determined to be the recording of initial phenomenology for studies leading to determinations of the efficiencies of the explosions. To record adequately these initial phenomena photographic speeds in excess of 8,000 frames per second are needed. It was therefore concluded that only the 8mm Fastax Cameras would suffice to accomplish this job, no other standard usable cameras being available. The original plan was to run these cameras at speeds up to 16,000 frames per second, but the cameras were determined to be unreliable at these speeds. The time required for a Fastax to expose its entire capacity of 100 feet of film at a terminal rate of 16,000 frames per second was determined to be less than three fourths of a second (see acceleration curves Appendix V, Fastax Acceleration Curves, for relative effects). In consideration of the amount of film unusably exposed in starting and the very short time remaining for recording remaining in conjunction with timing inconsistencies and camera unreliabilities, the speeds of operation were reduced to those shown in Appendix V. The quality of the photography of the Fastax is rather poor, especially so in the 8mm version. The next fastest procurable cameras for this type of recording were the Eastman high-speed models. It was decided to place all of the Eastman cameras in the air unit where the extremely high speeds were less important and definition discrimination of more value. This had the additional advantage of keeping all of one kind of camera in one unit, all of the other in another unit, thus facilitating maintenance and reducing the numbers of types of units within an organization.

2. Camera Selection, Motion

The best high speed movie cameras available were Mitchell 35mm cameras. It was therefore decided that for high quality, high speed movie recording, one Mitchell Hi-Speed would be mounted in each tower. Two Standard Speed Mitchells were also decided upon for each tower, these to give the basic documentary and indoctrination motion photography in color and in black and white. The high speed Mitchells were originally set to be operated at 128 frames per second. The dependability of the camera is seriously reduced at this speed, so they were slowed down to 96 frames per second. A B1E was then added to operate at 128 frames per second to obtain this high speed coverage. Two Maurer 16 mm movie cameras were added to give color coverage of the initial documentary periods.

3. Camera Selection, Aero Still

The large area negative for exacting analysis was allotted to two types of cameras: (1) the Aerial K-22 (9"x9" negative) with forty inch lens and (2) the Aerial K-18

(9" x 18" negative) with twenty-four inch lens. The early tests conducted with the K-22 determined that a great deal of maintenance troubles would be encountered, the space requirements great, and the dependability low. These cameras were discarded in favor of using three of the K-18s in a cycled bank in each tower. The K-18 operated under run-away conditions (i.e., if the exposing trigger is held down or if the electrical tripping pulse is maintained the camera will continue to take successive exposures as rapidly as it rewinds itself) will ordinarily take a picture approximately every three seconds. By cycling three cameras from a single control pictures may be obtained uniformly spaced at one-second time intervals. Because color has some advantages and some disadvantages it was concluded that the bank in one tower would be in color and in the other tower in black and white.

4. <u>Camera Selection, Special</u>

The Aerial K-24 (4-1/2" x 5" negative) is a fast rewinding camera which takes high quality negatives. It was decided to use these in banks of four, each bank cycled to give one exposure every 1/10th second. Each bank would then give a series of pictures in large size high quality negatives that could be related to the Fastax time-phenomenon. It was further decided that two such banks of four cameras each would be installed in each tower; one exposing black and white, the other exposing color. One serious drawback to the K-24 was recognized; its dependability is poor, but by careful selection of cameras, careful maintenance and adjustment, and by using large numbers of cameras, it was concluded that the basic series of negatives desired could be had.

The Sonne S-7 Aero strip camera can be used to give a good "smear" type of photography of the expanding explosion. One Sonne was added to each tower and a 1,000 cycle pip marker was added to the side of the negative so that the phenomena recorded by the Sonne could be related to those recorded by the Fastax. The 1,000 cycle pip was later reduced to 120 cycles, because the rate of travel of the film was so slow that the 1,000 cycle pips overlapped into a continuous smudge.

An O'Brien type image dissecting camera capable of extreme high speed recording (exposed 60 cm. of 16mm film in 5 milliseconds) was added to each tower to give very short time coverage of the very initial explosion. The O'Brien cameras were the highest speed cameras currently available for this project.

5. The Towers

The towers into which all the above selected cameras were to be mounted had been specified by AEC as being the standard Navy Radar tower. This tower is essentially a seventy-five foot steel skeleton with a sheet metal covered cab of external dimensions twelve feet square by eight feet high. It was further specified by AEC that an aperture two feet high by ten feet wide be left in the appropriate faces of these towers to be the opening through which the cameras would receive the light from the explosion. Early mounting trials indicated that the type of mounts required for the placement of the already selected cameras imposed an undue loading and servicing problem upon the Photo Tower crews. It was therefore decided to use also the standard window opening which existed in each side of the towers. The design then evolved into a system of mounting the Fastax complement upon two horizontal frames across the front of the window facing the explosion while the remaining cameras all mounted facing through the ten foot aperture.

6. Rotation of Cab

A further complication arose in the case of the Coral Head Tower which was to cover each of the three blasts. It faced essentially North to cover the X blast. This placed Y blast at approximately 45° from the North face of the tower. The Photo Tower Director requested that the cab be mounted upon a steel plate which would ride upon another steel plate secured to the top of the tower steelwork in such a manner that the top steel plate would be rotatable in respect to the second plate, thus allowing the cab to be rotated. The Army engineer in charge of the construction of the steel towers rejected this method because of the time implications and the additional field work required. It was therefore necessary to design camera mounts that would be used facing through the north aperture for the X explosion, face diagonally through both the north and east faces for the Y explosion, and then face within a few degrees of east for the Z explosion. This was accomplished in a reasonably satisfactory manner by constructing an extra set of mounts upon which the diagonally mounted cameras were installed for the Y day explosion.

7. Camera Mounts

The mounts were constructed primarily of steel angles and chrome-molybdenum tubing with ply-wood floor bases. The ply-wood sections were used because of the uneven structure of the floor of the cab. Construction details are included in the documentary photographic coverage. (See also Appendix VII, Camera Mounts.)

8. Automatic Towers

The time control problem became complex because of (1) the requirements that the tower be completely automatic, (2) the wide range of types of cameras, (3) the great range in operating speeds which gives a similarly great range in operating time, (4) the necessity that high speed Fastax cameras be stopped immediately upon exhaustion of their film and not before it has become exhausted, and (5) the time factor which precluded the design and construction of the best type of control devices. Because of the late start in selecting and procuring the detail planning people for the photographic recording aspects, the controls for the Fastax cameras were ordered from the Fastax manufacturers at the time that the cameras were ordered. The time controls that they supplied were strictly laboratory type control mechanisms (see Appendix VIII, Time and Sequence Controls) in two varieties. The 626 were supplied to control the high speed Fastax cameras while the simpler 623 were supplied to control the standard speed Fastaxes. All thirty of the 626 "gooses" were used while none of the sixty 623 "goslings" were used. Individual laboratory controls of this type inevitably lead to a great confusion of cables and connections which are a great liability in field testing work. It was concluded that it would be necessary to construct motor-driven cam and micro-switch units for the control of the series-cycled aerial cameras and to control the starting and stopping of the movie types with industrial time delay and duration timers.

9. Time Control Equipment

The basic time signals to set the various time-delay timers and duration timers into operation were to be supplied through submarine cables to two Raytheon railroad type relays (see Appendix VIII, Time and Sequence Controls). These were to be calibrated by the basic timing station to close at one minute ± five seconds before detonation, and at one second ± 0.02 seconds before detonation respectively. From these relays circuits had to be designed to control the starting of all equipment both for the starting and for the stopping of the cameras and auxiliaries. Dependability of operation and quality of photography were established as the two guiding principles. The equipment dependability, admittedly the hardest to obtain with a conglomerate mass of various types of laboratory-type time-control apparatus consisting of many relays, solenoid-operated, fast-acting clutches and small motor-driven "gizmos", etc., was complicated by a maze of wiring and cables and a tropical climate.

10. Rack and Panel Construction

It was concluded that a neat, rapidly-moveable series of units could be assembled by using rack and panel techniques. Appendix IX, Rack and Panel System, shows the schematic layout that was planned for the series of racks and panels. Each of the eight individual racks would be a complete entity in itself capable of being boxed as it was. The equipment would all be mounted, wired and ready for use. Heavy components were to be mounted to the frames, the lighter components to the swinging panels on the front. This type of construction allows rapid and complete inspection and maintenance. This plan was evolved to make it possible to move the crated equipment to the test ground where it could be set up without protracted wiring or connecting. All that would be necessary would be to bolt the eight racks together, connect the series of connectors mounted as an integral part of each rack, and then connect the camera harness to the cameras. The test panel was designed to test the time and sequence of operation of each component, determine the electrical state of each circuit and component on that circuit, make possible exact time-voltage-current-speed curves for each camera or operating component, and to give a visual light indication of readiness to operate. This type of construction gives minimum time delays in establishing a station and in determining the degree of readiness of the equipment. It requires some additional work and procurement in the assembly stages in the ZI, but it so greatly simplifies the problems encountered in field test that it far more than pays for these slight initial drawbacks.

This system failed to materialize because of the failure of procuring agencies to supply some of the needed components in time. The panels arrived only five days before the departure dead-line and the connectors were delivered even later. The oscillograph and the oscilloscope were not procurable and the switches for the test panel that were finally delivered were of the wrong type.

11. Time Mark Generators

The time mark generator procured to supply the millisecond electrical pulses to the Fastax Argon glow lights was a Potter Decade (see Appendix X, Potter Pulse Generator). These are very high quality and completely satisfactory units for this type of marking.

12. Electrical Fusing

It was also concluded that all electrical equipment and the associated circuits would be fused for each individual piece of equipment and that these fuses would, in many instances, be of greater than normal current capacity. The principle being, in the interests of dependability, that it is much wiser to protect the system as a whole against individual equipment failure than it is to protect the individual equipment. The system was therefore fused so that no individual piece of equipment could fail and cause other equipment to become inoperative. This was to be carried out to the point where any individual piece of equipment might destroy itself and still be supplied power to keep operating as long as possible without jeopardy to any other component. This approach was to be followed even to the extent of by-passing the main-circuit breakers of the power supply and disconnecting temperature and oil pressure safety shut-down devices on the main diesels. This applied only to X, Y, and Z Days. During test operations and preparations these safeguards were left in operation.

13. Aperture Closure Problems

The problems encountered in the use of the photographic apertures in the cab of the towers were never satisfactorily solved. (See Appendix XII, Cab Aperture Problems.) The apertures must be open at the time of exposure of the film but if they are left open for twenty some hours before detonation, rain blows in. There is also the danger of the intense sunlight burning holes in focal plane shutter, of the heat causing separation of the elements of the camera optical systems, of salt accumulation on the front lens elements, and of the gathering of dust in and on the equipment. Several systems were discussed. The short time remaining precluded the development of an entirely adequate system. Canvas curtains hung on bomb release mechanisms were devised but these were only used to close the apertures between tests. They were always lowered before final departure of the tower preceding a test. Problems encountered centered around wind loading and dependability. It must be appreciated that if the curtain failed to open all photography was lost, while if rain blew in only part of it might be destroyed.

14. Power Sources

The types of cameras so hurriedly acquired required both A.C. and D.C. power. Again the time was so short that the best solution could not be effected and the problems were resolved by planning to use two 15 kw., 3 phase, 220 volt, diesel power plants connected in parallel standby and two 7.5 kw., gasoline driven, D.C., 28 volt, generators connected in parallel to supply the power required for each tower. These plants adequately handled the anticipated load with no difficulties.

Appendix XIII, Power Circuits, gives the block and schematic diagrams of the circuits devised, and explains why they were constructed. The problems encountered are explained also.

15. Spares

Because of the difficulties of repair and maintenance of the delicate camera and control equipment under tropic equatorial conditions of high humidity and heat it was concluded that the best course of action was to assemble three complete tower loads of cameras, mounts, time equipment, etc., and to do only first echelon maintenance in the field. In addition to the third tower load of equipment certain categories of spares were expanded where these items were available and deemed necessary.

C. PERSONNEL SELECTION, TRAINING AND ASSEMBLY

1. Selection and Training

The personnel for the Photo Tower crews was selected by two methods. The Commanding General, 311th Air Division, Reconnaissance, asked for certain individuals by name. The remainder were obtained from the Departments of Army, Navy, and Air Force by allotting to each the number of personnel that it was desired that they furnish. These departments then asked the various commands within them each to supply a given number. Some units within the Air Force were then asked to supply additional personnel. The caliber of personnel thus received was surprisingly high, most units doing an admirable job in supplying the highest caliber men within the rank for which they were asked. As the men became available they were sent to Eglin Field for training. It was necessary to use the first arrivals in the construction of the equipment and in the gathering of the materials for much of the work. After this was under way training in the use of the equipment was undertaken, using a wooden model tower constructed at the Eglin Field proving ground. Two teams were formed and trained to assemble and install the equipment and to conduct a complete test.

2. Clearance Considerations

It is important to have a selection of men with appropriate clearances. If the clearance system is not adequate serious repercussions can increase the required effort tremendously. It is extremely important that requests for clearances be made very early, as long periods are required for the clearance system to produce results.

D. ESTABLISHMENT OF FILM REQUIREMENTS AND CONTROL

1. Film Requirements

The film requirements established for the Photo Tower mission were based upon a fully-loaded manned-tower daylight test designated Queen Day; a fully-loaded evacuated night test designated Peter Day (to be conducted with complete evacuation just as for the final tests); and a full spare load of film for the final test in addition to the film required in the loaded cameras for the test. This required four loads of film for each of the two towers for each of the three tests, or a total of twenty-four tower loads of film. Appendix XIV, Film Requirements, shows the breakdown of the film and the required deadline dates. These dates were established on the premise that the film should not remain in the tropic latitudes any longer than was absolutely necessary and should, therefore, arrive at the latest practical date before use. Failure of contracting agencies to deliver film to the ZI film control office by the contract dates together with transportation system delays, necessitated the substitution of some of the planned types of film for film of other categories and resulted in the curtailment of the Queen-X-Day tests. The test summaries presented later show the actual film utilization which was necessitated by the film delivery inadequacies.

Additional film for documentary purposes was also shipped to the Tower documentary team.

2. Film Marking System

Letter of 27 February 1948 from Headquarters 311th Reconnaissance Wing (Appendix XV, Film Marking System.) explains the film serial numbering system and explains how to mark and slate film. This system is adequate for ordinary documentary photography but was envisioned as being inadequate for the peculiarities of the Photo Tower requirements. Paragraph 4, Part I specifically states how film will be slated or marked with greased pencil. Fastax film as used by the tower setup cannot be either slated or reliably penciled. It is extremely difficult and completely unsatisfactory to try to slate the Mitchell and Maurer cameras. Therefore the system of perforating negatives as used by Kodak was investigated and perforators as described in Appendix XV were ordered and the system of Mark and Punch there explained was established. The perforators did not arrive in time for the X-Day test, but did arrive soon after and the system has been entirely satisfactory for field use. The value for analysis of the first Queen test Fastax results were lost because the waxed crayon marks were obliterated in processing. The film on all subsequent tests has been perforated with resultant positive identification. It is important to perforate film to be developed by Kodak and other commercial agencies "inside" of the emulsion number of the negative. Unless special arrangements are made the commerical concerns cut off the leader and trailer including the emulsion number.

3. Test Film Development

The original Photo Tower plan did not require the development of test Queen or Peter film. The field operation has shown this to be a severe oversight. Film has been developed aboard the USS Curtiss (AV-4) and this has been of inestimable value. A field unit must be able to determine accurately and quickly what gross errors it is making. Alignment, calibration, and malfunctioning characteristics must be determinable in short order.

E. PACKING AND MOVING

1. Preparation

All the equipment and personnel to depart the ZI for the Proving Ground were assembled at MacDill Field. The personnel were given their overseas medical examinations and final paper work was accomplished. The equipment was packaged and made ready for loading. After packaging the equipment was segregated by tower destination to expedite the delivery of the appropriate items to their proper location within the proving area. After segregation the corners were painted with distinctive color codes signifying the destination of the equipment. This turned out to be a valuable addition to the moving plan. It helped to expedite the movement of the first required items to the places they were needed and helped to simplify the problems of segregation and movement within the theater.

2. Moving

When dealing with the types of equipment involved in this kind of photographic recording it is important that the equipment not remain in the tropical humidity longer than is absolutely necessary. The date of departure from the ZI was therefore made as late as was deemed practical. The movement schedule was established (guaranteed by the moving agency) but five emergency days were allowed in the planning for the establishment of the field operation. The schedule of movement called for leaving MacDill Field on March 16 with all personnel and equipment aboard a single C-74 Aircraft to proceed to Fairfield-Suisun and there to reload into five C-54 Aircraft for movement to Eniwetok to arrive on the 20th. The first C-54 departed Fairfield on schedule and arrived Eniwetok two days late because of security delays at Hickam Field, Oahu. The last of the Aircraft arrived Eniwetok six days after scheduled arrival.

The intermediate Aircraft arrived either four or five days after schedule. These delays very seriously threatened to ruin the operation of the Photo Tower group. It was only because the five emergency days had been left in the planning schedule that the tower equipment was ready to operate on the first test date. With these emergency days lost it was extremely fortunate that no other emergencies arose. A bad weather period, for instance, when boats could not operate to the Coral Head Tower would have been disastrous.

F. PHOTO TOWER CONSTRUCTION

1. Tower Elevator System

An early inspection trip of the testing site was made to determine the adequacies of the Photo Towers. There were several aspects of these seventy-five foot towers that needed immediate improvement to make them acceptable to the operation as planned. The elevator system as supplied with the towers (for details see the documentary photographs in Appendix II, Description of Photo Towers), was a complete failure for several reasons. The guide rails were not straight, were not aligned and were originally installed wrong. This caused the very fragile elevator platforms to jump the track. Because the elevator is lifted by a point well below its center of gravity the elevator turns upside-down when off of the track and jettisons all of its load unless the load is lashed in place. The wheel structure and wheel mounting, in addition to the wheels themselves, are entirely inadequate for the job required of them. The basic concept of this particular elevator is poor. The winches supplied with the elevators were completely unusable. These things were discussed with the Army Engineer who agreed that they were wrong and had all the winches changed. The new winches were good ones, but the energy required by a person to lift a load to the top of the towers is great. This type of lift should have been power driven, especially on the Coral Head. The winches on the Island towers were rarely used. The hoist on the weapons carrier was connected to the cable and this sufficed.

2. Tower Platform

During this same early trip it was requested that a platform be built on the steel structure just below the cab level. This platform was to be used as a working level to prevent so much from having to be done within the crowded cab. It was also to serve as a storage area for batteries and radio gear and as a clean place in which to uncrate the cameras and timing gear, and for storage of the crates which were needed to return the equipment. The Army Engineers were unable to construct the platform and the operation had to be conducted without it, thus increasing the work load upon the tower crew. The tower crew built a partial platform on the Aniyaanii Tower in half a day.

3. Coral Head Improvements

Also during this inspection trip, it was observed that there was no realistic method of unloading equipment onto the Coral Head platform. Two things were requested: a float alongside of the tower onto which boats could be offloaded, and a simple crane for lifting heavy items onto the platform. The crane was built, but it was rigged so low that things could not be lifted onto the platform with the crane alone. The float was never accomplished. A small platform near water level was eventually installed (after X-Day, after most of the equipment had already been wrestled aboard.)

4. Aerial Transportation

The Inter-Island Airways using L-4s and L-5s was a very great help in the accomplishment of the mission. Utilization of four-place aircraft in place of the two-place aircraft would have further expedited the operation. A workable system of priorities for necessary travel would have improved the operations even more.

II. FIELD ACCOMPLISHMENT OF THE PHOTO TOWER MISSION

In addition to the foregoing discussion of the preparation for field operations, many techniques were devised after arriving "on location." These are described in conjunction with an account of the actual operating procedures established after arriving in the theater.

A. INITIAL THEATER OPERATIONS

1. Transportation Failure

Upon arrival of the first C-54 load of equipment and men at Eniwetok, transportation was requested for the men and equipment to the Coral Head Tower. The transportation system failed immediately. There were not enough boats (LCMs) available at Eniwetok to make any available for transportation of tower equipment on other than already scheduled trips which would carry the equipment at the convenience of the people already scheduling the boats. The truck and jeep transportation previously promised for the Photo Tower operations had "disappeared" into other operations. It was approximately fifty hours after the arrival of the first aircraft before the first of the equipment started moving to the Coral Head. As a result of this delay, a meeting was called between the scientific director, the operational director's office, and the Photo Tower director. JTF 7.1 voluntarily undertook to supply the needed vehicles out of their supply and further reoriented the operation of their boats to make available the necessary water transportation for the Photo Tower operations.

2. Personnel Distribution

A temporary office was established in the AEC VIP quarters from where the initial operations were conducted. As the aircraft and equipment continued to arrive the men were sent to the Coral Head with the equipment for that station until all the heavy moving was accomplished. The men were then segregated into three main groups: those that were to man the "moving" island tower, those that were to man the Coral Tower, and those that were to assist in major moves and incidental jobs. The personnel listing shows the actual distribution of the men and their specialties. See Appendix XXV for this listing. As soon as all of the equipment had arrived and was distributed either to the Coral Head, the island tower (Aomon Island being used at this time), placed in storage on Eniwetok, or placed in storage upon the USS Curtiss (AV-4), the office that had been established upon Eniwetok as headquarters was moved to the Curtiss. At this time the crew for the Coral Head was staying on the island of Runit where they continued to stay until evacuated from the island for the Zebra test. The Aomon Tower group stayed on Aomon while that tower was being attended, moved to Runit for the Runit Tower's operation, then continued to live on Runit until the Aniyaanii tower was operational at which time the crew moved to the Curtiss.

B. SETTING UP THE TOWERS FOR X-RAY

1. D. C. Power Troubles

The two towers to be used for the X-ray test were to be the Coral Head and the Aomon installations. These were set up as planned with the exception of the power situation. The 28-volt Waukesha power units supposedly shipped aboard the AV-4 were not located. Several improvisations were tried before a satisfactory solution was evolved. Six small gasoline-driven generators were borrowed, but upon delivery these turned out to be without fuel tanks or water cooling and circulating systems. The rectifiers that were installed with the SCR 603 radio sets were then connected into the heavy industrial standby batteries that had been brought for emergency stabilization. This system was devised as an emergency one but continued to be used throughout the operation as being satisfactory and in lieu of anything better being available.

2. Communications

During the X-ray setting up, operations were seriously handicapped by inadequate communications. The inter-island telephone system was overloaded and the routing from island to island and to the ships was such that in many instances intelligence was almost impossible to transmit over the system. Four SCR 247N aircraft radio transmitter and receiver sets had been brought along to tie the Photo Tower operations together in the event of just such an emergency. Permission to use these was not granted. Instead SCR 608 radios were installed with frequencies in the technical net set aside for the Photo Tower operations. After an initial period when the net was being established and debugged, and after it was made plain to the appropriate personnel that the Photo Towers must have communications, the technical net became operational and was from then on reliable and satisfactory. (See, also Appendix XVI, Communications.)

C. EVACUATION PROCEDURES

1. Film Delivery

A policy had been established creating the necessity for the evacuation of all Photo Tower personnel by 0600 on D-1. It was also established that film would not be left in the towers for a longer period than was absolutely necessary. The 0600 deadline was unnecessarily early and was revised to be 1000 hours D-1. This allowed for the delivery of the film on D-2. For Peter X, X, and Y operations the film was delivered to the tower on the morning of D-2, thus requiring the film to remain in the towers approximately forty hours before scheduled detonation. For the Z-test the film was held aboard the AV-4 in the air-conditioned laboratory until after the 1700 weather determination and briefing on D-2. The boats were then dispatched to each tower simultaneously. This method reduced the probability of the film remaining in the humid air for excessively long periods in case the test was delayed. See Appendix XXVI for the complete scheduling of film delivery and the evacuation of personnel.

2. Personnel Evacuation

The personnel were evacuated essentially in three groups. The group of people that were not required for the final preparations were drawn back to Eniwetok where they were mustered and then placed aboard the Pickaway (APA 222). Those required for final loading and checking were evacuated to the Curtiss where they were further divided, and those required for the film recovery were trans-shipped to Eniwetok.

D. FILM RECOVERY SYSTEM

1. General Aspects

Because of the remote chance of the radio-active fall-out or rain-out which might occur within four to ten hours and of the rush to return the exposed film to the ZI before it could further disintegrate in the tropic heat and high humidity, and further to prevent losing all of the results from one tower, two C-54 aircraft were scheduled to leave Eniwetok; one at plus six hours and one at plus twelve hours. It was necessary to depart Eniwetok for the towers to recover the exposed film as soon as was reasonable. It was concluded therefore that three Photo Tower men should go by LCM to the Coral Head Tower, leaving Eniwetok at D plus ten minutes and accompanied by a radiological safety officer. This system was put into effect on Peter-X-Day and was subsequently used on all the film recovery trips to the Coral Head. It was concluded that the most expeditious way to recover the island tower film would be to use the L-5 aircraft. While there had been no equipment damaged or wetted, no personnel hurt, no forced landings or engine failures in connection with these aircraft, there were still many people who questioned the abilities of the L-5 to safely return the exposed tower film. The advantages of the L-5 lie in the speed and convenience coupled with the dryness. The LCM trips were always wet from spray and presented difficulties in getting things aboard and off-loaded. By using the L-5s to retrieve the film from the island tower, two men could go to the tower, unload the film and magazines and place them in the L-5s, return to Eniwetok, unload and mark the film for delivery to the ZI by the time that the LCM returned from the Coral Head. The loading room at Eniwetok was then clear for the arrival of the Coral Head film. By thus operating the film was retrieved from both towers, marked, packaged, and made ready for audit by the CIC well before the deadline set for the departure of the aircraft for the ZI.

2. <u>Recovery</u>

Appendix XXVI gives the film recovery schedules for each of the three tests. In addition to film recovery on Zebra Day, all the equipment from both towers was evacuated and segregated as to AEC equipment and USAF equipment, the AEC equipment being delivered to the Curtiss, the USAF equipment being delivered to Eniwetok where the majority of it was loaded upon the plus six-hour and plus thirty-hour aircraft for return to the ZI. The only addition to the film recovery plan that was required for this was the scheduling of the additional LCM to Aniyaanii Island and the placing of personnel aboard the Curtiss before detonation to be picked up and taken to the towers with the film and evacuation equipment boats.

E. ANTICIPATED TESTS

1. The Tests

As shown in Appendix XIV, it was planned before leaving the ZI to expose a total of nine complete tower load tests. It was in the AEC plan that each unit would be prepared to run a Peter Test preceding each of the regular detonations. In addition, the Photo Tower plan was expanded to include three additional preparation tests. These were designated PPQ, PQ, and Q (Pre-Peter Queen, Peter Queen and Queen). PPQ was to determine that all installations were properly made, that all equipment was properly operating, and that the team work on distributing film and loading was reasonable. The actual operation of the cameras was not necessarily to have been in the final timed sequence. Observations were to have been made as to the operational suitability of the power plants and test equipment. PQ was to have been a manned full-scale test to determine the above plus the actualities of the timing sequences. This was to have been a full-scale test run with everything operating and with various personnel monitoring the various instruments. The film was to be exposed in daylight so that alignment checks, etc., would be obtainable. Focus of the cameras had been questioned, especially that of the Fastaxes, and this was of prime interest. Q Test was to have been a full-scale test without any interference or meticulous monitoring by personnel. The power plants were to have been set for twenty-four hour operation and the entire system left just as it was to be for a final test. The station was to be manned but only in a severe condition would anything be changed or shut down. Following the AEC directive, the PX Test was to be full-scale just as was the final X Test, complete even to evacuation as scheduled and to film recovery. This was to be a full-dress rehearsal. The actions and number of subsequent tests were to be determined upon the success of PX and X. For all of the tests other than the final the Photo Tower unit was to install a series of photo flash bulbs in the Zero Tower in place of the Atomic Weapon being tested. These flash bulbs were to be ignited at the time and with the same electric pulse that would have detonated the weapon.

2. Film Situation

Appendix XIV shows the total amount of film ordered and the distribution of it. It is pointed out that a reserve load of film was ordered as standby for each of the regular tests. This was to insure a reserve of film for two contingencies: (1) the spoiling of any film during loading, a reserve for that purpose is a must; (2) in case of a long delay or wetting of the film, which would necessitate reloading. The total film ordered then was twenty-four complete tower loads with delivery dates as shown. It is important to have the delivery dates as late as is reasonably possible to prevent the film from remaining in the tropical heat longer than is absolutely necessary. However it is even more important to assure that the film is on hand when needed, and it is imperative, therefore, that the film shipping schedule and the reliability of the delivery system be so integrated that the film is shipped to be on hand at the test site before the deadline date.

3. Test Changes

Two things combined to make the above-planned sequence of tests impossible: (1) the delay enroute of the Photo Tower Unit from the ZI to the theater did not permit the installation of the equipment in time to conduct all of the tests as planned; (2) the late arrival of all film and the failure of some categories to arrive until very late. The original plans were therefore altered to give a partial film test for QX. One magazine would be loaded and placed in sequence on each of the K-24s; also one on each of the K-18s. The Fastax rolls were divided into twenty-foot sections and just a small strip run through each Fastax. Movie magazines were transferred from camera to camera. The foregoing was to show the alignment and focus and to make available information from which the actual focal length of each of the lenses could be computed to determine that the focal length as marked on the lens was accurate. A full-scale PX was run with complete evacuation of all personnel. The equipment was not entirely installed and checked when the date for this test arrived but the test was carried out successfully by using some tentative arrangements which were then rectified for the X-Day test. PX could not be carried out with the planned film. The film summary that follows shows the film and camera settings that were actually used. Great concern was felt at this time because of the failure to receive the film as scheduled and because the situation surrounding the filters to be used had never been clarified. The information used for setting the X-Day test was fragmentary and was based upon some guesses.

4. <u>Modified Tests</u>

Because both PX and X evacuation and schedules worked well no more Peter tests were required by the AEC test director. Timing and test requirements were such that the Photo Tower Unit did run a full-scale Queen test before each of the Y and Z tests. The omission of the Peter rehearsals was very welcome, each rehearsal requiring at least three days of time which could not reasonably be afforded with the amount of moving of equipment that the tower crews had to accomplish.

5. Timing Error

Preliminary ZI analysis of the X-Day test film for the Fastax cameras indicated a timing error, magnitude not specified. Examination of the pre-X-Day film indicated an error of approximately two-tenth of a second. While the source of this discrepancy was never exactly located it was determined to be constant and thus the timers for the individual cameras could be set to allow for this discrepancy. The time control on the Y and Z tests were essentially correct.

6. Brilliance Corrections

No analyses of the movie footage was received by the Photo Tower Director while in the field. Fair reports were received of the black and white and color aero stills. From all of these analyses and by comparison of the various aspects of the technical data it was concluded that the inherent brilliance of the X-ray detonation had been nearer to one thousand times the brilliance of the sun than to the four hundred times that had been used in planning of the filters. The light intensities to be expected for Yoke and Zebra were rectified accordingly.

7. Fastax Analyses

The apparent unfamiliarity of the analyzing and reproducing agencies of the nature of the Fastax operation led to very poor reporting of the qualities of the Fastax film. The first reports received were to the effect that the time track had not registered. All the field tests had shown that the timing system worked well and all the film developed in the field had possessed good timing marks. It was therefore concluded that the agency copying the film had copied only the center or picture frame part of the film and had not reproduced the sprocket track wherein lay the timing marks. This proved to be the case upon notifying the viewing agency of this fact. The next received reports gave times based upon an assumed speed of the camera, the speed given on the caption sheet. This demonstrates the fallacy of a strict adherence to the caption sheet. A Fastax camera does not run at a constant speed when being operated at very high speeds. It accelerates throughout the entire length of the film. Therefore times derived by counting film footage and frames does not gives times that mean anything. The reports received after the Y-Day test gave the frames per second and the number of frames, but did not give the indication of density or adequacy of exposure. It is extremely important for the analysts who make the review to understand what the action of the camera is, what the problems involved are, and the need of correction. Permission to return one of the men from the Photo Tower operation had been denied.

F. FIELD HANDLING OF FILM

1. Film Control

All of the film to be used for the Sandstone project was given a security classification of TOP SECRET. This applied to the unexposed film being shipped to the theater as well as to the exposed film while in the theater and upon its return. The reason for this classification was to assure absolute control of all film and to assure that none would become stray film. Because of the security classification and because of the need for accurate records it was essential that a convenient workable system of film handling be established. The start of this system was somewhat confused because of the CIC monitors that were assigned to the job of monitoring all film and of auditing the control system had not been indoctrinated with a system to be used. Further, they did not understand the problems involved. The pre-establishment of a complete workable system would have been an advantage. It is, however, very difficult to establish a single system of film control that will work adequately for the various type units and yet not be ungainly for each of the individual units. There are problems encountered by a unit such as the Photo Tower Unit that are quite different than the ones encountered by the documentary teams.

2. Photo Tower System

As described in Appendix XV, it was necessary for the Photo Tower Unit to establish a system of mark and punch for their film because the slating of their movie film was impractical, the wax marking of their aero film unreliable, and the waxing or slating, or marking of the Fastax film impossible by the established means. The advantage of the Photo Tower Unit as compared to the documentary type of operation is that all values of the variables of photography are known in advance of the test. This means that data can be recorded on the caption sheets in advance and that all but the malfunctions can be recorded, thus preventing time delay after exposure. This time-saver is important where the time after exposure is limited as it was in this operation. The whole system of film handling requires controls and checks so that there will be no possibility of confusion of film or data pertaining to the film. This implies a straight forward, orderly system of film handling and control. The system used by Captain Harvey is presented below to show, not necessarily an ideal system, but the system that was evolved by him for the control of the Photo Tower film. This system required much meticulous work for Captain Harvey, who prepared nearly 700 caption sheets in quadruplicate. This system worked well enough in that all film was always ready for an audit and no confusion resulted; no film was lost or misplaced, nor was any misused. The system also kept all of the vital information in a readily accessible manner.

3. Captain Harvey's Description

The system that Captain Harvey used is presented as Appendix XXVIII, Film Field Issue Log.

4. Film Handling Sequence

The film handling sequence as it developed was as follows: the film arrived by air at Eniwetok, sometimes improperly addressed. After identification of the OEL case by some one (in the early stages, Major Elliott; in the later stages, haphazardly by several, until Lieutenant Kelley was assigned the job of watching for it), it was shipped by LCM to the AV-4 where Captain Harvey received it and had it transported to the humidity-controlled laboratory used by the Tower Photo Unit. The cases were then opened and the film checked against the invoices by both the Photo Tower Director and the designated CIC representative who would sign the audit. The film would then be systematically separated into the proper storage sequences and Captain Harvey would enter the film serial numbers in the Field Issue Log. He would also allot the film to the appropriate tests, sort the film, mark and perforate it and the containers, type and perforate the caption sheets, and segregate the film into tower loads. The tower photographic officers were then called in to load the film into the magazine and to transport the film to the site for exposure. After exposure the film in the magazines and containers was delivered back to the AV-4 if it was a Queen or Peter Test or delivered to Eniwetok if an X, Y, or Z Test. Capatin Harvey had pre-prepared the shipping sheets and invoices. The film was segregated accordingly, after unloading, the caption sheets laid out in sequence with the film. The caption sheets were then completed and segregated, while the film was stacked in the appropriate OEL cases for a final film monitor by the CIC. After this was accomplished the film was sealed and prepared for shipment to the ZI or it was delivered to the AV-4 film processing laboratory if it was to be developed in the theater (Q and P film).

5. Unsatisfactory Security Seals

The methods of placing seals upon the OEL cases containing film and classified materials was found to be entirely unsatisfactory. The sealing wire ran around the edge of the case where it was often cut by other cases. Few of the cases arrived in the theater with the wires intact. The method of re-sealing in the theater was even less satisfactory, few of the cases being so sealed by the security agency that film could not be removed without breaking the seals.

6. Film Segregation

In handling film of the value that the exposed tower film represented it was vitally necessary to segregate the various kinds into batches so that if any one batch was lost or damaged other batches would contain other film which would overlap that which had been damaged, and all the results of one investigating recording would not be lost. In recognition of this fact the film brought back by L-5s from the Island Towers was divided appropriately. At the direction of the Scientific Test Director, the Photo Tower Director was made responsible for the segregation of the film that was to be shipped from Eniwetok to the ZI. The Photo Tower film was therefore divided into four OEL cases after each test, two cases to go on the detonation-plus-six-hour aircraft, the other to go on the plus-thirty-hour aircraft. In one of the two cases in each aircraft was put one-half the aero still film destined for Bolling Field; in the other was placed one-half of the movie film for Los Angeles. The second aircraft carried the corresponding halves on the subsequent day.

7. Film Spoilage

No Photo Tower film after exposure was lost or damaged because of transportation systems used. Some damage to exposed film resulted from sweating of the film due to the fact that it was packaged in warm, humid air and eventually transported in colder air. Construction of a unit cab, air conditioned, within which the film is packaged and sealed for shipment would prevent this. For this unit cab recommendation see Appendix XIX. For divisioning of the film, see Appendix XXVI.

G. THE QUEEN X-RAY TEST

1. The Test

Queen X-Ray was established to permit operation of all cameras and to give an opportunity to check the alignment, focal length of lenses, and focus of the individual cameras. The test was a daylight test with the cameras operated individually under observation. No film had been received by this date other than the film carried with the unit on its trip from the ZI. There was therefore not enough film to completely load all the cameras. The following utilization shows the manner in which the film was used in towers one and two, the Coral Head and Aomon Towers:

Serial No.	Cameras	
RLCF-20	1F1-2,3,4	This roll was broken down into four equal lengths, each length being used in a separate Fastax.
RLCF-19	1F5,5,7,8	This roll was broken down and used in four separate Fastaxes.
RLCF-18	1F9,10,11 2F1	This roll was broken down and used in four separate Fastaxes.
MLG-3	1M12,13	This roll was loaded into a Mitchell magazine which was mounted on the two Mitchells in turn and operated.
RMF-57	1N15	All exposed in one Maurer.
RMF-56	1N16	All exposed in one Maurer.
ALB-1	1K17,18,19	This roll loaded into one K-18 magazine and exposed on the cameras in turn.
BLA-54	1L20-27	Loaded in one magazine and exposed on eight K-24s in sequence.
RLCF-13		Entire roll used as tower 1 dummy to check Fastax operation before exposing trial strips.

Serial No.	Cameras	
RLCF-12		Also used as dummy in tower 1.
RMF-9	1B30, 2B30	This roll was broken into two parts, one half being loaded into each B-1E.
RLCF-17	2F2,3,4,5	Divided into four lengths and used in four Fastaxes.
RLCF-16	2F6,7,8,9	Divided four ways and used in four Fastaxes.
MLG-5	2M13	Loaded into a magazine that would not mount on 2M12; therefore used in one Mitchell only, the third Mitchell not having arrived yet.
RMF-7	2N15	Entire roll exposed in Maurer.
RMF-8	2N16	All exposed in second Maurer.
ALB-2	2K17,18,19	Loaded into one magazine, exposed in turn in three K-18s.
BLA-55	2L20-27	One magazine loaded, exposed on eight K-25 in turn.
RLCF-14		Entire roll used as tower 2 dummy to test Fastax operation before exposing trial strip.
RLCF-15		Also used as dummy in tower 2.

2. Results

Queen X-ray test was accomplished on 5 April 1948. The weather was reasonably good and most of the exposed film showed detail of the zero island and its installations. The exposed film was returned to the processing facility aboard the AV-4 where parts of the film were processed and briefly viewed. The film was then turned over to the AEC for complete analysis and for permanent storage. It is noted that the original camera plan (see Appendix IV), could not be followed because of film shortages both in black and white and in color; also because of equipment shortages. The perforators that had been ordered for perforating the film had not arrived in the theater at this time. The system of using wax pencil that was prescribed in the operations order was therefore followed. Some of the Fastax film was negative, some reversal. The processing system developed all film to negative and in the process removed the wax identification from the Fastax rolls, thus destroying the positive identification of the relation between the film and the camera in which it was exposed. The term "wax head" has since been used in conjunction with those characters who have proposed using waxed pencils for marking film, or to those who question the need for perforators.

QUEEN-X SUMMARY

(See Appendix XV for serial and mark explanation)

Serial No.	Mark	Focal Length	Speed	Stop f/	Filter	
RLCF-20	1F1QX1	400.5mm	1,500fps		None	Film cut into four parts, used in each camera.
	1F2QX1	254mm	1,500fps			
	1F3QX1	100.48mm	1,500fps			
	1F4QX1	101.0mm	1,500fps			
RLCF-19	1F5QX1	100.9mm	1,500fps		None	Film cut into four parts, used in each.
	1F6QX1	401.97mm	1,500fps			
	1F7QX1	205.25mm	1,500fps			
	1F8QX1	100.83mm	1,500fps			
RLCF-18	1F9QX1	100.65mm	1,500fps		None	Film divided.
	1F10QX1	100.26mm	1,500fps			
	1F11QX1	100.79mm	1,500fps			
	2F1QX1	400.66mm	1,500fps			
MLG-3	1M12QX1	450mm	96fps		None	One magazine used on two cameras.
	1M13QX1	100mm	24fps			
RMF-57	1N15QX1	63mm	64fps	6.3	None	
RMF-56	1N16QX1	25mm	24fps	11.	None	
ALB-1	1K17QX1	610mm	1/150		None	One magazine loaded in turn on three K-18As.
	1K18QX1	610mm	1/150			
	1K19QX1	610mm	1/150			

QUEEN X SUMMARY

(Continued)

Serial No.	Mark	Focal Length	Speed	Stop f/	Filter	
BLA-54	1L20QX1	508mm	1/900		None	One magazine loaded in turn on eight K-24s.
	1L21QX1	508mm	1/900			
	1L22QX1	508mm	1/900			
	1L23QX1	508mm	1/900			
	1L24QX1	508mm	1/900			
	1L25QX1	508mm	1/900			
	1L26QX1	508mm	1/900			
	1L27QX1	508mm	1/900			
RLCF-13						Dummy for Fastax operation.
RLCF-12						Dummy for Fastax operation.
RMF-9	1B30	25mm	128fps	6.3	None	One roll divided and used in two B-1Es.
	2B30	25mm	128fps	6.3	None	
RLCF-17	2F2QX1	249.75mm	1,500fps		None	Film divided into four pieces and used separately.
	2F3QX1	254.0mm	1,500fps			
	2F4QX1	100.71mm	1,500fps			
	2F5QX1	100.45mm	1,500fps			
RLCF-16	2F6QX1	398.65mm	1,500fps		None	Film divided into four parts, used separately.
	2F7QX1	250.80mm	1,500fps			
	2F8QX1	100.80mm	1,500fps			
	2F9QX1	100.74mm	1,500fps			
MLG-5	2M13QX1	25mm	24fps		None	
RMF-7	2N15QX1	25mm	24fps	11.	None	
RMF-8	2N16QX1	63mm	64fps	6.3	None	

QUEEN X SUMMARY

(Continued)

Serial No.	Mark	Focal Length	Speed	Stop f/	Filter	
ALB-2	2K17QX1	610mm	1/150		None	One magazine exposed on three cameras.
	2K18QX1	610mm	1/150			
	2K19QX1	610mm	1/150			
BLA-55	2L20QX1	508mm	1/900		None	One magazine exposed in eight cameras.
	2L21QX1	508mm	1/900			
	2L22QX1	508mm	1/900			
	2L23QX1	508mm	1/900			
	2L24QX1	508mm	1/900			
	2L25QX1	508mm	1/900			
	2L26QX1	508mm	1/900			
	2L27QX1	508mm	1/900			
RLCF-14						Dummy for Fastax operation.
RLCF-15						Dummy for Fastax operation.

