A PORTABLE AUTOMATIC CAMERA SYSTEM FOR RECORDING ANIMAL ACTIVITY

by
D. G. H. Ray

FOREST RESEARCH LABORATORY
WINNIPEG, MANITOBA
INFORMATION REPORT MS-X-5

FORESTRY BRANCH
MARCH, 1967

A PORTABLE AUTOMATIC CAMERA SYSTEM FOR RECORDING ANIMAL ACTIVITY

by

D. G. H. Ray

FOREST RESEARCH LABORATORY

WINNIPEG, MANITOBA

INFORMATION REPORT MS-X-5

DEPARTMENT OF FORESTRY AND RURAL DEVELOPMENT

MARCH 1967

TABLE OF CONTENTS

ILLUSTRATIONS

INTRODUCTION

This report has been written expressly for the benefit of those potential users of automatic photographic apparatus who have low budgets and limited understanding of electrical and mechanical construction techniques. It is a detailed description of the construction and subsequent use, modification and repair of the final prototype of apparatus which has been refined during the previous five years.

The apparatus was designed for operation in extreme weather conditions (Fig. 1) and is quite portable. The complete apparatus (Fig. 2) consists of a camera case, instrument shelter, battery case and platform: the basic functional components (Fig. 3) are a photocell unit, control unit, camera, flash unit and instrument panel.

The prototype was designated for automatically recording small mammal activity through the use of a photo-electric sensing system, but has been designed with versatility a major prerequisite; with little modification, it may be used to record operations ranging from time-lapse microphotography to remotely-triggered telephotographic observation of birds, mammals, fishes, highway traffic, personnel, etc. Camera modification is minimal. The camera may be operated manually or remotely as a conventional movie camera without alteration of the attached solenoid assembly. The data are easily readable (Fig. 4) and are retrieved through use of an analysis projector.

The entire apparatus requires less current than 0.2 amperes per hour (a common two-cell flashlight requires 0.5) and will operate 22 days on power from a single rechargeable 6-volt auto battery; or for shorter periods, or where weight is a limiting factor, the unit may be powered though less economically, on dry cell batteries. Alternatively, 120-volt line current may be used. The camera records 4000 pictures on its 100-foot film spool, with the camera being re-wound every 500-600 frames. (An automatic winder is under development). The internally-synchronized camera triggers a modified "hobby" flash unit to produce 4000 flashes (at a speed of 1/1000 second each) at a cost of about $7.50.

Each unit, with readily available used camera and with the exception of the film and photoflash battery, costs $168.00 to build. The prototypes were built completely in a not-too-well-equipped workshop by the author who is by trade neither mechanic, electrician nor carpenter.

FIG. 1 CAMERA RECORDER AND SNOW CANOPY.