H. THE PETER-X TEST

Peter-X Test was established by directive of the Scientific Director of the Joint Task Force to test the readiness of all equipment and to determine the adequacy of the evacuation program. The test was therefore to be exactly like the X-ray test with the exception of the Atomic Weapon detonation which was to be replaced by a flash unit constructed by the Photo Tower Unit. It was decided not to use an M-1 photo flash bomb because of the concussion and fragmentation complications. The flash unit that was constructed consisted of two wooden panels each containing ten size fifty flash bulbs connected in parallel. These panels were mounted on the roof of the zero tower, one facing each Photo Tower. The electrical detonating circuit was connected into the same timing circuit that was to detonate the weapon. The Photo Tower Peter-X Test was therefore a night test using banks of photo flash bulbs for light instead of the weapon. The test was accomplished as scheduled with the exception of substitution of film in some of the cameras. This was necessitated by the failure of the required supply to arrive. Evacuation went according to the plan (see Appendix XXVI), as did also the film recovery sequence. Film recovery was to be exactly as would be the recovery on X-day up to the point of packaging the film for shipment, at which point the film would be returned to the AV-4 where it was developed and eventually viewed to determine the adequacy of the timing system and the aligning of the cameras. Peter-X was so close before X-day that the film was not analyzed until after X-day. The developed film from Peter-X was turned over to AEC for permanent possession and analysis. The following summary shows the actual values used with the Photo Tower cameras on the Peter-X Test. The flash from the Zero tower recorded well. It was easily visible on Eniwetok, also.

PETER-X SUMMARY

8 April 1948 - Aomon Island Tower

(See Appendix XV for mark, punch, serial explanations.)

Mark	Serial No.	Camera No.	Lens No.	Mag. No.	Focal Lgth.	Speed	Stop	Filter	Start Sec.	Run Sec.	Stop Sec.
2F1PX1	RLCF-1	8226	508328		15"	12,000fps	3.5	None	- 0.60	1.00	0.40
2F2PX1	RLCF-2	8203	606668		10"	12,000fps	3.5	None	- 0.57	1.00	0.43
2F3PX1	RLCF-3	8192	609085		4"	12,000fps	3.5	None	- 0.55	1.00	0.45
2F4PX1		Not used, no film									
2F5PX1		Not used, no film									
2F6PX1	RACF-1	8227	577764		398.65mm	12,000fps	5.6	None	- 0.40	1.00	0.60
2F7PX1	RACF-2	8219	606662		250.8mm	12,000fps	5.6	None	- 0.37	1.00	0.63
2F8PX1	RACF-3	8200	617371		100.8mm	12,000fps	3.5	None	- 0.35	1.00	0.65
2F9PX1		Not used, no film									
2F10PX1	RLCF-4	8209	617368		100.27mm	1,500fps	3.5	None	- 1.	12.	11.
2F11PX1	RACF-4	8210	617369		100.3mm	1,000fps	3.5	None	- 1.	12.	11.
2M12PX1	MLG-8	629	MA3991	6145	150. mm	96fps	2.7	None	-60.	160.	100.
2M13PX1		Not used, no camera									
2M14PX1		Not used, no camera									
2N15PX1	RMF-3	222	ES280	575	25 mm	24fps	1.4	None	-60.	660.	600.
2N16PX1	RMF-4	214	ES1552	529	63 mm	64fps	2.7	None	-60.	130.	190.
2K17PX1	ALB-6	44-187928	VF279R	41-1489	610 mm	1/150 sec.	6.	None	- 1.0	150.	149.
2K18PX1	ALB-8	44-187870	VF2019R	41-550	610 mm	1/150 sec.	6.	None	- 1.0	150.	149.
2K19PX1	ALB-7	44-188283	VF1332R	41-1480	610 mm	1/150 sec.	6.	None	- 1.0	150.	149.
2L20PX1	BLA-50	44-162083	VF3140R		508 mm	1/900 sec.	5.6	None	- 1.0	121.	120.
2L21PX1	BLA-51	44-162393	VF7755R		508 mm	1/900 sec.	5.6	None	- 1.0	121.	120.
2L22PX1	BLA-52	44-162075	VF2939R		508 mm	1/900 sec.	5.6	None	- 1.0	121.	120.
2L23PX1	BLA-53	44-172157	MS7121		508 mm	1/900 sec.	5.6	None	- 1.0	121.	120.
2L24PX1	Through 2L27PX1	Not used, no film									
2S28PX1	ALD-72				54.1mm	40"/sec.		None	- 1.0	61.	60.
2029PX1	O'Brien	Details from Brixner, AEC, Los Alamos									
2B30PX1	RMC-411	549902	313212		25 mm	128fps	1.5	None	- 1.0	29.	28.

PETER-X SUMMARY

8 April 1948 - Coral Head Tower

(See Appendix XV for mark, punch, serial explanations.)

Mark	Serial No.	Camera No.	Lens No.	Mag. No.	Focal Lgth.	Speed	Stop	Filter	Start Sec.	Run Sec.	Stop Sec.
1F1PX1	RLCF-5	8217	577766		400.5 mm	12,000fps	3.5	None	- 0.60	1.0	0.40
1F2PX1	RLCF-6	8190	606661		254. mm	12,000fps	3.5	None	- 0.57	1.0	0.43
1F3PX1	RLCF-7	8175	617367		100.48mm	12,000fps	3.5	None	- 0.55	1.0	0.45
1F4PX1		Not used, no film.									
1F5PX1		Not used, no film.									
1F6PX1	RACF-5	8205	598332		401.97mm	12,000fps	5.6	None	- 0.40	1.0	0.60
1F7PX1	RACF-6	8199	606665		205.25mm	12,000fps	5.6	None	- 0.37	1.0	0.63
1F8PX1	RACF-7	8180	617377		100.83mm	12,000fps	3.5	None	- 0.35	1.0	0.65
1F9PX1		Not used, no film.									
1F10PX1	RLCF-8	8186	617375		100.26mm	1,000fps	3.5	None	- 1.	12.	11.
1F11PX1	RACF-8	8189	617371		100.79mm	1,000fps			- 1.	12.	11.
1M12PX1	MLG-6	672	P136		450. mm	96fps	4.5	None	-60.	160.	100.
1M13PX1	MLG-7	406	BF8588		100. mm	24fps	2.3	None	-60.	660.	600.
1M14PX1		Not used, no camera.									
1N15PX1	RMF-1	217			63. mm	64fps	2.7	None	-60.	310.	250.
1N16PX1	RMF-2	218	ES202		25. mm	24fps	1.4	None	-60.	660.	600.
1K17PX1	ALB-3	44-133467	EE1793	41-1533	610. mm	1/150 sec.	6.0	None	- 1.0	150.	149.
1K18PX1	ALB-4	44-188362	EE1656	41-587	610. mm	1/150 sec.	6.0	None	- 1.0	150.	149.
1K19PX1	ALB-5	44-187861	VF7697R	41-1399	610. mm	1/150 sec.	6.0	None	- 1.0	150.	149.
1L20PX1	BLA-46	42-35595	VF3001R		508. mm	1/900 sec.	5.6	None	- 1.0	121.	120.
1L21PX1	BLA-47	42-35550	VF2980R		508. mm	1/900 sec.	5.6	None	- 1.0	121.	120.
1L22PX1	BLA-48	44-151011	VF7750R		508. mm	1/900 sec.	5.6	None	- 1.0	121.	120.
1L23PX1	BLA-49	44-151251	VF7778R		508. mm	1/900 sec.	5.6	None	- 1.0	121.	120.
1L24PX1	through 1L27PX1 Not used, no color film available for these cameras.										
1S28PX1	ALD-71	209	MF224		150.4 mm	40"/sec.	6.3	None	- 1.0	66.	65.
1029PX1		Details from Brixner, AEC, Los Alamos									
1B30PX1	RMC-412	549899	313160		25. mm	128fps	1.5	None	- 1.0	29.	28.

I. THE X-DAY TEST

1. Test Data

The X-Day Test was carried out according to the predetermined plans. It was accomplished precisely as scheduled all the way from the loading and final check and evacuation through the film recovery and packaging operations. The only exception to the plan as accepted by JTF was the substitution of some categories of film and the omission of a few cameras. The film shortage was still acute, especially in some types which were non-existent. Some of the cameras had not yet been delivered from the factories and therefore were not available. The summary which follows shows the cameras and film as used. This summary is a corrected version of the information appearing on the caption sheets, in which some errors occur. The filter utilization was specified in conjunction with certain aperture settings. The filters were then cut and delivered to the tower units for installation. While this was being done the caption sheets were typed. After the filters were installed it was discovered that not all of the cameras would stop down to the specified values. The caption sheets were not always corrected. The following tabulation has been corrected for these errors and for typing mistakes in the caption sheets.

2. Malfunctions

A complete analysis of the malfunctions encountered on X-Day is beyond the scope of this report as the final analysis must come from the viewing of the negatives. Much trouble was expected from the K-24 cameras. It was because of anticipated malfunctions in these that they were increased in total number so that good coverage would be obtained even with many malfunctions.

3. Low Speed Mitchell Malfunction

Associated with the detonation of an atomic weapon is a great dissociation of electrons. These recombine for considerable time periods after the fireball has disappeared, even after the resulting nitrogen fire has subsided. The resultant 'blue fog' is typical of recombination phenomena, but has been erroneously termed 'neutron glow' by some. The recombination glow is visible in two places after the detonation. In the early stages, it is visible against, or close to, the ground. In later stages it is visible as a cloud. In fact the so-called radio-active cloud has the recombination glow associated with it for a very long period. During the Sandstone tests this glow was visible until the increasing daylight became more intense than the glow, thus making it indiscernible to the eye.

The Standard Mitchell movie camera 2M13 was aimed high for the X-Day test in order to determine if the recombination glow in the resultant cloud could be recorded. Because of long time period and the low light intensity of the glow the camera was set for 8fps (frames per second) which is about as slow as a Mitchell will operate. The light emitted from the glow is about equal in intensity to a first magnitude star. The aperture of the camera was therefore fully opened. The early energy reception by this camera was so great that the negative not only reversed, but was burned, the image being clearly visible even when the undeveloped negative was viewed in daylight. This burning caused the emulsion to swell and jam the camera by virtue of the film sticking to the aperture plate.

4. Fastax Runaway

The Time Control Equipment on one of the Fastax cameras caused the camera to run away just as the tower was being evacuated after the final check. It is believed that the clutch facings swell a small amount in the high humidity. This reduces the clearance between the two faces and sometimes the faces touch without the solenoid being energized. It was not expected that anything would be on this roll of film.

5. <u>High Speed Mitchell</u>

Some trouble was experienced with the High Speed Mitchells. This test indicated that a Mitchell does not reliably run at high speed for 1,000 feet of film without being shut down and lubricated. In the case of the remote tower, as used here, this is impossible. Later tests confirmed this fact and the cameras were loaded with only 400 feet of film.

6. <u>Clouds</u>

It was known during the time of the test that clouds were between the detonation and the Coral Head Tower, also that there was probably a rain storm in progress. For these reasons it was anticipated that poor overall coverage of the detonation would result from X-Day tower photography. Fastax reports indicated, however, that enough data were available on the Fastax film to allow the analysis for which the Fastax cameras had been installed.

7. <u>Time Error</u>

The Fastax returns from analyses made in the ZI indicated that the weapon had detonated too soon in relation to the starting of the Fastax cameras. Either the cameras were starting late or the weapon was detonating early. The times given in the start and stop columns of the summary are the theoretical times which were set, not the actual times before detonation as measured afterwards. Actual times must come from a review of the film. Actually the start time should be given in terms of the time delay (TD) between receiving the minus-one second signal and the starting of the Fastax. This became the standard method for Fastaxes after it was realized that a peculiar timing discrepancy had crept in. Thus the TD for 1F1 would be 0.4; for 1F2, 0.43; for 1F3, 0.45; etc. Some cameras were started from the minus-one minute signal by giving them a longer delay, as with 1M12 which had a 57-second delay for a -3 second starting time. These time comments also apply to the previous data sheets.

X-RAY SUMMARY

Tower 1 - Coral Head

Mark	Serial No.	Camera No.	Lens No.	Focal Lgth.	Speed	Stop	Filter	Shutter	Start Sec.	Run Sec.	Stop Sec.
1F1X1	RLCF 39	8204	577766	400.5 mm	12,000fps	32	ND 2-29F		- 0.60	1.00	0.40
1F2X1	RLCF 40	8190	606661	250.0 mm	12,000fps	22	ND 1.5-29F		- 0.57	1.00	0.43
1F3X1	RLCF 41	8175	617367	100.48mm	12,000fps	22	29F		- 0.55	1.00	0.45
1F4X1	RLCF 43	8176	617373	101.0 mm	12,000fps	11			- 0.50	1.00	0.50
1F5X1	RLCF 44	8177	617376	100.9 mm	12,000fps	32			- 0.45	1.00	0.55
1F6X1	RACF 9	8205	508332	401.97mm	12,000fps	32	ND 1.5		- 0.40	1.00	0.60
1F7X1	RACF 10	8213	606665	250.25mm	12,000fps	32	ND 2.0		- 0.37	1.00	0.63
1F8X1	RACF 11	8180	617377	100.83mm	12,000fps	22	ND 1.5		- 0.35	1.00	0.65
1F9X1	RLCF 45	8183	617365	100.65mm	12,000fps	11	29F		- 0.30	1.00	0.70
1F10X1	RLCF 42	8186	617375	100.26mm	1,000fps	22	ND 2.0		- 1.0	12	11
1F11X1	RACF 12	8189	617371	100.79mm	1,000fps	32	ND 1.5		- 1.0	12	11
1M12X1	MLG 18	672	P-153	450.0 mm	96fps	32	ND 1.5	15°	- 3.0	180	177
1M13X1	MLG 19	406	BF-8588	100.0 mm	24fps	32	ND 1.5	15°	-60	900	840
1M14X1	Not used										
1N15X1	RMF 24	217	ES 4473	63 mm	64fps	22	ND 1.5	15°	-60	250	190
1N16X1	RMF 23	218	ES 202	25 mm	24fps	11	ND 1.5	15°	-60	660	600
1K17X1	ALB 11	44-133467	EE 1793	610 mm	1/150 sec.	16	ND 1.5-29F		- 1	150	149
1K18X1	ALB 12	44-188362	EE 1656	610 mm	1/100 sec.	16			- 1	150	149
1K19X1	ALB 13	44-187861	VF 7697R	610 mm	1/50 sec.	6			- 1	150	149
1L20X1	BLA 56	44-35595	VF 3001R	508 mm	1/900 sec.	5.6			- 1	44	43
1L21X1	BLA 57	42-35550	VF 2980R	508 mm	1/900 sec.	18			- 1	44	43
1L22X1	BLA 58	44-151011	VF 7750R	508 mm	1/900 sec.	11	ND 1.5		- 1	44	43
1L23X1	BLA 59	44-151251	VF 7778R	508 mm	1/900 sec.	22	ND 2.0		- 1	44	43
1L24X1	BLA 80	44-160108	MA 2076R	508 mm	1/900 sec.	5.6			- 1	44	43
1L25X1	BLA 81	44-158613	AS 2477R	508 mm	1/900 sec.	18			- 1	44	43
1L26X1	BLA 82	44-160806	VF 2975R	508 mm	1/900 sec.	11	ND 1.5		- 1	44	43
1L27X1	BLA 83	44-88222	VF 8763R	508 mm	1/900 sec.	22	ND 2.0		- 1	44	43
1S28X1	ALB 9	209	MF 224	150.4 mm	40"/sec.	16	ND 2.0-29F		- 1	50	49
1029X1	Details from Brixner, AEC, Los Alamos										
1B30X1	RMC 415	549899	313160	75 mm	128fps	22	ND 1.5	Full Open	- 1	31	30

15 April 1948

X-RAY SUMMARY

Tower 2 - Aomon

Mark	Serial No.	Camera No.	Lens No.	Focal Lgth.	Speed	Stop	Filter	Shutter	Start Sec.	Run Sec.	Stop Sec.
2F1X1	RLCF 9	8226	508328	400.66mm	12,000fps	32	ND 2.0-29F		- 0.60	1.00	0.40
2F2X1	RLCF 10	8203	606668	249.75mm	12,000fps	22	ND 1.5-29F		- 0.57	1.00	0.43
2F3X1	RLCF 11	8192	609085	100. mm	12,000fps	22	29F		- 0.55	1.00	0.45
2F4X1	RLCF 46	8197	617363	100.71mm	12,000fps	11			- 0.50	1.00	0.50
2F5X1	RLCF 47	8198	617378	100.45mm	12,000fps	32			- 0.45	1.00	0.55
2F6X1	RACF 13	8227	577764	398.65mm	12,000fps	32	ND 1.5		- 0.40	1.00	0.60
2F7X1	RACF 14	8219	606662	250.80mm	12,000fps	32	ND 2.0		- 0.37	1.00	0.63
2F8X1	RACF 15	8200	617361	100.80mm	12,000fps	22	ND 1.5		- 0.35	1.00	0.65
2F9X1	RLCF 48	8207	617372	100.74mm	12,000fps	11	29F		- 0.30	1.00	0.70
2F10X1	RLCF 22	8209	617368	100.27mm	1,000fps	22	ND 2.0		- 1.00	12.00	11.00
2F11X1	RACF 16	8210	617369	100.30mm	1,000fps	32	ND 1.5		- 1.00	12.00	11.00
2M12X1	MLG 20	629	422830	12"	96fps	32	29F	15°	- 3.00	180.00	177.00
2M13X1	MLG 40	625	MA4073R	6"	24fps	32	ND 1.5	15°	-60.00	900.00	840.00
2M14X1	MLG 21	410	BF5406	35mm	8fps	2.3		170°	-60.00	2700.00	2640.00
2N15X1	RMF 5	222	ES280	25mm	24fps	11	ND 1.5	15°	-60.00	250.00	190.00
2N16X1	RMF 6	214	ES1552	63mm	64fps	22	ND 1.5	15°	-60.00	660.00	600.00
2K17X1	AMB 17	44-187928	VF279R	610mm	1/50 sec.	6.0	EF-HF		- 1.00	150.00	149.00
2K18X1	AMB 18	44-187870	VF2019R	610mm	1/100 sec.	16	EF-HF		- 1.00	150.00	149.00
2K19X1	AMB 19	44-188283	VF1332R	610mm	1/100 sec.	16	EF-HF		- 1.00	150.00	149.00
2L20X1	BLA 60	44-162083	VF3140R	508mm	1/900 sec.	5.6			- 1.00	44.00	43.00
2L21X1	BLA 61	44-162393	VF7755R	508mm	1/900 sec.	18			- 1.00	44.00	43.00
2L22X1	BLA 78	44-162075	VF2939R	508mm	1/900 sec.	11	ND 1.5		- 1.00	44.00	43.00
2L23X1	BLA 79	44-162157	MS7121R	508mm	1/900 sec.	22	ND 2.0		- 1.00	44.00	43.00
2L24X1	BLA 84	44-161897	MS6489R	508mm	1/900 sec.	5.6			- 1.00	44.00	43.00
2L25X1	BLA 85	44-160035	US1908R	508mm	1/900 sec.	18			- 1.00	44.00	43.00
2L26X1	BLA 86	44-160679	US1743R	508mm	1/900 sec.	11	ND 1.5		- 1.00	44.00	43.00
2L27X1	BLA 87	44-110595	VF1770R	508mm	1/900 sec.	22	ND 2.0		- 1.00	44.00	43.00
2S28X1	ALB 10	44-187025	MA1735	154.1mm	40"/sec.	16	ND 2.0-29F		- 1.00	50.00	49.00
2029X1	Details from Brixner, AEC, Los Alamos										
2B30X1	RMC 416	549902	313212	25mm	128fps	22	ND 1.5		- 1.00	31.00	30.00

J. THE QUEEN-Y TEST

1. Reasons For Test

The fact that the Fastax timing system had been in error prompted a new test procedure to determine the source of the discrepancy. Clock time checks were run throughout all the equipment, measurements were made of all starting times, and circuits were studied to determine the probable or actual cause of the delay. No good answer was found in the tower equipment. A brief study of the central timing system was then made and some questions arose as to the system of time calibrating the end stations. Again no conclusion was reached and it was decided that the mechanism for the time error was unimportant in relation to determining the correct time. The determination of the constancy of the error was also important. The Queen-Y Test was established as a daytime test to determine the timing sequences and the source of malfunctions in the cameras, in addition to establishing scale and alignment pictures.

2. Time Check Method

The time was to be checked on an overall basis in relation to the final flash. Two banks of ten flash bulbs each were mounted in the Zero Tower in place of the weapon.

Therefore four individual flash bulbs were connected:

1. From the master relay (minus 1 second) to ground, this bulb to flash when the minus-one-second pulse started all the timing units in the tower.

2. Across the power circuits that operated F1 (Fastax 1F1 in Tower 1, 3F1 in Tower 3), F2 and F3, thus giving a flash when the timing system controlling each of these cameras started those cameras.

3. Time Relations

All the bulbs were mounted so that their light output entered the lens systems of two other Fastax cameras: F6 and F7. These two cameras were mounted so as to record also the flash in the Zero Tower. F7 was manually started at a reduced voltage at minus two seconds. It would then record five flashes: a flash bulb showing minus-one-second impulse, the starting flash for F1, F2, and F3, and then the flash from the Zero Tower. F6 was to start on the minus-one-second signal to show the starting characteristic until the bulbs mounted across the other Fastax cameras were detonated, and finally until the flash from the Zero Tower was recorded. By this arrangement an absolute time relation could be established between the various units.

4. Two-Tenth Delay

The analysis of the results obtained was very difficult. On one of the towers one of the flash bulbs exploded, breaking another bulb at the same time. Thus one flash was missing and the sequence was difficult to confirm. On the other tower, F7 failed to start due to a faulty resistor in the timing unit. The test indicated that there was an error of about 0.2 second in the timing system but it did not demonstrate where the error originated. This test was conducted using the same time for the Fastax starting that had been used on the X-Day Test. The Peter Test to follow this one was designed to incorporate a delay, the amount of delay to be determined by this test. The Peter Test would then confirm the amount of delay which was consistant and correct.

5. Pip Marking System

Another fact that made the analysis of the film difficult was that the bulbs used could not be placed far enough away from the cameras to be in focus, so the light entering the lens system just made a smudge. It was concluded from this that a relay-condenser system would be employed in the future to mark Fastax film through the argon glow lights installed in the camera. This could be done easily by connecting the magnet of a double-pole, double-throw relay across the power line which operated the Fastax. The condenser would be connected across the armature contacts of the relay. The normally closed contacts would be connected to a source of DC potential ranging from 200 to 250 volts, and the normally open contacts would be connected across the line that leads from the pip generator to the Fastax pip light. Before the Fastax was started the armature would connect the potential source across the condenser, thus charging it. When the Fastax starts, the armature closes the other set of contacts discharging the condenser into the pip light system, thus marking the film. It might be necessary to add a resistor in series with the condenser to limit the discharge current flow. Two cautions must be observed: (a) the voltage placed on the pip marking circuit must not interfere with the pip generator; (b) the condenser placed across the line by the closing of the relay must not absorb so much energy that the pip marking system ceases to operate. The latter can be overcome by placing a small spark gap of the proper dimensions in the condenser output if necessary. The Potter generator that was used in the Sandstone tests had a cathode follower output and was probably not bothered by the added potential. Tests would show the results.

6. <u>Daylight Flash Recorded</u>

This daylight flash was clearly visible in both of the Photo Towers and the flash did record well on the cameras with suitable f ratio lenses.

7. <u>Queen-Yoke Summary</u>

The following Queen-Y summary sheets give the Time Delay (TD) and Time (T) of operation of the camera. From the film, the approximate times may be derived. The previously given start, run, stop system means little when peculiar delays are inherent in the system. The values in the TD column are delays in seconds from the minus-one-second signal unless the figure is followed by an M, in which case the figure is the number of seconds delay from the minus-one-minute signal.

24 April 1948

QUEEN-Y SUMMARY

Tower 1 - Coral Head

Mark	Punch	Serial No.	Camera No.	Focal Lgth.	Speed	Stop	Filter	TD Sec.	T Sec.	Fastax Voltage
1F1QY1	110141	RLCF 49	8204	400.5 mm	12,000fps	5.6	None	0.4	1	180
1F2QY1	110241	RLCF 50	8190	250. mm	12,000fps	5.6	None	0.5	1	180
1F3QY1	110341	RLCF 52	8175	100.48mm	12,000fps	5.6	None	0.6	1	180
1F4QY1	110441	RACF 17	8176	101. mm	12,000fps	5.6	None	0.5	1	180
1F5QY1	110541	RACF 18	8177	100.9 mm	12,000fps	6.3	None	0.55	1	180
1F6QY1	110641	RACF 19	8205	401.97mm	3,000fps	6.3	None	0.0	3.5	80
1F7QY1	110741	RACF 20	8213	205.25mm	3,000fps	8	None	58 M	6	50
1F8QY1	110841	RACF 21	8180	100.83mm	12,000fps	6.3	None	0.65	1	180
1F9QY1	110941	RACF 22	8183	100.65mm	12,000fps	6.3	None	0.7	1	180
1F10QY1	111041	RLCF 53	8186	100.26mm	1,000fps	11	None	0.0	12	35
1F11QY1	111141	RACF 23	8189	100.79mm	1,000fps	11	None	0.0	12	35
1M12QY1	121241	MLG 9	672	450. mm	96fps	5.6	None	57 M	180	
1M13QY1	121341	MLG 22	406	100. mm	24fps	11-16	None	0 M	666	
1N14QY1	Not used, no camera									
1N15QY1	131541	RMF 25	217	63 mm	64fps	5.6	None	0 M	250	
1N16QY1	131641	RMF 26	218	25 mm	24fps	11-16	None	0 M	660	
1K17QY1	141741	ALB 14	44-133467	610 mm	1/150	8	None	0	150	
1K18QY1	141841	ALB 15	44-188362	610 mm	1/150	8	None	0	150	
1K19QY1	141941	ALB 16	44-187861	610 mm	1/150	8	None	0	150	
1L20QY1	152041	BLA 88	44-35595	508 mm	1/900	6.3	None	0	45	
1L21QY1	152141	BLA 89	42-35550	508 mm	1/900	6.3	None	0	45	
1L22QY1	152241	BLA 90	44-151011	508 mm	1/900	6.3	None	0	45	
1L23QY1	152341	BLA 91	44-151251	508 mm	1/900	6.3	None	0	45	
1L24QY1	152441	BLA 92	44-160108	508 mm	1/900	6.3	None	0	45	
1L25QY1	152541	BLA 93	44-158613	508 mm	1/900	6.3	None	0	45	
1L26QY1	152641	BLA 94	44-160806	508 mm	1/900	6.3	None	0	45	
1L27QY1	152741	BLA 95	44-88222	508 mm	1/900	6.3	None	0	45	
1S28QY1	162841	ALB 17	209	150.4 mm	40"/sec.	8	None	0	22	
1029QY1	Details from Brixner, AEC, Los Alamos									
1B30QY1	183041	RMC 413	549899	25 mm	128fps	3.5	None	0	31	

24 April 1948

QUEEN-Y SUMMARY

Tower 3 - Runit

Mark	Punch	Serial No.	Focal Lgth.	Speed	Stop	Filter	TD Sec.	T Sec.	Fastax Voltage
3F1QY1	310141	RLCF 55	400.66mm	12,000fps	5.6	None	0.40	1	180
3F2QY1	310241	RLCF 56	249.75mm	12,000fps	4.5	None	0.50	1	180
3F3QY1	310341	RLCF 57	4 inch	12,000fps	3.5	None	0.60	1	180
3F4QY1	310441	RACF 24	4 inch	12,000fps	3.5	None	0.50	1	180
3F5QY1	310541	RACF 25	4 inch	12,000fps	3.5	None	0.45	1	180
3F6QY1	310641	RACF 26	15 inch	3,000fps	5.6	None	0.0	3.5	60
3F7QY1	310741	RACF 27	10 inch	3,000fps	4.5	None	58 M	3.5	60
3F8QY1	310841	RACF 28	4 inch	12,000fps	3.5	None	0.65	1	180
3F9QY1	310941	RACF 29	4 inch	12,000fps	3.5	None	0.70	1	180
3F10QY1	311041	RLCF 58	4 inch	1,000fps	3.5	None	0.0	12	
3F11QY1	311141	RACF 30	4 inch	1,000fps	3.5	None	0.0	12	
3M12QY1	321241	MLG 23	12 inch	96fps	11	None	57 M	180	
3M13QY1	321341	MLG 37	35 inch	24fps	16	None	0 M	660	
3M14QY1	Not used, no camera								
3N15QY1	331541	RMF 27	63 mm	64fps	8	None	0 M	250	
3N16QY1	331641	RMF 28	25 mm	24fps	11	None	0 M	666	
3K17QY1	341741	ALB 18	610 mm	1/150	16	None	0	150	
3K18QY1	341841	ALB 19	610 mm	1/150	16	None	0	150	
3K19QY1	341941	ALB 20	610 mm	1/150	16	None	0	150	
3L20QY1	352041	BLA 96	508 mm	1/900	8	None	0	45	
3L21QY1	352141	BLA 97	508 mm	1/900	8	None	0	45	
3L22QY1	352241	BLA 98	508 mm	1/900	8	None	0	45	
3L23QY1	352341	BLA 99	508 mm	1/900	8	None	0	45	
3L24QY1	352441	BLA 100	508 mm	1/900	8	None	0	45	
3L25QY1	352541	BLA 101	508 mm	1/900	8	None	0	45	
3L26QY1	352641	BLA 107	508 mm	1/900	8	None	0	45	
3L27QY1	352741	BLA 108	508 mm	1/900	8	None	0	45	
3S28QY1	362841	ALB 21	6 inch	40"/sec.	16	None	0	22	
3029QY1	Details from Brixner, AEC, Los Alamos								
3B30QY1	383041	RMC 414	25 mm	128fps	6.3	None	0	31	

K. THE PETER-Y TEST

1. Time Test

The Peter-Y Test was designed to accomplish a twofold purpose. First, it was to give a check on the time sequence of operation of the tower cameras with the additional time set in as determined by the Queen-Y Test. The Queen-Y Test indicated approximately 0.2 second discrepancy, so this amount was to be allowed and only the Fastax cameras F1, F2, F3, F6, and F7 in each tower operated to show the time relation under the new settings. These cameras were set up the same as for the Queen-Y Test with the exception that they were set for night operation instead of day use. Secondly, the test was to give the air unit practice under simulated conditions; i.e., that of having a flash to look at and to determine if their aiming was good.

2. Flash Failure

As in the Queen-Y Test, two banks of ten bulbs each were installed in the Zero Tower and connected as before. In addition, a "Hedda Hopper" hat of ten flash bulbs was hung down the side of the Zero Tower "shack" for the use of the gamma radiation unit. Because a switch had been left open the flash units failed to go at the time of the test. The air unit had its practice. As an example of the

24 April 1948

QUEEN-Y SUMMARY

Tower 3 - Runit

Mark	Punch	Serial No.	Focal Lgth.	Speed	Stop	Filter	TD Sec.	T Sec.	Fastax Voltage
3F1QY1	310141	RLCF 55	400.66mm	12,000fps	5.6	None	0.40	1	180
3F2QY1	310241	RLCF 56	249.75mm	12,000fps	4.5	None	0.50	1	180
3F3QY1	310341	RLCF 57	4 inch	12,000fps	3.5	None	0.60	1	180
3F4QY1	310441	RACF 24	4 inch	12,000fps	3.5	None	0.50	1	180
3F5QY1	310541	RACF 25	4 inch	12,000fps	3.5	None	0.45	1	180
3F6QY1	310641	RACF 26	15 inch	3,000fps	5.6	None	0.0	3.5	60
3F7QY1	310741	RACF 27	10 inch	3,000fps	4.5	None	58 M	3.5	60
3F8QY1	310841	RACF 28	4 inch	12,000fps	3.5	None	0.65	1	180
3F9QY1	310941	RACF 29	4 inch	12,000fps	3.5	None	0.70	1	180
3F10QY1	311041	RLCF 58	4 inch	1,000fps	3.5	None	0.0	12	
3F11QY1	311141	RACF 30	4 inch	1,000fps	3.5	None	0.0	12	
3M12QY1	321241	MLG 23	12 inch	96fps	11	None	57 M	180	
3M13QY1	321341	MLG 37	35 inch	24fps	16	None	0 M	660	
3M14QY1	Not used, no camera								
3N15QY1	331541	RMF 27	63 mm	64fps	8	None	0 M	250	
3N16QY1	331641	RMF 28	25 mm	24fps	11	None	0 M	666	
3K17QY1	341741	ALB 18	610 mm	1/150	16	None	0	150	
3K18QY1	341841	ALB 19	610 mm	1/150	16	None	0	150	
3K19QY1	341941	ALB 20	610 mm	1/150	16	None	0	150	
3L20QY1	352041	BLA 96	508 mm	1/900	8	None	0	45	
3L21QY1	352141	BLA 97	508 mm	1/900	8	None	0	45	
3L22QY1	352241	BLA 98	508 mm	1/900	8	None	0	45	
3L23QY1	352341	BLA 99	508 mm	1/900	8	None	0	45	
3L24QY1	352441	BLA 100	508 mm	1/900	8	None	0	45	
3L25QY1	352541	BLA 101	508 mm	1/900	8	None	0	45	
3L26QY1	352641	BLA 107	508 mm	1/900	8	None	0	45	
3L27QY1	352741	BLA 108	508 mm	1/900	8	None	0	45	
3S28QY1	362841	ALB 21	6 inch	40"/sec.	16	None	0	22	
3029QY1	Details from Brixner, AEC, Los Alamos								
3B30QY1	383041	RMC 414	25 mm	128fps	6.3	None	0	31	

severity of the air unit orbiting and aiming problems, especially where many other lights exist in the area, many of the aerial photographers were sure that they had seen the flash even though there was no flash.

3. No Time Check

Because of the failure of the flash unit to ignite no concrete results were obtained as to the exactness of the timing. Some concern was felt, but the limited time precluded a repeat of the test. Film shortage was also acute at this time.

26 April 1948

PETER-Y SUMMARY

Mark	Punch	Serial No.	Camera No.	Focal Lgth.	Speed	Stop	TD Sec.	T Sec.	Fastax Voltage
Tower 1 - Coral Head									
1F1PY1		RLCF 67	8204	400.5 mm	12,000fps	5.6	0.20	1.0	180
1F2PY1		RLCF 68	8190	250. mm	12,000fps	5.6	0.30	1.0	180
1F3PY1		RACF 32	8175	100.48 mm	12,000fps	3.5	0.40	1.0	180
1F5PY1		RACF 33	8205	401.97 mm	12,000fps	5.6	0.0	3.5	80
1F7PY1		RACF 35	8199	250.25 mm	3,000fps	5.6	58	6	50
Tower 3 - Runit									
3F1PY1		RLCF 59	8226	400.66 mm	12,000fps	5.6	0.20	1.0	180
3F2PY1		RLCF 62	8203	249.75 mm	12,000fps	5.6	0.30	1.0	180
3F3PY1		RACF 31	8192	200. mm	12,000fps	3.5	0.40	1.0	180
3F6PY1		RLCF 69	8227	398.65 mm	12,000fps	5.6	0.0	3.5	80
3F7PY1		RACF 34	8219	250.8 mm	3,000fps	3.5	58	6	50

L. THE Y-DAY TEST

1. Weather Delay

The Y-Day Test was tentatively moved forward one day and preparations were made to conduct it on 29 April. The weather turned out to be prohibitively bad so the test was delayed for twenty-four hours. This delay occurred after the Photo Towers had been set into final operation and the evacuation of personnel from the tower sites completed. It was necessary, therefore, to send an emergency crew back to each of the towers to give another final check. A rain storm, in the meantime, had soaked some of the cameras in the Coral Head Tower. Some film had been wetted slightly.

Other than for the delay, the test was carried out as planned, the evacuation and recovery plans having been only slightly altered as shown in Appendix XXVI which gives the plans of operation.

2. Camera Operation

The camera operation for Y-Day was better than for X-Day. Fewer malfunctions occurred and the weather was much better. No review of camera malfunctions is made here as the report on these can best come from the units analyzing the film. The K-24s were still the prime offenders, but were working somewhat better than before. Most of the K-24 malfunctions were due to poor adjustment of the metering roller and due to the poor design of the capping curtain and its control. Again, however, film was still short in some categories and substitutions from the original plan were made.

3. Shock Effects At Tower

Before evacuating the towers for the X-Day detonation some concern had been felt in regard to the shock difficulties that might be encountered. Therefore, some primitive gadgetry was constructed to indicate the amount of shock to the tower and all heavy objects were secured so that they would not upset. However, the shock reaching both the Aomon and Coral Head Towers was so small that no indications in the structure or equipment were noted. The shock and sway indicators registered a very slight amount of displacement, but not more than was registered in a buffeting wind or when an LCM would butt the Coral Head landing pier. From this evidence it was again concluded that the towers could be safely manned and the men not experience any inconvenience. Because the sway had been so small on X-Day no additional equipment was procured for the Y-Day Test, since it was known that the shock would be somewhat greater but not significantly so.

Two things happened as a result of the shock on Y-Day. A single panel of glass fell out of one window. The glass fell into the cab from a window on the back side of the cab. From the position of the fragments on the floor it was concluded that the glass had hit the floor in one piece and breakage was due to landing. The window frame had no putty to retain the glass as did most of the rest of the frames. No other glass was broken or cracked.

The second and more serious event that took place was the stopping of all cameras that were still operating at the time the blast hit the towers. This was eventually determined to be the result of faulty relays. Because of the difficulty in obtaining relays during the early periods of construction in the ZI, some poor 28 volt Leach relays were installed as master holding relays. The relays ordered to replace these did not arrive so these were left in the circuit. The method of holding them in the energized position includes a cotter pin pressure device. Upon this longitudinally-mounted cotter pin, the cross mounting bar that holds the contacts can roll. Thus, when hit, this relay can open one set of contacts even though energized and even when the energizing potential is high. Tests showed that this relay had been opened on the Y-Day towers when the shock struck the tower, even though nothing else was disturbed and the shock level was low enough not to break windows or knock things from shelves in the cab of the tower.

4. Film Markings

The perforators had arrived before this test was commenced so that the film for QY,PY, and Y was all "punched." This is a satisfactory solution to a perplexing situation and saves a great deal of time and worry over other methods of marking. As shown in the plan, the caption sheets and boxes were also perforated. This gave an excellent system of cross checking thus preventing confusion and errors from creeping into the system.

The unloading, auditing, and packaging of the film at Eniwetok went very smoothly, all operations being completed and film ready to go aboard the six-hour aircraft one-and-one-half hours early.

30 April 1948

YOKE SUMMARY

Tower 1 - Coral Head

Mark	Punch	Serial No.	Camera No.	Lens No.	Focal Lgth.	Speed	Stop	Filter	Shutter	TD Sec.	T Sec.	Fastax Voltage
1F1Y1	110161	RLCF 71	8204	577766	400.5 mm	12,000fps	16	ND 4.0		0.20	1.0	180
1F2Y1	110261	RLCF 72	8190	606661	250.0 mm	12,000fps	22	ND 1.5-29F		0.23	1.0	180
1F3Y1	110361	RLCF 76	8175	617367	100.48mm	12,000fps	16	ND 4.0		0.25	1.0	180
1F4Y1	110461	RMCF 23	8176	617373	101.0 mm	12,000fps	11	ND 4.0		0.30	1.0	180
1F5Y1	110561	RMCF 24	8177	617376	100.9 mm	12,000fps	22	ND 1.5		0.35	1.0	180
1F6Y1	110661	RACF 36	8205	508332	401.97mm	12,000fps	32	ND 1.5		0.40	1.0	180
1F7Y1	110761	RACF 37	8213	606665	250.25mm	12,000fps	16	ND 1.5		0.43	1.0	180
1F8Y1	110861	RACF 38	8180	617377	100.83mm	12,000fps	16	29F		0.45	1.0	180
1F9Y1	110961	RKCF 2	8183	617365	100.65mm	12,000fps	22	ND 1.5-29F		0.50	1.0	180
1F10Y1	111061	RLCF 74	8186	617375	100.26mm	1,000fps	22	ND 4.0		0.0	12	35
1F11Y1	111161	RACF 39	8189	617371	100.79mm	1,000fps	16	ND 1.5		0.0	12	35
1M12Y1	121261	MCF 181	672	P-153	450.0 mm	96fps	32	ND 1.5	15°	57 M	180	
1M13Y1	121361	MCG 110	406	BF8588	100.0 mm	24fps	5.6	29F	15°	0 M	666	
1M14Y1	Not used, no camera											
1N15Y1	131561	RMF 67	217	ES4473	63 mm	64fps	22	ND 1.5	15°	0 M	250	
1N16Y1	131661	RMF 68	218	ES 202	25 mm	24fps	11	ND 1.5	15°	0 M	666	
1K17Y1	141761	ALB 22	44-133467	EE1793	610 mm	1/150	16	ND 4.0		0	150	
1K18Y1	141861	ALB 23	44-188362	EE1656	610 mm	1/150	16	ND 1.5		0	150	
1K19Y1	141961	ALB 24	44-187861	VF7697R	610 mm	1/50	6.0	None		0	150	
1L20Y1	152061	BLA 109	44-35595	VF3001R	508 mm	1/900	32	ND 1.5		0	45	
1L21Y1	152161	BLA 110	42-35550	VF2980R	508 mm	1/900	8	ND 1.5		0	45	
1L22Y1	152261	BLA 111	44-151011	VF7750R	508 mm	1/900	11	None		0	45	
1L23Y1	152361	BLA 112	44-151251	VF7775R	508 mm	1/150	5.6	None		0	45	
1L24Y1	152461	BLA 113	44-160108	MO2076R	508 mm	1/900	32	ND 1.5		0	45	
1L25Y1	152561	BLA 114	44-158613	AS2477R	508 mm	1/900	8	ND 1.5		0	45	
1L26Y1	152661	BLA 115	44-160806	VF2975R	508 mm	1/900	11	None		0	45	
1L27Y1	152761	BLA 116	44-88222	VF8763R	508 mm	1/150	5.6	None		0	45	
1S28Y1	162861	ALB 25	209	MF 224	150.4 mm	40"/sec.	16	ND 4.0		0	22	
1029Y1	Details from Brixner, AEC, Los Alamos					480" Slit						
1B30Y1	183061	RMC 567	549899	313160	25 mm	128fps	22	ND 1.5		0	31	

30 April 1948

YOKE SUMMARY

Tower 3 - Runit

Mark	Punch	Serial No.	Camera No.	Lens No.	Focal Lgth.	Speed	Stop	Filter	Shutter	TD Sec.	T Sec.	Fastax Voltage
3F1Y1	310161	RLCF 75	8226	508328	400.66mm	12,000fps	16	ND 4.0		0.2	1	180
3F2Y1	310261	RLCF 73	8203	606668	249.75mm	12,000fps	22	ND 1.5-29F		0.2	1	180
3F3Y1	310361	RLCF 77	8192	609085		12,000fps	16	ND 4.0		0.2	1	180
3F4Y1	310461	RMCF 25	8197	617363	100.71mm	12,000fps	5.6	ND 4.0		0.3	1	180
3F5Y1	310561	RMCF 26	8198	617378	100.45mm	12,000fps	11	ND 1.5		0.3	1	180
3F6Y1	310661	RACF 40	8227	577764	398.65mm	12,000fps	22	ND 1.5		0.4	1	180
3F7Y1	310761	RACF 41	8219	606662	250.80mm	12,000fps	16	ND 1.5		0.4	1	180
3F8Y1	310861	RACF 42	8200	617361	100.80mm	12,000fps	16	29F		0.4	1	180
3F9Y1	310961	RKCF 3	8207	617372	100.74mm	12,000fps	8	ND 1.5-29F		0.5	1	180
3F10Y1	311061	RLCF 78	8209	617368	100.27mm	1,000fps	8	ND 4.0		0.0	12	35
3F11Y1	311161	RACF 43	8210	617369	100.30mm	1,000fps	5.6	ND 1.5		0.0	12	35
3M12Y1	321261	MCF 183	629	422830	12"	96fps	22	#36 #46	15°	57 M	180	
3M13Y1	321361	MCG 166	410	BS1659	75 mm	24fps	11	ND 1.5	15°	0 M	666	
3M14Y1	321461	MLG 38	408	BF4052	35 mm	12fps	2.3	None	170°			
3N15Y1	331561	RMF 70	214	ES1552	63 mm	64fps	11	ND 1.5	15°	0 M	250	
3N16Y1	331661	RMF 69	222	ES 280	25 mm	24fps	22	ND 1.5	15°	0 M	666	
3K17Y1	341761	AMB 21	44-187928	VF279R	610 mm	1/150	16	ND 4.0		0	150	
3K18Y1	341861	AMB 22	44-187870	VF2019R	610 mm	1/150	16	ND 1.5		0	150	
3K19Y1	341961	AMB 23	44-188283	VF1332R	610 mm	1/50	6.0	None		0	150	
3L20Y1	352061	BLA 117	44-162083	VF3140R	508 mm	1/900	32	ND 1.5		0	45	
3L21Y1	352161	BLA 118	44-162393	VF7755R	508 mm	1/900	8	ND 1.5		0	45	
3L22Y1	352261	BLA 119	44-162075	VF2939R	508 mm	1/900	11	None		0	45	
3L23Y1	352361	BLA 120	44-162157	MS7121R	508 mm	1/150	5.6	None		0	45	
3L24Y1	352461	BLA 121	44-161897	MS6489R	508 mm	1/900	32	ND 1.5		0	45	
3L25Y1	352561	BLA 122	44-160035	US1908R	508 mm	1/900	32	ND 1.5		0	45	
3L26Y1	352661	BLA 123	44-160679	US1743R	508 mm	1/900	11	None		0	45	
3L27Y1	352761	BLA 124	44-110595	VF1770R	508 mm	1/150	5.6	None		0	45	
3S28Y1	362861	ALB 37	44-187025	MA1735	154.1 mm	40"/sec	16			0	22	
3029Y1	Details from Brixner, AEC, Los Alamos					480" Slit						
3B30Y1	383061	RMC 568	549902	313212	25 mm	128fps	22	ND 1.5		0	31	

M. THE QUEEN ZEBRA TEST

1. The Test and Results

The Queen Zebra Test was again a full daylight test with flash unit installed in the Zero Tower. Queen-Z was to give a further timing check and to ascertain that all equipment was ready for operation after the moving. Many of the K-24 cameras had had malfunctions corrected in them during the period between Y-Day and Queen Zebra, so that Queen Zebra also gave a good chance to again evaluate the maintenance standing of the cameras. The film from this test was delivered to the AV-4 photo shop for processing. Analyses made of the film showed good definition of the Zero Island and the structures and targets there, thus making available material from which to study the scale. Trouble had been encountered with the Sonne S-7 cameras and their pip markers. At 40" per second the 1,000 cycle pips from the Potter were to close together using the argon gas lights that had been installed in the Sonne by the Photo Tower Unit. A simple RC pip generator was tested on this try and found to be satisfactory at the 120 per second used. In general, fewer malfunctions occurred and the test was predominantly successful. The same system of using Fastax cameras F1, F2, F3, F6, and F7 for a timing check was used again in each tower to check the timing system. It was again demonstrated that the two-tenths of a second put the camera timing essentially where it belonged in relation to the burst. The system worked fairly well, especially with the Coral Head Tower from which the film was readable. It was again confirmed, however, that a system of marking with timing lights would be a distinct advantage.

The need for absolute time marks on the Fastax film was further discussed at this time and a requirement for the construction of a system that would give this type of marking was expressed.

8 May 1948

QUEEN-Z SUMMARY

Tower 1 - Coral Head

Mark	Punch	Serial No.	Camera No.	Lens No.	Focal Lgth.	Speed	Stop	Filter	Shutter	TD Sec.	T Sec.	Fastax Voltage
1F1QZ1	110171	RLCF 70	8204	577766	400.5 mm	12,000fps	5.6	No filters used, daylight test	All shutters open full	0.4	1	180
1F2QZ1	110271	RLCF 79	8190	606661	250.0 mm	12,000fps	4.5			0.5	1	180
1F3QZ1	110371	RLCF 80	8175	617367	100.48 mm	12,000fps	3.5			0.6	1	180
1F4QZ1	110471	RLCF 81	8176	617373	101.0 mm	12,000fps	3.5			0.3	1	180
1F5QZ1	110571	RLCF 82	8177	617376	100.9 mm	12,000fps	3.5			0.35	1	180
1F6QZ1	110671	RACF 44	8205	508332	401.97 mm	7,000fps	5.6			0.0	3.5	80
1F7QZ1	110771	RACF 45	8213	606665	250.25 mm	4,000fps	4.5			58 M	6	50
1F8QZ1	110871	RACF 50	8180	617377	100.83 mm	12,000fps	3.5			0.45	1	180
1F9QZ1	110971	RLCF 83	8183	617365	100.65 mm	12,000fps	3.5			0.50	1	180
1F10QZ1	111071	RLCF 84	8186	617375	100.26 mm	1,000fps	3.5			0.0	12	35
1F11QZ1	111171	RACF 51	8189	617371	100.79 mm	1,000fps	3.5			0.0	12	35
1M12QZ1	121271	MLG 42	672	P-153	450.0 mm	80fps	6.3			57 M	180	
1M13QZ1	121371	MLG 43	406	BF8588	100.0 mm	24fps	11			0 M	666	
1M14QZ1	121471	Not used, no camera										
1N15QZ1	131571	RMF 169	217	ES4473	63 mm	64fps	4			0 M	250	
1N16QZ1	131671	RMF 168	218	ES202	25 mm	24fps	8			0 M	666	
1K17QZ1	141771	ALB 26	44-133467	EE1793	610 mm	1/150	11			0	150	
1K18QZ1	141871	ALB 27	44-188362	EE1656	610 mm	1/150	11			0	150	
1K19QZ1	141971	ALB 29	44-187861	VF7697R	610 mm	1/150	16			0	150	
1L20QZ1	152071	BLA 125	44-35595	VF3001R	508 mm	1/900	8			0	45	
1L21QZ1	152171	BLA 126	42-35550	VF2980R	508 mm	1/900	8			0	45	
1L22QZ1	152271	BLA 160	44-151011	VF7750R	508 mm	1/900	8			0	45	
1L23QZ1	152371	BLA 161	44-151251	VF7778R	508 mm	1/150	11			0	45	
1L24QZ1	152471	BLA 162	44-160108	MO2076R	508 mm	1/900	8			0	45	
1L25QZ1	152571	BLA 163	44-158613	AS2477R	508 mm	1/900	8			0	45	
1L26QZ1	152671	BLA 164	44-160806	VF2975R	508 mm	1/900	8			0	45	
1L27QZ1	Not used, camera malfunction											
1S28QZ1	162871	ALB 43	209	MF224	150.4 mm	40"/sec. 0.480"slit	8			0	22	
1029QZ1	Details from Brixner, AEC, Los Alamos											
1B30QZ1	183071	RMCF 41	549899	313160	25 mm	128fps	6.3			1	31	

8 May 1948

QUEEN-Z SUMMARY

Tower 4 - Aniyaanii

Mark	Punch	Serial No.	Camera No.	Lens No.	Focal Lgth.	Speed	Stop	Filter	Shutter	TD Sec.	T Sec.	Fastax Voltage
4F1QZ1	410171	RLCF 97	8226	508328	400.66 mm	12,000fps	5.6	No filters used, daylight test	All shutters open full	0.2	1	180
4F2QZ1	410271	RLCF 98	8203	606668	249.75 mm	12,000fps	5.6			0.2	1	180
4F3QZ1	410371	RLCF 99	8192	609085		12,000fps	3.5			0.2	1	180
4F4QZ1	410471	RLCF 100	8197	617363	100.71 mm	12,000fps	3.5			0.3	1	180
4F5QZ1	410571	RLCF 101	8198	617378	100.45 mm	12,000fps	3.5			0.3	1	180
4F6QZ1	410671	RACF 52	8227	577764	398.65 mm	4,000fps	5.6			0.0	3	80
4F7QZ1	410771	RACF 53	8219	606662	250.80 mm	4,000fps	5.6			58 M	3	80
4F8QZ1	410871	RACF 54	8200	617361	100.80 mm	12,000fps	3.5			0.4	1	180
4F9QZ1	410971	RLCF 102	8207	617372	100.74 mm	12,000fps	3.5			0.5	1	180
4F10QZ1	411071	RLCF 103	8209	617368	100.27 mm	1,000fps	3.5			0.0	12	35
4F11QZ1	411171	RACF 55	8210	617369	100.30 mm	1,000fps	3.5			0.0	12	35
4M12QZ1	421271	MLG 44	629	422830	12"	96fps	8			57 M	180	
4M13QZ1	421371	MLG 49	410	BS1659	75 mm	24fps	22			0 M	666	
4M14QZ1	421471	MLG 50	408	BF4042	35 mm	12fps	32			0 M	1320	
4N15QZ1	431571	RMF 170	214	ES1552	63 mm	64fps	8			0 M	240	
4N16QZ1	431671	RMF 171	222	ES280	25 mm	24fps	11			0 M	666	
4K17QZ1	441771	ALB 30	44-187928	VF279R	610 mm	1/150	16			0.0	150	
4K18QZ1	441871	ALB 31	44-187870	VF2019R	610 mm	1/150	16			0.0	150	
4K19QZ1	441971	ALB 32	44-188283	VF1332R	610 mm	1/150	16			0.0	150	
4L20QZ1	452071	BLA 127	44-162083	VF3140R	508 mm	1/900	5.6			0.0	45	
4L21QZ1	452171	BLA 128	44-162393	VF7755R	508 mm	1/900	5.6			0.0	45	
4L22QZ1	452271	BLA 129	44-162075	VF2939R	508 mm	1/900	5.6			0.0	45	
4L23QZ1	452371	BLA 130	44-162157	MS7121R	508 mm	1/900	5.6			0.0	45	
4L24QZ1	452471	BLA 157	44-161897	MS6438R	508 mm	1/900	5.6			0.0	45	
4L25QZ1	452571	BLA 158	44-160035	US1908R	508 mm	1/900	5.6			0.0	45	
4L26QZ1	452671	BLA 159	44-160679	US1743R	508 mm	1/900	5.6			0.0	45	
4L27QZ1	Not used, camera malfunction											
4S28QZ1	462871	ALB 44	44-187025	MA1735	154.1 mm	40"/sec. 0.480"width	16			0.0	22	
4029QZ1	Details from Brixner, AEC, Los Alamos											
4B30QZ1	483071	RMCF 44	549902	313212	25 mm	128fps	6.3			0.0	31	

N. THE Z-DAY TEST

1. Changes In Procedure

The Z-Day Test was carried out essentially according to the standard procedure. The loading schedule was compressed as shown in Appendix XXVI. This was done to make less probable a prolonged time of film "stew" in the towers if a delay was encountered. By not moving out until after the 1700 briefing on D-minus-two, there was a much better chance that if a weather delay was to be encountered the information would then be available and the film could be held in the temperature and humidity-controlled vault until the next D-minus-two day.

2. Filters

Filter values were again corrected based upon the results obtained from the Y-Day analyses. The types of filters used are shown on the summary sheet. Some of the filter positions, i.e., the position of mounting the filters on the cameras, were changed to see if the burning of the filters encountered on Y-Day could be reduced or eliminated on the Z-Day Test. The proper placing of the filter is important and must be well considered to prevent burning, wetting, etc. Some of the Y-Day photography shows the results of the filters burning. Some samples of the burned filters are maintained in the Photo Tower books which are currently being stored in Operations Analysis, SAC.

The preparations for Z-Day Test went smoothly and everything was in readiness at least two full days ahead of schedule, even after letting all the men have a day off.

3. Film

The color film had finally arrived for the K-24s. Although it was actually K-20 film, magazines with adapters had been sent at the same time so that the film was useable. The magazines were very old ones in many instances, and several were in poor condition. All of the film had arrived by this time, and a surplus had developed. This surplus was in existence because some of the earlier film requirements could not be met. However, the film for those requirements was now on hand.

4. Evacuation of Equipment

Another aspect of Z-Day that was new was the evacuation of the tower equipment as shown in the section on evacuation. All the tower equipment was removed on Z-Day.

5. Spare Film

It is usually difficult to convince photographers that they must carry spare or emergency film with them. During the X-Day loading, the loading crews took no spare film of any kind with them to the towers even though this had been planned. The standard comment was that there was no need for any, none would be dropped in loading, nor was there any likelihood that anything would go wrong. Those sentiments were almost representative of fact. On the X-Day Test, one Fastax ran away by itself. There was no spare film and it could not be reloaded. On Y-Day loading, it was attempted to load the Fastax cameras at night in one tower and some film was dropped. There was spare Fastax film available this time. There are other things that can (usually do not) but can go wrong. Z-Day was unique. A complete load of spare film was available and ready for each tower, this film to be "standby" in case of spoilage while loading, or in case of a long delay the film could be changed. None of the stand-by film was used, although one of the Mitchells should have been reloaded. The film loaded into it was torn upon loading, but rather than delay the departure of the waiting boat the magazine was not reloaded.

15 May 1948

Z-DAY SUMMARY

Tower 1 - Coral Head

Mark	Punch	Serial No.	Camera No.	Lens No.	Focal Lgth.	Speed	Stop	Filter	Shutter	TD Sec.	T Sec.	Fastax Voltage
1F1Z1	110191	RLCF 116	8204	577766	400.5 mm	12,000fps	16	ND 4.0		0.20	1	180
1F2Z1	110291	RLCF 117	8190	606661	250.0 mm	12,000fps	22	ND 3.0		0.23	1	180
1F3Z1	110391	RLCF 118	8175	617367	100.48 mm	12,000fps	11	ND 4.0		0.25	1	180
1F4Z1	110491	RMCF 33	8176	617373	101.0 mm	12,000fps	16	ND 2.0		0.30	1	180
1F5Z1	110591	RMCF 34	8177	617376	100.9 mm	12,000fps	16	ND 1.5		0.35	1	180
1F6Z1	110691	RACF 49	8205	508332	401.97 mm	12,000fps	11	ND 3.0		0.40	1	180
1F7Z1	110791	RACF 58	8213	606665	250.25 mm	12,000fps	22	ND 2.0		0.43	1	180
1F8Z1	110891	RACF 59	8180	617377	100.83 mm	12,000fps	22	ND 1.5		0.45	1	180
1F9Z1	110991	RKCF 12	8183	617365	100.65 mm	12,000fps	32	29F		0.50	1	180
1F10Z1	111091	RLCF 119	8186	617375	100.26 mm	1,000fps	16	ND 4.0		0.0	12	35
1F11Z1	111191	RACF 60	8189	617371	100.79 mm	1,000fps	11	ND 3.0		0.0	12	35
1M12Z1	121291	MAF 130	672	P153	450 mm	96fps	32	ND 2.0	15°	57 M	180	
1M13Z1	121391	MCG 167	406	BF8588	100 mm	24fps	16	ND 2.0	15°	0 M	666	
1M14Z1	121491	MAG 121	411	BF8173	35 mm	12fps	2.3	None	170°	0 M	1320	
1N15Z1	131591	RMF 172	217	ES4473	63 mm	64fps	11.	ND 3.0	15°	0 M	250	
1N16Z1	131691	RMF 173	218	ES202	25 mm	24fps	11	ND 1.5	15°	0 M	666	
1K17Z1	141791	ALB 33	44-133467	EE1793	610 mm	1/150	16	ND 4.0		0	150	
1K18Z1	141891	ALB 34	44-188362	EE1656	610 mm	1/150	11	ND 2.0		0	150	
1K19Z1	141991	ALB 35	44-187861	VF7697R	610 mm	1/50	6.0	None		0	150	
1L20Z1	152091	BLA 149	42-35595	VF3001R	508 mm	1/900	16	ND 4.0		1	45	
1L21Z1	152191	BLA 150	42-35550	VF2980R	508 mm	1/900	22	ND 2.0		1	45	
1L22Z1	152291	BLA 151	44-151011	VF775CR	508 mm	1/900	8	ND 1.5		1	45	
1L23Z1	152391	BLA 152	44-151251	VF7778R	508 mm	1/150	16	None		1	45	
1L24Z1	152491	BMJ 76	44-160108	MA2076R	508 mm	1/900	16	ND 4.0		1	45	
1L25Z1	152591	BMJ 77	44-158613	AS2477R	508 mm	1/900	22	ND 2.0		1	45	
1L26Z1	152691	BMJ 78	44-160806	VF2976R	508 mm	1/900	8	ND 1.5		1	45	
1L27Z1	152791	BMJ 79	44-88222	VF8763R	508 mm	1/150	16	None		1	45	
1S28Z1	162891	ALB 45	209	MF224	150.4 mm	40"/sec.	16	ND 4.0		1	22	
1O29Z1	Details from Brixner, AEC, Los Alamos											
1B30Z1	183091	RMC 702	549899	313160	25 mm	128fps	11	ND 3.0		1	31	

15 May 1948

Z-DAY SUMMARY

Tower 4 - Aniyaanii

Mark	Punch	Serial No.	Camera No.	Lens No.	Focal Lgth.	Speed	Stop	Filter	Shutter	TD Sec.	T Sec.	Fastax Voltage
4F1Z1	410191	RLCF 105	8226	508328	400.66 mm	12,000fps	11	ND 4.0		0.2	1	180
4F2Z1	410291	RLCF 106	8203	606668	249.75 mm	12,000fps	22	ND 3.0		0.2	1	180
4F3Z1	410391	RLCF 107	8192	609085	100. mm	12,000fps	11	ND 4.0		0.2	1	180
4F4Z1	410491	RMCF 35	8197	617363	100.71 mm	12,000fps	11	ND 3.0		0.3	1	180
4F5Z1	410591	RMCF 36	8198	617378	100.45 mm	12,000fps	32	ND 1.5		0.3	1	180
4F6Z1	410691	RACF 61	8227	577764	398.65 mm	12,000fps	11	ND 3.0		0.4	1	
4F7Z1	410791	RACF 62	8219	606662	250.80 mm	12,000fps	22	ND 3.0		0.4	1	
4F8Z1	410891	RACF 63	8200	617361	100.80 mm	12,000fps	22	ND 1.5		0.4	1	180
4F9Z1	410991	RKCF 13	8207	617372	100.74 mm	12,000fps	22	ND 1.5-29F		0.5	1	180
4F10Z1	411091	RLCF 104	8209	617368	100.27 mm	1,000fps	22	ND 4.0		0.0	12	35
4F11Z1	411191	RACF 64	8210	617369	100.30 mm	1,000fps	11	ND 2.0		0.0	12	35
4M12Z1	421291	MAF 131	629	422830	12"	96fps	22	ND 2.0	#63 15°	57 M	180	
4M13Z1	421391	MAG 122	410	BS1659	75 mm	24fps	16	29F	10°	0 M	666	
4M14Z1	421491	MAG 64	408	BF4052	35 mm	12fps	2.3	None	170°	0 M	1320	
4N15Z1	431591	RMF 174	214	ES1552	63 mm	64fps	11	ND 2.0	15°	0 M	250	
4N16Z1	431691	RMF 175	222	ES 280	25 mm	24fps	11	None	15°	0 M	666	
4K17Z1	441791	AMB 134	44-187928	VF279R	610 mm	1/150	16	ND 4.0		0	150	
4K18Z1	441891	AMB 135	44-187870	VF2019R	610 mm	1/150	11	ND 2.0		0	150	
4K19Z1	441991	AMB 136	44-188283	VF1332R	610 mm	1/50	6.0	None		0	150	
4L20Z1	452091	BLA 153	44-162083	VF3140R	508 mm	1/900	16	ND 3.0		1	45	
4L21Z1	452191	BLA 154	44-162393	VF7755R	508 mm	1/900	11	ND 2.0		1	45	
4L22Z1	452291	BLA 155	44-162075	VF2939R	508 mm	1/900	16	None		1	45	
4L23Z1	452391	BLA 156	44-162157	MS7121R	508 mm	1/150	5.6	None		1	45	
4L24Z1	452491	BMJ 80	44-161897	MS6489R	508 mm	1/900	16	ND 3.0		1	45	
4L25Z1	452591	BMJ 81	44-160035	US1908R	508 mm	1/900	11	ND 2.0		1	45	
4L26Z1	452691	BMJ 82	44-160679	US1743R	508 mm	1/900	16	None		1	45	
4L27Z1	452791	BMJ 83	44-110595	VF1770R	508 mm	1/150	5.6	None		1	45	
4S28Z1	462891	ALB 46	44-187025	MA1735	154.1 mm	40"/sec.	16	ND 2.0	A beam splitter	1	22	
4029Z1	Details from Brixner, AEC, Los Alamos											
4B30Z1	483091	RMC 703	549902	313212	25 mm	128fps	11	ND 4.0		1	31	

O. SUMMARY OF THE COMPLETED TESTS

Of the nine planned tests, eight were completed. Except for the time discrepancy PY and QZ would have been omitted. This demonstrates that training before the operation reduces the field requirement. It is important in tests of this caliber to get the men and equipment into the operation and get the operational procedures smoothed out well in advance of the movement to the field testing site. By the time the preparations had been completed for Z-Day the teams were well indoctrinated and the setting-up procedures for Z-Day were simple and direct with very little confusion. The team work should have been developed in the ZI until the unit could establish itself for X-Day as it did for Z-Day. The following summary shows the sequence and basic reason for each of the eight tests.

QX	Manned	Day		Equipment check
PX	Auto-remote	Night	Flash	Equipment and procedure check
X	Auto-remote	Night	Weapon	Scientific recording
QY	Manned	Day	Flash	Time determination and equipment check
PY	Manned	Night	Flash (failed)	Time determination
Y	Auto-remote	Night	Weapon	Scientific recording
QZ	Manned	Day	Flash	Time determination and equipment check
Z	Auto-remote	Night	Weapon	Scientific recording

III. RECOMMENDATIONS FOR FUTURE TESTS

From the experiences gained on both Crossroads and Sandstone, and in view of the facts presented in this paper, the following recommendations are submitted:

A. POST-TEST FILM STUDY

A post-test film study of all Photo Tower film (some of the Aero and documentary unit films will add to this study), from Sandstone should be accomplished with the aid of the best photo evaluation men and equipment to produce these badly needed answers:

1. Brilliance, Light Intensity and Illumination Vs. Time Curves

The brilliance of the burst and the resulting phenomena in relation to time curve (see Appendix III for an approximation of the pre x-ray thinking) is important because from it may be drawn the necessary information for the appropriate selection of light values and recording speeds for the recording of the desired phenomenon. It is of further interest from an academic standpoint, giving a closer relation between the events and an understanding of them. From the Trinity test data, the Able Day Bikini data, and the three Sandstone tests, five Brilliance-Time Curves could be reduced. This family of curves would then indicate the relationship between various tonnage equivalent bombs and the resultant brilliance in terms of time.

The production of Illumination vs Time curves in a similar manner will have important bearings upon future military utilization of the light emanated during the explosion for bomb strike evaluation and for the determination of the range from an observing point to a detonation.

It is recommended that a thorough study be instituted to use the best available talent and photo evaluation equipment to produce the above-mentioned curves so that future test personnel will have a solid basis from which to commence their studies for the selection of the appropriate equipment and techniques and so that basic information will be available to the military for their planning of the tools for an Atomic war.

2. Establishment Of Requirements For Atom Bomb Test Photography

At the beginning of the Sandstone Project, there was not available a basic document of the photographic problems, limitations, requirements, and possibilities. This made it very difficult to choose wisely the appropriate array of camera types and quantities to cover the test adequately.

It is recommended that a comprehensive study be assembled giving summation of the experience gathered through the testing of atomic weapons to date. This report should include a listing of the types of cameras, their abilities, limitations, and the requirements for improvements of each. This report should also include the various phenomena that are present and the requirements for recording each. The report should then indicate the direction of development of additional techniques and equipment for better testing in the future, and for the coverage of phenomenon not now being recorded.

Notably lacking on the Sandstone Project has been the requirement for spectroscopic recording. This situation should be reviewed and documented so that wise policy may be formulated rapidly in the future. The Sonne S-7 cameras that were used on the Sandstone tests showed some very interesting results. The 'smear' speed of these cameras was so low as to make the prints almost unusable. Much higher film travel speeds are needed. A study with tests should be implemented to determine what techniques could best be used to give adequate smear recording.

3. <u>Establishment of Military Requirements for Combat Atom Bomb Photography</u>

Many of the results photographically gathered during the Sandstone tests are applicable to combat evaluation of atomic strike. The techniques currently in use are, however, not applicable to combat utilization. There are other combat requirements as yet unfulfilled both in the photographic recording and in the reconnaissance field. It is recommended that a comprehensive study be undertaken to evaluate the need for, and the equipment and techniques for the fulfillment of Atomic Bomb warfare reconnaissance.

B. HIGH SPEED CAMERA REQUIREMENT

The currently-used 8mm Fastax cameras have been somewhat unsatisfactory. Their resolution and photographic qualities are poor, their time of operation is short. They have demonstrated, however, that a requirement for a good high-speed camera exists. The camera that is needed should be developed toward these features:

1. Variable speed up to at least 10,000 frames per second.

2. Mitchell quality exposures on at least Mitchell size frames.

3. The equivalent of at least 1,000 feet of Mitchell film.

4. Self correcting light control, to lag light

intensity by not more than 1/1,000 second.

5. Mountable in aircraft upon tracking unit.

6. Camera to be able to run at speed without film being used, film to be started within 1/100th of a second after an electrical signal is introduced into the camera.

7. Camera to be self-braking after initial detonation, so that as light intensity and rapidity of events slow down, slower speed photography is employed, thus prolonging the period of coverage.

8. Reliable, simple method of marking either absolute or relative time upon the negative.

9. Camera to dependably cease all its operations upon depletion of its film.

A camera incorporating these features would be more expensive and certainly more cumbersome, but it would do a fine photographic job that is currently not being well accomplished by five Fastax with their heavy, bulky, and cumbersome time control mechanism.

It is recommended that a comprehensive study be conducted to determine what principles should be utilized in the fulfillment of the foregoing required characteristics. There are several approaches to the fulfillment of each requirement. For example, Wyckoff has utilized the principle of a rotating drum mounting a 20 lens system, with twenty corresponding framing apertures, the light passing in through an individual lens, reflecting back through the framing aperture from a fixed mirror placed within the rotating drum. This camera was satisfactory up to about 1,500 frames per second with two hundred feet of film. Brixner has suggested the use of one hundred foot lengths of 10-inch Aero type film to have exposed upon it multiple tracks formed by a rotating prism system. There are many other principles that have been used for high-speed spark photography. If it is desired to use the 1,000 foot loads of 35mm film, problems of acceleration are encountered. The limiting speed on the Fastax-type camera is the rate at which the supply spool can be accelerated. This difficulty may be overcome by the use of "nested" film, a technique recently conceived and partially demonstrated. The film, instead of unrolling, is nested somewhat as is a surveyor's tape. By proper placement, the film can then be pulled out of the nest at very high speeds without encountering severe accelerative loadings. A light control mechanism can be built using either rotating polaroid screen or variable density filters. By combining a high speed servo system with a photo-electric pickup and amplifier, control of the variable density filter could be maintained within 1/1,000 of a second of the light change. Some recent photographic developments by commercial organizations indicate that a satisfactory unit for doing this may already exist. It is rumored that Kodak has a lens system that will change from f ratio of 0.9 to 22 in 1/10,000 second and is completely self contained.

For use of this camera where the relation between the explosion and the mounting is not fixed, a dependable tracking mount is needed. This is especially needed for aircraft utilization during combat bombing. The camera must be so constructed that it will go onto a convenient mount for either fixed or tracking operation in aircraft. The film 'pick up' requirement for allowing the camera to come up to speed without using film can be built for the 35mm sprocket driven film by one of several methods. Two auxiliary tension guide wheels are added around which the two tapes travel. These tapes prevent the film from leaving the face of the recording drum due to centrifugal action. They also act as a clutch to start the film when the starting pawl advances to the leading end of the film into the V between the tapes and the drum. If the friction to bind the film to the drum is not great enough to prevent creepage of the film in relation to the framing apertures in the drum, then sprocket drive teeth may be added. These would be held retracted until after the film slippage had ceased at which time they would be released. The sprocket teeth would move out against the film and then move forward in the direction of rotation the equivalent of one frame. Somewhere along this motion, they would engage the sprocket hole in the film and move it forward and from then on, the film would be sprocket driven in exact relation to the framing aperture. With careful design and construction, this entire action for the Wyckoff-type camera could be accomplished in less than the time specified.

For atomic explosion photography it is important to have very high speeds during the initial explosion only. During the later stages when the light emission is much lower, the rate of development of the phenomenon is much slower. The addition of proper magnetic braking to the camera would allow the camera action to be slowed during the later stages thus prolonging both the times of exposure and the length of film coverage. The current method of time pip marking the Fastax cameras is acceptable for the limited uses being made of them at present. The method of marking the Mitchells is less satisfactory. To make the really exacting studies that will be required in the future, a system of adding absolute time marks to film is needed. This is not a complex problem if studies are instituted early enough to allow orderly development of the system. Absolute time marking allows comparisons between various recordings on a single basic time comparison. This relates phenomena exactly. All remotely operated recording cameras should have built into them devices that reliably close down all the functions of the camera at depletion of the film. This saves the great amount of complicated timing equipment that has had to be built and maintained for Sandstone tests because the cameras do not possess the simple type mechanisms that can be incorporated within them to accomplish this function.

C. PHOTO TOWER IMPROVEMENTS

While the photography taken from the Photo Towers on the Sandstone project has been quite successful, the basic concepts of equipment for the accomplishment of this mission have been notably lacking in understanding of field test problems. The basic approach has been one of laboratory test and development. This places a great burden in effort and time on the actual field operation and reduces the reliability of equipment operation. To improve this situation for future field test, the following recommendations are offered. In addition, it is again pointed out that there was on this test a great deal of basically good military and scientific information to be photo recorded during the blast at other than zero tower camera alignments.

1. Tower Positioning

The Sandstone Photographic Towers were placed in their postions from other than strictly technical photographic requirements. The towers as placed did inconveniently gather the basically required data, that of determining bomb detonation efficiency with the Fastax cameras. A great deal of good and necessary information could have been much more advantageously gathered had this test had the ability to place photo recording units at more and closer positions. Small, compact, prefabricated, rapidly-establishable, easily-maintained, radio-controlled units make it relatively simple to place several units at varying distances. Studies of the Trinity, Crossroads and Sandstone tests will demonstrate that units may be placed at relatively close positions without suffering physical or radiation damage if these units are properly prepared. It is suggested that units could have been placed as close as 1,000 yards, with proper shielding, or at 3,000 yards with no shielding. A series of units placed at approximately one-half, one, and two miles would have produced great advantages in comparison with the five-to-seven-mile spacing of Sandstone. One of the most important advantages is the lessened probability of weather interference. A great deal of coverage was lost on X-ray detonation due to intervening clouds and rain. Another advantage is that of shorter focal length lenses, which make it possible to get more reliable coverage without the increased susceptibility to vibration, misalignment, shock motion, atmospheric refractions, focus difficulties, and a host of other minor susceptibilities. Placing the units closer to the zero point also makes the photo recording of the effects of the radiation and blast upon natural and test objects effective and valuable. Simple stations may be anchored in the lagoon if necessary. To prevent the wave motion from causing misalignment, one of two approaches may be followed. A triangular anchoring of a submerged float with pedestal may be used. By holding the buoyant structure below the average wave motion level with at least three anchor cables under tension, a relatively low structure may be maintained in good alignment. Or a simple guyed pedestal may be easily established upon which the simple photo unit could be installed. The photo cab envisioned for this type of mounting would be hermetically sealed unit containing from three to ten cameras which are battery powered and timed with the simple timing unit later discussed. The units could have dimensions in the order of six feet wide, four feet deep and four feet high.

Dispersion of the recording sites adds the ability to obtain stereo photography, and analysis in depth. It also makes possible more views from which to determine such things as the degree of lack of symmetry of the explosion and the resulting shock waves.

2. <u>The Simple Tower</u>

The type of tower utilized for the Automatic Photo Recording for Sandstone could be developed into a fairly satisfactory type of tower by the addition of a high level platform, a useable elevator, good visor, and a few other detail changes. The great expense in time, labor and money involved in the construction and transportation of this type precludes the utilization of many of them on a single test.

The tower type that is needed is one that can be rapidly established with a minimum of time and effort, and with a minimum of preparation of the site. The solution of this lies in a simple sectionalized vertical supporting structure upon which a cab containing all of the cameras and timing equipment can easily be hoisted. Appendix XVIII gives the details of two types of towers that could be advantageously used. Appendix XIX gives details of a cab that would fulfill these requirements. In action, the system would follow these lines: a truck containing the entire setup for a single tower would be off-loaded from the central station (ship, aircraft, or island) onto an LCM or similar type boat. This LCM would deposit the truck on an island or tie up to the floating base or water foundation. In the case of the island, the truck would unload the tower frame in the appropriate sequence of assembly. The tower would then be assembled flat on the ground and hoisted into place with the winch mounted upon the truck. If of the biped type, the tower would be secured by cables which are tightened completing the erection. The truck would then back up to the base of the tower, attach the top hoisting lug of the photo cab to the hoisting cable and lift the cab into position on the track built onto the face of the tower. The truck would then be driven out from under the cab, but left attached so that the winch may be used to elevate the cab. The cameras and timing equipment in the cab can then be given a final check and alignment after which the cab is hoisted to the top of the tower and the cab aligned with the target. Because the cab, timing and power systems are complete, the operation is complete and the area ready for evacuation.

By powering all of the equipment in the cab with batteries, no power stand-by unit complications arise. Simple type

D.C. generators may be used to recharge the batteries. By this method, all major potential losses in cables are eliminated, establishing time is reduced, and reliability is increased.

Because the cab may be insulated, hermetically sealed and dehumidified, no deterioration of film or equipment occurs in hot humid climates and the cab may be heated in cold climates.

The very complicated time control circuit that was used on Sandstone is strictly laboratory type and requires a great deal of maintenance to guarantee reasonable probability of operation. A much simpler system based upon a series of cams mounted upon a single shaft is described in Appendix XXIX. This system is designed to be a reliable field test system, making use of camera shut down upon film exhaustion in each camera and cam-contact type starting. The system employs a synchronous motor drive controlled by a tuning fork or crystal controlled clock, the motor being clutched to the cam system by a splined shaft controlled by the central timing center.

By incorporating the ability to ship the entire tower equipment as a unit from the ZI, slightly greater ZI cost is encountered, but the field cost in time, effort and manpower is very greatly reduced. By use of such things as built in telescopes for alignment, optical "Twindows," standard cab for many units, built-in test panel and instrumentation, and other items as described in Appendix XII, the time required for the field installation is so greatly reduced that the overall cost of an operation would be materially lessened. The probability of reliable operation is greatly increased.

3. The Time Control Unit

The Sandstone tests were conducted using submarine cables radiating from a central timing station to each of the units to receive a timing pulse. The expense involved and the time required in this system preclude the utilization of many small stations conveniently placed. The system also has severe limitations in combat operations where units may have to be placed in drone controlled vehicles. Appendix XXX discusses several electronic possibilities that make use of either VHF Frequency Modulation or Radar techniques to supply the needed timing control. By using either a dual channel system, or one with two tones on a single channel, or a combination of these two systems, a control network may be produced wherein a continuous signal holds a relay in the 'safe' position. Another continuous signal can only start the action after the first signal has been stopped. The time between the cessation of the first signal and the commencement of the second signal may be made very small, less than one-one-hundredth of a second. The action can not then be started unless the first signal is interrupted and the second signal started within the very short time interval designed into the equipment. Because no natural or man-made signal can interfere with the first signal, the equipment cannot be timed too early. If equipment failure causes the first signal to cease, the second signal must start within the very short time interval or the time unit will not operate. The probability that this will accidentally happen is very remote especially where the VHF Frequency modulated system is used as there are no FM static sources in nature and the few man made ones must occur in an exact sequence. If greater reliability is needed, two tone channels on each of two carriers may be employed to operate two independent systems in parallel. Directional antenna add even greater reliability.

IV. CONCLUSIONS

From experience on Crossroads with the Air Unit, with Sandstone as Director of Tower Photography, and from the foregoing presented information, it is concluded that:

A. ADVANCE PLANNING

While the Photo Tower Mission was a success and the plan under which this mission was established was adequate considering the time allotted and the procurement difficulties encountered, the mission could have operated at a greatly-reduced cost in time and manpower had adequate time and planning been done in advance of the actual commencement of the project. The stockpiling of prototype equipment, the development of ideas and equipment, and the analysis of the things that would best come out of any anticipated test during the periods between tests would greatly enhance the value of the tests and would reduce the cost to accomplish the total mission.

B. TRANSPORTATION

While the transportation system to the theater did eventually transport most of the Photo Tower equipment and personnel to the appropriate final destination, that system nearly caused the failure of the Photo Tower Mission on the X-ray test because of the very slow manner in which the men and equipment were delivered. The transportation system to a theater of operation must be dependable both as to getting the shipped items to the proper destination and in anticipating the schedule that the system can make good. A guaranteed schedule not made good is far worse than an unguaranteed delivery system in which an anticipated delay occurs.

C. PREPARATION TIME

Preparation time must be increased, thus decreasing field time and increasing the probability of reliable operation.

D. COLLABORATION OF THE MILITARY AND SCIENTIFIC

Much greater value to the United States would result from combined military and scientific studies carried out to recommend the manner in which tests of the Sandstone nature may be utilized for testing of the other tools of combat in addition to the weapon being tested. The reconnaissance aspects not exploited in the last two tests are good examples of this. These studies should tabulate the complete needs for the test and from these studies, prototype equipment should be assembled; from these, lists should be produced from which complete equipment may be rapidly procured and assembled.

E. TRANSPORTATION AND COMMUNICATION AT THE SITE

Transportation and communications at the site of the test are of greatest importance. Sandstone demonstrated very clearly the need for small aircraft travel, the difficulties encountered in scheduling and operating. The system demonstrated further that the need had not been as well anticipated as it should have been. Completely adequate local air and surface transportation is an absolute must if a complex job of the Photo Tower type is to be successfully accomplished without undue time delays and expense. Communications that work are of great importance. The time wasted with unreliable communications not only slows the operation but very greatly taxes the patience and tends to destroy the aggressive approacn of many of the men.

APPENDICES FOR

PRELIMINARY REPORT OF

SANDSTONE PHOTOGRAPHY

APPENDICES I through XXX

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APPENDIX I

PHOTO TOWER PHYSICAL RELATIONS

1. Photo Towers Used

Four photo towers were used to support and house the photographic equipment used for the three Sandstone Tests: X, Y, and Z. The Coral Head (also termed Reef, Shoal, Lagoon) Photo Tower was used on each test while each of the other towers were used but once:

Test	Photo Towers Used		Facing Zero Tower On:
X	Coral Head	Aomon	Engebi
Y	Coral Head	Runit	Aomon
Z	Coral Head	Aniyaanii	Runit

The cabs of the Aomon, Runit, and Aniyaanii Towers were installed with their apertures facing the X, Y, and Z Zero Towers respectively. Because the cab of the Coral Head Tower was not rotatable, it was necessary to make two "faces" in this cab, a North face aligned toward the X Zero Tower on Engebi, and an East face aligned approximately toward the Z Zero Tower on Runit. The North face alone was used for the X test, the East face for the Z day test, while both faces were used for the Y day test with the camera equipment set diagonally in relation to the faces instead of perpendicularly.

2. Surveyed Relations

Figure I-A, Surveyed Relations, shows the surveyed relations between the established reference points of the test sites. Notice that the Coral survey station is not the Coral Head (Reef) Photo Tower; that the Elgin, Graflex, N. Base, Runit, Sand, and Aniyaanii markers are not either zero nor photo tower sites but are permanent bench marks. For exact relations existing upon the islands refer to Los Alamos, J-Division maps:

MJ 3201 D

MJ 3301 D

MJ 3401 D

which may be tied together by map

MJ 3606.

These maps give the distances and azimuths of all important positions including the photo range poles.

3. Photo Tower Relations

Figure I-B, Photo Tower Relations, is a simplified map showing the center lines of the camera alignments from each of the towers for each of the three tests. The arrows indicate the direction of view of the cameras: the X, Y, and Z indicating the tests to which the arrows apply. The termination point of the arrowed lines represents only the approximate positions of the Zero Towers.

4. <u>Table of Data</u>

Table I, Surveyed Data, gives the exact survey data as derived by the USN survey of 1944; expanded and corrected by the U.S. Army Engineers in 1947. J Division, Los Alamos Scientific Laboratory, Los Alamos, New Mexico can supply additional information on the surveys. The azimuth data is South Azimuth, i.e., the readings are given in a clockwise direction from true South, as shown by the circular arrow in Figure I-A.