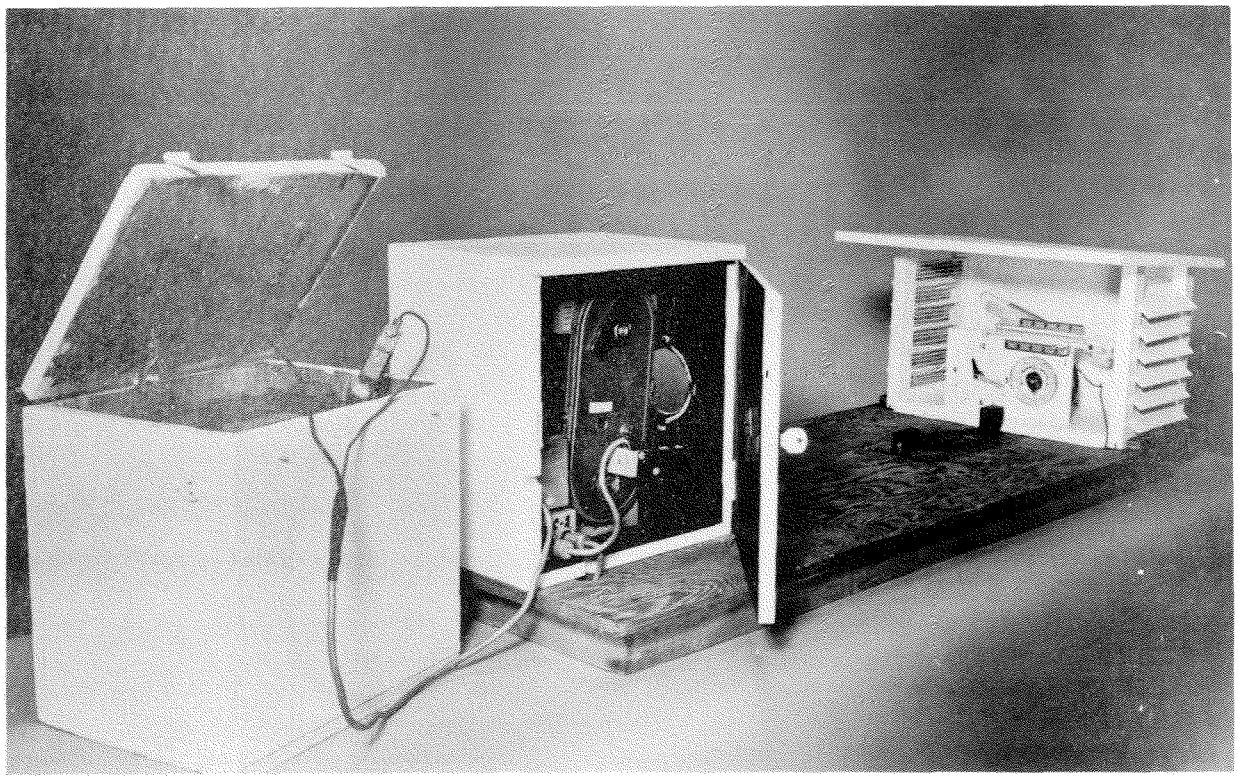


FIG. 2 THE COMPLETE APPARATUS.