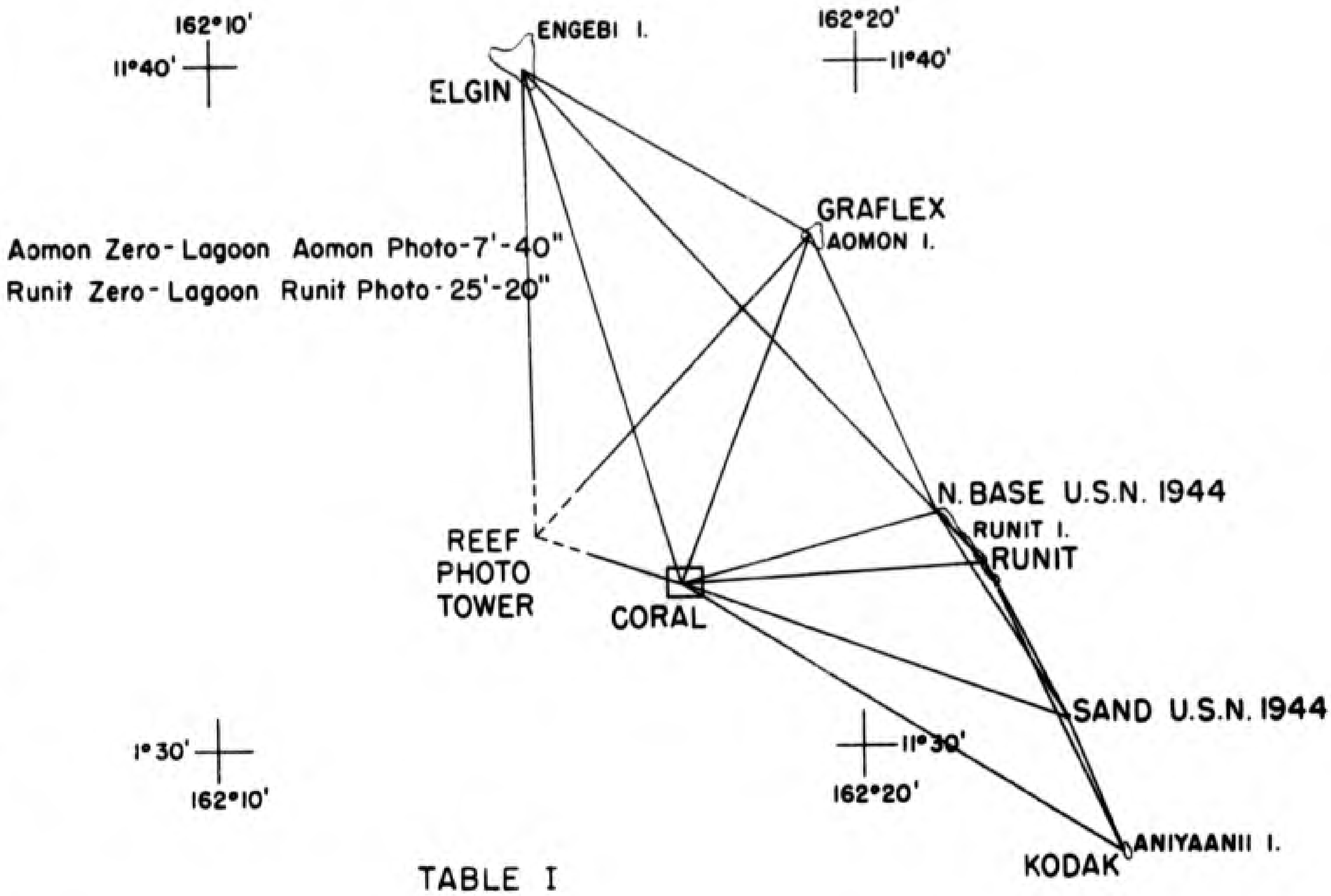


TABLE I
LEGEND

AZIMUTH					DISTANCE IN FEET
FROM	TO	°	'	"	
NO. BASE U.S.N. 1944	SAND U.S.N. 1944	327	56	52.40	
SAND U.S.N. 1944	NO. BASE U.S.N. 1944	147	57	15.78	21,917.0
CORAL	NO. BASE U.S.N. 1944	255	01	25.04	24,589.7
"	SAND U.S.N. 1944	289	02	52.95	37,440.0
RUNIT	CORAL	90	50	32.70	28,901.9
"	NO. BASE U.S.N. 1944	142	47	27.46	8,503.818
KODAK	CORAL	120	56	28.70	47,268.1
"	RUNIT	154	00	12.79	26,562.8
GRAFLEX	NO. BASE U.S.N. 1944	335	23	28.37	27,529.9
"	CORAL	21	23	21.18	33,702.3
ELGIN	GRAFLEX	297	00	43.32	26,972.4
"	CORAL	343	08	00.30	46,530.1
REEF PHOTO TOWER	ELGIN	180	09	04.00	40,715
" " "	CORAL	285	39	19.73	14,132.2
REEF PHOTO TOWER	RUNIT ZERO TOWER	266	31	08.64	38,043.2
" " "	AOMON " "	223	22	17.41	37,274.9
" " "	ENGEBI " "	176	16	49.13	43,608.6
ANIYAANI " "	RUNIT " "	151	58	51.18	34,516.3
RUNIT " "	AOMON " "	154	09	19.38	27,263.8
AOMON " "	ENGEBI " "	118	55	49.96	32,891.2

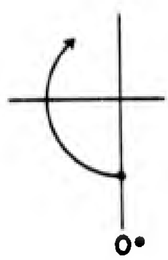


FIG. Ia. SURVEYED RELATIONS

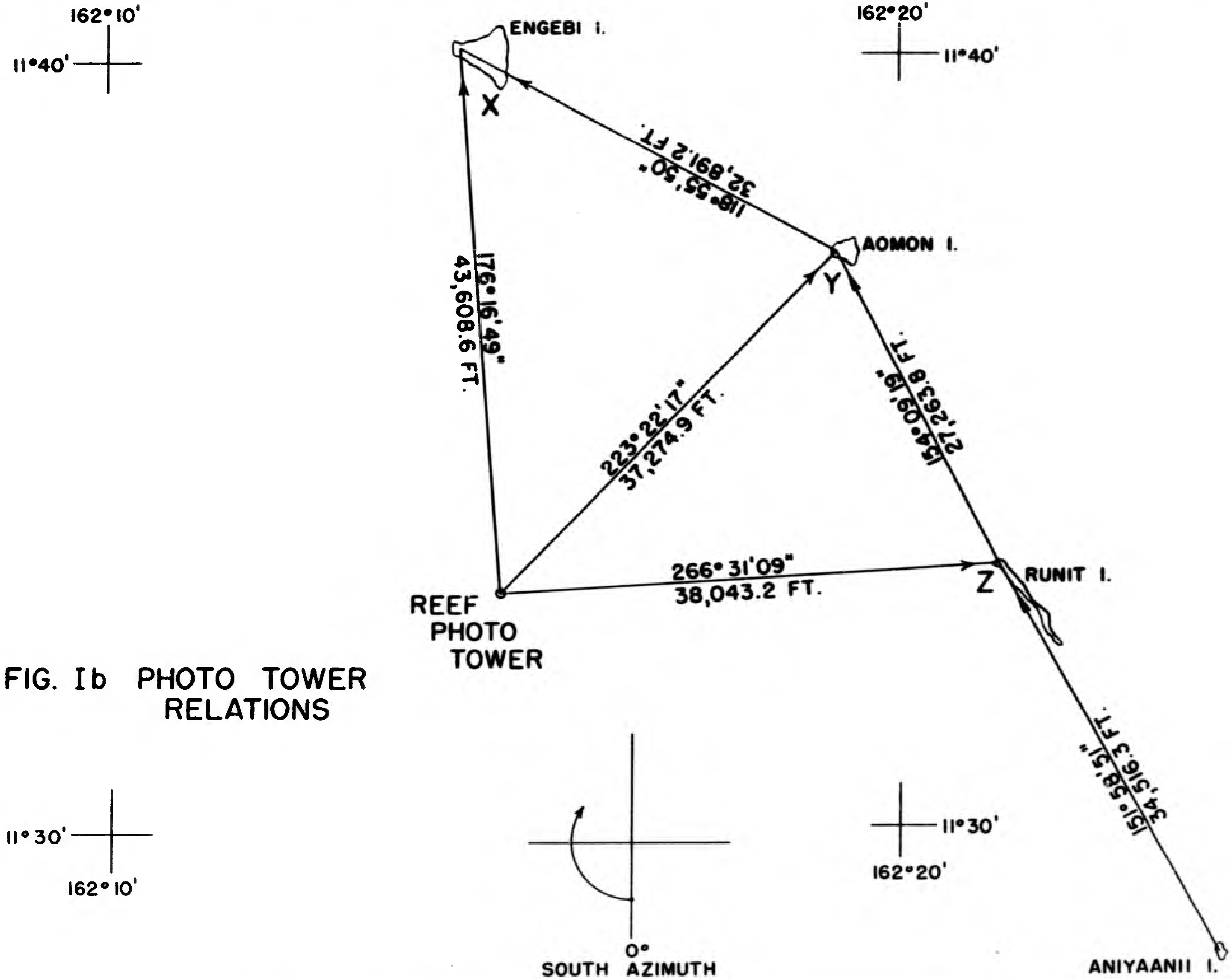


FIG. Ib PHOTO TOWER RELATIONS

APPENDIX II

DESCRIPTION OF THE PHOTO TOWERS

1. Complete Description

A complete engineering description of the Navy-Radar type towers used for the photo towers is on file with J-Division, Los Alamos Scientific Laboratory, Los Alamos, New Mexico.

2. Brief Description

Briefly, the four towers consisted of angle iron supporting construction seventy-five feet tall, upon which were mounted sheet metal covered cabs of 12 X 12 X 8 foot external dimensions. The steel was mounted upon four concrete pedestal foundations. Steel framed windows were mounted in each side with a 2 X 10 foot aperture in the side facing the Zero Tower. A stairway was supplied which wound around inside and outside of the tower framework, terminating on an external platform by the single metal door. A hand operated winch-activated-"dumb-waiter" type of elevator running between channel rails was supplied. The upper terminus of the dumb-waiter was a trap door in the floor of the cab. The Coral Head Tower was set upon a plank platform mounted on concrete clad steel channels.

Adjacent to the tower foundations was a power house built upon a smaller but similar type platform. The Coral Head Tower had a 2 x 10 foot aperture added to its East face in addition to the standard aperture in the North face.

3. Elevator Inadequacies

So many things were wrong with the Coral Head Tower elevator that the majority of the equipment was carried up the steep narrow stairway. Neither the contracting agency which erected the tower nor the Army Engineers accepting the structure tried to elevate the dumb-waiter platform. The first attempt to operate the elevator by the tower crew resulted in the jamming of the elevator close to the top. Inspection showed that the rail supporting brackets at the top were installed backwards, thus bending the guide rails inward. The body of the report summarizes other characteristics found on all elevators. The concept, design, and installation of these lifts were entirely inadequate.

4. Coral Head Tower Offloading Facilities

No suitable landing and offloading facilities were supplied with the Coral Head Tower facilities. Upon complaint from the Director of Tower Photography, the Army Engineers built an unsatisfactory crane to be operated by men pulling on a rope while standing on a narrow catwalk.

The compression arm of the crane was so low that the loads on the bottom block of the block and tackle suspended under the compression arm would not lift the loads above the catwalk with the result that all of the larger objects had to be wrestled onto the power house catwalk, then rolled or carried down the steps onto the tower base platform. The request for an offloading float was turned down for various mysterious and inadequate reasons. A near water level catwalk was later added. This was an improvement but still was not adequate, especially from a safety standpoint. It is emphasized that unloading from a bouncing LCM is dangerous at best.

5. <u>Pictorial Demonstration</u>

The following pictures with comments amplify the foregoing discussion.

PA-52-5668-1 This shows a general view of the Aniyaanii Tower which is similar to the other towers. The truck is backed up to the elevator bottom landing, the two guide rails of the elevator system and the lift cables shown rising behind the truck. The four visible cables to the right and left of the tower are catenaries added to the tower design by the Army Engineers to reduce tower sway in the event of a high wind. The cables were left loose by the tower crews to prevent the possibility of a high frequency vibration which might develop because of the elasticity of the cables. The face of the cab shows the 2' x 10' opening used as a camera aperture, the removed window opening also used, and the two small holes which were cut into the sheet metal front to allow rigging the curtain to the front of the cab. The curtain has not yet been installed. The storage shed is behind the truck. The tarp on the lower girders is for rain protection and a sunshade.

PA-52-5675-8 General view of the Aniyaanii Tower site before the tower photo crew arrived. This shows the ground conditions which give rise to blowing sand and dust, the catenaries to the four corners of the tower.

PA-202-7363-12 This is the Aniyaanii diesel power shed with the two diesels installed. No gasoline 28V units were used in this installation because of the failure of those units to arrive.

PL-440-7058-11 The Aniyaanii beach landing for LCM and lighter craft. The steel matting is for the trucks.

PL-440-7057-10 The only Sandstone installation on Aniyaanii was the Photo Tower. A shipping marker shows in the extreme left of the picture. The unbroken palm forest prevented wind circulation on the ground which made for uncomfortable temperatures. A living platform was eventually built above the tree level.

PA-202-7257-6 General view of the Coral Head Photo Tower showing the power house on the right with the boom from the crane rotated across the doorway. The barrels are residing on the upper catwalk. Just above the water level and under the upper catwalk, is the unloading catwalk with the steps leading to the tower lower platform. Immediately above the DO NOT LAND sign is the elevator winch placed in a very convenient position for pushing the operating personnel into the shark infested lagoon. The picture is taken of the western face of the tower. The canvas is the storage area in which the men often spend nights rather than to make the long time-consuming trip to Runit and return.

PL-424-4421-2 A view showing the southern and eastern faces of the Coral Head Tower. The eastern face still has the original metal door in the 2' x 10' aperture. This door was removed when the curtain was installed. Notice the ventilators in the rear of the power house. The radio antenna is protruding above the cab roof. The elevator rails show on the left side of the tower.

PL-313-2739-3 This aerial view of the eastern face shows the type of roof construction of the cab on the Coral Head Tower.

PL-84-2210-2 Two LCMs butting the Coral Head Tower landing. LCMs tied up for unloading continually pounded the tower foundations and caused wavering of the tower.

PL-424-4424-5 The Coral Head Tower with the north face curtain in place. A lightning grounding cable is visible on the top front of the cab roof.

PL-563-5361-6 A "tepee" was added to the cab for the Y-test. This was to be jetisoned after a radio-active fall-out, thus removing any hazard while the tower was made ready for the Z-test. No fall-out was measured. The elevator platform is visible just below the cab floor level as it rises into the cab. The man on the lower platform is fishing for shark. Shows also the crane and catwalks.

PA-203-7267-4 The very poorly designed and installed "tepee" flapped in the breeze and soon cut through at the corners. It was made from a tent, just "rigged", not fashion fitted to the cab. In addition to preventing cooling circulation through the cab while men were working, it created eddy currents and may have created more hazard than was inherent in the original cab.

PA-202-7256-5 The inadequate crane, the catwalks, sharp edged boat tie-up cleats, and the old winch (left) with the new winch (right) for the elevator show in this close-up of the Coral Head Tower landing facilities.

PL-563-5365-10 Landings at the Coral Head Tower were always interesting and hazardous. This was after the water level landing was built. Before, a flying leap onto the steel ladder was the only way.

PL-563-5364-9 A worried and wetted photographer prepares to go aboard a small craft.

PL-440-7051-4   The Coral Head Tower group visits Runit Island Tower. Navy Lt. Robert L. Warner (right) made an outstanding contribution to the photo tower operation. Air Force CWO Lloyd Davis (left) was another very valuable man.

PL-561-5343-12 Scale relations are shown between the Photo Tower and the Zero Tower on Aomon. The photo range marker boards show against the palms in the extreme right. These palms which were destroyed by the Y-day test should have been used for an infra-red test to determine the ability to detect damage in treed areas.

PL-571-5451-12 The Aomon range marker shows between the Zero Tower and the abandoned Photo Tower. Two more range markers were installed on Bijiiri Island. The original marker pole, the taller one on the right side of the board could not be resolved by the cameras from the photo towers. The pole on the left was then added and the planks nailed on. The poles were set so that the perpendicular to the plane of the boards would bisect the angle formed by the lines of view from the board to the Zero Tower and to the Coral Head Tower. Thus, the face of the board was illuminated by the detonation giving maximum light transfer from the detonation to the cameras. Three of these boards were put up for each detonation. Unless otherwise specified, range measurements from the center line of the Zero Tower to the marker will be the straight line distance from the Zero Tower center line to the center of the range pole on the right (the taller one, farther from the Zero Tower in each instance). Very interesting results were obtained by the impact of the detonations on the range poles and boards. See a detailed damage account in results of test.

PA-199-5 The tall pole to the right was originally set as a Photo Tower range marker. It was later decided that a greater area should be presented to the cameras to aid in resolution. The left pole and the cross boards were then added. The boards were added on the backs of the poles, the front sides then being painted.

PL-315-2760-12 An aerial view of the Zero and Photo Towers on Runit, showing the landing facilities and road network.

PL-84-2214-6 Loading the first load onto the Coral Head Tower elevator. Notice the K-24 camera racks in the foreground.

PL-84-2215-7 The first load starts up on the Coral Head Tower elevator. Notice that the point of support of the elevator is well below the center of gravity and displaced horizontally away from the center line of thrust. The resulting torque tends to rotate the elevator. The unevenness in the guide rails also cause a lateral twisting, which tends to bend the wheel brackets. This load failed to arrive at the top, the platform becoming stuck. The remainder of the equipment was carried up the stairway.

PL-440-7050-3 The Runit elevator was repaired and became quite useful. A heavy load is being taken up while careful supervision is given from the top landing.

PL-85-2874-6 Notice the man on the steelwork watching the wheels of the elevator as a power hoisted load goes slowly up. The weapons carrier at the right is using its winch to hoist the load.

PL-85-2873-5 A load on the Aomon elevator ready to go up. The cable sliding around the winch drum cut grooves into it.

PL-440-7048-1 The weapons carrier hoists a load on Runit. The men soon learned that standing under the tower during lifting operations was a sure way to go home, in the horizontal. Sometimes the surface was not so soft and the cable was hooked to the bumper of the vehicle so that the platform was elevated by backing the truck. This method was especially good for lowering the equipment.

PA-203-7270-7 This load going up on Aniyaanii shows the trap door in the floor of the cab already open. Curved rails on the elevator were designed to open the trap door but because the curved rail first made contact with the trap door close to the hinge line of the door, very high loadings on the elevator resulted. The door was usually manually opened before the arrival of the platform.

PA-52-5672-5 Two of the Fastax time control panels are loaded onto the Aniyaanii elevator. The O'Brien type camera is on the ground to the right.

PL-440-7052-5 The Fastax camera cases are carefully tied to the elevator. This saved several loads of equipment from being dumped. One load of Fastax cameras was dumped, none were damaged as the safety tarp in the background caught all but one which only smashed its case.

PL-440-7049-2 Unloading directly from the weapons carrier onto the elevator saves effort. The block saved the cable from cutting up the hoisting drum. Good blocks must be used or the cable will spread the faces and cut between the pulley and the face.

PA-202-7252-1 A bolt shank was welded onto the elevator frame so that the elevator could not turn over when it jumped the track. It was still wise to tie the load to the platform to prevent sudden motions from spilling things.

APPENDIX III

BRIGHTNESS VS. TIME

1. Source of Curves

The following curves of brightness plotted against time were obtained from the Los Alamos scientists (especially B. Brixner) as the best available pre-X-data. The scientists used measured values from the Trinity and Able day tests modified by technical considerations of the X-ray weapon to produce what they considered to be a fair guess.

2. Scales

The brightness scale is the log, of the brightness in relation to the sun's brightness which is taken as 160,000 candles/cm^2, or 1.5 X 10^8 candles/ft.^{2}. The time scale is the log of the time in seconds. The antilog of the scale reading will give the values in brightness relative to the sun, or time in seconds.

3. Atmospheric Correction

The upper curve of the first set of curves is the zero range or vacuum curve. The lower curve is corrected for an average clear Mid-Pacific day based on a transmission factor of 80 per cent per mile for six nautical slant range miles. This figure was obtained from Dr. Brian O'Brien, University of Rochester. The lower curve is approximately 26 per cent of the upper curve.

4. Filter Selection

The curves to the right show the light latitude of the color and black and white films used. The vertical distance between the two outside lines shows the total normally useable latitude of the film. When using the center line as the exposure setting, the upper line gives the maximum light that the film will record, while the lower line shows the minimum light. The horizontal projection of vertical latitude gives the band of light that will be recorded from the detonation of a bomb with the characteristics shown by the Brightness Curve. The intersection of the band of light with the Brightness Curve gives the time, or section of curve, over which the film will record. Filters are chosen for the various cameras to slide the bands up or down until all times will be recorded. The block of horizontal lines shows the designed cut-off time of each of the cameras installed in the towers. Thus, the time coverage may be figured from the center line of the latitude curves and the cut-off of the individual cameras.

5. X-Day Confirmation

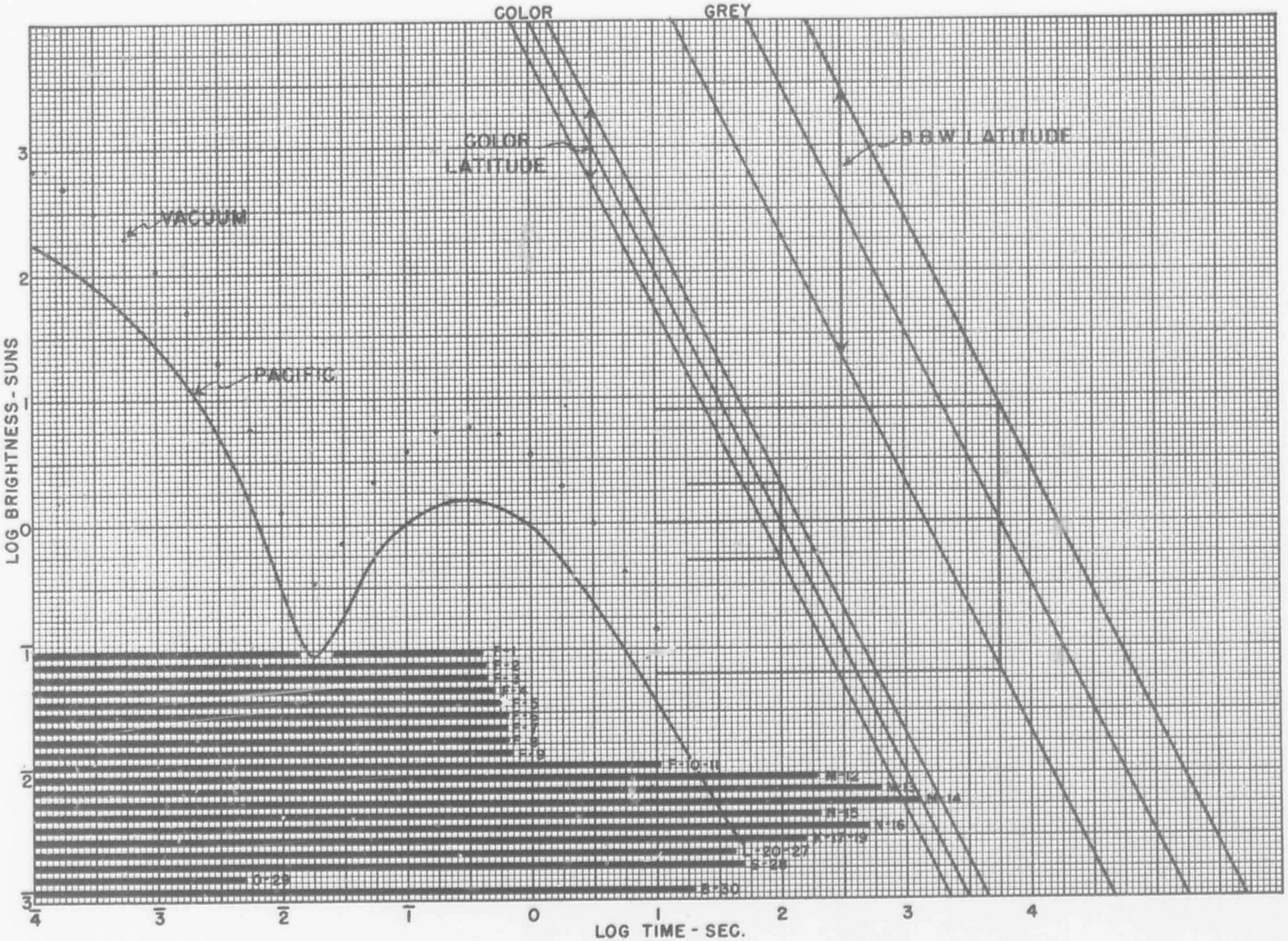
The filters for the Photo Tower cameras for X-Day were calculated from these curves. Preliminary examination of the film indicates that the highest brilliance was nearer to 1000 suns than to the 400 as anticipated. Actually, this made little difference in view of the method by which the filters overlapped.

6. Plotting of Results

It is suggested that careful measurement of the Trinity, Able, X, Y, and Z test films would lead to data from which very interesting relations might be derived. It might be possible to relate the time required for the brightness to drop to the first minimum to the equivalent tonnage of the weapon. If this were possible, it might lead to a simple combat method of determining the efficiency of explosion of the weapon. The relative areas beneath the curves might also give significant hints, as might also the changing natures of the curves.

7. Future Measurements.

It is suggested that various direct recording methods to rapidly measure and record the brilliance phenomena should be developed for utilization in subsequent tests and that these be considered for development as combat weapons. If the illumination curves derived using atomic weapons as the source of illumination show the same general characteristics as the Brilliance Curves, then simple photo-electric pick-up and electronic recording devices in the bomb carrying aircraft will be able to immediately give a good determination of weapon efficiency.


COLOR
GREY
COLOR LATITUDE
B&W LATITUDE
VACUUM
PACIFIC
F-10-11
M-12
M-14
M-15
M-16
M-17-19
I-20-27
S-28
O-29
S-30
LOG BRIGHTNESS - SUNS
LOG TIME - SEC.

APPENDIX IV

CAMERA SELECTION

1. Original Plan

The following extract is taken from the "Photo Tower Bible" and is the thinking upon which the cameras for the towers were selected:

CAMERA UTILIZATION AND JUSTIFICATION

FASTAX SERIES

PRIMARY BRACKET

Three Fastax Cameras F-1, 2, 3, constitute the basic sequence to record phenomenology. The times of start of the individual cameras in this block are set close together and ahead of zero time far enough that the cameras will be above 9,000 frames per second at zero time. These cameras continue to accelerate until they run out of film at which time they will be running approximately 12,000 frames per second. F-1 with a 15" lens is to record minute details of the initial phenomena. F-2, with the 10" lens is to record the initial phenomenon on a less detailed basis and over a longer period of time as the phenomena grows out of the frame size of the 15" lens. F-3, with the 4" lens is to record the initial phenomena on an even less detailed scale and over an even larger area. The millisecond time marks on each Fastax film will relate all films to the initial phenomena and show the relation between the various details as expanded in the various focal length lenses.

COLOR BRACKET

Two Fastax cameras F-4 and 5 with 4" lenses are included to record the primary phenomenology in color. These cameras are started next in time sequence to the primary bracket and are thus running slightly slower at zero time, but continue to operate for a longer time after zero.

SECONDARY BRACKET

Cameras F-6, 7, and 8, are included to assure adequate Fastax coverage in case of time, mechanical or electrical malfunctions of the primary bracket. These cameras repeat the operations of the primary bank starting 0.2 seconds after the primary. This allows adequate coverage of the basic phenomena in case that the time signal is off in time as much as 0.3 seconds. If the time signal is correct, this bracket gives additional pictures which will be valuable for statistical analyses.

INFRA-RED BRACKET

Fastax F-9 is included to record the primary phenomena, and the start of the nitrogen fire, in infra-red. This will demonstrate the utility of infra-red recording under this type of test and may also give superior results if the atmospheric conditions are unfavorable to conventional recording.

LONG TIME BRACKETS

Fastax cameras F-10 and 11 equipped with 4" lenses are slow running cameras included to show the growth of the phenomena over a relatively long period of time and are set to include the entire useful light period.

MOVIE SERIES

The movie series M-12, 13, 14, 15, and 16 include a high speed 35mm Mitchell, two standard 35mm Mitchells, and two 16mm Maurers. The high speed Mitchell is included to record the basic phenomenology and to supply high speed documentary coverage of the primary and secondary phenomena. The low speed Mitchells are included to cover the secondary documentary phenomena over a continuing period which includes all of the usable light. The 16mm Maurers are included to cover the secondary phases of the documentary phenomena in color. One of these is high speed (64 fps), and the other, standard (24 fps).

REPETITIVE STILL SERIES

K-18 CYCLED

Three K-18 cameras K-17, 18, 19 are included. These cameras are cycled so that each camera takes one exposure every three seconds and the bank takes one every second. The cameras are included to produce large negative areas for precise shock wave measurements, water reaction studies, and for documentary purposes. The bank in tower #1 will be loaded with black and white while the bank in #2 will be loaded with color, the color being of primary documentary value.

K-24 CYCLED

Two banks each of four K-24 cameras K-20 thru 27 are included. Each bank is cycled to give one exposure every 1/10th second, each camera operating every 0.4 second. The prints from these negatives will be the source of the basic documentary study by which the other films and documentations will be tied together. One bank will be black and white, and the other in color.

SPECIAL EQUIPMENT

SONNE S-7

A Sonne camera, S-28, is included to act as a "smear" camera from which accurate width of phenomena measurements may be made. Millisecond marks on the film will tie this "smear" into the Fastax series.

O'BRIEN

An O'Brien camera, O-29, is included for ultra high speed recording of the basic phenomena during the first few milliseconds.

DISPOSITION OF EQUIPMENT

The foregoing list of cameras will be duplicated in each of two towers for each test, the only difference in utilization being in the K-18 cycled series. The Shoal Tower will use black and white in the K-18's while the migrating or island based tower will expose color.

2. High Speed Movie

A Bell and Howell B1E camera was added to the above list. This camera, B-30, was added to give high speed motion color coverage, its speed being 128 fps on 16mm kodachrome.

3. Mounting and Descriptions

The methods of mounting the cameras are given in Appendix VII; pictures of the cameras appear in this appendix, and also in Appendix II.

4. Table of Design Characteristics

The two following Tables I and II show the design data used with the selection of the cameras.

The first column of each table gives the commercial or Air Force name of the camera. The second column gives the tower and camera position number. Thus, in 1F1, this equipment will go into tower 1, the Coral Head Tower, it is a Fastax for camera position 1. 2M12 designates the equipment as being for tower 2, the Island Tower (later this will be 3, then 4, as the equipment moves from the Aomon to Runit to Aniyaanii Towers); as a Mitchell for position 12.

Table I

Film Numbering and Exposure Data (Shoal Tower)

Tower	and Camera	Lens	Film	Cycling	Start	Run	Stop	Add. Notes
Fastax	1 F 1	15"	L	12,000 fps	- 0.60	1	+ 0.40	100' film
	1 F 2	10"	L	12,000	- 0.57	1	+ 0.43	"
	1 F 3	4"	L	12,000	- 0.55	1	+ 0.45	"
	1 F 4	4"	M	12,000	- 0.50	1	+ 0.50	"
	1 F 5	4"	M	12,000	- 0.45	1	+ 0.55	"
	1 F 6	15"	A	12,000	- 0.40	1	+ 0.60	"
	1 F 7	10"	A	12,000	- 0.37	1	+ 0.63	"
	1 F 8	4"	A	12,000	- 0.35	1	+ 0.65	"
	1 F 9	4"	K	12,000	- 0.30	1	+ 0.70	"
	1 F 10	4"	L	1,000	- 1.0	12	+ 11.0	"
	1 F 11	4"	A	1,000	- 1.0	12	+ 11.0	"
Mitchell	1 M 12	450mm	L	94 fps	- 3.0	180sec	+177.0	1000' film
	1 M 13	150mm	L	24 fps	-60.0	15min	+ 14 min	"
	1 M 14	25mm	L	8 fps	-60.0	15min	+ 14 min	"
Maurer	1 N 15	63mm	M	64 fps	-60.0	250sec	+190 sec	400' film
	1 N 16	25mm	M	24 fps	-60.0	660sec	+600	"
K-18	1 K 17	24"	L	Cycled 1/sec	- 1.0	150sec	+149 sec	75' film
	1 K 18	24"	L	"	"	"	"	"
	1 K 19	24"	L	"	"	"	"	"
K-24	1 L 20	20"	L	Cycled 0.10/sec	- 1.0	44	+ 43	56' - 110 exp.
	1 L 21	20"	L	"	"	"	"	"
	1 L 22	20"	L	"	"	"	"	"
	1 L 23	20"	L	"	"	"	"	"
	1 L 24	20"	M	"	"	"	"	"
	1 L 25	20"	M	"	"	"	"	"
	1 L 26	20"	M	"	"	"	"	"
	1 L 27	20"	M	"	"	"	"	"
S-7	1 S 28	6"	L	40"/sec	- 1.0	50	+ 49	200' film
O'Brien	1 O 29	--	-	----	--	---	--	--------
B1E	1 B 30		M	128fps		22	+ 21	

Table II

Film Numbering and Exposure Data (Island Tower)

	Tower and Camera	Lens	Film	Cycling	Start	Run	Stop	Add. Notes
	2 F 1	15"	L	12,000 fps	- 0.60	1	+ 0.40	100' film
	2 F 2	10"	L	"	- 0.57	1	+ 0.43	"
	2 F 3	4"	L	"	- 0.55	1	+ 0.45	"
	2 F 4	4"	M	"	- 0.50	1	+ 0.50	"
	2 F 5	4"	M	"	- 0.45	1	+ 0.55	"
Fastax	2 F 6	15"	A	"	- 0.40	1	+ 0.60	"
	2 F 7	10"	A	"	- 0.37	1	+ 0.63	"
	2 F 8	4"	A	"	- 0.35	1	+ 0.65	"
	2 F 9	4"	K	"	- 0.30	1	+ 0.70	"
	2 F 10	4"	L	1,000 fps	- 1.0	12	+ 11.0	"
	2 F 11	4"	A	"	- 1.0	12	+ 11.0	"
	2 M 12	450mm	L	94 fps	- 3.0	180 sec	+177.0	1000' film
Mitchell	2 M 13	150mm	L	24 fps	-60.0	15 min	+ 14 min	"
	2 M 14	25mm	L	8 fps	-60.0	15 min	+ 14 min	"
	2 N 15	63mm	M	64 fps	-60.0	250 sec	+190 sec	400' film
Maurer	2 N 16	25mm	M	24 fps	-60.0	660	+600	"
	2 K 17	24"	M	Cycled 1/sec	- 1.0	150 sec	+149	75' film
K-18	2 K 18	24"	M	"	"	"	"	"
	2 K 19	24"	M	"	"	"	"	"
	2 L 20	20"	L	Cycled 0.10/sec	- 1.0	44	+ 43	56' - 110 exp.
	2 L 21	20"	L	"	"	"	"	"
	2 L 22	20"	L	""	"	"	"	"
	2 L 23	20"	L	"	"	"	"	"
K-24	2 L 24	20"	M	"	"	"	"	"
	2 L 25	20"	M	"	"	"	"	"
	2 L 26	20"	M	"	"	"	"	"
	2 L 27	20"	M	"	"	"	"	"
S-7	2 S 28	6"	L	40"/sec	- 1.0	50	+ 49	200'
O'Brien	2 0 29	**	**	**	**	**	**	******
B1E	2 B 30		M					

The lens column gives the approximate focal length of the lenses to be used in each of the cameras. For the exact focal length of each lens, see the data summary sheets for the test desired in the body of the report.

The film column gives the Air Force classification of the film speed to be used.

- L has a Weston speed of 100 = super XX
- M is color
- A has a Weston speed of 50 = pan X
- K is infra-red

The cycling column gives the speed data from which exposure and time between frames may be derived. Note that the 12,000fps given for the Fastax cameras is the ultimate speeds, not necessarily the speeds at which initial detonation photography was accomplished. For more details, see Appendix V, Fastax Acceleration Curves. For various reasons, the field utilization varied from these values. See the summary sheets for actual utilization. The K-18 and K-24 banks were cycled; i.e., three K-18's were electrically synchronized so that while each camera took one exposure every three seconds, the bank took one every second. The K-24's were synchronized in banks of four, each camera making an exposure every 0.4 second; the bank making an exposure every 0.1 second. Two K-24 banks were installed in each tower. The Sonne was run at 40 inches per second, the highest speed for which it was designed.

The start column is given in seconds before detonation. Camera 1F1 was to be set to start accelerating at -0.6 seconds before detonation, to run one second as shown in the run column, and to be shut down at 0.4 seconds as in the stop column. These were design times, derived from the time of operation considerations to give overlapping of coverage and latitude in case of central time control error. For actual field usage after the X-Day test, see the applicable data sheets. PX, QX, and X conformed with these values. Later tests used various "corrective" times designed to overcome the timing errors so that the results would give the designed overlap.

Under added notes is given the film length. Some of these were later changed.

APPENDIX V

FASTAX ACCELERATION CURVES

1. Fastax Acceleration

The attached curves show that Fastax cameras operated to reach high terminal velocities are still accelerating when the film is exhausted. When the number of frames per second is specified loosely, it is generally the terminal velocity frames per second that is given. On the attached curves, which are approximate, the speed at detonation time is different for each camera, the speed depending upon the accelerating time before detonation. The curves for slow running Fastax cameras like F10 and 11 reach terminal velocity and the speed then remains constant over the recording period.

2. Effect of Time Discrepancy

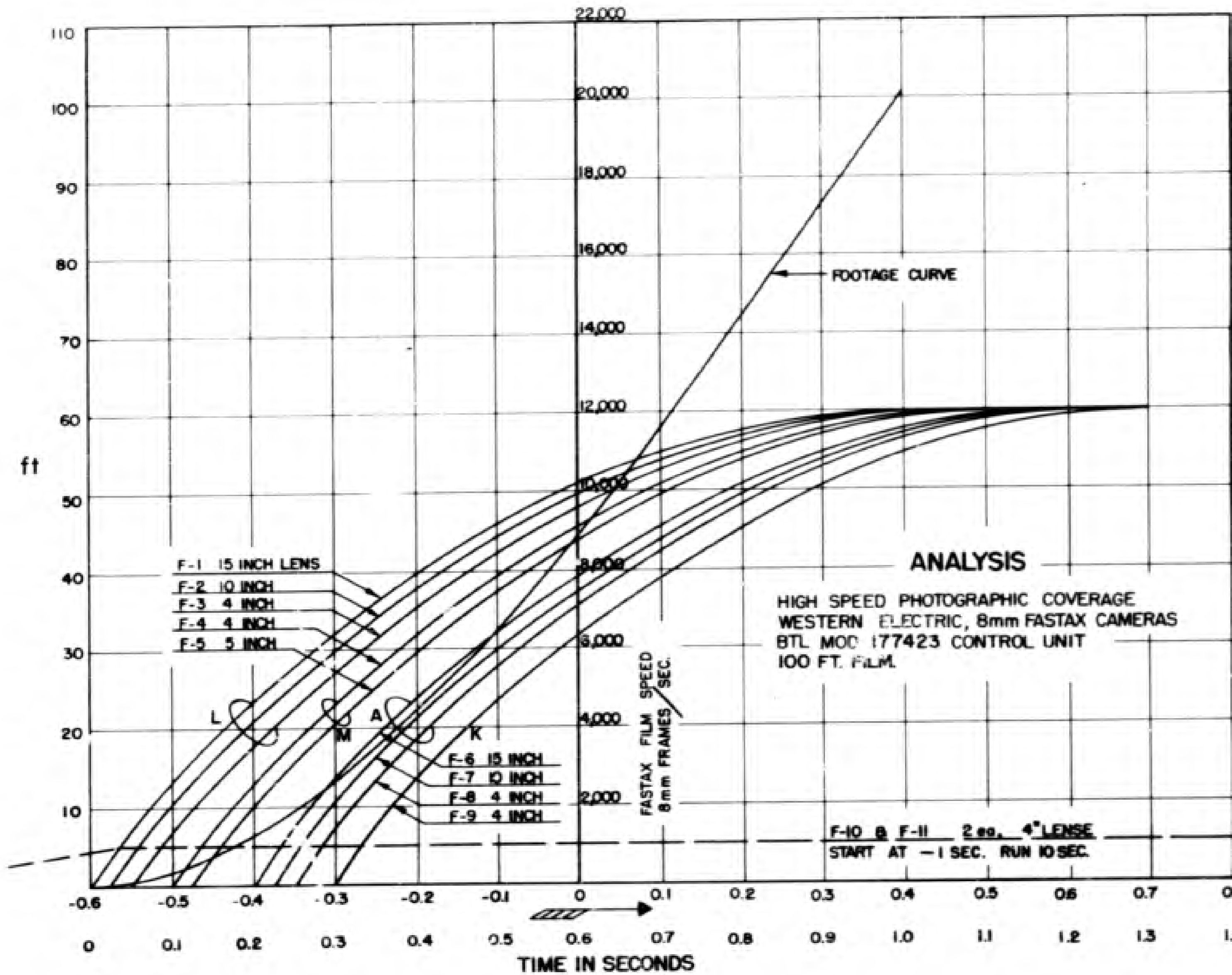
The effect of timing errors or discrepancies may be shown by moving the zero time mark in the direction of error. Thus, a 0.2 second error where detonation occurs earlier than planned reduces:

F 1	from	10,200fps	to	7,900
F 4	from	8,800fps	to	6,500
F 9	from	6,400fps	to	2,600

but does not affect F10 or 11. The timing difficulties in past atomic weapon testing have demonstrated the wisdom of staggering the starting times of Fastax or other short operating time cameras.

3. Footage Curve

The footage curve shows the rate of use of film versus time for a Fastax camera operated as is F1 of the acceleration curve.


ANALYSIS
HIGH SPEED PHOTOGRAPHIC COVERAGE
WESTERN ELECTRIC, 8mm FASTAX CAMERAS
BTL MOD 177423 CONTROL UNIT
100 FT. FILM
FOOTAGE CURVE
F-1 15 INCH LENS
F-2 10 INCH
F-3 4 INCH
F-4 4 INCH
F-5 5 INCH
F-6 15 INCH
F-7 10 INCH
F-8 4 INCH
F-9 4 INCH
F-10 & F-11 2 ea. 4" LENSE
START AT −1 SEC. RUN 10 SEC.
FASTAX FILM SPEED 8mm FRAMES/SEC.
L
M
A
K
ft
TIME IN SECONDS

APPENDIX VI

REPORT OF THE CORAL HEAD TOWER CHIEF

1. Source of the Report

The included report by Robert L. Warner is derived from his experience in helping to gather the equipment, assemble the unit in the ZI, and then in commanding the Coral Head, or number one Photo Tower.

2. Contents of the Report

The following outline of the report gives a breakdown of the included material by paragraphs:

Paragraph Number

1. Design and Construction Considerations
2. Control Requirements
3. The Power System
4. Power Distribution
5. Time Signal Relays
6. Relay Characteristics
7. Correction of Relay Failure
8. Sub-panel Controls
9. Fastax Operation and Control
10. Control Failures
11. Built-in Booby Trap
12. Inadequate Industrial Timers

13. Poor Assembly of Industrial Timers

14. Relay Inadequacies in Industrial Timers

15. Future Technical Liaison

16. Early Assignment of Technical Personnel

PROJECT SANDSTONE

REPORT OF PHOTO TOWER REMOTE CONTROL

1 June 1948

Submitted by

LTJG R. L. Warner, USN
Tower Chief, Photo Tower #1

HEADQUARTERS
311TH AIR DIVISION, RECONNAISSANCE
ANDREWS AIR FORCE BASE
WASHINGTON 20, D.C.

1 June 1948

FROM: Tower Chief, Photo Tower #1.

TO: Director of Tower Photography, Project Sandstone.

SUBJECT: PHOTO TOWER REMOTE CONTROL, REPORT OF:

1. This report is submitted for the purpose of clarifying certain features of the design and construction of the remote control equipment used in the Photographic Towers during Project Sandstone. The design was developed over a period of three months (Dec. 1947 to Mar. 1948) and was dictated largely by the characteristics of equipment already under contract and the availability of electrical components necessary to the construction of the timing circuits. Last minute changes in the photographic plan and repeated delays in delivery of electrical components ordered out of Air Forces Supply forced abandonment of the original design. The final design may best be termed an adaquate compromise. Successful operation of the system was the result of close calibration and continuous maintenance in the field.

2. Tower photography required the control of some thirty cameras and auxiliary equipment from two timing signals wired into the installation by submarine cable. The signals were generated by the master timing station and were timed to arrive at Zero minus one minute and Zero minus one second. These signals were required to actuate cameras starting at times ranging from Zero minus one minute to Zero minus 0.30 second and operating for intervals ranging from one second to

15 minutes. The general system used is sketched briefly in the following sections. Reference should be made to the block diagram of the tower circuits.

3. The types of cameras specified for the tower locations required the installation of both 120 volt, 60 cycle A.C. and 28 volt D.C. power supplies. The A.C. system incorporated two 15 kw diesel-driven Ready-Power Units with automatic switch gear to drop one machine from the line and connect in the other in the event of power failure. These generators were installed by the Army Engineers to operate from 100 gallon auxiliary fuel tanks. For the most part they were running light. Under such conditions the machines will operate in excess of one hundred hours on one tank of fuel oil. The total operating time of these units during the operation was approximately 250 hours. During this period a minimum of maintenance was required and operation was generally satisfactory. Only one generator failure was experienced but this occurred at a critical time and definitely justified the installation of the stand-by unit. The D.C. Power was supplied from a 7.5 kw C13A gasoline powered generator with two 117 ampere-hour, 12 volt storage batteries connected in series across the line. The C13A was provided with an auxiliary 50 gallon fuel tank, extending its operating time to approximately thirty hours. These units operated for extended periods generate considerable heat and must be well ventilated. Otherwise only standard maintenance procedure was required. The Operation of the D.C. System was considered satisfactory in every respect.

4. The generators for the tower installations were located

in a power house at the base of the towers necessitating a run of 85 to 100 feet for the power cables. Power cables on both systems were 4/0 or larger. The A.C. System was wired four wire, three phase; the D.C., two wire ungrounded. Voltage drop in this distance under full load conditions made it desirable to operate the generators at 120 volt no-load. Voltage drop in the D.C. lines was minimized by locating the batteries at the top of the tower. This is recommended as good practice where heavy transient loads may momentarily lower the D.C. voltage to values in the vicinity of drop-out for the relays, especially where shock is anticipated.

5. The Block Diagram illustrates the manner in which the cameras were controlled from the -M and -S signals. The system uses a 4-pole Master Relay (Raytheon DN-11) which is closed by the timing signal to set into operation a system of timers. These timers actuate the camera circuits at the appropriate times and hold them closed for the required intervals. On completion of the cycle the timers open the holding circuits and stop the cameras. The circuits are wired in such a manner that it is impossible to recycle without a recurrence of the timing signal. This was one of the primary design specifications.

6. The camera control system is composed of five basic units; the -M Master Relay, the -M Holding Relay Panel, the -S Master Relay, the -S Holding Relay Panel and the Movie Camera Power Relay Panel. The Master Relay in each case is a Raytheon Type DN-11 Signal Relay with a coil rated normally at 7.3 volts, 0.0073 amp. The action of the DN-11 is slow and extremely positive. At rated voltage it closes in 0.5 second. For tower operation the actuating signal was raised to

30 volts, reducing the closing time to 0.13 second. The delay introduced into the circuit by this slow closure was calibrated out (according to the Timing Station personnel) by using the DN-11 relay at all timing locations. There is, however, reason to believe that this relay may have been responsible for the time lag noticed on the initial test and it is recommended that a fast closing relay be used in timing circuits of this type in future operations.