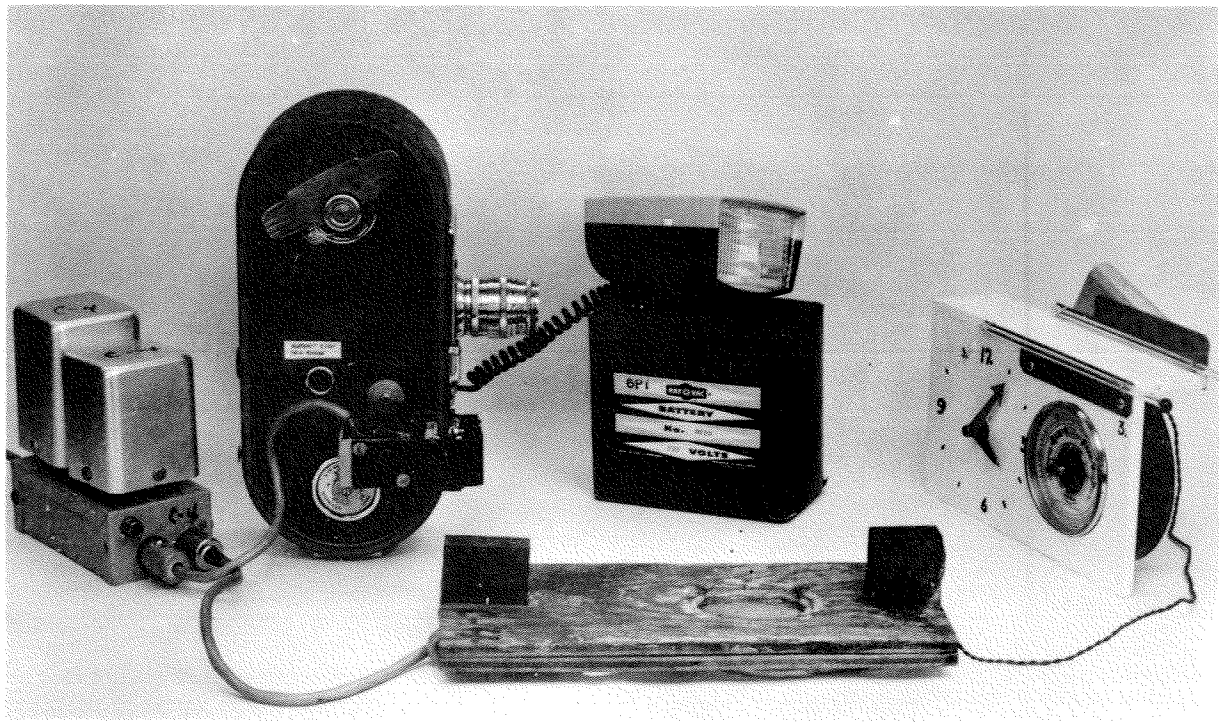


FIG. 3 THE FUNCTIONAL COMPONENTS.

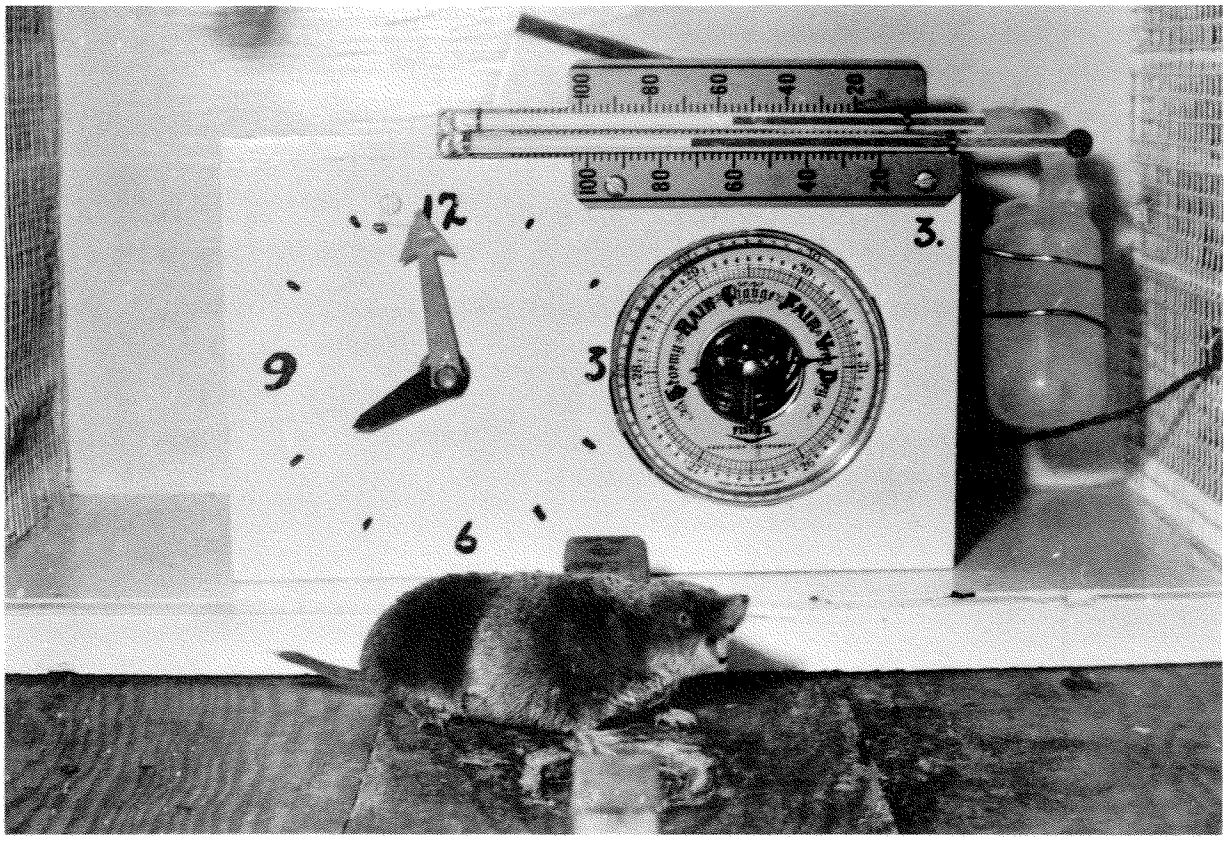


FIG. 4 FIELD COVERED BY THE CAMERA.

1. PORTABLE AUTOMATIC CAMERA SYSTEMS

The task of watching is sometimes a very expensive part of research, and many important questions will remain unanswered until it becomes more convenient to monitor the activities involved. In an effort to provide this convenience, Pearson (1959) synchronized a 16 mm single frame movie camera with an electronic repeating flash unit and was first to report on the use of such an apparatus for monitoring small mammal activity. Dodge and Snyder (1960) subsequently designed a similar device with the increased convenience of a portable power supply, and Abbot and Coombs (1964) reported on the use of the same principle, but with a larger 35 mm film format. Whether the format is 35 mm or 16 mm, and whether the power is line current, rechargeable storage batteries, or disposable dry cells, is largely a matter of what the recorder is intended to do.

The advantages of the 16 mm format are many. The difference between the cost of colour and black and white in the 16 mm films is so slight that high quality Kodachrome II can be used. Four thousand pictures can be made on each 100-foot spool of film. Also, used 16 mm cameras are plentiful and reasonably priced because the advent of the 8 mm format for "home movies" made much 16 mm equipment obsolete. The only disadvantage of the 16 mm format is that it provides a small picture. Although small, however, it is still easily read and reproduced.

The advantage of 35 mm is a larger picture; the disadvantages are that the film is very expensive, especially for colour. The larger format usually means less pictures per load, and 35 mm cameras with large film magazines are more expensive than most programs could afford.

The question of storage batteries, dry batteries, or line current has been eliminated with this system as it will work equally well from all three sources. Every effort was made during design to reduce battery drain to the absolute minimum, and the final prototype, using transistorized circuitry draws less than 0.2 amperes (1.2 watts) per hour. With this negligible current drain, the unit will operate about 24 hours on a light weight dry-cell lantern battery, or 22 days on a rechargeable 6-volt auto battery. For use on line current a 1.5 amp. 6-volt transformer with full wave rectifier is available from any radio repair shop.

The apparatus was designed to be both reliable and simple to use. Each part and modification was designed for simplicity of reproduction, availability of materials and reliability. Each plug can only plug into its own socket; no wrong connections. For the utmost of simplicity in servicing, the main circuits are packaged in two socket-turrets which plug into the main chassis unit. Their sockets are identical and the wiring has been so designed that they will operate in either socket. All components are of this "plug-in" nature so that a faulty component may be located through the exchange system, making it possible to service the equipment in the field without elaborate equipment or special knowledge of electronics.

In 1961, Buckner (1964) foresaw the value of the automatic camera recorder for monitoring populations of small mammals throughout the winter when trapping is highly impractical. The author immediately undertook the responsibility of producing the apparatus necessary for such a project. The apparatus described in this report operates to 0°F., and a system presently under development will make it possible to use the system at temperatures below -40°F.

The design of the apparatus serves a twofold purpose; it has provided the intended system for monitoring populations in winter; but of equal significance, it has placed within the reach of every minimum budget research program, amateur or professional, a means of taking the work out of watching through the automatic monitoring of almost any activity.