7. The only function of the Master Relays is to initiate the action at the proper time. The Holding Relays then take control. The Holding Relay panels are designed to operate from the Master Relays in such manner as to control the starting and operating times of the individual cameras. The Holding Panels mount a number of 28 volt D.C. relays whose time of closure and fall-out is determined by synchronous timers. The setting of the timers is determined by the type of camera and the film load. Individual relays were employed for each type of camera to reduce the possibility of malfunction. The circuit is simple and meets the requirement that it be impossible to recycle. Components used in the construction of these panels were those available from Air Forces Supply at the time. Special types ordered were never delivered. The relays are Leach, 28 volt aircraft type, two and four pole. The synchronous timers are Industrial Timer Corp. TD - 60 with 15 minute dial. While none of these are precision components their operation during the tests was satisfactory. It is to be noted that the timing of the majority of the aerial cameras was not critical and accuracy of plus or minus two seconds was permissible. The holding relays are however, susceptible to physical

shock - especially under low voltage conditions. Due to the anti-recycle requirements of the design once the holding relays are jarred open the cycle is complete and all cameras controlled by that circuit are disabled. The original design supplied power to the holding relays from the same D.C. source used for the camera power load. Under load conditions the D.C. voltage might drop as much as 25% from the normal 28 volt value. This drop, coupled with the shock wave, is believed to be responsible for the early cut off of cameras on the second test. The cause of this malfunction was eliminated by the following:

1. Shock mounting of all relay panels.
2. Installation of separate 36 volt battery for Holding Relay power.
3. Installation of camera power batteries at top of tower.

No further difficulty was experienced. It is recommended that similiar action be taken in future operations, if it is necessary to employ holding relays in the control circuits.

8. The design of the control equipment is such that the Holding Relays are required to handle only control currents. In the case of the aerial cameras the power leads are wired directly from the D.C. bus. A.C. power for the six movie cameras is supplied through the Movie Camera Panel. Relays on this panel are actuated from the Holding Panel. The use of the Movie Camera Power Panel eliminated the necessity of long power leads to the movie cameras and provided a convenient method of testing these cameras without activating the other circuits. The system gave no malfunctions.

9. The foregoing sections have dealt exclusively with the control of the standard aerial and movie camera installations. The high speed Fastax Cameras required more precise treatment. At the speeds specified by the photographic plan, these cameras operate for slightly less than one second. The eleven W.E. Fastax cameras were mounted in two banks and controlled by ten Western Electric Type D-177423 Control Units - more familiarly known as the "Goose" Control. The D-177423 Control is a device designed by Bell Labs to permit the operation of the W.E. Fastax Camera at speeds in the vicinity of 16,000 8mm. frames per second. Tests run at the factory show that it will attain this speed with most cameras and maintain speed in excess of 15,000 fps for the last fifteen to twenty feet of the standard one hundred foot Fastax roll. The first eighty feet of the film is consumed in accelerating the camera to speed. Operation at these speeds is accomplished without breaking the film by applying over-voltage to the camera in two steps. The camera starts at normal voltage. An R-C delay circuit operating a fast acting mercury relay delays the application of the high voltage until power has been on the camera for slightly less than 0.1 second. By this means voltages up to 280 volts may be applied to a camera designed to operate at 110 volts. Tests show that the terminal speed of the camera increases very slowly as the voltage is raised above 200 volts. For example: 180 volts gives a terminal speed of 12,000 fps, 280 volts gives 16,000 fps. The reduced quality and corresponding shorter time of run at the higher speeds make it inadvisable to operate at speeds in excess of 12,000. In addition there is much less stress on the camera. Timers are incorporated in the "Goose" Control to

permit delay in starting from 0 to 6 seconds after the initiating impulse is applied and to set the time of operation at any desired value up to six seconds. A Power-Stat voltage control permits the use of speeds down to approximately 5,000 fps. Lower speeds may be used if the unit is suitably modified to permit operating times in excess of six seconds. This modification was made in the tower installation to permit the operation of two Fastax cameras at 1,000 fps from a single Goose Control. One of the features of the modification is the disabling of the delay circuit which is obviously of no use at speeds less than 8,000 fps.

10. The basic theory of the "Goose" Control is sound but it is improperly designed and poorly constructed for use on operations requiring field service. The result is a piece of laboratory equipment, inconveniently laid out and inadaptable to portable use. The Control was a source of constant trouble and was responsible for failures such as the following:

1. Overspeed and damage of two cameras.
2. Premature operation of one camera.
3. Operation of several cameras below desired speed.
4. Loss of two rolls of test film through failure of camera to turn off at end of cycle.
5. Necessity for continuous maintenance check and adjustment.

The most common cause of trouble was failure of the delay circuit. A malfunction in this part of the circuit results in the operation of the camera at approximately half the desired speed. The majority of failures were traced to the mercury relay. This relay is designed to short out a twenty ohm resistor in the camera power circuit at the end of the initial delay period (approx 80 milliseconds). These relays are apparently too delicate to stand the shock of repeated handling encountered in field operations. Failure of either the mercury relay or of the delay circuit results in the same effect. The twenty ohm resistor is not shorted; remains in the camera power circuit throughout the cycle dropping the voltage at the camera and causing operation at reduced speed. A number of instances of this type of malfunction were discovered while reviewing the QUEEN Tests. A system of checking the operation of the mercury relay was devised and made a part of the test procedure. No instances of this type of failure during actual operations have been brought to the attention of the Tower personnel but it is possible that some may have occurred.

11. The "Goose" Control has a number of other troublesome features. All connections are brought out to receptacles on the front panel. This necessitates wiring from the front when connection to the back would give a much cleaner design. The plug type connectors supplied fitted poorly and were not entirely reliable. A particularly troublesome feature was the lack of polarized plugs. When a number of "Goose" Controls are operated from a single starting relay contact, as was the case in the Tower installations, the accidental reversal of the power connection at any one of the paralleled Controls will short circuit the A.C. line and burn out the wiring in that unit and in the control harness. Since the power connection was not polarized and the control unit was not fused this amounted to a built-in booby trap. Difficulty was avoided by careful coding of the power and trigger plugs and fusing of the power circuits.

This modification was performed in the field between tests.

12. The time delay and time interval units used in the "Goose" are Industrial Timing Corp. Six-Second Synchronous Timers. These units are not considered sufficiently reliable for an operation requiring precise timing over long periods under adverse climatic conditions. When operating properly these timers are capable of repeated cycles varying no more than plus or minus 0.02 second. Calibration against a master timing unit used as a test-set eliminates scale error. However, after several hours of operation and continued exposure to humidity, they develop erratic tendencies. Tests show that at random intervals erratic times are produced. The trouble has been traced to maladjustment of the timer clutch mechanism. Industrial Timer takes pride in the simplicity of this clutch. It is the opinion of the Tower Crews that it is a bit too simple to be completely reliable. The adjustment is coarse and critical and does not seem to hold adjustment. The parts are metal stampings - in some cases poorly fitted.

13. Trouble in the Industrial Timer has not been confined to the clutch. The synchronous motor gear train is crudely constructed and has on occasion caused stalling of the timer - preventing it from running out its cycle. Misalignment seems to be the main difficulty though burrs on the gear teeth are a contributing factor. In one case erratic operation of a timer was traced to burrs on the end of the gear cutting into the mounting plate. Inspection of other timers disclosed a similar condition in several of the others. It was necessary to dis-assemble these units to eliminate this source

of potential trouble. A small brass shim or washer inserted behind the gear during manufacture would have eliminated this type of trouble. It is likely that a malfunction of this type was responsible for the over-speeding and damage of one of the Fastax cameras.

14. The relays in the Industrial Timers were another source of concern. It is doubtful that these relays are JAN-Spec. In any case they are lightly constructed, easily bent out of adjustment and susceptible to shock - all features which make them undesirable for applications where reliability is of prime importance.

15. The "Goose" Timing Units built around the six-second Industrial Timer gave good account of themselves during the SANDSTONE operations despite the features described in the foregoing sections. Failures on actual tests were less then 10%. Most of the troubles were discovered in daily maintenance checks. However, it is the opinion of the Tower personnel that satisfactory operation was the result of careful handling, continuous inspection and maintenance - much of which would have been unnecessary with a properly constructed unit. This type of timer is not considered precision equipment and is not recommended for future operations. While the basic concept is sound, the engineering and construction (especially in the selection of components) leave much to be desired. In fairness to the contractor, it must be recorded that these units were built with incomplete knowledge of the proposed application and barely sufficient time. This is not considered an adaquate excuse for the poor design. In this connection it is suggested that the presence of

an Air Force technical officer during the planning stages of the operation would have eliminated much of this trouble. Such a technician operating in liaison with the contractor would have been in position to dictate the design without in any way jeopardizing the security of the operation.

16. A review of the reports on tower photography discloses that the operation of the timing equipment was for the most part satisfactory and that the desired results were obtained. It is the opinion of the Tower personnel that better results would have been obtained had more time been allotted for the design and construction of the timing equipment. In this connection it is recommended that in future operations of this nature the technical officers who are to be assigned the responsibility of conducting the operation in the field be assigned to the project early in the planning stages, in time for them to design the equipment to the requirements of the project and completely test all components under simulated conditions before departing the ZI. It is considered that such a procedure will reduce the technical difficulties to a minimum and assure the success of the project.

Respectfully submitted,

SIGNED ROBERT L. WARNER

Robert L. Warner
Lt. (jg), USN

APPENDIX VII

CAMERA MOUNTS

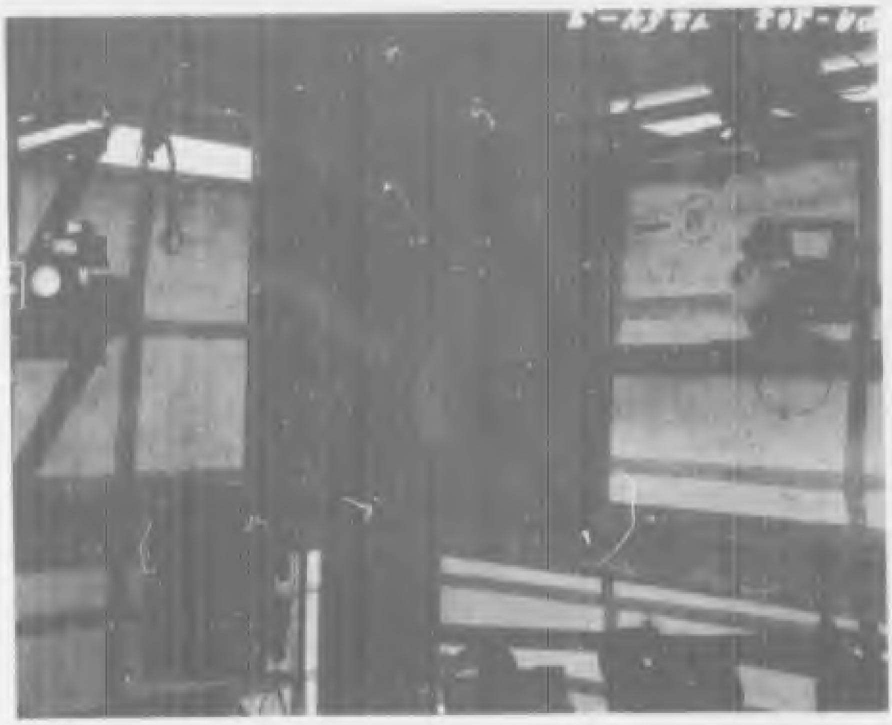
1. Mount Requirements

Camera mounting is different for this remotely controlled unmanned type of tower than it is for almost any other type of installation. The great number of cameras installed required that no space be sacrificed for unnecessary functions. There must, however, be space left to properly load and service the cameras. They must be easily and rapidly installed and dismantled. A means must be provided for lateral and vertical alignment of each camera individually and rough adjustment should be provided for the bank as a whole where cameras are banked together. They must, of course, all receive light through the apertures in the cab without interference from either other cameras or external projections or parts of the cab. It was not practical because of the short time allotted to the designing and procurement of mounts to get the ultimate in design and arrangement of the mounts. The great number of expected changes in camera types and in numbers used also added a burden on the design and construction aspects of the project. The many unforeseen changes also complicated the situation.

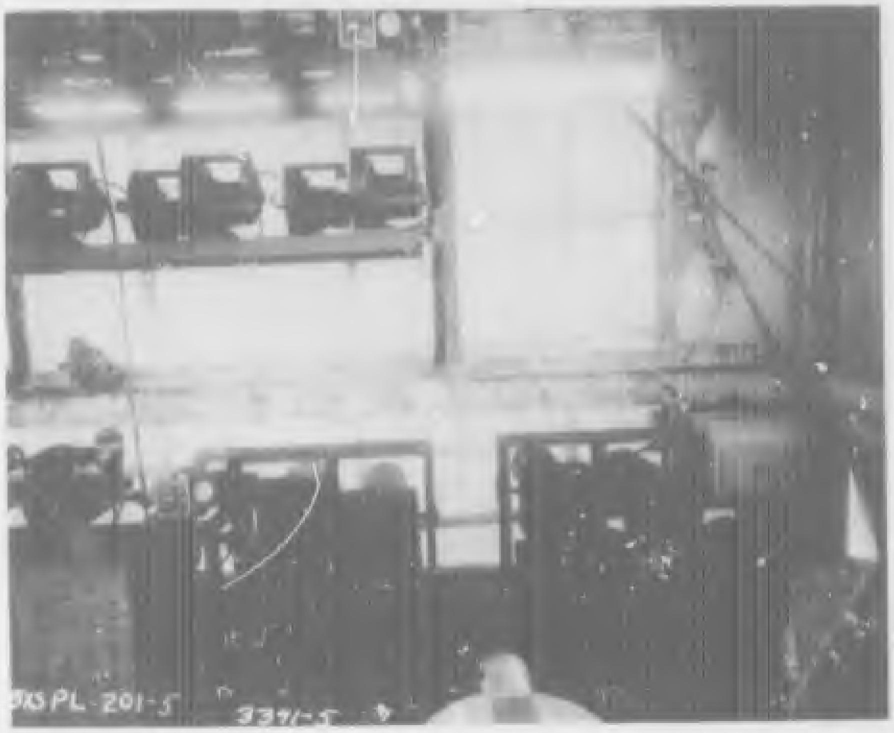
2. Mount Dimensions

Blue print and engineering data of the mounts are not included in this report as it is obvious that this particular arrangement will not again be used. These data are currently held by the 311th Air Division Reconnaissance at Topeka Air Force Base, Topeka, Kansas. The types of mountings that were used are shown in the following series of photographs. The control equipment arrangement is also shown in these pictures.

PL-201-4-3340-4 The Fastax cameras F1 through F11 were mounted on two angle iron racks attached to the upper aperture or window frame. Space was allowed for six cameras on the upper level, six more on the lower level, each level consisting of two rows of three cameras. Because only eleven Fastaxes were used, instead of the twelve for which space was allowed, one of the Maurer cameras was installed on this rack. Notice the adjusting screws on the inner corners of the rack. Each camera had its position number stenciled onto it, the camera in the lower bank on the right hand side being 1F8 showing that this camera is installed in tower number one, the Coral Tower, that this is a Fastax, and that it is camera number eight in the tower sequence. These cameras are in position for the X-Day detonation. The aperture curtain is in the raised position.



PA-202-7354-3 The Coral Head Tower cameras are set on the diagonal for the Y-Day detonation. Both the north face and east face curtains are up, and some of the cameras are mounted in position on their racks. Lower left is the Sonne number S-28 mounted above a K-18 on a chrome-moly tube frame set upon plywood on the cab floor. Lower right shows the tops of the other K-18s aimed through the 2 x 10 foot aperture.

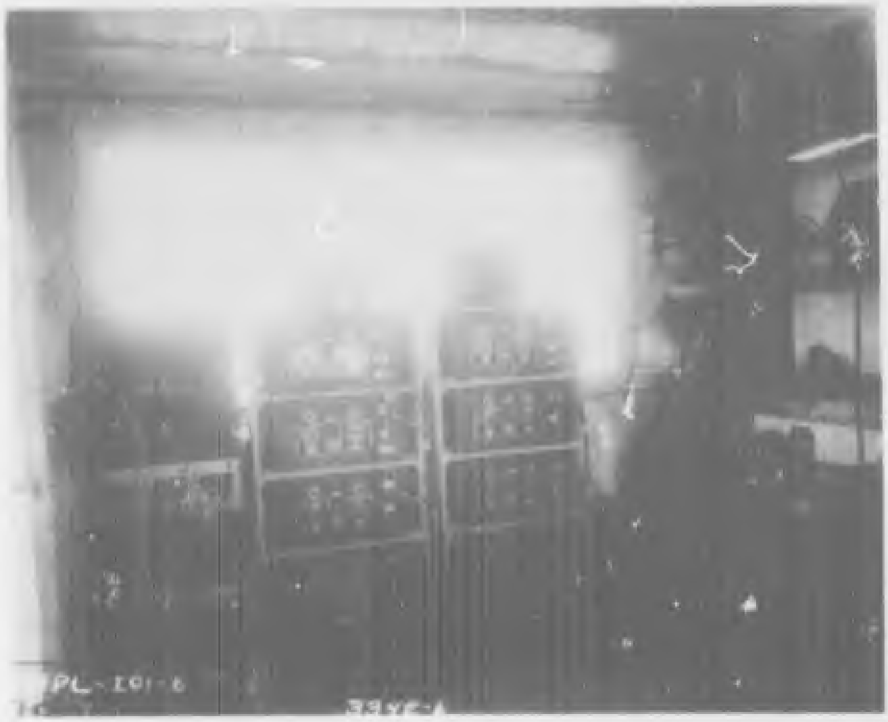


PL-201-5-3341-5 Coral cameras in the positions that they occupied for the X detonation recordings. The aperture curtain is in the up position. In addition to the already mentioned Fastaxes and one Maurer, the BlE Bell and Howell, number B-30, movie camera shows to the left of the picture mounted on the cross member between the window aperture and the slit aperture. Directly below it is the Mitchell Standard, M-13, with the Mitchell Hi-Speed, M-12, barely showing to the left. Maurer N-15 shows just to the right of the Mitchells. In the lower center are mounted the two banks of K-24s with the Sonne mounted above a K-18 in the extreme right corner. The O'Brien camera just peeps into the picture in the bottom foreground. The rope stretched diagonally across the right corner is one of the curtain control lines.

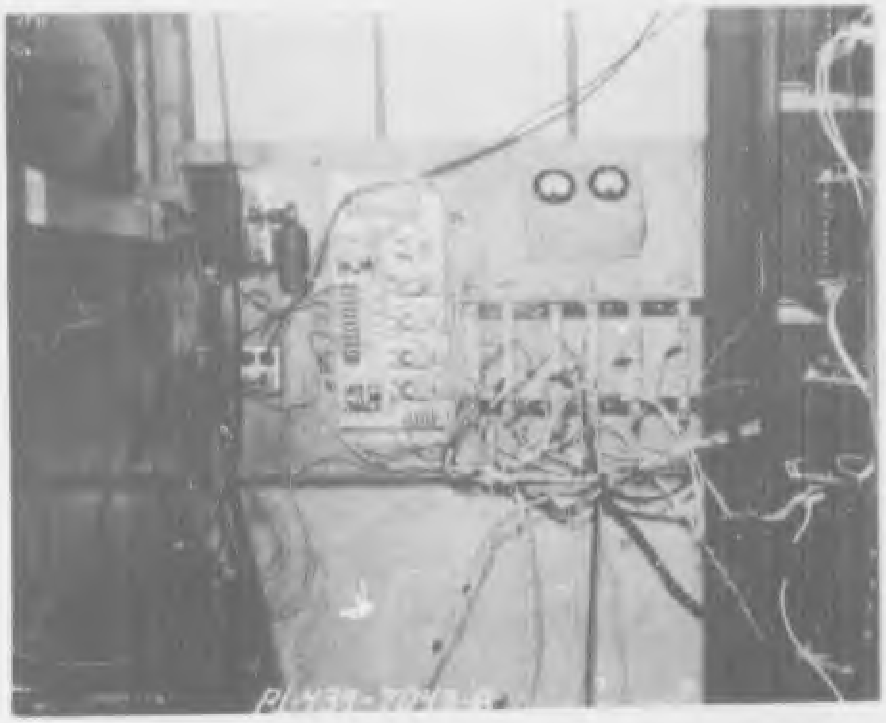
PL-426-5586-3 The K-24 camera banks facing North in the Coral Tower with the curtain up. The cycling control gizmo for the left K-24 bank shows just barely off of the floor on the right hand side of that bank. The photo-electric control for the O'Brien is shown on the O'Brien in the foreground. Notice that the original metal door for the Eastern slit aperture is slightly open allowing ventilation into an otherwise unbearably hot cab.

PL-201-2-3338-2 The cover of the O'Brien is removed by lifting it vertically, thus preventing the installation of the camera underneath other low racks. The photo-electric pick-up is on top of the amplifier-control box. The O'Brien is resting upon the uneven metal cab floor.

PL-201-3-3339-3 The O'Brien with the top on in operating position. The original plan had been to place this camera under the movie rack, but it had to be moved back into the center of the room and receive its light through the space between the K-24 racks.



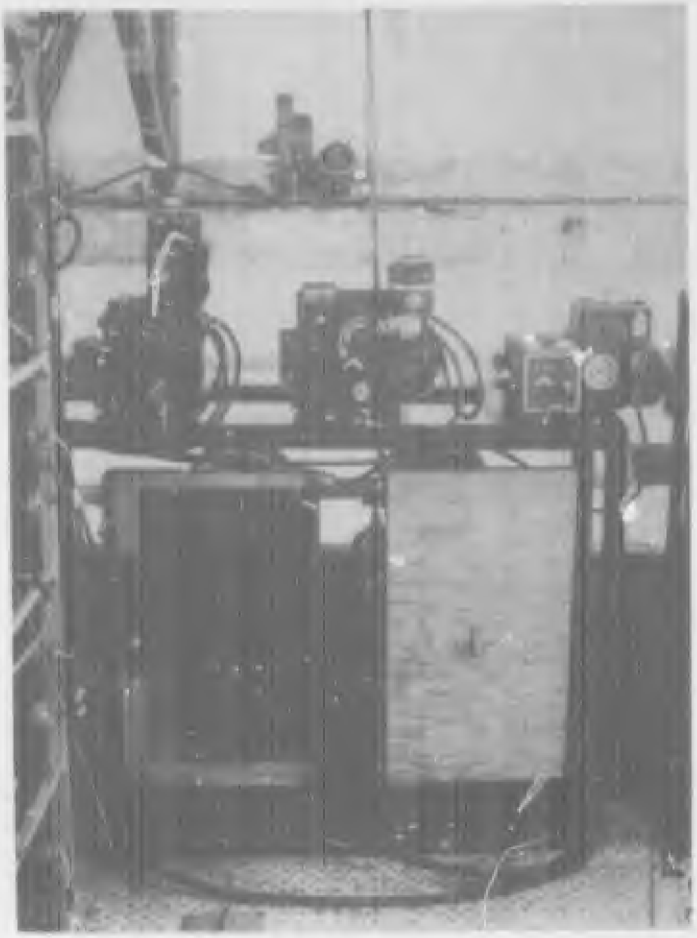
PL-201-6-3342-6 This light struck photograph shows the relation of the three timing banks and the cameras. The bank to the left has the timers that control the gizmos which in turn control the cycled series and the motion cameras. The other two banks control the Fastax series. The functions of these three banks could have been all built into two boxes the size of the individual Fastax control boxes had the control been built for field use instead of for individual control of laboratory cameras.



PL-439-7043-8 The sub-control relay panel on the Runit Tower. The cameras are mounted to the left, the back of the Fastax timing control is to the right. The accumulation of "junk" and a great maze of wire is the inevitable result of adapting laboratory test equipment to a field program.

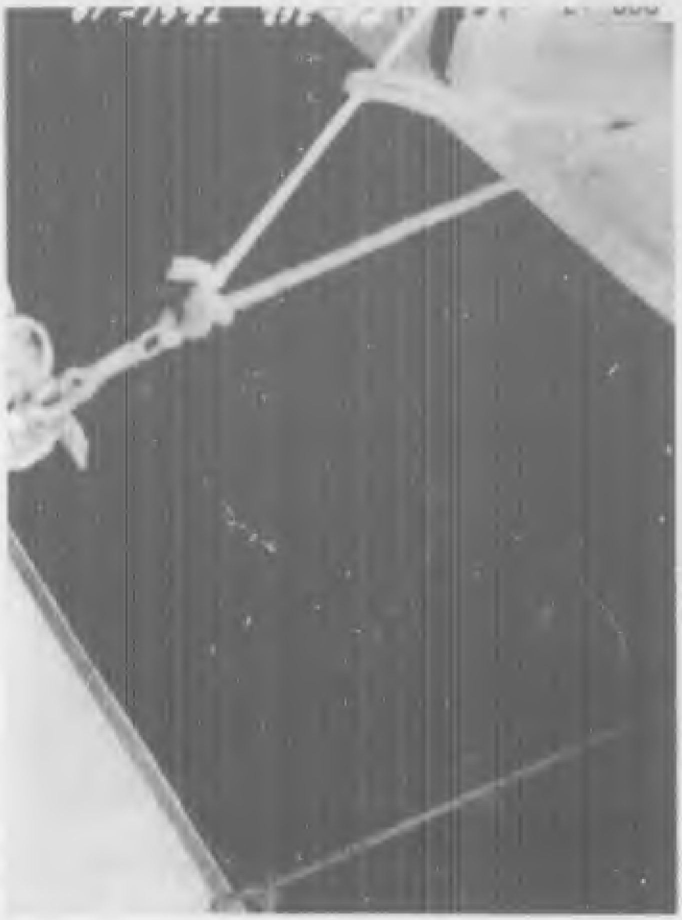
PL-439-7042-7 The front of the time control panels as used in the Runit Photo Tower. The Fastax units were removed from their individual boxes and mounted upon panels with the wiring permanently harnessed and brought out of the back. This made a much cleaner and more reliable unit than the other systems. It had been planned that all timing equipment would thus be mounted, but the failure of additional panels to arrive stopped the conversion. The few cables seen on the front are part of the test and measurement equipment seen on the top of the second rack.

PA-202-7359-8 Captain Harvey making adjustments to a Hi-Speed Mitchell in the Aomon Tower. The standard Mitchell with magazine installed, shows with the Hi-Speed Maurer 2N15 directly behind. In the immediate foreground is the O'Brien. The maze of hanging wires and cables are the inevitable result of taking laboratory test equipment into the field to do the job of field equipment.

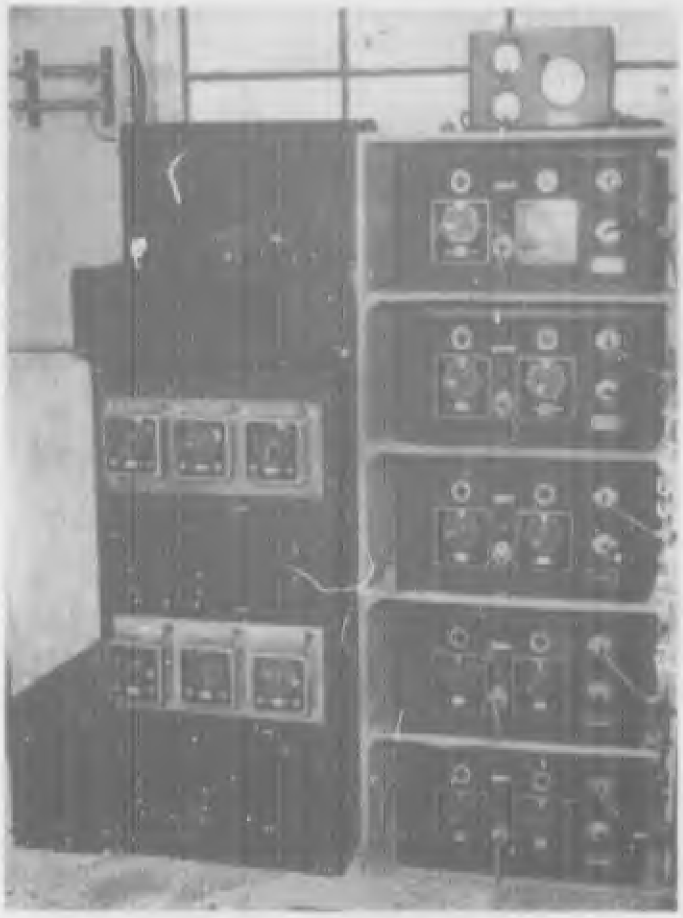


PL-201-1-3337-1 The B1E, the movie bank, and two of the three K-18s all with magazines removed on the Coral Head Tower looking North with the curtain in place show the relation of these units to the timing bank on the left.

PL-426-5585-2 The magazines in this Coral Tower view are in place. Sitting atop of the Fastax timer bank is the Potter decade counter which supplied the millisecond timing pulses for the Fastax cameras. The front mounting non-locking panel plugs of the Fastax timers are a mistake for field testing, again demonstrating the fallacy of using laboratory test equipment for field use. On the face of each timing unit, there are three plasters. The top middle one shows the camera number that this unit controls. The bottom left one shows the time delay between the received minus one second pulse and the starting of the Fastax. The bottom right one shows the time of running of the Fastax. These times are calibrated times, checked against the test set supplied with the timing units. The bottom timer has a jury rigged double outlet plug. This controls the two slow running Fastaxes which were both controlled through this one control. Notice that type A-8 magazines were used on the K-18 cameras. These were the only ones found to be reliable in this type of operation. The figure 2K17 on the other magazine shows that the magazine really belongs on the camera mounted in the Aomon Tower.



PA-202-7361-10 Looking through the upper aperture with the curtain partially lowered to show the flash bulbs attached to a fish pole for Queen Y time-calibration test. The flash bulbs were connected to go off with the starting of individual Fastax cameras and to be recorded by a manually operated Fastax which was started before the minus one second time. Thus the running Fastax would record the time elapses between the received minus one second signal, and the Zero Tower simulated flash, and the starting of each Fastax.

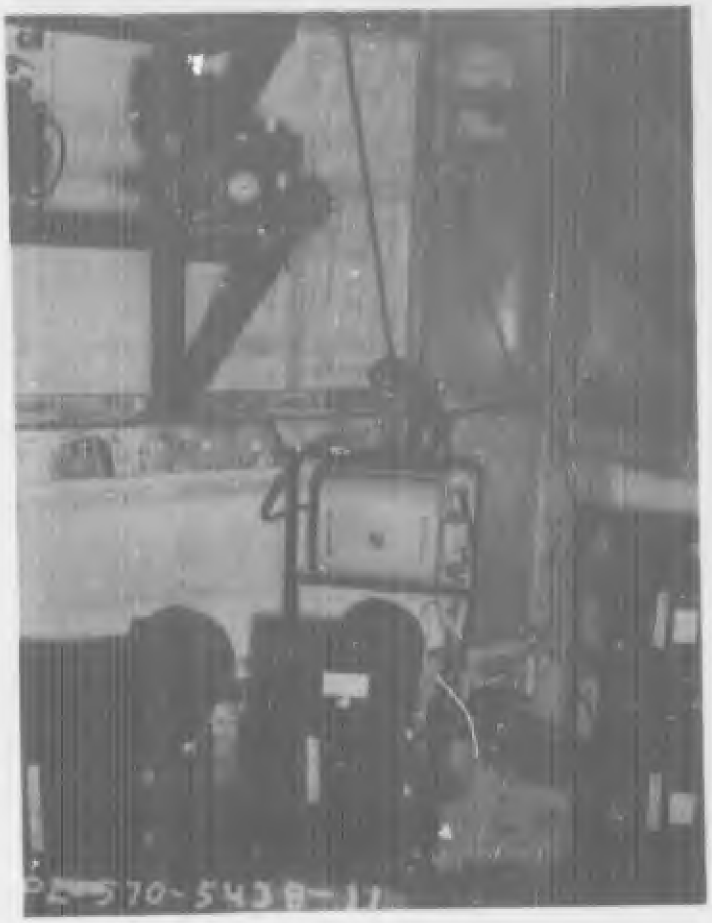


PL-426-5584-1 Two of the Coral Tower control panels with the magnetic tape sound recorder resting on the left one and the timing test set resting on the other.

PL-570-9 The Coral Tower Fastax controls were mounted in wooden cabinets with the necessary cables harnessed into the fronts. The tower chiefs report tells of the troubles and worries caused by the non-polarized and non-locking plugs supplied with the equipment.

PL-425-11 Navy Lt. Bob Warner and USAF CWO Lloyd Davis remove the lens covers from K-24s before final inspection.

PL-425-10 Warner, Coral Tower Chief, and Davis, Coral Photo Chief, accomplish maintenance inspection. Davis is on the outside of the cab working through the upper aperture.

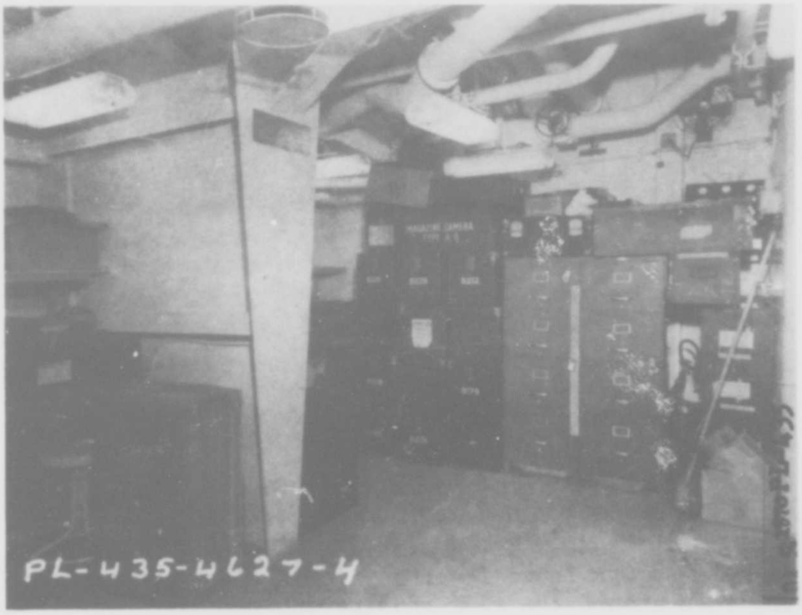


PL-570-11 The Coral Tower cameras set at an angle for the Y-Day recording. A Maurer shows in the upper left, the Sonne in the lower center, two K-18s in the lower left, and two K-24s in the lower right. Notice also the tapes on the magazines showing the film loading for the Y-Test.

PL-570-12 Coral Tower Fastax and K-24 banks mounted to view through the Eastern or right hand face for Y-Day test. The magazines are loaded for the test.

PL-570-10 Coral Tower Fastax and movie banks obliquely mounted to record the Y-Day test. The BIE, Mitchell, and Maurer movie cameras shown are loaded ready to view the test through the North or left window.

PL-435-3 The Photo Tower air conditioned storage and loading room aboard the AV-4 showing the magazine cases brought to the ship with the magazines for loading. The OEL cases hold the film that will be loaded. This room was also used by Capt. Harvey for maintaining the records and for preparation of the caption and data sheets.



PL-435-4 The other half of the air conditioned room was used for camera storage and files for classified material.

APPENDIX VIII

TIME AND SEQUENCE CONTROLS

1. Central Time Control

A central time control station was established on Parry Island to control all the time functions and sequence controls for the entire test. See the appropriate J-Division, Los Alamos Scientific Laboratory, reports for complete data on the central timing unit.

2. Photo Tower Tie-In

The central time station at Parry was to have been operated in such a manner that the energy supplied to the submarine cables connecting to the various towers would close the Raytheon railroad relays (SP 26) in those towers at the specified times of minus one minute plus or minus five seconds and minus one second plus or minus 0.02 seconds. Further details of the Raytheon relay are available through J Division, Los Alamos Scientific Laboratory and from Edgerton, Germeshausen and Grier, Massachusetts Institute of Technology. These relays are so constructed that the armature carries four contactors which complete four normally closed circuits, or when energized, close four normally open circuits. The Raytheon relay armature circuits were connected as shown in Appendix XXII, Block and

Schematic diagrams, to initiate the action for the various camera control units. The energy to the Raytheon relays was interrupted at detonation plus one second, thus requiring holding circuit relays in some of the camera control units.

3. Fastax Control Units

Two types of control units were supplied with the Fastax cameras. The type D-177426 or "gosling" control was not used by the photo tower unit. It is designed for low Fastax operating speeds where the voltage to operate the camera may be applied directly to the camera at standstill. The instructions supplied by Fastax are attached.

The type D-177423 control unit, or "goose" was used exclusively for Fastax control of all high speed Fastaxes F1 through F9. Cameras F10 and F11 were both operated through one of these units. Ten of these 423 units were then used per tower. These 423 controls are fair laboratory equipment, but lead to complications where so many of them must be used in a field test. Even for laboratory use, the plug-in in the front panel should be a positive locking type. Simpler, single unit time controls for many camera controls are discussed in the body of the report, and also in Appendixes II, XI, and XIX. Fastax supplied operating instructions are attached. The 426 closes the Fastax circuit at a variable time (TD) after the power is supplied to the unit, and opens the circuit after the set time of running (T) has expired. The 423 closes the Fastax circuit a variable time (TD) after a trigger signal is received and opens the circuit a variable time (T) later.

4. <u>Other Controls</u>

Other simple time controls were necessary as explained in the Appendix XXII, Block and Schematic Diagrams. Among the controls necessary were gizmos Mark I, III, and IV. Gizmo Mark I was a motor driven rheostat inserted in the High-Speed Mitchell line to bring that camera up to operating speed. Gizmo Mark III type control, designed to give sequence operation for the three K-18 cameras, consisted of three micro-switches running on a cam driven through a gear train by a camera intervalometer motor. Each micro-switch supplied the electrical trip for one K-18 camera. The three K-18's were thus synchronized to give a series of K-18 exposures at one second intervals. Each Gizmo Mark IV controlled four K-24 cameras in a similar manner to give a series of K-24 exposures at 0.1 second intervals. Intervalometer motors were used to drive these because the governor control on these is fairly good and easily set.

5. Submarine Cable System Calibration

Complete calibration procedures and data are available through J Division, Los Alamos, or from E. G. & G., M.I.T. Data recorded by the photo tower unit shows the Raytheon relay closes very slowly with low voltage and only moderately fast at high voltages, but that the relays are very consistent and uniform both for repeatability with one relay and uniformity between relays. These relays had a minimum pick-up voltage of about five volts and required approximately one second to close at this voltage. At about eight volts, the time to close was about one-half second; while at eleven volts, the time was nearly 0.3 second. Great increases of voltage, above fifteen, only reduced the closing time slightly, the time being about 0.16 second at eighteen volts, and only 0.15 second at twenty-four volts. This approximate data does show, however, that the closing time of these relays are sensitive to the rate of rise of the voltage wave applied.

In the field use of these relays, the central timing station applied equal voltages at a given time to the circuits leading to each submarine cable which in turn went to a Raytheon relay in a tower. A variable resistor was then added to each circuit at the central timing station. These resistors were supposedly adjusted so that each of the relays at the towers could close simultaneously and at minus one second. There was always some question as to the adequacy of the calibration system used to set the resistors and thus to set the actual time of closing of the contacts in the towers. When a 0.2 second error in Fastax starting times was found on the X-Day test, timing tests were conducted in the towers, and the discrepancy was not located. No satisfactory explanation was found for the delay in Fastax starting, but the 0.2 second remained almost constant so all the photo tower cameras were set ahead that amount making Y and Z tests come out well.

OPERATING INSTRUCTIONS FOR D-177426 CONTROL BOX

1. COMPONENTS

1.1 15 Second Time Delay.

1.2 15 Second Interval Timer.

1.3 Box with suitable receptacles and one female power plug.

2. PURPOSE OF D-177426 CONTROL BOX

2.1 To permit controlled operation of Fastax High Speed motion picture cameras at speeds from 150 to 10,000 pictures per second.

3. METHOD OF OPERATION

3.1 Plug in leads coming from control relay or switch which will have 115 volts AC on it when circuit is closed.

3.2 Plug in voltmeter (PG3) of D-177594 test set and set timer for 15 seconds.

3.3 Close control circuit and check voltage.

3.4 If constant current transformer such as a "Variac" or "Powerstat" is used between camera and control box, insert voltmeter plug (PG3) into female outlet of transformer to measure voltage instead of camera outlet of control box.

3.5 Calibrate time delay and timer by using D-177594 Test Box. Camera operating time for timer to be obtained from Fastax Instruction Book #1079, Issue 2, Page 24.

3.6 Remove test plug (PG2) and voltmeter plug (PG3) from control box.

3.7 Insert plug from camera or constant current transformer into camera output receptacle.

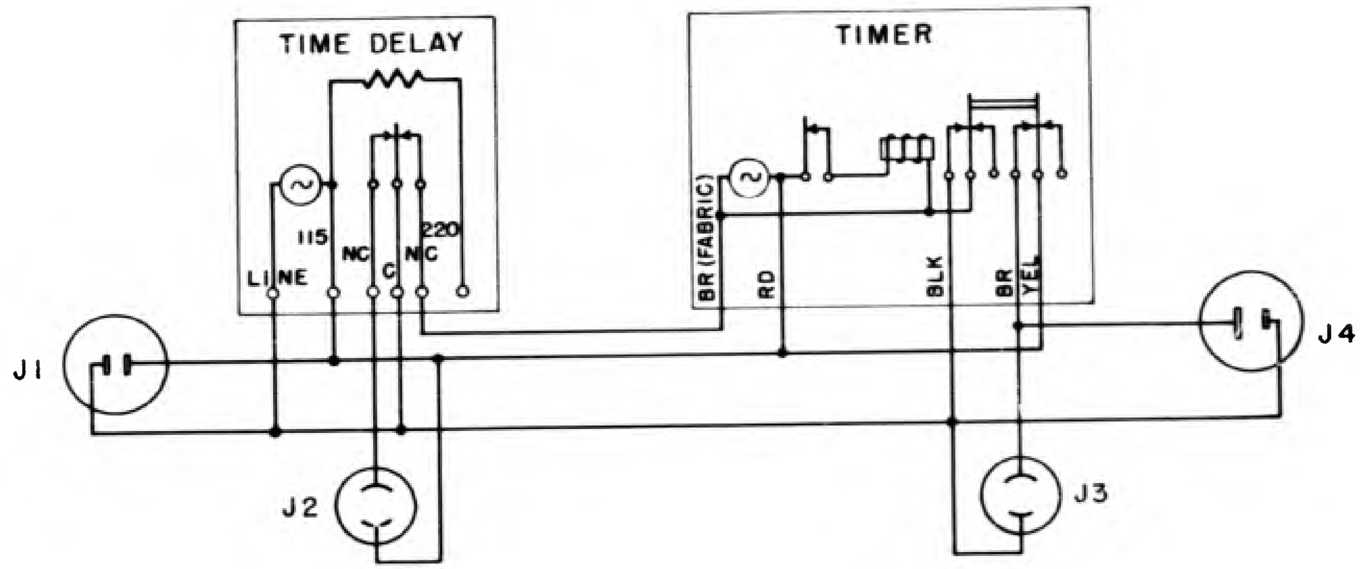
3.8 Camera is loaded with film as per Instruction Book #1079 and is operated by closing relay or switch discussed in 3.1.

3.9 Open control circuit at earliest convenience.

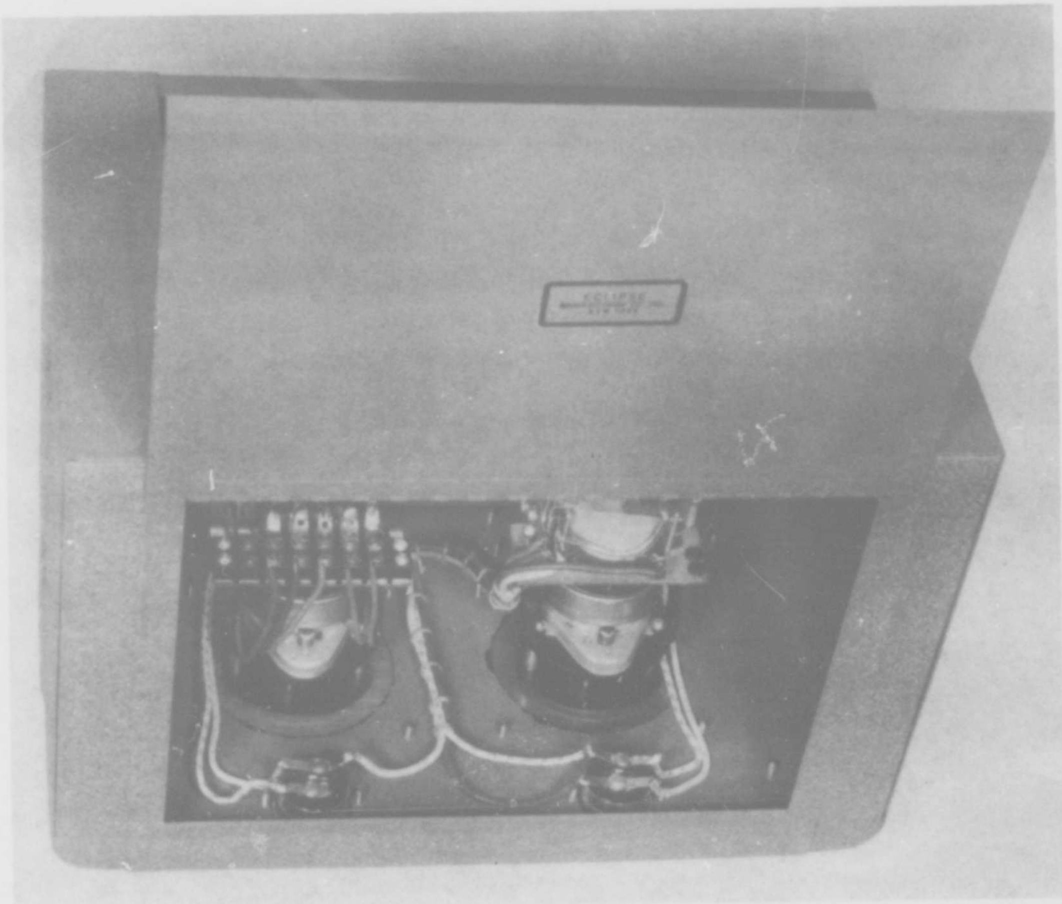
4. EXPECTED ACCURACY OF D-177426 CONTROL BOX

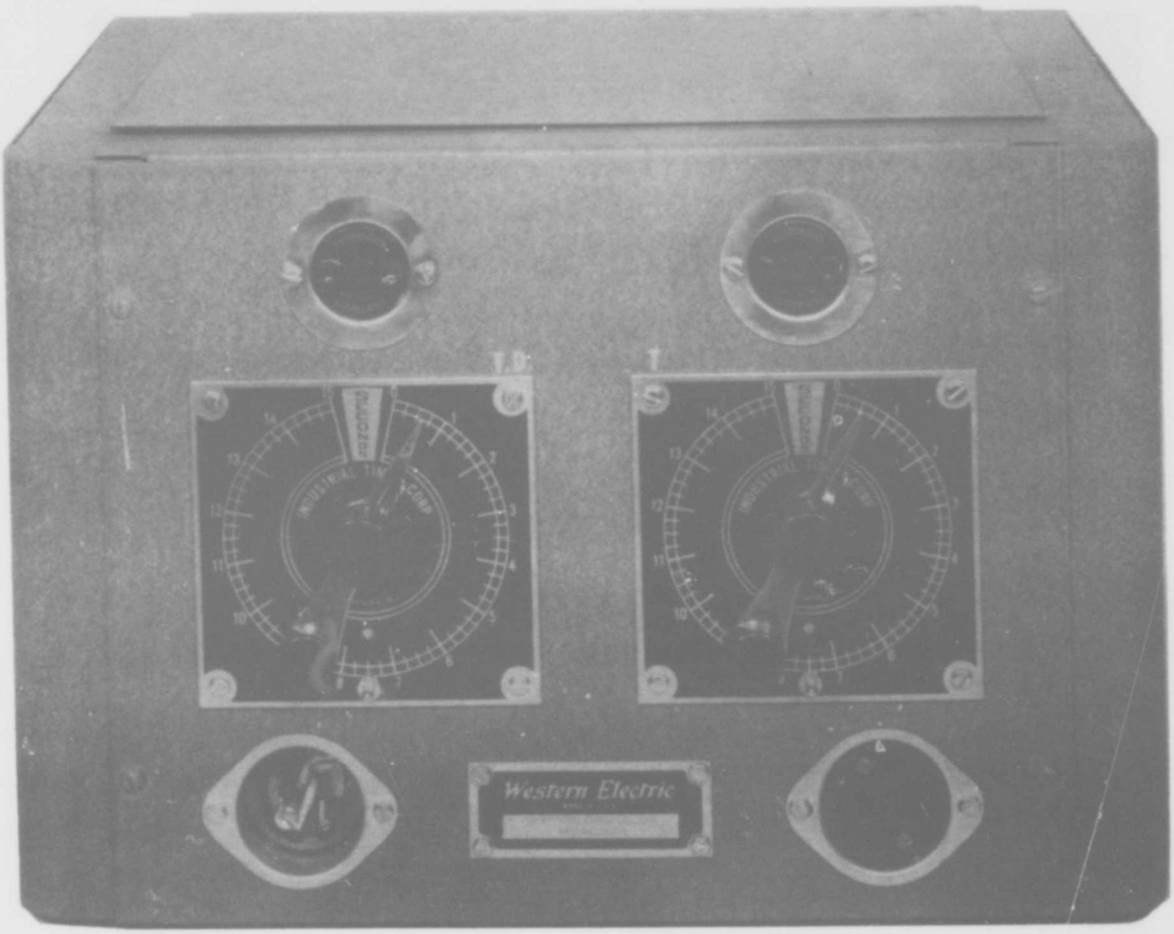
4.1 Scale approximately .3 second low over whole scale due to starting lag.

4.2 Successive readings for a given setting may be ±.1 second.


TIME DELAY
115
LINE
NC
C
NC
220
TIMER
BR (FABRIC)
RD
BLK
BR
YEL
J1
J2
J3
J4

Control Box




T.D.
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Western Electric

OPERATING INSTRUCTIONS FOR D-177423 CONTROL BOX

1. COMPONENTS

One six second timer
One six second time delay
One 10 ampere 270 volt powerstat
One auxiliary circuit for operating output of powerstat at 140 volts for 70 milliseconds and then immediately cutting over to full voltage of powerstat.

Case with suitable plugs and connectors for operating control box.

2. PURPOSE OF D-177423 CONTROL BOX

To operate Fastax High Speed Motion Picture Cameras at speeds in excess of their normal operating speeds.

3. SETTING-UP INSTRUCTIONS FOR CONTROL BOX

3.1 Connect 120 volt supply to connector at plug J5.

3.2 Check rear of time delay and interval timer to be sure motors are running. This can be seen by observing small gear on end of shaft which is enclosed in the transparent housing.

3.3 Check little red knob to be sure that it is on the counterclockwise side of the retaining stop of control handle. Also check same small red knob to be sure that it is set at the same positive time setting that the control knob is set at and is not in position zero.

3.4 Insert 300 volt voltmeter plug connector from test box into camera outlet.

3.5 Insert initiating circuit plug supplied with test set into signal outlet.

3.6 Close signal circuit when timer is set at 6 seconds and measure output voltage. For 270 volt operation and 125 volt supply, the setting will be about 92 on the powerstat.

3.7 Insert test plug from test set into first the time delay and then the timer for the purpose of setting accurately within three 100ths of a second the necessary time delay and operate time for the camera.

3.8 Remove test plug, voltmeter plug and signal plug from their respective receptacles.

4. INSTRUCTION FOR OPERATION OF CONTROL BOX

4.1 Insert connector from control relay which shall have no potential on it in signal receptacle.

4.2 Insert connector from camera into camera receptacle.

4.3 Be sure that the box is placed with the control panel in a vertical position. Since this unit has a mercury relay as one of the components, it is necessary to use it in this position. A tolerance of 20 degrees from either side of vertical is permissible but not recommended.

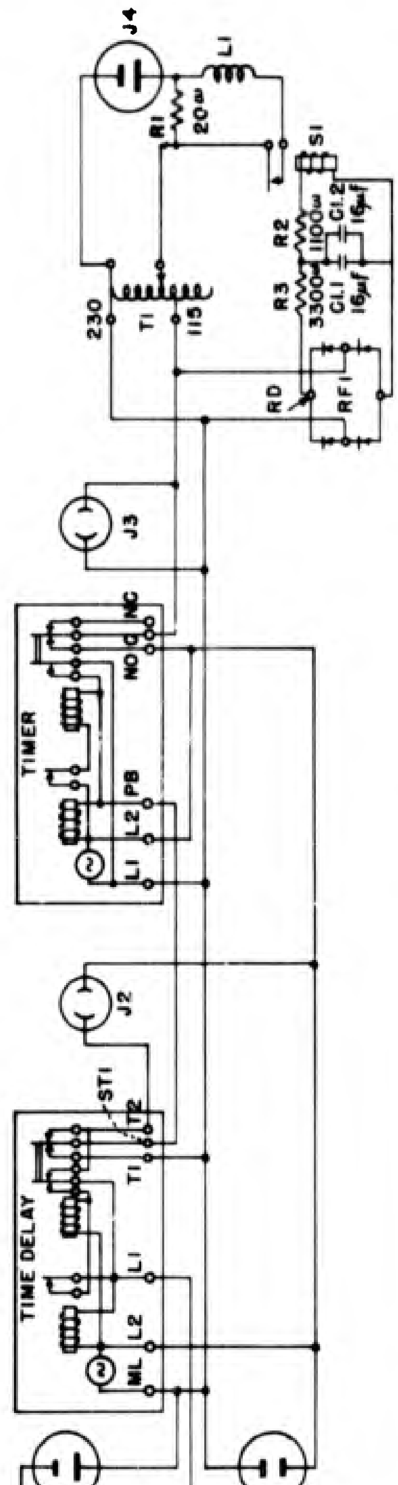
5. NOTES

5.1 With 60 cycles as a source on the AC the timer and time delay are accurate within .03 second of the desired time setting.

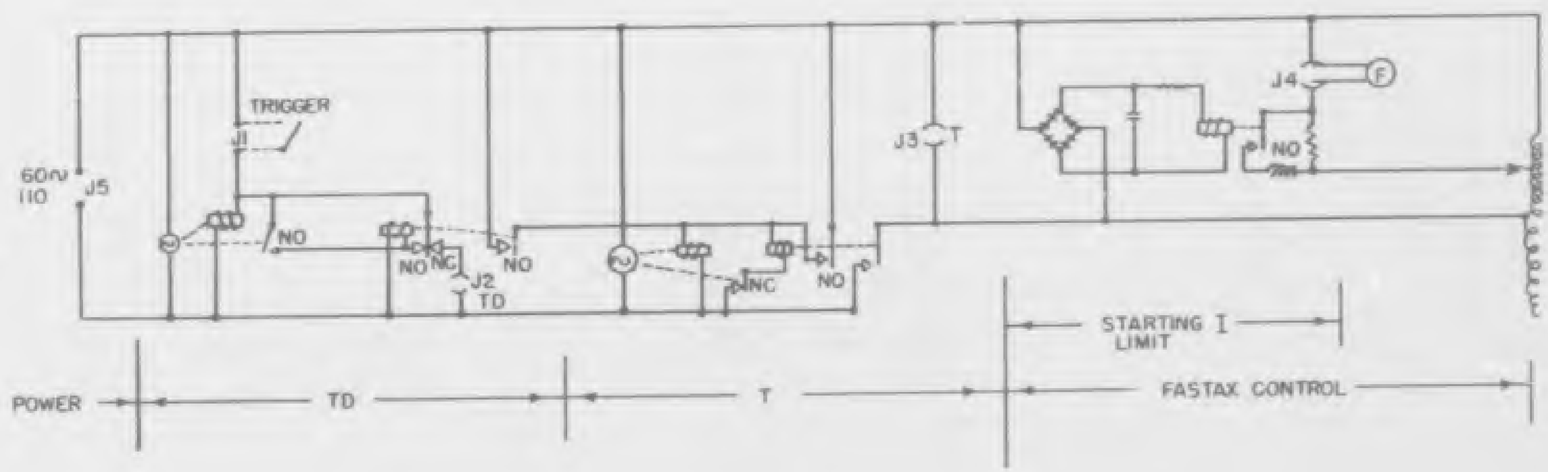
5.2 Camera operate time at 270 volts is .85 seconds.

6. MAINTENANCE

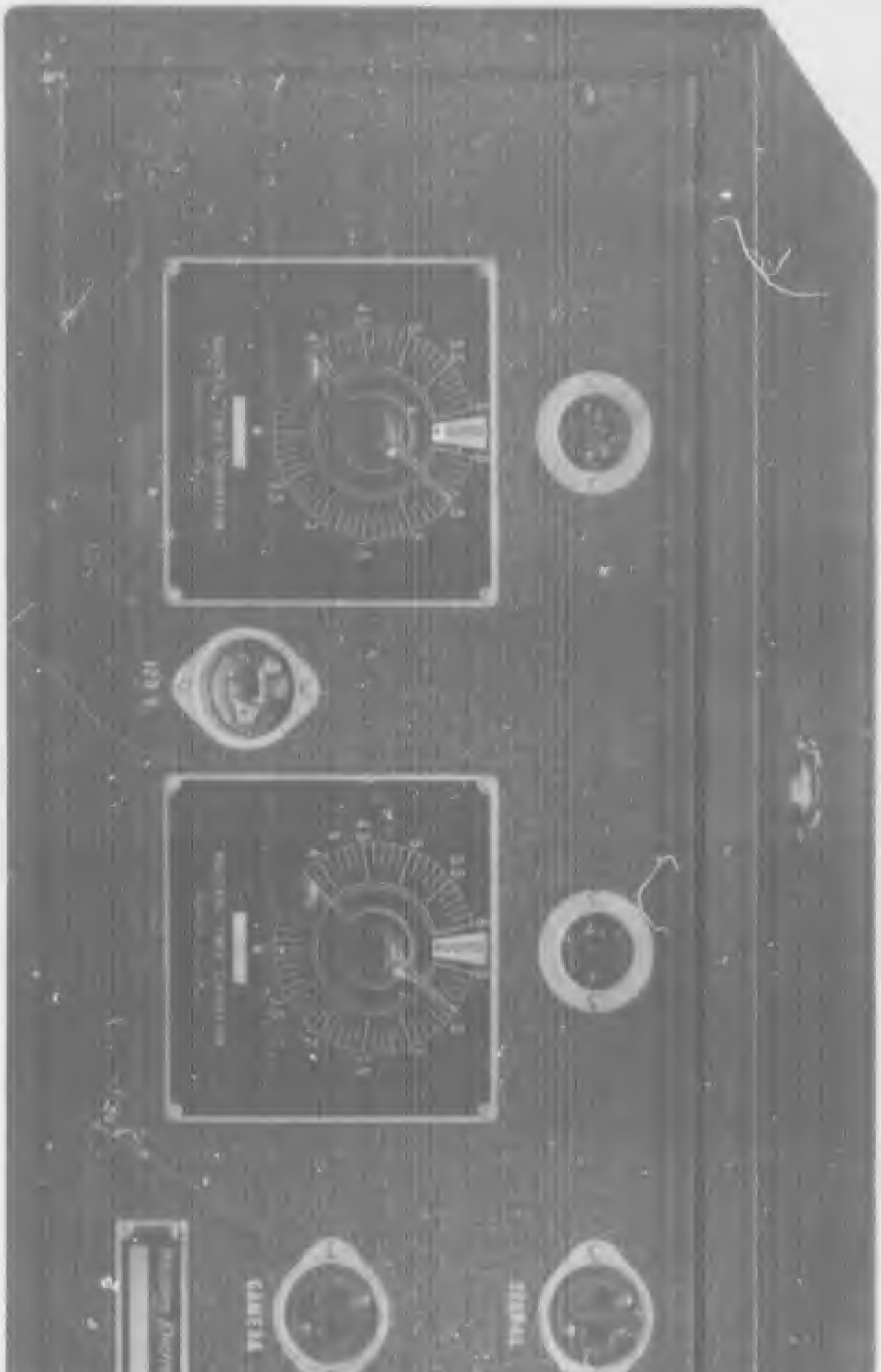
At camera maintenance station there will be a limited number of spare 275A mercury relays and timer and time delay relays. Do not attempt to make any circuit adjustments while in field.

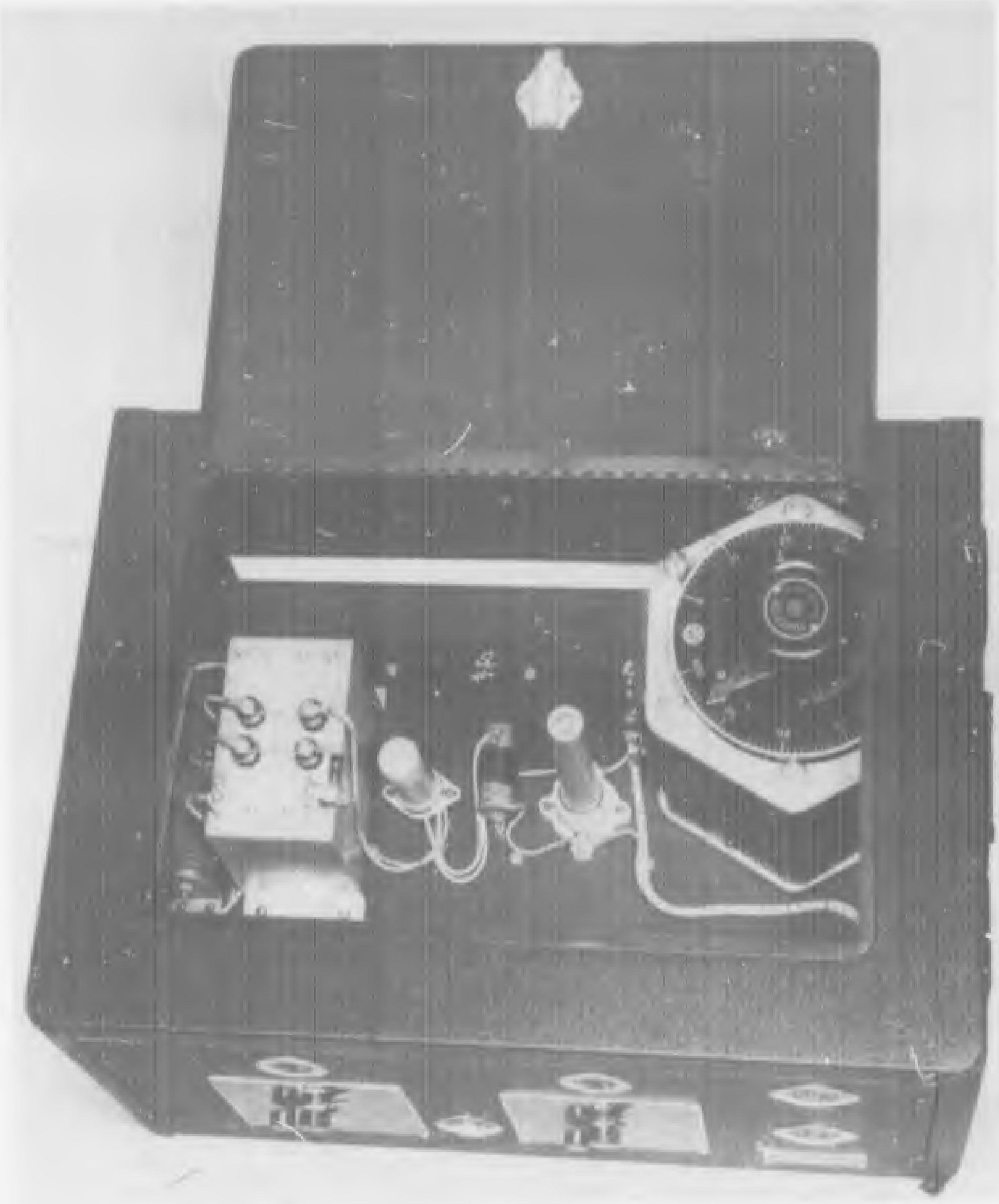

J4
L1
R1
20Ω
S1
R2
1100Ω
C1.2
16μf
R3
3300Ω
C1.1
16μf
230
T1
115
RD
RF1
J3
TIMER
NO
NC
PB
L2
L1
J2
TIME DELAY
ST1
T2
T1
L1
L2
ML
J1
J5

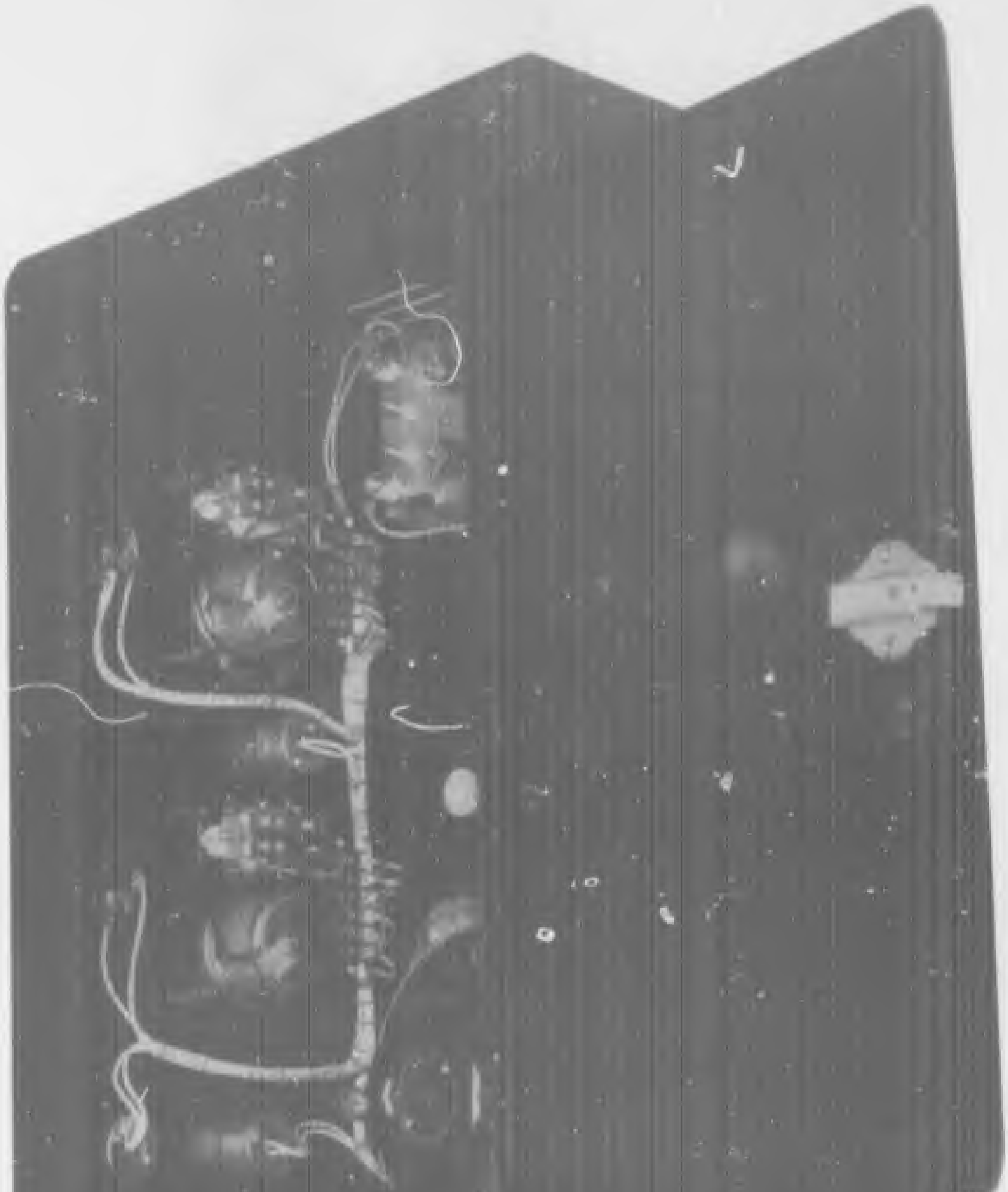
Control Box



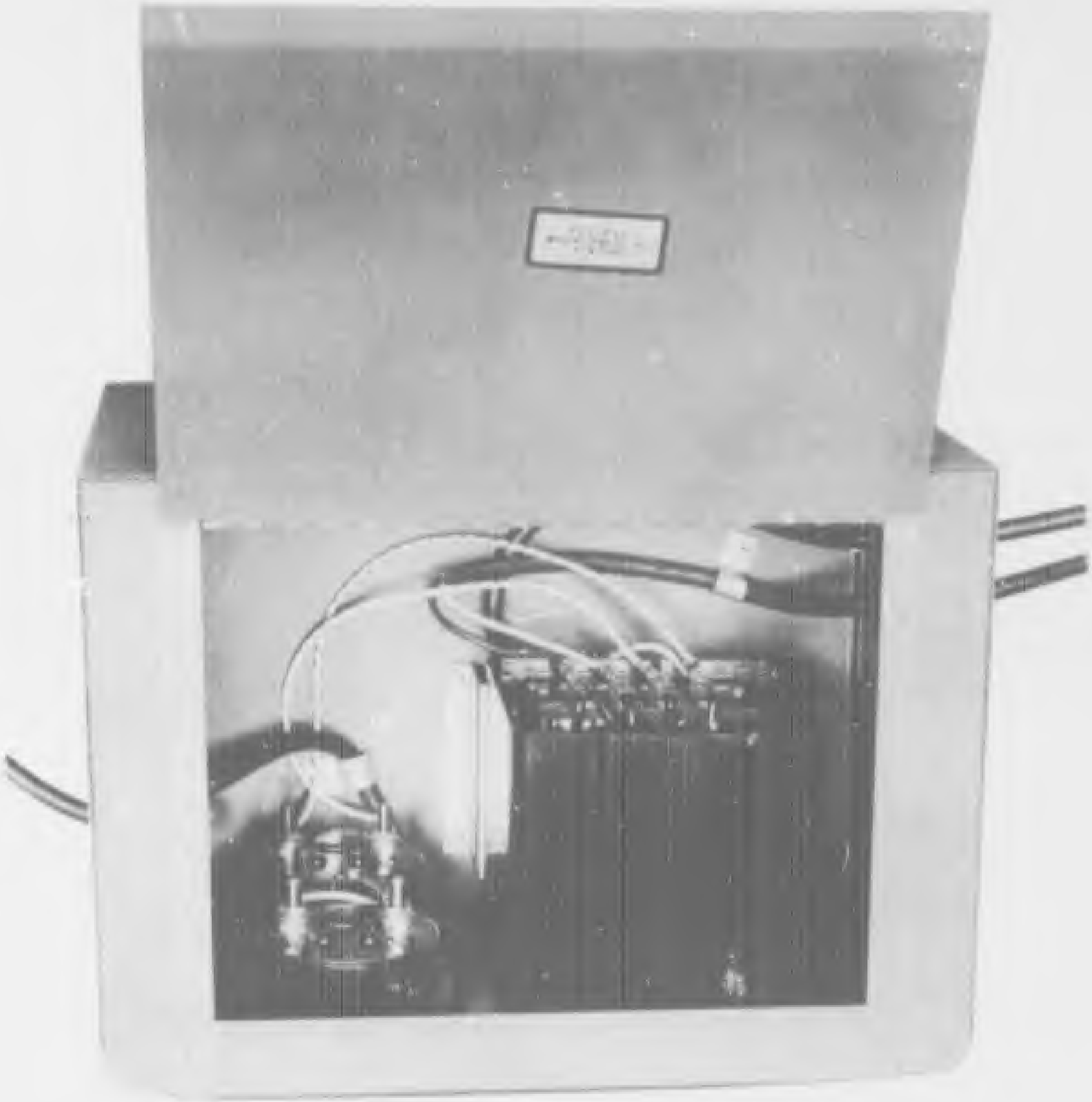
"Goose"
Control Box


CAMERA
SIGNAL





Time Test Set



Time Test Set

APPENDIX IX

RACK AND PANEL SYSTEM

1. The System

The rack and panel system was to have consisted essentially of eight units, each completely mounted and wired into permanent enclosed racks with sectionalized swing front doors where necessary. Each of these racks would be boxed and shipped to the site. For erection, each rack would be bolted to the next appropriate unit, thus the eight become one unit. Terminal strips were to be mounted in the side walls of each rack so that these would align with the next unit. The connectors to each terminal strip would then need to be only two inch long copper bars which would be put in place and then soldered, thus preventing corrosion, resistance troubles and loose joints. Properly designed and constructed, this type of rack and panel system can be reliably established in an extremely short time, and there is little chance of error.

2. Power Control and Indicator Panel

The system was designed so that all the power, i.e., the three phase, center grounded Y, 120 volt, AC, and the two wire 28 volt DC, both came into a single panel upon which were the main power switches. Also on this panel, were to have been voltmeters, ammeters, a frequency meter and indicator lights. The meters were to have green bands marked for the acceptable readings. Thus, a brief glance at the panel would indicate the condition of the power source. The lights were to be connected so that they must all be off before the system was ready for automatic operation. The bulbs were to have been neon glow type for dependability. With some added complication, voltage control could also have been added to this panel.

3. Raytheon Relay Rack

The two Raytheon relays for giving the minus-one-minute and minus-one-second signals were to have been mounted on one rack. Associated with them on this rack were to have been some holding, or circuit maintaining relays.

4. High Speed Fastax Rack

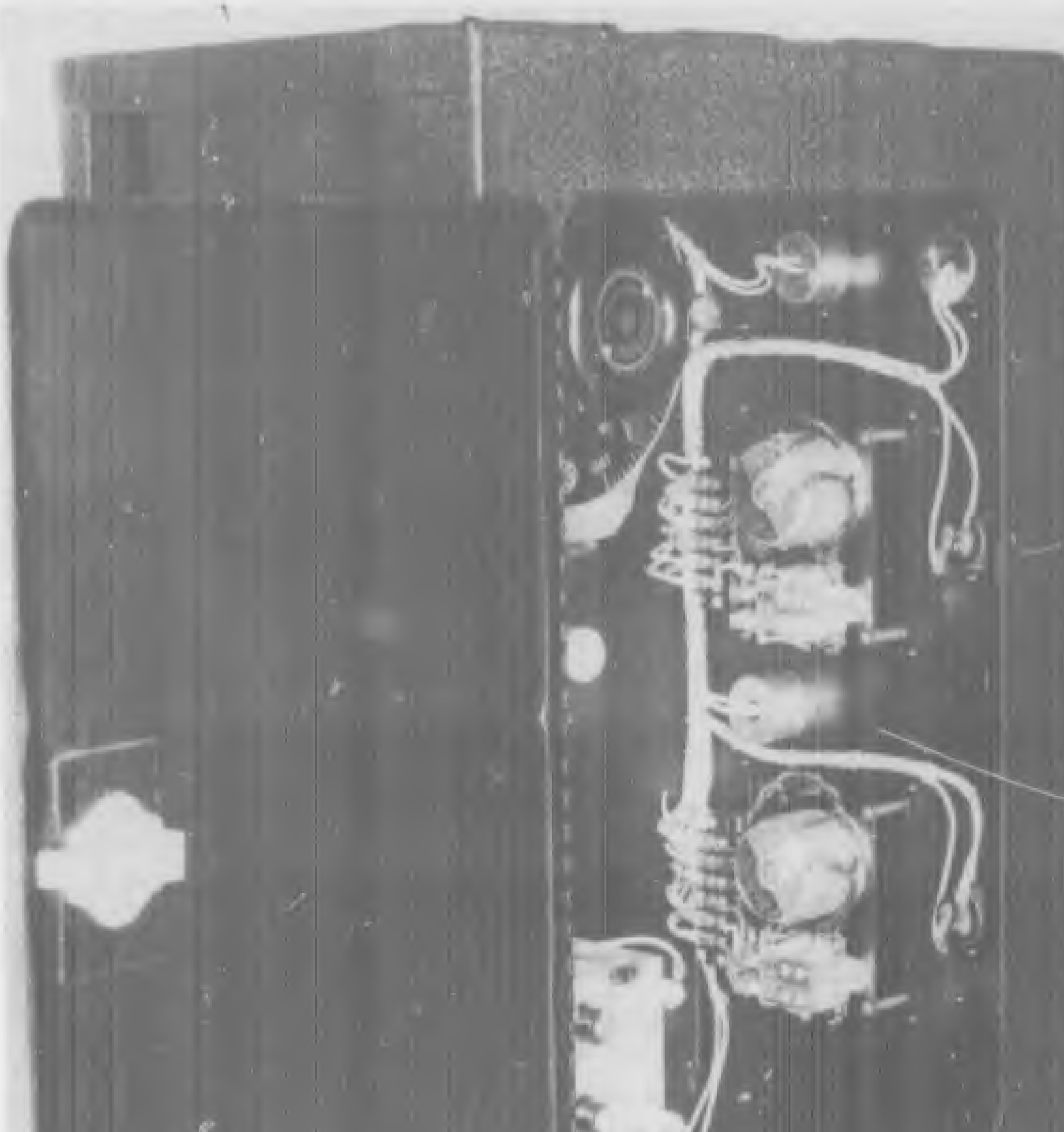
This rack was to have been constructed by removing the components from the 423 Fastax control units supplied by Fastax and compactly mounting the timers, relays and resistors on the hinged fronts, while the heavy powerstats, the condenser, and rectifier were to have been mounted on the frame. No plugs would have been brought out of the front, the power for the cameras going into the bus system for delivery to the camera harness. All output functions of these controls would have been measurable on the test panel. Clip-on or plug-in test lugs were to have been installed for testing within the unit. The following photographs show the 423 control boxes and components. See also Appendix VIII. Marked fuze strips were to be utilized to fuze each function.

5. Slow Speed Fastax Rack

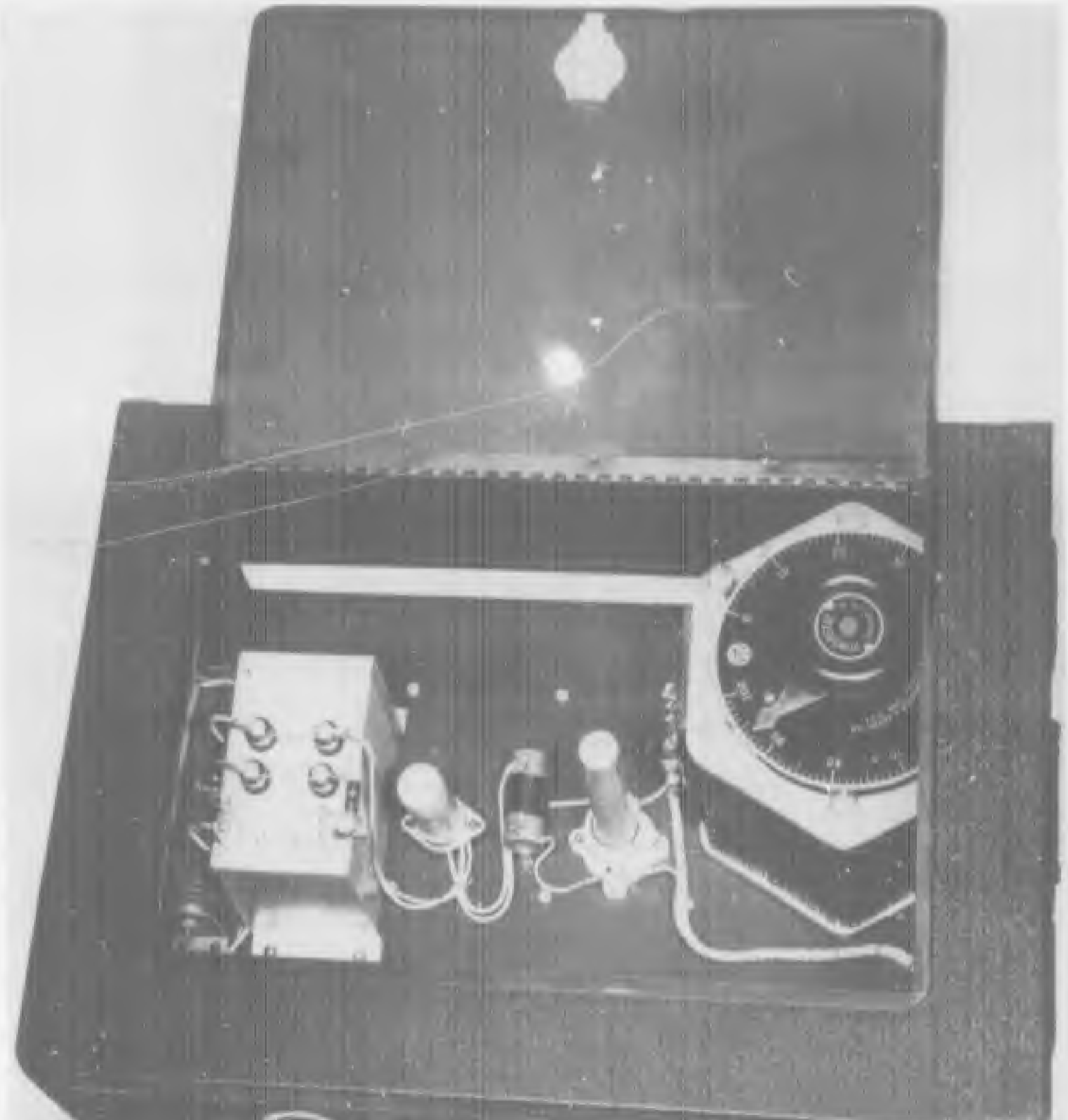
The slow speed Fastax controls, all the gizmo controls for the aero stills, and the movie controls were to have been mounted on this rack along with sound equipment and miscellaneous controls. The timers were to be mounted on the front hinged panels, the heavier equipment to the frame. Pictures of the 426 control and components follows.

6. The Oscillograph

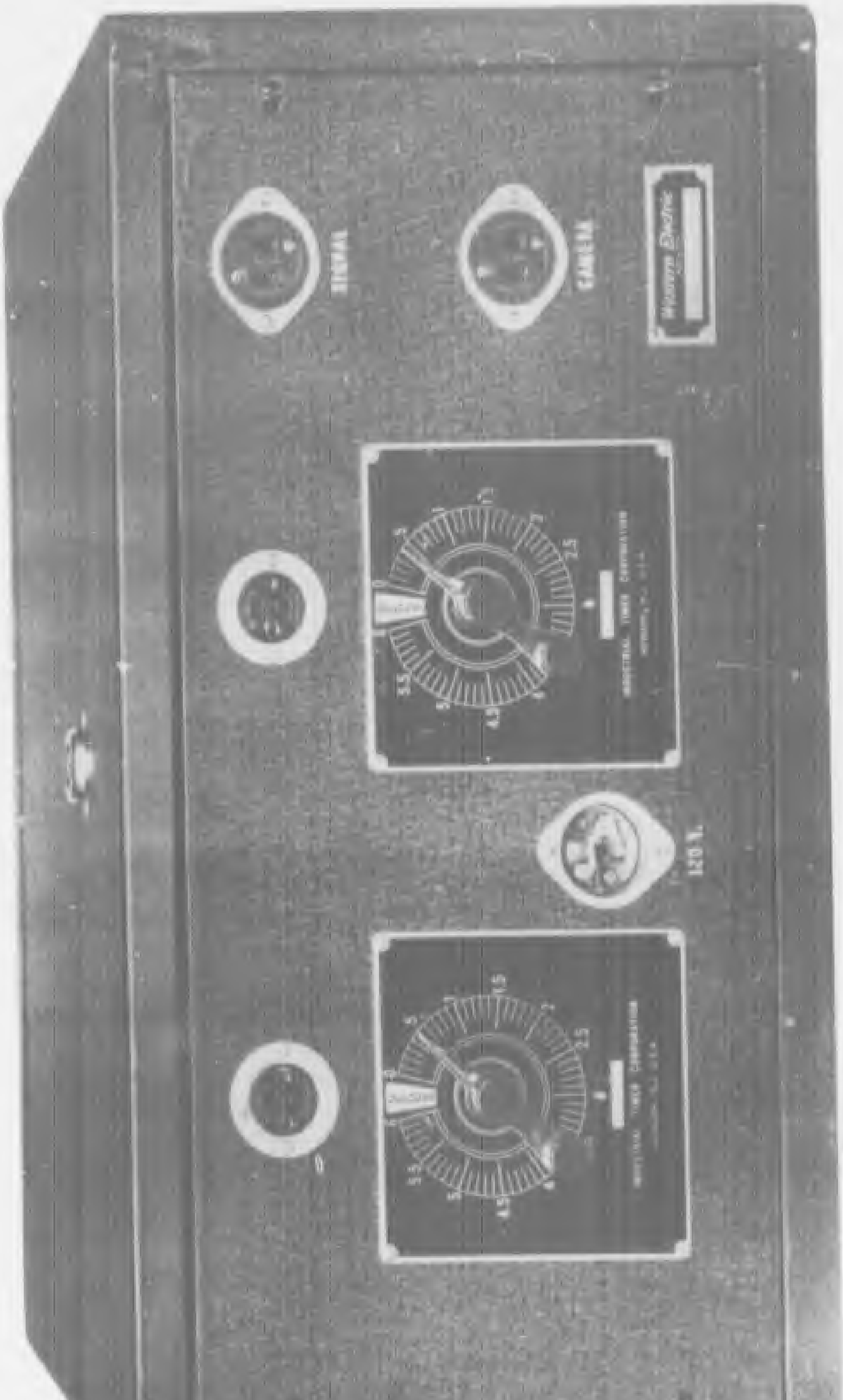
This instrument was to have been a fourteen element recording oscillograph upon which the various current and voltage functions could be recorded in relation to time. Other things like the relation of the starting times and running times of each camera could be recorded. Permanent records of the relation between the receipt of the minus-one-second pulse and the starting of each Fastax would have been obtainable for each test.



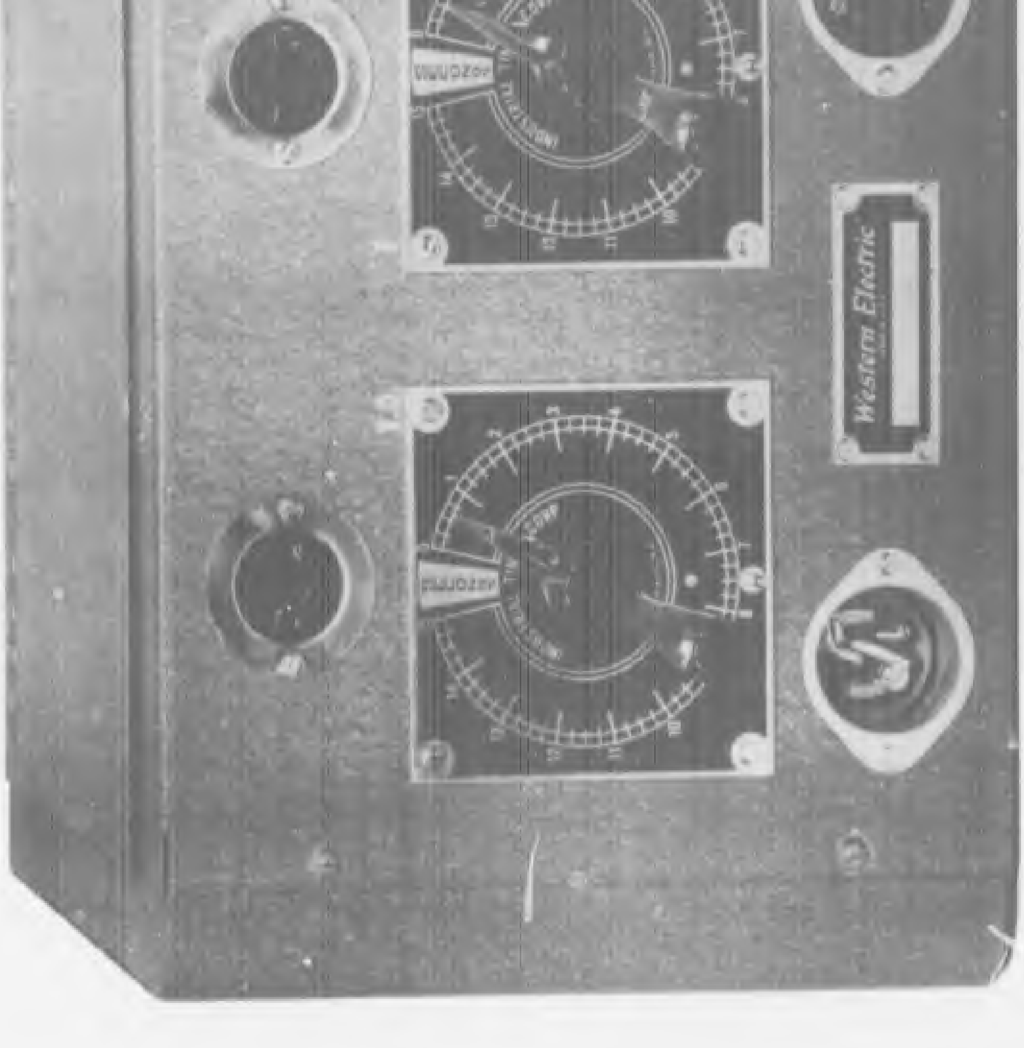
423 Control



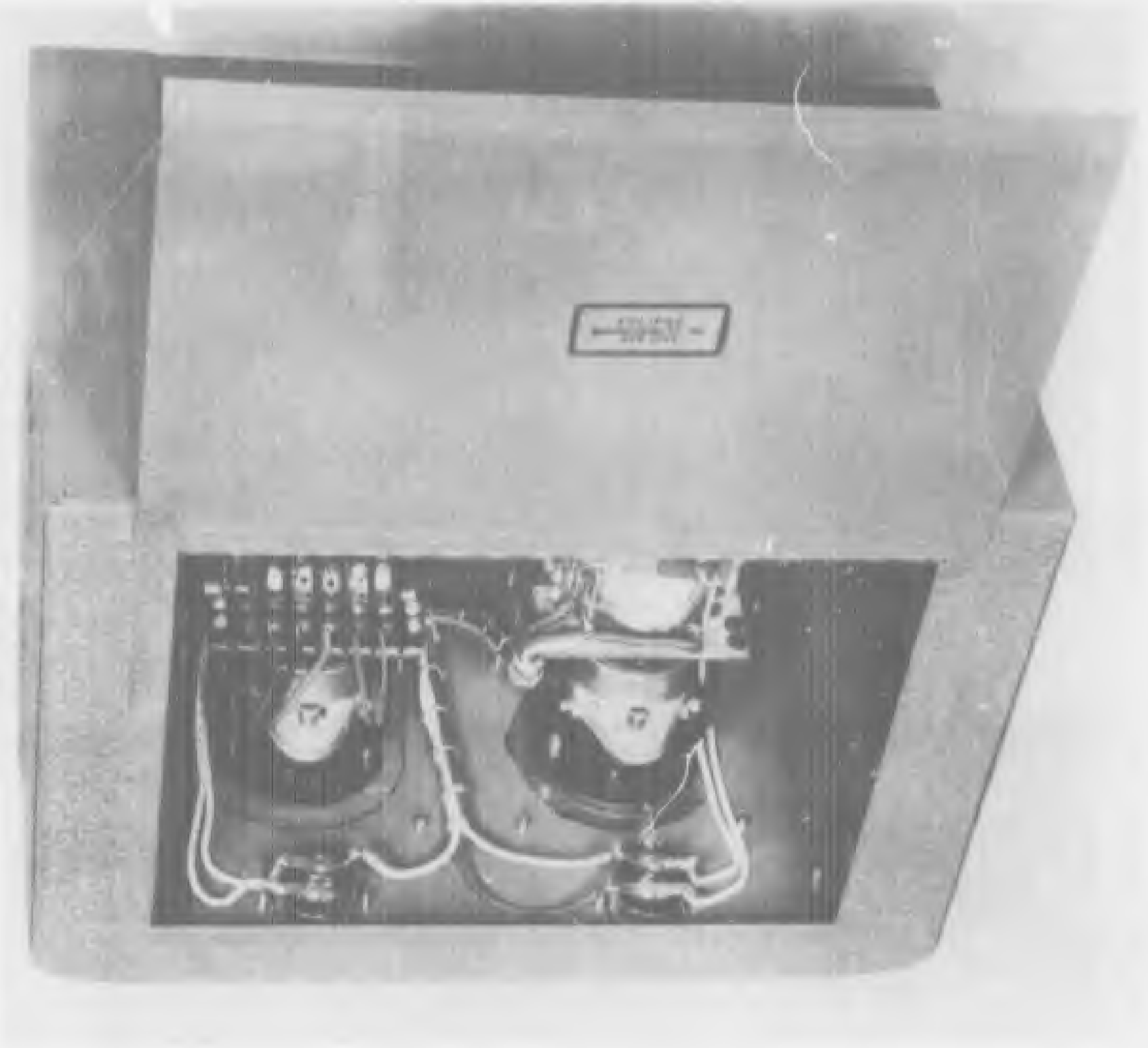
423 Control


SIGNAL
CAMERA
Western Electric
INDUSTRIAL TIMER CORPORATION
120 V.
INDUSTRIAL TIMER CORPORATION

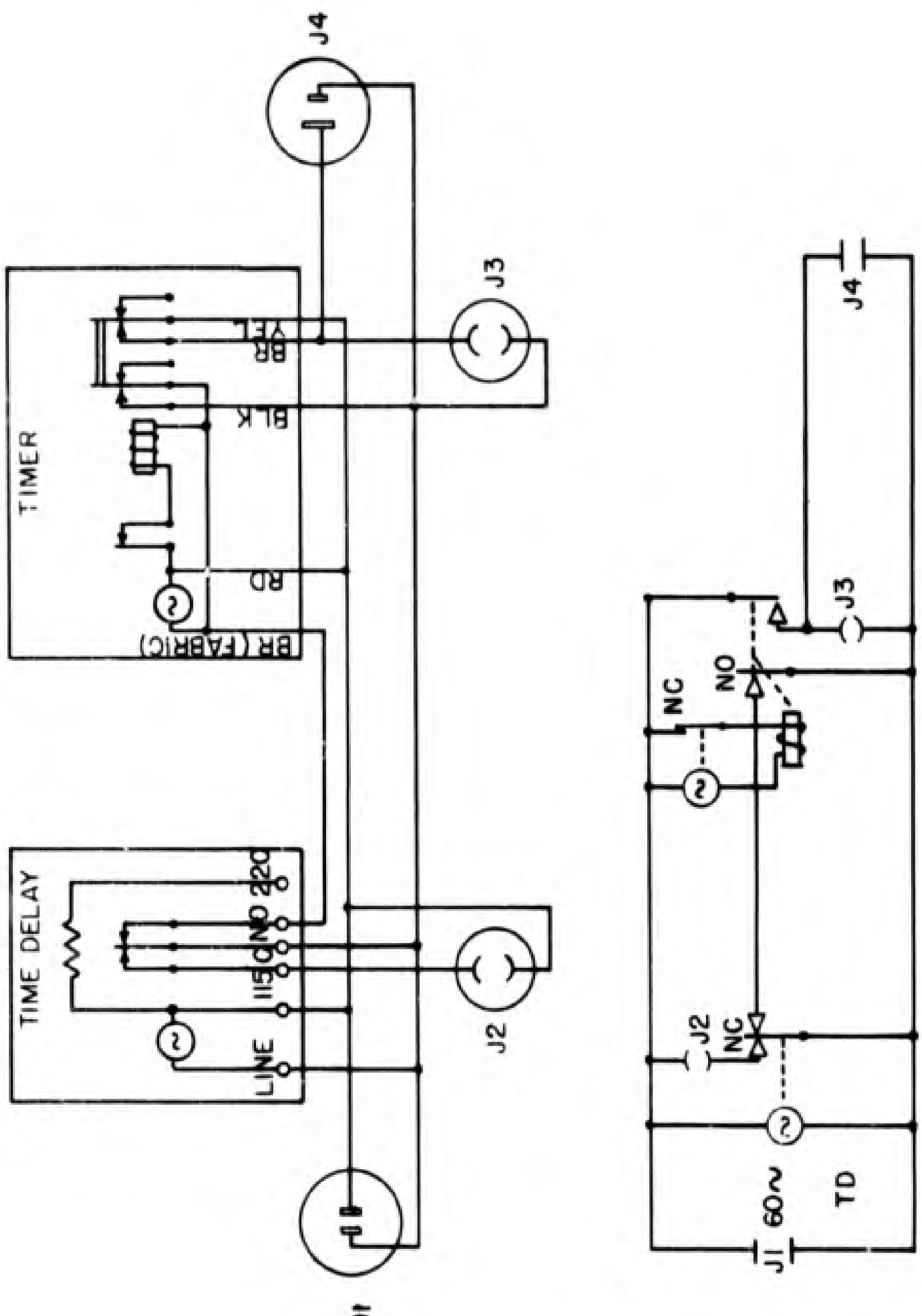
423 Control



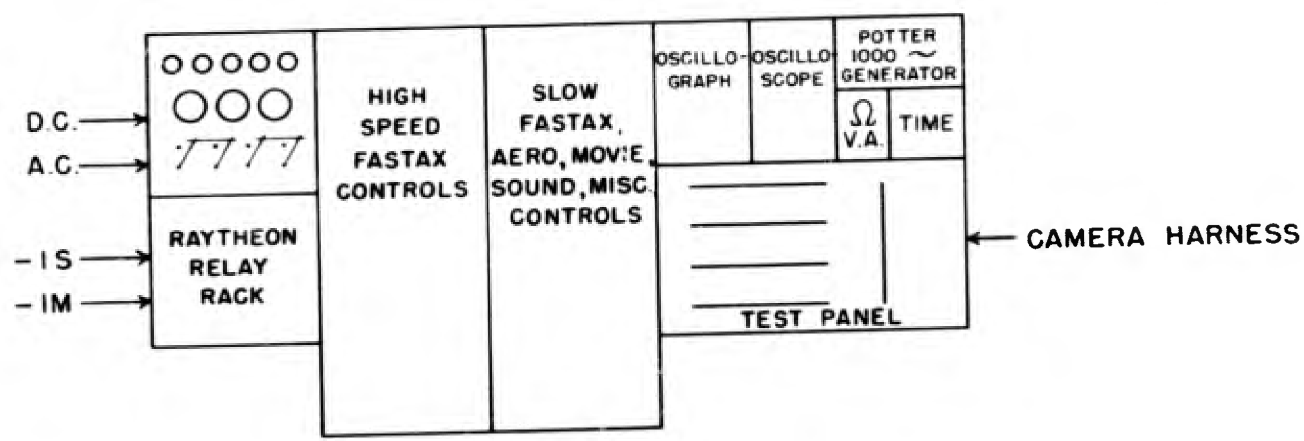
426 Control



426 Control



Control Box
Schematic



CONTROL AND TEST PANEL

7. <u>The Oscilloscope</u>

This instrument was to have been used as the basic unit for preventive maintenance. The electrical contition of all running units can be determined by properly applying the various electrical functions to an oscilloscope. The make-and-break transient phenomena associated with relays indicate the condition of a relay. The current wave shape and noise transients show the condition of driving motors. Time comparisons are easily made. The instrument that was desired for this was the five inch DuMont wide band oscilloscope.

8. <u>The Potter Generator</u>

The Potter 1000 cycle generator was to be mounted as a component with the test equipment. It is a nicely packaged unit and would not have been removed from its case but the case would have been secured to the rack and permanent connections made to the busses running to the cameras through the test panel. Appendix X gives details of the Potter generator.

9. <u>The Ohm-Volt-Ammeter</u>

The seventh panel was to include an ohm-volt-ammeter in addition to the Potter generator and a time test set. This instrument was to be connected into the test panel to be capable of rapidly determining the resistance, voltage, and current conditions of all circuits. Continuity of circuits is rapidly established with this instrument.

10. The Time Test

The time test clock was to have been removed from the test set and mounted on the seventh panel. The function of this test clock was primarily to check and set the time delay (TD) and the time of operation (T) of the timers.

11. The Test Panel

The test panel was to have been the heart of the test system. From this panel all functions of the timing system would have been ascertainable. The condition of each piece of equipment rapidly determinable, and the adequacy of each circuit measured. On the right side of this panel was to have been a master switch that would disconnect all power to the cameras. A switch on the panel would have furnished either a minus-one-minute or minus-one-second pulse to the Raytheon relay system. Thus, all timing functions could have been checked, after the cameras were loaded; or, with the master switch closed, under load. Individual switches were to give time control to each timer so that the operation of each timer could be ascertained or set. The panel would also have contained a series of spring-loadedneutral-position three-contact switches. These switches would supply the contact to give resistance, current, or voltage reading of each circuit. Other switches were to be mounted to allow placing the appropriate information onto the oscilloscopes. Telephone type jacks and plugs would make some connections more convenient.

12. The Test System

The test system added to the panel construction would have given a field control system that could have been very rapidly installed, condition immediately ascertained, and any malfunctions or incipient failures detected and corrected. A final check before leaving would record the time relations as set and the adequacy of each piece of equipment. The recording equipment would make a permanent record of the actual times of operation of critical speed cameras during the actual operation.

13. Failure of the System

The Rack and Panel System failed to materialize because of the short preparation time, and the failure of the Air Force depot system to supply some of the required components. The schematic diagrams that were developed for this system are not presented in this report because it is hoped that there will never again be the hasty requirement for the assembly of great quantities of this style of laboratory research equipment into field test units.

APPENDIX X

THE POTTER PULSE GENERATOR

1. Fastax Millisecond Time Marks

Relative time marks were applied to the Fastax film through the Fastax argon glow marking tubes installed in the Fastax cameras. The argon glow tubes were energized with 1000 pulses per second, each pulse being of C.2 millisecond duration. The pulses were supplied to all the Fastaxes in parallel from a single Model 2098 Potter Instrument Company 1000 cycle generator in each tower. This output was also used on the Sonne cameras in the early stages, but was replaced by a 120 cycle pulse because of the slow film travel speed of the Sonne.

2. The Potter Pulse Generator

The Potter 1000 cycle pulse generator was an entirely satisfactory instrument for the job required of it. No maintenance or calibration difficulties were encountered on the entire project. This instrument, and/or others from the same company can be built into an absolute time marking system as discussed in Appendix XI. The attached sheets give some technical details of the instrument. Additional information on this and other similar or related type marking and counting systems are available from John T. Potter, 13-56 Roosevelt Avenue, Flushing, New York.

MODEL 2098 - 1000 CYCLE GENERATOR

CHARACTERISTICS

OUTPUT: 1000 cps. positive pulses, 0.2 milliseconds duration, 150 volts into a 500 ohm load.

CRYSTAL OSCILLATOR: 100 KC, temperature coef. - 1 cycle per megacycle per degree centigrade.

POWER INPUT: 105-125 volts, 60 cycles, 130 watts.

DESCRIPTION

The Model 2098 - 1000 cycle generator is composed of a 100 K.C. oscillator unit, two electronic decade divider units, an output amplifier, and power supply.

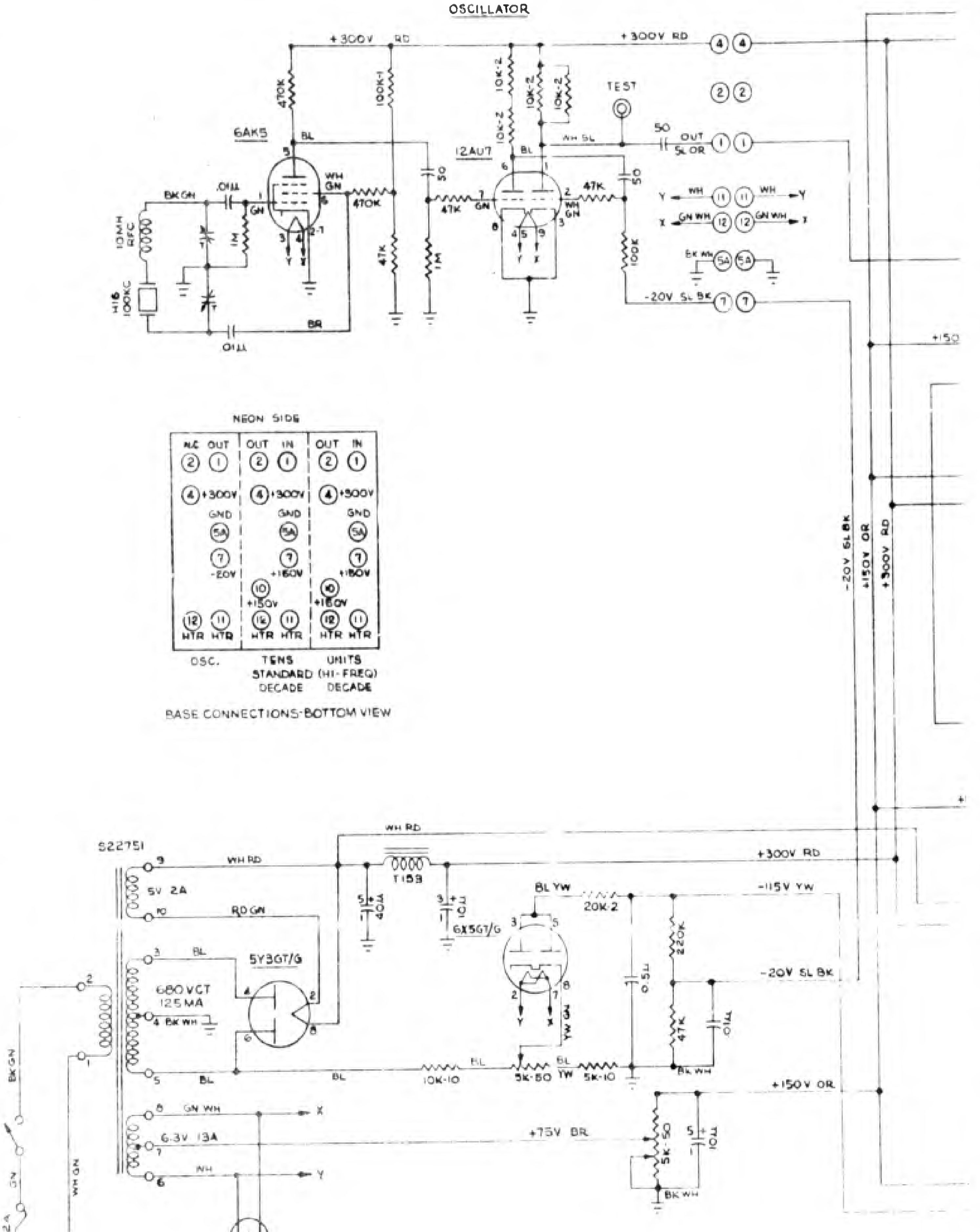
A modified Colpitt's oscillator circuit is employed as the crystal controlled 100 K.C. signal source. Tuning capacitors, located at the top of the oscillator unit, are provided for precise adjustment of the oscillator frequency against a primary frequency standard. Following the oscillator circuit is a two stage amplifier, the output of which supplies the first decade with the proper signal shape and amplitude.

The two electronic counter decades in cascade divide the oscillator frequency by the ratio of 100 to supply the output circuits with the precisely controlled 1000 cps. pulses. Functionally, the operation of the two decades is identical; the one designated "Hi-frequency decade" being specially adapted for 100 K.C. operation.

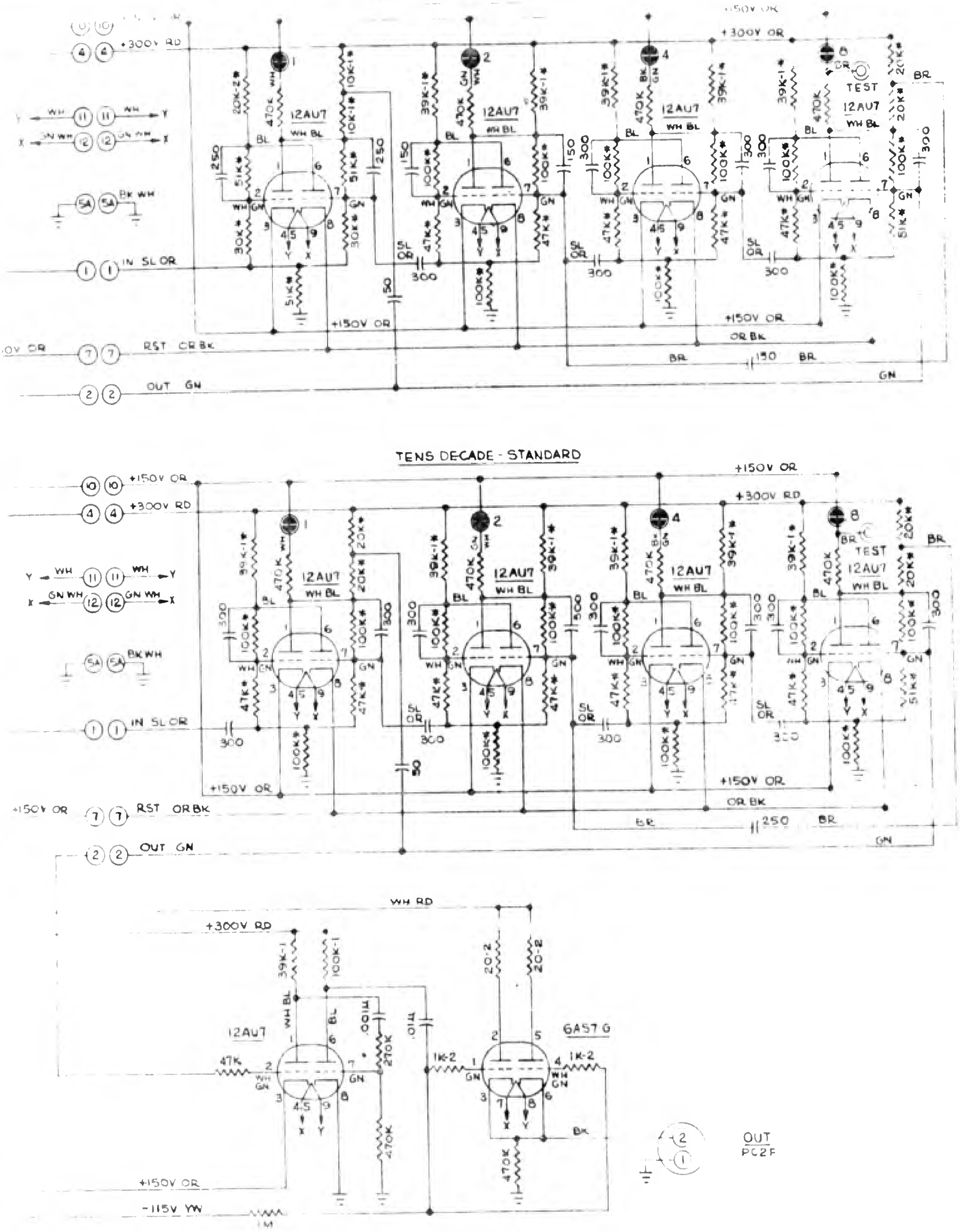
Each decade consists of four trigger circuits connected in series to form a binary scaling group of 16. However, by the addition of special resetting circuits the scaling group is forced to reset to zero at the end of ten counts. The combination of two decades therefore scales by the factor of 100.

Normal operation of the decade may be ascertained by observing (with the aid of an oscilloscope) one output pulse for ten input pulses. This is easily accomplished by setting up a pattern of ten pulses on the oscilloscope with the test probe at the input then moving the test probe to the output. An isolating resistor of about 50,000 ohms may be necessary at the end of the test probe to avoid spurious coupling. Neon glow lamps on the front panel indicate the condition of each trigger circuit in the decade.

The useful output of the second decade consists of positive pulses, 0.2 milliseconds in duration. These pulses are raised to final amplitude by a two stage amplifier and then applied to a cathode follow power tube.



NOTE 1- RESISTORS ARE HALF
"-1" FOR ONE WATT, "-2"
2- CAPACITORS ARE SHO
UNLESS INDICATED "
* 3- ACTUAL VALUES OF T
WITHIN 5% OF VALUE



WATT UNLESS INDICATED
FOR TWO WATT, ETC.
OWN IN MICROMICROFARADS
"μ" FOR MICRO FARADS.
THESE RESISTORS ARE
IFS SHOWN.

DRN LGB 1-20-48	POTTER INSTRUMENT CO FLUSHING NEW YORK	
CHD CH 2-4-48		
APP NM 1-30-48	MODEL NO 2090	
NAME 1000-CYCLE GENERATOR	SCALE NONE	DRG NO 2C0801

APPENDIX XI

TIME MARKING SYSTEMS

1. As Used

The time marking system used on the Photo Tower equipment for Sandstone, consisted of a single Potter 1000 cps generator connected to each of the Fastax cameras as explained in Appendix X. A simple 120 cps system was used with the Sonne cameras. A spark gap system driven by a crystal controlled strobotron was used to mark the Hi-Speed Mitchells. All of these are relative systems, placing upon the film only marks which are known to be separated by the calibrated time of the marking system. When an event common to each film is recorded and when this common event can be identified as being common, then relations between the films can be established by counting marks from that event. This is sufficient for much of the atomic weapon detonation photography, as the first recorded light of the detonation can be taken as near zero and an interpretation made. There are conditions, however, when the relative system fails, and an absolute system would be an advantage.

2. Coordinated Relative System

A coordinated relative system might consist of a method of inserting an extra long mark into each camera at some given time. This might be accomplished through a radio link so that a receiver in each camera control station added a pip to the marking system. Thus, each of the films from a test would contain a mark that had been made at the same time. All films so marked would then be related in time whether common phenomena were recorded or not. This might be very important when, in the future, not all cameras are aimed to record the detonation; but some are used to record other phenomena resulting from the detonation. In these cases, it might be wise to know the time in relation to the time of detonation.

3. <u>An Absolute System</u>

Best of all the systems would be one that put on absolute time marks. This would simplify the analysis of long running time films, and make it possible to coordinate the results from widely separated stations. It is complicated to make such a system and the cost may not be warranted. However, the basis for such a system existed on the Sandstone tests, but under a project so highly classified that few projects could take advantage of the system. A workable system would probably consist of radio correctable time generators; or of a series of coded radio pip signals that would be added into the local relative marking systems. A more complicated system consisting of two radio carriers can be constructed. At the reception of modulated carrier A, all the time marking receivers prepare for operation, setting themselves to zero. Modulated carrier B must be received within, say, one thousandth of a second of the termination of A or the clocks will not start. Thus A must be interrupted and B must be commenced or the clocks will not respond. The clock driving control may actually be taken from the modulation of the B carrier; but, crystal controlled clocks might be more satisfactory. Confirmatory pips could later be added at one second or other intervals over channel A if desired.

4. The Mitchell Marking System

The spark gap system supplied by E, G & G for marking high speed Mitchells is not basically good for field utilization, as an examination of the photo tower Mitchell film for the Z test will demonstrate. In addition, that system was considered to represent a fire hazard. Nitrate film can be, and was, ignited by the spark. This only happens when a camera malfunctions; but malfunctions do, and did, occur, and are more probable with high speed cameras than with standard ones. A glow or spark tube with slit or lens system built into the camera would be much more satisfactory. All the Mitchells and other movie cameras at one location should be run from the same time mark producing unit. The

Potter generator is an ideal type for this. If the 1000 cycle mark is too fast, additional stages can be added to give lower cyclic rates. The cross references used in calculating, and the difficulties of calculations are reduced where standard marking rates are used. The 1000 cps rate for the Fastaxes is a very convenient one.

5. Still Camera Systems

There is a need for a time marking system for repetitive still cameras. Consideration of the Aero K-18 shows that a simple pip generator will not suffice. The markers must show some relative, or absolute, time relation that continues from frame to frame, or from start to finish. In some types of cameras, sweep-second hand clocks may be reasonably added. These could be radio synchronized if necessary. In some aero cameras it will be necessary to add an additional synchronized shutter when the clock is added. For some types of photography, this shutter is not required. The clock image will smear on the film between exposures with the end of the smear corresponding to the beginning of film change, or end of exposure. Light masking systems can be produced that could, if necessary mark the film in times less than 1/1000 second. These systems consist of various kinds of disks which rotate at various speeds, each with a mechanism for letting light through. A vernier type might be the best. If three concentric rings of holes are drilled in a plate, say 1000 in the outer, 100 in the middle, and then 10 in the closest; and this plate is covered with a rotatable disk which also has three rings of holes corresponding to the rings in the plate except that this disk has, say 999, 99, and 9 holes respectively, then a vernier effect of light passage will give ratios of time markings.

6. Additional Information

Under certain conditions, it is desirable to add marks to some cameras. This was the case when the two tenths of a second was lost in the time between actual and anticipated detonation for the X Day test. It was desired to record on a Fastax film, the time of receipt of the minus-one-second pulse, the starting of Fastaxes F1, F2, F3; and the zero tower flash. No good system was immediately available, so flash bulbs were connected across the Fastaxes and also across the minus-one-second relay. These flash bulbs were then photographed by a Fastax manually started at minus-two-seconds. This was a clumsy system and failed more often than it succeeded. A system of using charged condensers which would be discharged into the Potter generator Fastax marker light system was suggested, but not built and debugged. Some such system is needed, however, and a reasonable approach is through the already existing marker lights in the Fastaxes. The design of a marker system should include provision for additional pips, whether they be radio delivered or tower generated.

7. Compactness

Any system designed for field use should be compact and dependable. It should preferably consist of a single box or unit that needs no assembly and is easily installed. It should be a system that either operates accurately or fails and the failure is apparent.

APPENDIX XII

CAB APERTURE PROBLEMS

1. The Sandstone Tower

Appendixes II and VII contain pictures of the curtain system that was used on the Sandstone tests. This was not a satisfactory solution of the problem of what to do about closure of the cab aperture through which the cameras must receive their light. Wind loading might have prevented the canvas from falling so it was always lowered before evacuation of the tower. As a result, water, salt spray, and dust were at various times found upon the photographic equipment. The curtain could have been weighted so that it would roll down the front of the cab. The releases could have been made so that they had to be energized to be made to hold the curtain. If one release were AC, and one DC, any failure in either system would have dropped the curtain. If no failures occurred, the holding circuits would have been interrupted as the minus-one-minute signal. The curtain solution, as used, was adopted because of time and equipment limitations.

2. Other Types

Counter balanced solid door types were also considered. These would be hinged along the top, and counter weights added so that the door would open under gravity. Catches would hold the doors down until the energization of the catch mechanism was relinquished at which time the catch would fall down, the door up. The door also acts as a visor under these conditions. Folding canvases could have been added to the sides of the doors to make awnings for more complete protection. Sliding doors, either horizontal or vertical were also discussed, but discarded from considerations of dependability.

3. Recommended System

The best type considered would require some early planning and procurement. Each camera would have a small "twindow" porthole to look through. The twin layers of sealed glass preventing condensation and steam troubles. Over each one of these windows would be a small, spring actuated cover, held tightly closed by a latch. A gasket around the door would protect the window from dirt, salt, and water. The minus-one-second would actuate the release mechanisms. Maybe it would be desirable to make both the minus-one-minute and minus-one-second signals trip the releases, through separate circuits, thus making failure less probable. This solution is particularly applicable to the pre-prepared unit type cab as discussed in Appendix XIX.

APPENDIX XIII

POWER CIRCUITS

The schematic and block diagrams required for the completion of this appendix were not available in suitable form when the deadline for the completion of this report was encountered. The basic material for these drawings is available at E, G & G, Inc., Boston. J-Division, Los Alamos, has diagrams of the general power set up and the reasons for this distribution and utilization. The basic reasoning behind the power distribution and generation systems was to supply power with the greatest dependability consistent with time and effort available. One unusual possibility arose in connection with the Tower Photography. If one of the diesels had failed thus causing the second one to come onto the line at the precisely wrong time, recycling of some of the fast camera time control circuits would have happened. The camera control circuits were, therefore changed to accommodate such a contingency, but this added considerable complexity to the relay control set up of the Photo Tower system.

APPENDIX XIV

PHOTO TOWER FILM REQUIREMENTS

1. Original Requirements

The requirement for film was originally established upon this table:

Test	Tower #1	Tower #2	Total	To be delivered to AV-4 not later than
PPQ	1	1	2	PX-14
PQ	1	1	2	PX-10
Q	1	1	2	PX- 6
PX	2	2	4	PX- 4
X	1	1	2	X- 4
PY	2	2	4	PY- 4
Y	1	1	2	Y- 4
PZ	2	2	4	PZ- 4
Z	1	1	2	Z- 4
			24 tower loads	

Tests PPQ and PQ were established as debugging, correcting, and training tests. Q was to be a full scale manned/daylight test with everything in final form. PX was established by AEC as a full scale evacuated test to be exactly like X except for the substitution of flash bulbs for the weapon. Two loads of film were ordered for PX, one for loading; one for spare for both PX and X. For security reasons, the dates were given in relation of test days, not dates.

2. Revised Requirements

The late arrival of the Photo Tower unit, aggravated by the delay in arrival of film, necessitated alteration of the schedule:

Tower Loads of Film Required

Test	Tower #1	Tower #2	Tower #3	Tower #4	Total
QX	1	1			2
PX	1	1			2
X	2	2			4
QY	1		1		2
PY	1		1		2
Y	2		2		4
QZ	1			1	2
PZ	1			1	2
Z	2			2	4
					24

This does not include the film needed for documentary purposes.

3. Tower Load Consistency

4	RLCF	16mm	Class L	100 ft.	Fastax	B&W
4	RACF	16mm	Class A	100 ft.	Fastax	B&W
2	RMCF	16mm	Class M	100 ft.	Fastax	Color
1	RKCF	16mm	Class K	100 ft.	Fastax	Infra-Red
3	MLG	35mm	Class L	1000 ft.	Mitchell	B&W Movie
2	RMF	16mm	Class M	400 ft.	Maurer	Color Movie
1	RMF	16mm	Class M	400 ft.	B-1E	Color Movie
3	ALB	9½in.	Class L	75 ft.	K-18	B&W Aero Still
3	AMB	9½in.	Class M	75 ft.	K-18	Color Aero Still
4	BLA	5½in.	Class L	56 ft.	K-24	B&W Aero Still
4	BMA	5½in.	Class M	56 ft.	K-24	Color Aero Still
1	ALD	9½in.	Class L	200 ft.	Sonne S-7	B&W Smear

This does not include the film for the O'Brien camera which is to be supplied by Mr. Brixner.

4. <u>Substitutions</u>

Late arrival of film, or changes in plan necessitated the substitution of film for other kinds of film. This sometimes depleted one class of film which should have been restored. A good system of film procurement and delivery can mean a great deal.

APPENDIX XV

FILM MARKING SYSTEM

1. Film Serial Numbering System

The attached document issued by Headquarters, 311th Reconnaissance Wing gave the original film handling instructions. Paragraphs 1 and 2 establish the method of assigning film serial numbers to every roll or package of film to be used on Project Sandstone, and gave the code showing the meaning of the serial number. Paragraph 3 gives the intended importance of the serial number. Appendix XX gives the serial numbers of all film used by the Photo Tower unit.

2. Inapplicability of Marking System

Paragraph 4 gives the methods by which the various kinds of film will be marked. Slating of motion picture film may be right for documentary crews, but is nearly impossible and highly undesirable in the case of the Photo Tower operations. Grease pencil marking is never completely reliable, it sometimes rubs off. Careless marking by individuals produces unintelligible writing. Neither slating nor waxing of Fastax film is reasonable. Because of the foregoing difficulties the Photo Tower group adopted the concept of perforating used by Eastman Kodak Company.

3. Photo Tower Film Mark System

The mark number, when deciphered with the following mark code gives all the information as to the origin of the film.

A system of marking each camera position was established for the Photo Tower cameras. The MARK consists of a sequence of numbers and letters which give the elements of position and operation of each camera. The first element of the MARK is a number which designates the tower in which the camera was mounted; the second element is a letter which designates the type of camera used in this position; the third element is a number which designates the position in the tower; the fourth element is a letter designating the test for which the exposure was made; and the fifth element is a number designating the roll being used as original or standby. To illustrate this, the MARK 1F9Y1 shows that:

a. The film was exposed in Tower #1 (The Coral Tower).

b. The camera was a Fastax.

c. The camera position in the tower was #9.

d. The film was exposed for the Yoke Day test.

e. The film was the original roll.

4. Photo Tower Film Punch System

Because of the unreliable aspects of marking or slating film as pointed out previously, a system for converting the Photo Tower MARK into numbers was established so that the basic information could be perforated into the film, the caption sheets, the containers, and into gummed tape. The PUNCH presents the same information as does the MARK, the MARK being more convenient for thinking and conversing; the PUNCH being an indestructible identity for each film.

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5. **Mark and Punch Code for Designation of Sandstone Photo Tower Film**

1	F	1	X	1	--- Mark
1	1	01	3	1	--- Punch

TOWER NUMBER
1.- Coral
2.- Aoman
3.- Runit
4.- Aniyaanii

CAMERA KIND

Punch	Mark	Make
1	F	Fastax
2	M	Mitchell
3	N	Maurer
4	K	K-18
5	L	K-24
6	S	Sonne
7	O	O'Brien
8	B	BLE

CAMERA NUMBER
01 thru 30

TEST NO.
1 - QX
2 - PX
3 - X
4 - QY
5 - PY
6 - Y
7 - QZ
8 - PZ
9 - Z

ROLL NO.
1 - Original
2 - Standby
3 - Standby, repunched
4 - Standby, twice repunched

Either the Mark or the Punch in the above example shows these facts:

The film was exposed in Tower #1

The camera was a Fastax

The camera position was #1

The run was X test

The film was the original roll

From the Tower Number and the camera position, all pertinent data about the use of the camera may be obtained from either the Caption Sheet or the Camera Book.

6. Perforators Used

The perforators used by the Photo Tower unit for punching the tower film were purchased from Cummings Business Machines, Corporation, Chicago 40, Illinois. The Model 539 was procured because it could be delivered in the least time. It came with six matrix rings, all numbers. With more time, these matrix rings may be had with letters or numbers, more matrix rings may be added, and the index on the matrix may be made luminous for visibility in the dark room. The machines may also be electrically operated if desired, or a foot attachment may be added. Various size and combination of holes in the matrix are available. A combination of numbers and letters would allow complete data to be perforated into the film.

7. For Future Test

It is suggested that the serial numbers of the films should be perforated into the film by the manufacturer before delivery. Every roll and every sheet of every pack would thus be permanently identified. The carton should be perforated with the film, and a gummed perforated tape attached to a metal container. The caption sheet can thus be marked with the serial number at any stage of the film handling. If a card type caption system is utilized, the perforated cards can be delivered with the film, and returned with the film. By making a section of this card punchable and giving photographers punches like railway conductor's punches, then the f ratio, focus, aperture etc. can be punched into the card with the photographer's symbol, thus reducing the probability of errors and mixing of film. Convenient note books supplied to the photographers will make it easier for them to record captions which will then be kept on the spot, not reconceived later.

HEADQUARTERS 311TH RECONNAISSANCE WING

FILM HANDLING INSTRUCTIONS

PART A: GENERAL INSTRUCTIONS

I - Film Serial Numbering System 27 February 1948

1. All film when accepted by the Film Control Officer from the AEC Supply Officer for use on Project Sandstone will be assigned an individual permanent serial number to each roll, box or pack by the Film Control Officer and a permanent record made of this number in the master Film Accounting Log Maintained by him at Bolling Air Field, D. C.

2. The serial number will consist of a code letter prefix followed by a number. The code letters will be assigned from the following code key:

FIRST LETTER	SECOND LETTER	THIRD LETTER
A-Aerial film 9½"	L-Class L (high Speed Pan)	A-56 ft
B-Aerial film 5½"	A-Class A (regular pan)	B-75 ft
C-Cut film 4x5"	C-Class C (low speed pan)	C-100 ft
P-Film Pack 4x5"	F-Class f (Sound Recording)	D-200 ft
V-Cut film 8x10"	H-Class H (process pan)	E-390 ft
M-35mm film	N-Class N (extra high speed pan)	F-400 ft
R-16mm film	M-Class M (color, daylight type)	G-1000 ft
	T-Class-1 (color tungsten)	H-20 exposures
	F-1-Class F-1 (fine grain sound recording)	K-36 exposures

The FIRST LETTER indicates the width of the film, or the dimensions in the case of cut film and packs. The SECOND LETTER indicates the type of emulsion on the film. The THIRD LETTER indicates the length of the roll, in feet or exposures. For example a piece of film marked as "ALD354" means:

A - It is aerial film 9½ inches wide
L - It is Class L Film (high speed pan)
D - It is a roll 200 feet long
354 - It is number 354 in the series

3. This individual serial number is the fundamental

means of identification for all film. It will identify any particular piece of film for security accountability purposes. It may also be of considerable value in operational identification. The importance of this serial number cannot be overemphasized. It will be used in every matter pertaining to a particular piece of film.

4. Each individual film container will be plainly marked by two gummed seals with its serial number by the Film Control Officer before the film is issued. Ordinarily container manufacturer's seals will not be broken before issue; therefore, this serial number must be transcribed on the film immediately after the film is removed from the container. In the case of motion picture film this will be done by using a slate; in the case of aerial still film this will be done by marking on the emulsion with grease pencil; in the case of film pack, it will be done by using a titling strip when exposing. This marking will be done by the person actually breaking the outer container seal. In addition to marking the film, the metal container will also be marked by this person by grease pencil. The responsibility for accomplishing this will be fixed on the individual responsible for the security of the film of this particular time.

II - Photographer's Identification Code

1. Each photographer on this project will be assigned a code number which will be his specific identification on all matters pertaining to his particular photography. This code number will be assigned by Headquarters, 311th Reconnaissance Wing, USAF.

2. A permanent record of these assigned code numbers will be kept in a Photographers' Code Number Log maintained by the Film Control Officer at Bolling Air Field, D.C. This log will record the photographer's code number, full name and rank, and so far as possible his current address or new assignment. This log will be kept in the following form:

Code Number	Full Name & Rank	Current Addresses
27	JOHN RAY DOE CPO USN	Crew #3 AEC
28	ROGER BEN GAY M/Sgt AF	Crew #2 Released 12 June 48

III - Phase Symbols

1. In order to identify photographs by the phase of the project they are concerned with, phase sysmbols will be used to identify all photographic exposures. The phase symbol will consist of two letters.

2. The first letter in the symbol will be determined from the following:

B - before the detonation
D - during the detonation
A - after the detonation

3. The second letter in the symbol will be determined from the following code:

X - in connection with the "X" detonation
Y - in connection with the "Y" detonation
Z - in connection with the "Z" detonation

PART B: STILL PHOTOGRAPHY

I - Ground Photography

1. Only 4 x 5 film packs will be used for black and white photography.

2. Each pack will be assigned a permanent serial number by the Film Control Officer and a permanent record made of this number in the Master Film Accounting Log. Each pack will be plainly marked with the serial number on the outside protective box by the Film Control Officer BEFORE ISSUE. This serial number will be placed on the metal back of the pack (by means of grease pencil) by the photographer immediately upon breaking the seal and removing the pack from the box.

3. A Titling Strip will be prepared by the Film Control Officer for each pack and will be issued with the pack at the time of original issue. This Titling Strip will be made of cleared film stock, cellulose acetate, or similar available material. When ready for use it will contain appropriate identifying symbols, the photographer's code number, and the pack serial number. The project symbol and the serial number will be printed on the strip before issue. The remainder of the data will be entered on it with ink by the photographer. This Titling Strip will be affixed by tape to the face of the pack, by the photographer, before exposure in such manner that the date on it is photographed on the film each time an exposure is made. This Titling Strip will also be used for color cut film. The photographer will inspect the Titling Strip before use to make certain it is complete and that the data is clearly legible. It is extremely important because it provides the only positive identification of individual sheets of film. Each Chief of Crew will be furnished a supply of complete blank titling strips for use only if the original should be lost or damaged.

4. Titling Strips will be 1/2 inches long and 1/4 inch wide outside dimensions. They will be prepared as illustrated by the following example:

(See Exhibit "A" for detail data.)

The meaning of the symbols in the sketch on the previous page:

Space #1 (To be filled in by the photographer) Insert B, D, or A, indicating if the photograph was taken before, during or after detonation.

Space #2 (To be filled in by the photographer) Insert X, Y, or Z indicating the photograph was taken in connection with the corresponding detonation.

"S" Is the identifying symbol of the overall operation.

Space #3 (To be filled in by the Photographer) For the Photographer's code number.

"PL" Indicates film pack and film speed (from serial numbering code).

Remaining spaces (t be filled in by photographer) are for the pack serial number. After the film is developed, but before it is printed, a number is inserted in the blank space to the right of the serial number on the negative. This number is the sheet number of the pack (stamped on the edge of the film by the manufacturer). This number is placed in this space so that it will appear in masked prints.

II - Aerial Photography

1. Each roll of film used on this project will be assigned a permanent serial number by the Film Control Officer and a permanent record made of this in the Master Film Accounting Log. Each roll will be plainly marked on the outside protective box by the Film Control Officer before issue. This serial number will be transcribed on the emulsion of the film with grease pencil by the person breaking the container seal and removing the film when loading the magazine. It will be especially noted the complete serial number will be written on the emulsion, not on the leader. The responsibility for accomplishing this will be fixed on the individual responsible for the security of the film at this particular time.

2. At the completion of the mission, the photographer will further identify each piece of film he has exposed by writing appropriate identification on the emulsion at the end of the exposed portion. In event the entire roll was exposed, this additional identifying data will be written on

the trailer or otherwise affixed directly to the film.

3. Immediately after exposure, the photographer will complete a set of caption sheets for each roll exposed. To identify subject of each exposure and to record pertinent data. The sheet will be filled out in quadruplicate. Two copies will be sent with film to processing laboratory. One copy will be sent to Film Issuing Officer, Bolling Field. The fourth copy will be retained for permanent file by the camera crew chief.

4. Whenever possible, exposed film will be returned to the original can or container, properly sealed with tape, and marked "EXPOSED". The Chief of Crew will make certain the can is properly marked with correct identification, being particularly careful to insure that the film serial number is legible and correct on the outside of the can.

5. After processing all aerial still film, it will be titled with the standard type title. The processing laboratory will prepare a title as specifically explained below. This title will be inked on the first and last negatives on the roll and acetate titling strips will be prepared for use when printing other negatives of the roll. The following title will be used on all negatives exposed by aerial still cameras whether operated from aircraft or from ground positions.

Negative	Phase Symbol Project Symbol	Mission No.	Film Serial No. (Complete)	Camera Position	Aircraft or Tower No.	Day	Month	Year	Local Time	Camera Type	Focal Length	Camera Attitude	Altitude	Classification
25	BXS	18B	A1D135	22	999	7	May	48	0950	K22	40"	Obl	18500	SECRET

All of the above data will be obtained from the Caption Sheet.

PART C - MOTION PICTURE PHOTOGRAPHY

I - Ground Photography

1. Each roll of film used on this project will be assigned a permanent serial number by the Film Control Officer and a permanent record made of this number in the Master Film Accounting Log. Each roll will be plainly marked with this serial number on the outside protective box by the Film Control Officer before issue. When the container is opened and the film is loaded in a magazine, the photographer will take adequate precautions that the identity of the magazine is clearly marked until the film can be permanently identified by photographing a slate. This slating will be done as soon after loading as possible. The serial numbers of individual rolls of film must be definitely known at all times.

2. After each period of exposure, the photographer will enter the required data on the Caption Sheet. When a roll is completed, he will unload it from the magazine and return the roll to the original can it was issued in. In any case, the can the exposed film is returned in must be correctly marked by grease pencil indicating the film serial number and that it is exposed. Disposition of the Caption Sheets will be as prescribed in Part B, Section II, Paragraph 3, above.

II - Aerial Photography

1. Since the same general types of cameras are used for both aerial and ground motion picture photography, the procedures outlined in Section I, above, may be applied to the handling of film.

PART D - GENERAL INFORMATION FOR ALL PHOTOGRAPHERS

I - Screening

1. Screening: Immediately upon receipt of processed film (at the Cataloguing Dept - Motion Picture or Still) subject matter will be carefully checked against caption sheets and screened for items listed below:

(1) Correct exposure.
(2) Camera operation.
(3) Composition.
(4) Laboratory processing. (Motion picture negative will be checked whenever there appears to be faulty laboratory work.)
(5) Completeness of information on caption sheets.
(6) Subject matter: List from beginning of roll or pack, negative by negative, or frame.

NOTE: By comparing negative and the caption sheet, personnel screening film should be able to gain sufficient information to write a complete story of subject material, and adequately compose negative captions.

II - Quality Code

1. Quality Code: The following listed numbers will be used to designate quality of photography in film catalogs and in TWX message or confirming reports to camera crews in the field.

(1) Excellent over-all quality.
(2) Satisfactory over-all quality.
(3) Negative underexposed.
(4) Negative overexposed.
(5) Poor composition.
(6) Camera malfunction.
(7) Out of focus.
(8) Fogged, light struck or camera scratched (explain appearance)
(9) Will be used to show that a particular negative scene, group of negatives, roll or pack, is of no value.

III - Messages and Reports

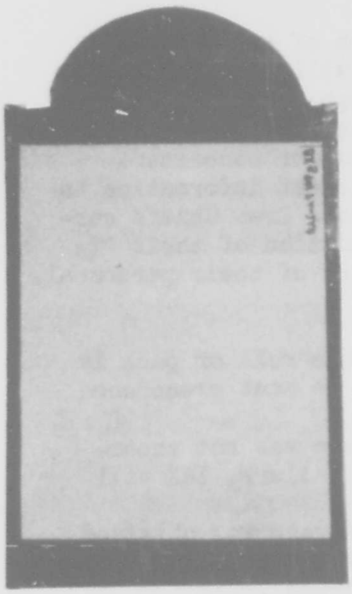
(1) Immediately upon completion of screening and inspection of film, a TWX will be sent to the JTF - 7 Photographer through Sandpiper, marked Attention of the particular photo crew chief or photographic units commander concerned. Message will contain sufficient information to keep Unit Commanders or Photo Crew Chiefs currently informed on the condition of their equipment and the efficiency of their personnel.

(a) Priorities

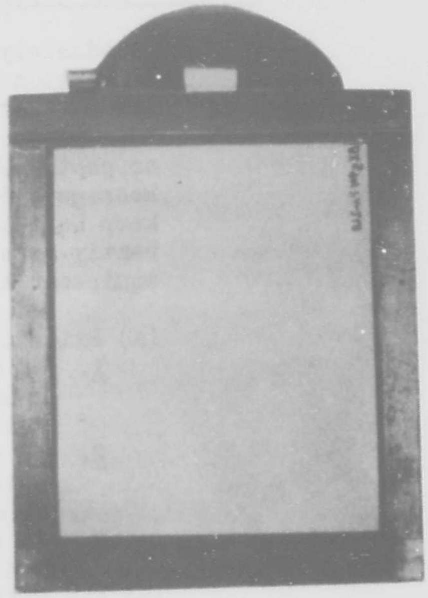
1. If any portion of the roll or pack is unusable, TWX will be sent precedence Priority action.
2. If important coverage was not accomplished due to any failure, TWX will be sent Urgent.
3. If satisfactory coverage was obtained TWX will be sent as Routine.

(b) All TWX's will be confirmed by letter.

E X H I B I T "A"



Film pack showing titling
strip correctly mounted.
Notice the lettering is reversed.



The pack in the adapter showing
correctly positioned titling
strip.

A print made from the pack shown above.

APPENDIX XVI

COMMUNICATIONS

1. Importance of Reliable Communications

The ability to communicate rapidly and reliably is a great asset, the reduces the overall time and effort tremendously. The cost of good communications is small in comparison to the value gained. Much of the communications system of the Sandstone tests was aggravating and often useless. They improved toward the end, but even then, it was difficult to reach the various stations by the telephone or radio telephone systems in use. Security of communications is also important, the aspects of this are mentioned under the security problems.

2. The Tower Communications System

In anticipation of the need for reliable inter-tower communications, the Photo Tower group took with them to the theater four SCR 274N radio sets which included the transmitters and receivers. Permission to use these was never granted. Instead, places on the technical net were allotted to the towers and SCR 608 radios were installed in each of the towers. This net, after getting it actually into operation, was a very great help and was technically quite satisfactory. Early troubles were encountered in malfunctions of the installations, late assignment of positions on the technical net, and in the fact that the net had been set up directly in the international 10 meter band. All frequencies then had to be changed. The big advantage that occurred to the tower photography through this net was the number of stations that could be contacted outside of the towers themselves. This turned out to be a great advantage in view of the very poor telephone system operation. In addition to this technical net, the Island Tower sites had field telephone installations that connected from the tower cab to the surface, and to the living quarters on Aomon and Runit. Aniyaanii had no living quarters, and there was no telephonic connections with the Coral Tower except through the timing cable. This link was only used when correlating the timing system.

3. Radio Discipline

The radio discipline on the technical net was, in general, poor. This was due to both lack of training and intelligent disciplining of offenders, and to lack of realization of the capabilities of the equipment. The technical net consisted of many stations, each station having installed an SCR 608 which is composed of a ten channel transmitter and two ten channel receivers, all crystal controlled. Channels were selected by a push button control. There would be as many as ten stations assigned on one frequency. Thus your listening frequency or channel would be assigned, but there would be others on that channel. To call another station, your transmitter would be tuned to the appropriate channel by pushing the button on the transmitter corresponding to the channel being called. Your first receiver would remain on your assigned listening frequency. The second receiver should be tuned to the same channel as the transmitter. This enables you to listen on the channel upon which you will be broadcasting, and thus prevent you from breaking into another transmission already in progress. Two receivers were installed at nearly all stations, and yet, very rarely were they used as above described. Sometimes both receivers were on the same channel, the listening channel; but more often, one was turned off and left off. A strict insistence upon good radio techniques would have materially improved the quality and quantity of communications.

PA-166-1371-5 Many of the shipboard sets were mounted in banks. Many users had feedback troubles from their receivers putting their own outgoing signals back into the transmitting microphone. The familiar squeak that resulted often destroyed more than just the transmitted intelligence of that set.

PL-569-5422-7 The SCR-608 could be used for many things besides just straight communications. They can be used for recording and have been left in continuous operation at an unmanned station so that a listening monitor of the events could be recorded.

PL-439-7044-9 Air Force Major Bill Miller answers a call at "Debark". Miller, a long time "ham" operator, had exceptionally fine radio habits and demonstrated the advantages of good radio discipling in improving the amount and ease with which communications could be handled.

PL-426-5587-4 Navy Lt. R. L. Warner selects the "Debark" channel to call the Runit Photo Tower from the Coral Tower. Battery charger for the radio set is in the lower right corner of the picture, batteries are on the floor under the set.

APPENDIX XVII

EXPERIMENTAL PROJECTS

1. Tower Purpose

The purpose of the Photo Tower operation was to obtain certain phases of photographic coverage of the weapon tests. There was no test, development, or experimental plan included with the tower operation. However some development was needed to accomplish the mission. In addition, several minor tests were conducted on the initiative of various members of the group. Some of these are briefly discussed.

2. "Blow Away" Photography

All tower photography was designed to record detonation phenomena only. There was no photography known to the Photo Tower Director which was designed to show the result of the blast upon objects or terrain. All tower photography was being accomplished from ranges which were far greater than the minimum required from gamma radiation and blast considerations. Two days before the Yoke detonation, permission was received to install a camera on the causeway between Aomon and Biijiri. As shown in the pictures, this was a well protected position, and was chosen because the camera could obtain a view of the palm trees and concrete structures without the camera receiving direct radiation from the detonation. This particular detonation was of particular interest because of the great number of palm trees which would be scorched, and after starting to smoke, would be blown away by the blast.

3. <u>Failure of Experiment</u>

The experiment was very rapidly assembled. A ship's clock was procured, contacts were soldered upon the face, relays connected from a battery to the clock and camera, and a single switch added. The camera was set up during a rain storm and then left. The switch was closed by the last people to leave the island. The experiment was a complete failure. The pressure wave compacted the fill material of the causeway, springing the steel sides outward. The camera had been braced for every kind of loading except the sudden outward motion of the sides. The camera was, therefore, flipped out of its mounting when only about half of its film had been used. Because of lack of appreciation by the military of experimental technique control; and because of the very poor and awkward C.I.C. control, the people performing the experiment were not allowed to return and retrieve the camera, film, and controls. The camera and film magazine were turned into the C.I.C. control station, but only after the camera lenses had been stolen. The clock was also stolen. The worthless relay, battery, wiring, and supports were not molested. The lens was not broken off, it had been carefully removed, and the camera then again pushed into the mud to attempt to create the illusion of damage. The clock had been unscrewed from its heavy base. The base was then battered, but the threads and a pivot bar were not damaged as would have been the case if the concussion had knocked the clock off the base. The magazine had been wound with adhesive tape to prevent it and its lids from rupturing during the negative pressure cycle of the shock wave. One of the interesting points of the experiment was the ability of the equipment to withstand the imposed loadings. All control of this aspect was lost. The tape was removed from the magazine without noting its condition. The control on the film was lost, it is not known whether the film that ran through the camera was light struck from the magazine lids opening or from penetrating radiation. The part of the film that was not transported by the camera was removed from the magazine and left in the open to become totally exposed. This prevented a comparison of the transported and untransported film.

4. Pictorial Section

PL-88-12 This steel causeway connected the Islands of Aomon in the background and Biijiri in the foreground. The Aomon Zero Tower and the short Photo Tower are in the background. The position chosen for the test camera installation was close to the block shown at the sand and water intersection on the Aomon end of the causeway.

PA-87-7 The causeway was constructed of interlocking angular steel pieces driven into the corral sand and welded together. This picture was made during construction.

PA-87-9 Crane with long boom used to place the steel.

PL-571-7 The camera was set into one of the recessions where it was bolted to an OEL case lid. The camera was wedged into position with wooden wedges. Wedges were driven along side of the magazine plates to help prevent them from coming off during the rarifaction which follows the compression wave.

PL-571-8 The camera carried a four hundred foot magazine. The covers of the magazine were taped into place.

PL-571 The clock was placed in the OEL box on top of the battery. The clock operated the relay shown sitting upon the clock face. The power cable connected from the relay to the camera. The twisted pair of leads extending through the top of the case are the ones that the last person leaving the island twisted together to connect the electrical circuit to the clock. The camera has not yet been wedged into place.

PL-571-4 Adjustments are made to the camera before wedging. Notice how the camera is recessed into the steel frame.

PL-571-3 A rainstorm soaked the set up. The pieces of plywood were inserted to give protection to the camera. The OEL case containing the battery, clock, and relay is shown in its final place, but before wedging.

PL-571-2 Camera and OEL case wedged into position.

PL-571-9 Final inspection. The actual set up shown here was removed the next day and the camera cleaned, better wedging installed, and a top shelter built. Time was available for this because of the delay in the Y day test.

5. Action Recording Photography

From the experiences of watching five atomic explosions, being concerned with various details of preparations and analysis of photographic and physical results, the Sandstone Photo Tower Director has concluded that there is much valuable military material to be obtained by placing photo and other recording devices closer than the great distances that were used at Crossroads and Sandstone; and there should be some concern with other than purely detonation phenomena.

6. Telescopic Viewing

Viewing of the detonation with binoculars was tried on each of the X, Y, and Z tests, but it was not until the last that a workable system was produced. The previous failure centered around the failure of the viewing personnel to realize the great light latitude and the inability of the eye to accommodate to the great changes. If the glasses were filtered for the initial periods, the observer would very soon not be able to see through the glasses, and if he then looked over them, he was still blinded. Scattered light entered the side of the eyepieces, thus interfering with the viewing.

7. Dramatic Z Day Results

The Photo Tower Director viewed the Z day detonation from Eniwetok through 7 X 50 binoculars which were secured to a weighted table. The field of view of the binoculars was aligned on the red light of the Zero Tower with the light somewhat below the center of field of view. Three ND 1.5 filter sheets were then hinged to the table in front of the binoculars. These sheets were individually hinged so that the initial detonation would be viewed through filters totalling ND 4.5. When the observed light became low, the first sheet was flipped down out of the field of the glasses, thus leaving a total of ND 3. Later, one more sheet was flipped down, and still later the last one. This worked remarkably well. A system of crossed polaroid might be better, but the method used is a system that can be easily constructed and all phases of the explosion can be comfortably viewed by an observer. Many things previously observed only in films, were readily apparent by visual observation. This was by far the most dramatic viewing that this observer had had. The dust explosions from the ground were spectacular. The passage of the shock wave through and along the various density strata and the resulting refractions were observed. Some phenomena attributed to later stages of the Mach Y were also detected. For impressing observers this system is very good. It should be added that the head of the observer was covered, and the covering carefully wrapped around the binoculars to prevent light leaks. This is quite important.

8. Sound Recording

Magnetic sound and film recordings were made by Capt. Strandberg of the USAF, and by Mr. Voss of the USN. Reports of their activities should be in the Technical Director's Report. These recordings were made at Eniwetok and in the Photo Towers. In addition, underwater recording was attempted at Eniwetok, but this did not give usable results. Recordings were made in the Photo Towers of the operation of the equipment. This presented an interesting study of the automatic sequence of operation of the cameras. It also confined the fact that nearly all of the cameras in both towers on the Yoke day detonation ceased operation at the time the shock wave reached the Photo Tower.

9. Underwater Sound

Underwater listening tests were conducted on Eniwetok on both X and Y days. A stethoscope with thin rubber diaphragms was used. The sensitivity of the system was good enough that small pebbles could be heard striking the lagoon bottom when dropped in six feet of still water. It was never certain that the sound heard was the water sound wave. The X day determination was made while leaning over the stern of a small boat which was close to metal floats. The air sound wave was transmitted through these floats into the water and this sound was heard. The Y day test was made while standing waist deep in the water on the Eniwetok Officer's Club beach. Nothing unusual was heard.

10. Wedge Filters

One partially reflecting wedge filter was mounted on the Island Tower Sonne camera for test Z. The filter was so designed that it broke up the received light into many non-parallel beams graded in intensity. These beams would then make separate streaked images on the negative, the streaks being successively dimmer to extinction. This seemed to have great promise for some types of analysis, although the linear travel of the Sonne was only forty inches per second. This type of wedge filter applied to a fast streak image camera like the General Radio might yield interesting data. Details of the filter and the results on the film are obtainable through B. Brixner, Los Alamos Scientific Laboratory.

11. Shock and Sway Detection

The tower crews were greatly interested in the reaction of the towers to the impact of the shock waves against them. Several crude indicators were constructed to give an indication of the shock effect and sway of the tower. None of these were calibrated, they were indicators only. The type used to measure sway consisted of a cross-board suspended by two parallel strings. Upon the board were mounted two pencils so that as the board swung, the pencils marked on a paper. The plane of the strings was established to be perpendicular to the shock wave front. The lines made by the pencils really represented a combination of the shock acceleration and tower sway. The resulting indications led to the conclusion that the tower sway was actually less from the X detonation than it was from wind buffeting during storm periods; and far less than the reaction caused in the Coral Tower when the LCM boats butted it. A shock type indicator consisted of a tightly stretched horizontal string with a series of washers strung onto it. These washers, about an inch and a half in external diameter, were uniformly spaced along the string, thus giving the string a modified catenary. The resultant positions of the washers then indicated the effect of shock. The shock to the Island Tower on Y day was considerably more than was the X day shock, but not extreme under any condition. Only one pane of glass was knocked from the tower windows. This occurred on Y day to the Runit Tower. The pane fell from the frame and did not break until after hitting the steel floor of the cab. The pane had not been attached to the frame with putty, one small pre-puttying wire was all that was holding it in. Several other panes thus mounted did not fall out. The Y day shock also "knocked" out the critical holding relay that maintained the majority of the cameras in operation after the minus-one-second pulse ceased at plus-one-second.

APPENDIX XVIII

PROPOSED TOWER TYPES

This appendix was designed to suggest several aspects of tiped and tripod towers as suggested under Photo Tower Improvements in the body of the report, Page 105. The principles suggested in the body of the report have been accepted by both J-Division, Los Alamos and E, G & G, Inc., Boston, as worth while development projects. For further details upon this type of construction, it is suggested that either J-Division or E, G & G Inc., be contacted.

APPENDIX XIX

PROPOSED CAB TYPES

This appendix was originally conceived to be a more complete discussion of the principles suggested in the body of the report under Photo Tower Improvements, Page 105, etc. Many of these principles have been accepted by J-Division, Los Alamos and by E, G & G, Inc., Boston, as principles for incorporation in future test equipments. For detailed information upon these items, it is suggested that contact be made with either J-Division, or E, G & G, Inc.

APPENDIX XX

PHOTO TOWER FILM BY FILM SERIAL NUMBER

The following lists give the film serial numbers of the film exposed by the Photo Tower crews. All listings that do not contain a MARK number are special films and are listed under MISCELLANEOUS in the Photo Tower Caption Book (made of fourth copy of the Photo Tower Caption Sheets).

ALB - 1	1K17, 18, 19 QX	ALB -17	1S28 QY
- 2	2K17, 18, 19 QX	-18	3K17 QY
- 3	1K17 PX	-19	3K18 QY
- 4	1K18 PX	-20	3K19 QY
- 5	1K19 PX	-21	3S28 QY
- 6	2K17 PX	-22	1K17 Y
- 7	2K19 PX	-23	1K18 Y
- 8	2K18 PX	-24	1K19 Y
- 9	1S28 X	-25	1S28 Y
-10	2S28 X	-26	1K17 QZ
-11	1K17 X	-27	1K18 QZ
-12	1K18 X		
-13	1K19 X	-29	1K19 QZ
-14	1K17 QY	-30	4K17 QZ
-15	1K18 QY	-31	4K18 QZ
-16	1K19 QY	-32	4K19 QZ

ALB -33 1K17 Z
-34 1K18 Z
-35 1K19 Z

-37 3S28 Y

-43 1S28 QZ
-44 4S28 QZ
-45 1S28 Z
-46 4S28 Z

ALD--71 1S28 PX
-72 2S28 PX

AMB -17 2K17 X
-18 2K18 X
-19 2K19 X

-21 3K17 Y
-22 3K18 Y
AMB -23 3K19 Y

-134 4K17 Z
-135 4K18 Z
-136 4K19 Z

BIA -46 1L20 PX
-47 1L21 PX
-48 1L22 PX
-49 1L23 PX
-50 2L20 PX
-51 2L21 PX
-52 2L22 PX
-53 2L23 PX
-54 1L20 thru 72 QX
-55 2L20 thru 27 QX
-56 1L20 X
-57 1L21 X
-58 1L22 X
-59 1L23 X
-60 2L20 X
-61 2L21 X

-78 2L22 X

BLA - 79	2L23 X	BLA -105	
- 80	1L24 X	-106	
- 81	1L25 X	-107	3L26 QY
- 82	1L26 X	-108	3L27 QY
- 83	1L27 X	-109	1L20 Y
- 84	2L24 X	-110	1L21 Y
- 85	2L25 X	-111	1L22 Y
- 86	2L26 X	-112	1L23 Y
- 87	2L27 X	-113	1L24 Y
- 88	1L20 QY	-114	1L25 Y
- 89	1L21 QY	-115	1L26 Y
- 90	1L22 QY	-116	1L27 Y
- 91	1L23 QY	-117	3L20 Y
- 92	1L24 QY	-118	3L21 Y
- 93	1L25 QY	-119	3L22 Y
- 94	1L26 QY	-120	3L23 Y
- 95	1L27 QY	-121	3L24 Y
- 96	3L20 QY	-122	3L25 Y
- 97	3L21 QY	-123	3L26 Y
- 98	3L22 QY	-124	3L27 Y
- 99	3L23 QY	-125	1L20 QZ
-100	3L24 QY	-126	1L21 QZ
-101	3L25 QY	-127	4L20 QZ
		-128	4L21 QZ

BIA -129 4L22 QZ
-130 4L23 QZ

-149 1L20 Z
-150 1L21 Z
-151 1L22 Z
-152 1L23 Z
-153 4L20 Z
-154 4L21 Z
-155 4L22 Z
-156 4L23 Z
-157 4L24 QZ
-158 4L25 QZ
-159 4L26 QZ
-160 1L22 QZ
-161 1L23 QZ
-162 1L24 QZ
-163 1L25 QZ
-164 1L26 QZ

BMJ - 76 1L24 Z
- 77 1L25 Z
- 78 1L26 Z
- 79 1L27 Z
- 80 4L24 Z
- 81 4L25 Z
- 82 4L26 Z
- 83 4L27 Z

MAC -483 Aniyaanii Time Test

MAF - 80 Special Y

-130 1M12 Z
-131 4M12 Z

MAG - 48 Special X*

- 64 4M14 Z
-121 1M14 Z

*Under Miscellaneous

MAG -122 4M13 Z

MCF -180

-181 1M12 Y

-183 3M12 Y

MCG -110 1M13 Y

-166 3M13 Y

-167 1M13 Z

MLG - 3 1M12, 13 QX

- 4 Fogged NG*

- 5 2M13 QX

- 6 1M12 PX

- 7 1M13 PX

- 8 2M12 PX

- 9 1M12 QY

MLG - 18 1M12 X

-- 19 1M13 X

- 20 2M12 X

- 21 2M13 X

- 22 1M13 QY

- 23 3M12 QY

- 37 3M13 QY

- 38 3M14 Y

- 40 2M14 X

- 42 1M12 QZ

- 43 1M13 QZ

- 44 4M13 QZ

- 49 4M13 QZ

- 50 4M14 QZ

PA -202 Documentation*

-203 Documentation*

*See Miscellaneous

RACF - 1 2F6PX	RACF -25 3F5QY	RACF -49 1F6Z
- 2 2F7PX	-26 3F6QY	-50 1F8QZ
- 3 2F8PX	-27 3F7QY	-51 1F11QZ
- 4 2F11PX	-28 3F8QY	-52 4F6QZ
- 5 1F6PX	-29 3F9QY	-53 4F7QZ
- 6 1F7PX	-30 3F11QY	-54 4F8QZ
- 7 1F8PX	-31 3F3PY	-55 4F11QZ
- 8 1F11PX	-32 1F3PY	
- 9 1F6X	-33 1F6PY	
-10 1F7X	-34 3F7PY	-58 1F7Z
-11 1F8X	-35 1F7PY	-59 1F8Z
-12 1F11X	-36 1F6Y	-60 1F11Z
-13 2F6X	-37 1F7Y	-61 4F6Z
-14 2F7X	-38 1F8Y	-62 4F7Z
-15 2F8X	-39 1F11Y	-63 4F8Z
-16 2F11X	-40 3F6Y	-64 4F11Z
-17 1F4QY	-41 3F7Y	
-18 1F5QY	-42 3F8Y	
-19 1F6QY	-43 3F11Y	
-20 1F7QY	-44 1F6QZ	RKCF - 1 Special*
-21 1F8QY	-45 1F7QZ	- 2 1F9Y
-22 1F9QY	-46	- 3 3F9Y
-23 1F11QY	-47	
-24 3F4QY	-48	

*Miscellaneous

RKCF - 12 1F9Z

- 13 4F9Z

RLCF - 8 1F10PX

- 9 2F1X
- 10 2F2X
- 11 2F3X
- 12 1 Dummy QX
- 13 1 Dummy QX
- 14 2 Dummy QX
- 15 2 Dummy QX
- 16 2F6,7,8,9,QX
- 17 2F2,3,4,5,QX
- 18 1F9,10,11,2F1 QX
- 19 1F5,6,7,8,QX
- 20 1F1,2,3,4,QX
- 21 Dummy*
- 22 2F10X

- 39 1F1X
- 40 1F2X
- 41 1F3X
- 42 1F10X
- 43 1F4X

RLCF - 44 1F5X

- 45 1F9X
- 46 2F4X
- 47 2F5X
- 48 2F9X
- 49 1F1QY
- 50 1F2QY

- 52 1F3QY
- 53 1F10QY
- 54 Special*
- 55 3F1QY
- 56 3F2QY
- 57 3F3QY
- 58 3F10QY
- 59 3F1PY
- 60 Special*
- 61 Special*
- 62 3F2PY

- 67 1F1PY
- 68 1F2PY

RLCF - 69 3F6PY

- 70 1F1QZ
- 71 1F1Y
- 72 1F2Y
- 73 1F3Y
- 74 1F10Y
- 75 3F1Y
- 76 3F2Y
- 77 3F3Y
- 78 3F10Y
- 79 1F2QZ
- 80 1F3QZ
- 81 1F4QZ
- 82 1F5QZ
- 83 1F9QZ
- 84 1F10QZ

- 97 4F1QZ
- 98 4F2QZ
- 99 4F3QZ
- 100 4F4QZ
- 101 4F5QZ
- 102 4F9QZ

*Miscellaneous

RLCF -103 4F10QZ
-104 4F10Z
-105 4F1Z
-106 4F2Z
-107 4F3Z

-116 1F1Z
-117 1F2Z
-118 1F3Z
-119 1F10Z

RMC -411 2B30PX
-412 1B30PX
-413 1B30QY
-414 3B30QY
-415 1B30X
-416 2B30X

-567 1B30Y
-568 3B30Y

RMC -702 1B30Z
-703 4B30Z

RMCF - 23 1F4Y
- 24 1F5Y
- 25 3F4Y
- 26 3F5Y

-33 1F4Z
-34 1F5Z
-35 4F4Z
-36 4F5Z

-41 1B30QZ
-42 4B30QZ

RMF - 1 1N15PX
- 2 1N16PX
- 3 2N15PX

RMF - 4 2N16PX
- 5 2N15PX
- 6 2N16PX
- 7 2N15QX
- 8 2N16QX
- 9 1B30, 2B30 QX

- 23 1N16X
- 24 1N15X
- 25 1N15QY
- 26 1N16QY
- 27 3N15QY
- 28 3N16QY

- 56 1N16QX
- 57 1N15QX

- 67 1N15Y
- 68 1N16Y
- 69 3N16Y
- 70 3N15Y

RMF - 75	Sunset*
-168	1N16QZ
-169	1N15QZ
-170	4N15QZ
-171	4N16QZ
-172	1N15Z
-173	1N16Z
-174	4N15Z
-175	4N16Z
-208	Sunset*
-209	Sunset*
-210	Sunset*
-211	"
-212	"
-213	"
-214	"
-215	"
-216	"
-217	"

*Miscellaneous

APPENDIX XXI

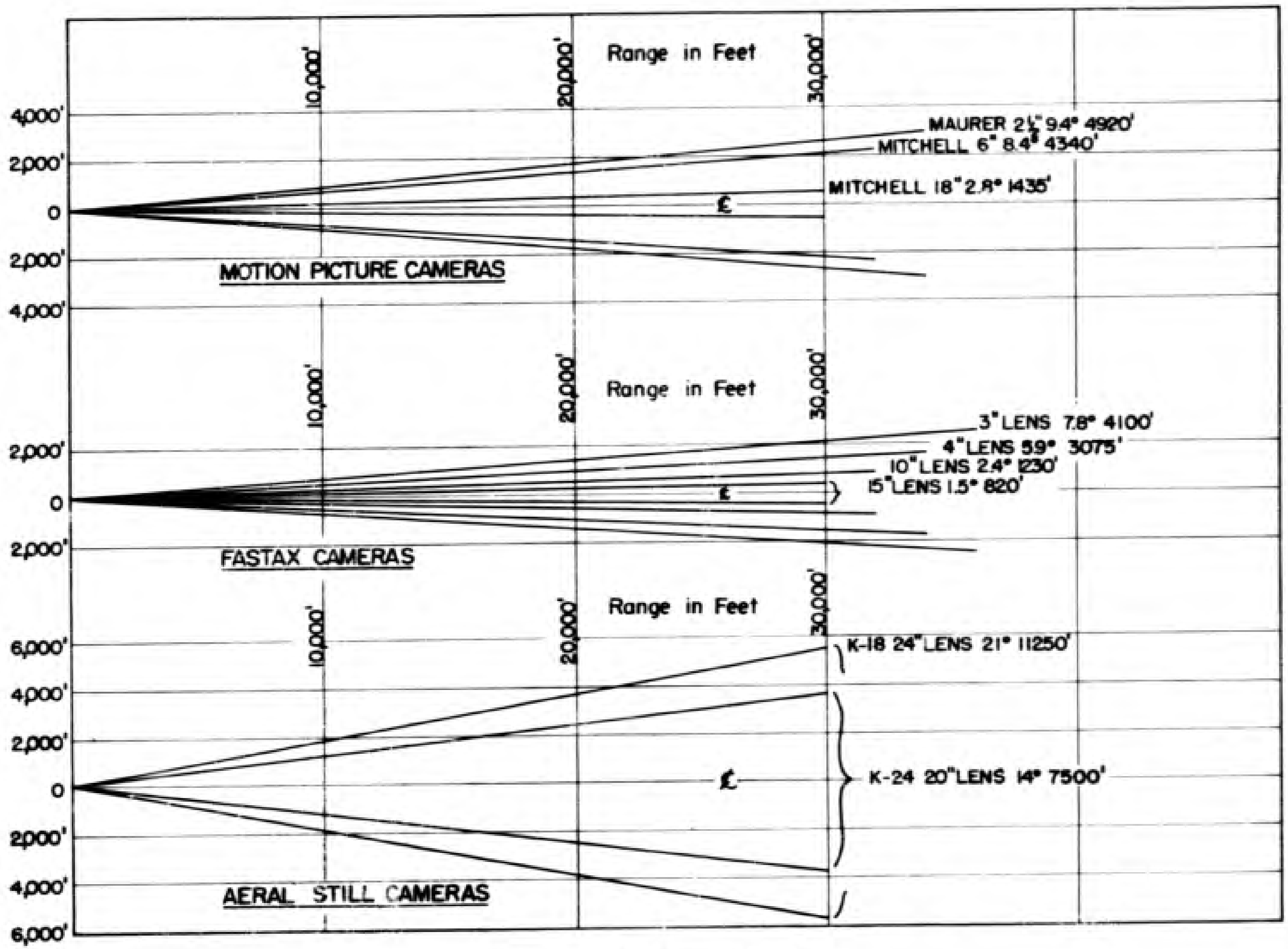
LATERAL FIELD OF VIEW

1. Horizontal Field of View

The associated diagrams give the lateral fields of view of some of the cameras used by the Photo Towers. In addition to the angular view, the charts are made so that the width of the field in feet may be determined at various ranges. The width of the horizontal field is written in for the 30,000 foot range.

2. Vertical Field

The vertical field of view of the cameras is not given. These may be obtained by calculation from the distances and the focal lengths, or by application of the frame height to width ratio to the horizontal field of view.



TOWER CAMERAS
LATERAL FIELD OF VIEW
AT 30,000'

APPENDIX XXII

PHOTO TOWER BLOCK AND SCHEMATIC DIAGRAMS

This appendix was designed to present the electrical control system as used in the Photo Tower operations. The method of presentation was to have been a series of diagrams with explanations, the diagrams including a general block diagram of a complete tower system, specific block diagrams for major divisions within the tower system, and specific schematic diagrams showing the electrical characteristics of each circuit used. The explanations were planned to tell what the circuits were and why those circuits were used. The material has not been adequately pulled together for formal presentation as of this writing. The details are available through E, G & G, Inc., Boston.

APPENDIX XXIII

TRANSPORTATION

1. Requirements

Without water, land, and air transportation an operation of this nature ceases to function unless it is adequately supported with the appropriate vehicles. The better the transportation, the better the accomplishment of the mission.

2. Transportation Facilities

The following pictures demonstrate some of the vehicles and facilities supplied for the Sandstone Tests. These pictures do not by any means portray all of the transportation and loading facilities.

PL-424-7 While not used for mass transportation, the helicopters provided a very vital link for some of the operations. This shot of Aomon Island shows the tall Zero Tower and the shorter Photo Tower.

PL-313-2 The L-5s became one of the most valuable assets of the operation. One takes off of the long runway on Engebi between the flight control tower on the left with the Zero Tower in the right background.

PL-439-10 Looking East from the Photo Tower at Runit Island with the Zero Tower on the left, trucks in the foreground, one L-5 at the guard shack with another starting a take-off down the runway.

PL-132-8 Wherever the vegetation is removed, the surface becomes one of fine coral sand which creates dust clouds in the winds unless rain is falling.

PL-487-4 Two L-5s stand by waiting for passengers. These airplanes and pilots did a Herculean job trying to cope with the tremendous requirements that were pushed upon them.

PL-439-11 Weapons carriers were indespensible for much of the Island work.

PA-99-2 The Runit dock where the smaller boats landed personnel and light equipment. The jeep is waiting in front of the LCM landing beach. Runit Photo Tower in background.

PA-131-1 A battered LCM has a broken down jeep loaded aboard by an Island based crane. One of the AV class ships in the background.

PL-405-12 An LCM pulls away from a larger ship in the calm lagoon. Much spray came aboard these craft on windy days, or even with little wind if there were swells.

PL-565-11 The smaller craft took aboard a lot of spray even on very quiet days.

PA-18-3 There is no end to what goes aboard a ship. This DUKW is bound for Eniwetok.

PL-212-10 Typical method of offloading supplies and equipment. Here, a load goes onto an LCM at night.

PL-213-3 Any sort of collapsing nightmare may be found aboard a ship.

PA-106-20 Jeeps waiting for 'Brass' to arrive by L-5s.

APPENDIX XXIV

TOWER CHECK SYSTEM

This appendix was designed to demonstrate the need and importance of a complete sequence check system for evacuation and maintenance of the towers before a test. The actual check sequence with the reasons and methods of each check were to be explained. The material is not in a presentable form as of this date.

APPENDIX XXV

PERSONNEL ASSIGNMENTS

This appendix was designed to show the stations of origin, the qualifications, and the Photo Tower assignments of the men utilized by the Photo Tower operation from its origin to its completion. The data for this is mostly in rough note form as of this date and is available from R. N. Davis, E, G & G., Inc., Boston.

APPENDIX XXVI

PERSONNEL EVACUATION AND FILM DELIVERY

This appendix was designed to show the personnel duty stations, times and positions of evacuation, film delivery and recovery schedules, and film divisioning for delivery and recovery, and to show the film packaging for delivery to the Z.I. Included was to have been notes as to why these schedules were established and to the degree of workability and success.

The material for this is currently held in rough form by R. N. Davis of E, G & G, Inc., Boston.

APPENDIX XXVII

LIGHT ANALYSIS SYSTEM

1. Need for System

Good photographers carry a great deal of information in their heads, and so rarely need to have formal equations for setting light values. Where close technical control of results is desired and where the values are to be specified before a test - as for atomic weapon detonation - and the exact reason for each setting is to be known afterwards - it is orderly and convenient to have a standard equation. The following system was rapidly developed and was sufficient for the test. It may not represent the ideal. There was no time for research nor procurement and study of all existing computers. A circular disk type computer was constructed to use these equations. This gave a convenient, rapid, reliable method of setting the light values and made rapid determinations of the limits of coverage possible without guess work.

2. The Equation

See next page.

This equation was used for the analysis of the light intensity encountered: $B \cdot t \cdot f \cdot W \cdot A \cdot a = 1$.

- B - Brilliance, candles/ft^2 (Weston scale)
- t - Exposure time, seconds (See below for Fastax and Movie conversions)
- f - Relative exposure ratio (Chart I, below)
- W - Weston film speed (Chart II, below)
- A - Relative attenuation for filter (Chart III, below)
- a - Attenuation due to air (Chart IV, below)

Chart I Relative Exposure Ratio		Chart II Film Speed			Chart III Filter Atten.		Chart IV Air Atten. K = atmos. absorp. constant/naut.mi. n = naut. mi. $a = K^n$ where K = 0.80	
F	f	Class		W	ND	A Ratio	n	a
1	64	L	100W	2	0	1	0	1.00
1.4	32	A	50W	1	0.1	4/5	1	0.80
2	16		24W	1/2	0.3	1/2	2	0.64
2.8	8	M	8W	1/6	1.0	1/10	3	0.51
4	4				1.5	1/30	4	0.41
5.6	2				2.0	1/100	5	0.33
8	1				3.0	1/1000	5	1/3
11	1/2				4.0	1/10,000	6	0.26
16	1/4				29F	1/10 (for A bomb)	6	1/4
22	1/8						7	1/5
32	1/16							
45	1/32							
64	1/64							

The above equation as given is for ideal exposure. Its value may go as high as 8 for upper limit, as low as 1/16 for a lower limit for black and white; as high as 2 and as low as 1/2 for color.

The light transmission used for Fastax cameras is 1/6 that which the frames per second would indicate (at 1,000 fps, t is 1/6,000).

The exposure time for movie cameras is computed as 1/fps times the shutter opening in degrees over 360 degrees.

The Sun's brilliance is used as 160,000 candles/cm^2 or 1.5×10^8 candles/ft^2.

APPENDIX XXVIII

FILM FIELD LOG

1. Need for Film Field Log

The need for a log has been explained in the body of the report under Field Handling of Film beginning on Page 48.

2. Captain Harvey's Description

In establishing a Film Field Issue Log it was first necessary to determine the total quantities of each film type that was planned to be shipped. Arranging the film types into alphabetical order was next. After this had been done it was planned to make a maximum of twelve entries per page, using only the right hand or odd numbered pages, the reason for this being that when making a good many entries at one time and where time is a factor, it shows you up considerably when making entries at the bottom of the pages, especially in a book of this thickness. A couple of pages were left blank at the end of each film type section to allow for overflow, etc. As devit invoices were received it was an easy matter to extract the information and post it to the Issue Log.

Prior to issue of film for test, the film load was broken out and film cans and boxes marked with the tower number, camera position, etc., (the mark). After the film had been obligated to a specific camera position, it was punched and an entry made in the log opposite the film serial number showing what camera position that particular roll was obligated to as well as the test such as QX, X, QY, etc. After the entry in the log had been made the film serial was entered on the appropriate caption sheet.

In advance of each test, invoices were prepared for shipment of the film to the proper agency for processing. When the invoice was signed as receipted, then it was posted to the Issue Log, the invoice itself going to the credit file.

I do not say that this system is infallible nor do I mean that it is the best in the world, for after all any system can be made to work if there is dogmatic attention and perseverance.

Recommendations:

1. That field Issue Logs be printed so as to have a proper space for entering the camera position and test designation. This problem exists not only in the tower, but also in the Air Unit.

2. That if at all possible in advance of printing and binding, a composite layout be made for both towers and air unit Issue Logs consistent with the film amounts and types that they are going to use.

3. That pages be printed in the upper right hand corner with the film type such as ALB, etc.

4. That, if at all possible after printing and before cutting the paper, a tab be left on the end of each sheet so that when the log is assembled a way of indexing exists. Either this can be done, or a box of tabs can be furnished with each blank log book.

APPENDIX XXIX

TIME CONTROL SYSTEM

This appendix was originally designed to suggest certain details of the system outline in the body of the report under The Simple Tower on Page 108. The principle of simplified field test control equipment has been accepted by both J-Division and E, G & G, Inc. Problems relating to simplified control are currently being considered by E, G & G, Inc., Boston.

[redacted]

APPENDIX XXX

RADIO AND RADAR CONTROLS

This appendix was originally designed to point out the details of a study of the preliminary considerations of systems based upon the principles discussed in The Time Control Unit on Page 111. These principles have since been reviewed by J-Division and questions as to their applicability have arisen. E, G & G, Inc., will probably make further studies of these or similar types of control if the concept of smaller more dispersed recording sites is adopted.

RESTRICTED DATA

... person is prohibited.

[redacted]