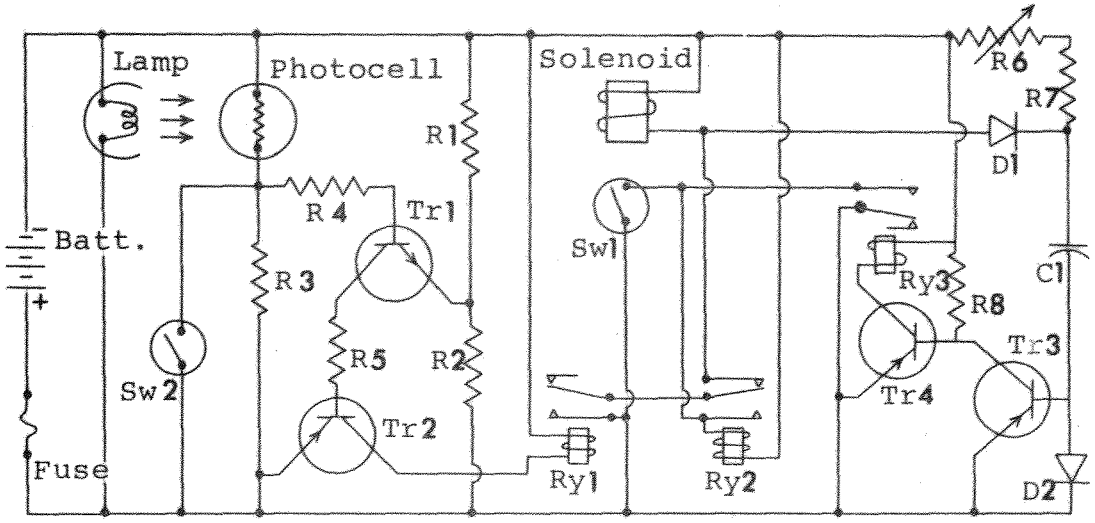


FIG. 5 SCHEMATIC OF THE CIRCUIT FUNCTION.

LEGEND OF FIGURES

R1, 2	330 Ohm ¼ Watt Resistor
R3	18,000 Ohm ¼ Watt Resistor
R4	5,600 Ohm ¼ Watt Resistor
R5, 7, 9	1,000 Ohm ¼ Watt Resistor
R6	500,000 Ohm Potentiometer
R8	10,000 Ohm ¼ Watt Resistor
Ry-1, 2, 3	Potter & Brumfield RS5D-6V-SPDT Relay
Solenoid	Guardian #11-Cont.-6VDC Solenoid
Tr-1	2N1102 Transistor
Rr-2, 3, 4	2N508 Transistor
C1	100 Mfd. 6V Capacitor
D1, 2	Sarkes-Tarzian F4-1N2483 Silicon Rectifier
Lamp	GE #12, 6.3 Volt 0.15 Amp Long-Life Panel Lamp
Photocell	Lafayette #19G2101, Cadmium-Sulphide Photocell
Sw1	Unimax USM56 Microswitch
Sw2	Contacts on Clock

2. THE ELECTRONIC CIRCUIT

When the light beam from the lamp to the photocell (PC) is interrupted, the resistance across the photocell increases and the voltage at the junction of PC and R-3 becomes positive with respect to the junction of voltage-dividing resistors R-1 and R-2. (Fig. 5). Thus, a forward bias is applied (through R-4) to the base of Tr-1, which conducts (via R-5) through the base of Tr-2, which in turn conducts, energizing Ry-1. This closes a circuit from the positive battery terminal through the normally-open (lower) contacts of Ry-1 and the normally closed (upper) contacts of Ry-2, through the solenoid winding to the negative battery terminal. The solenoid mechanically triggers the camera, momentarily closing Sw-1 which energizes Ry-2, breaking the circuit through the solenoid. A circuit is now completed from the positive battery terminal, through the normally-open contacts of Ry-1 and the normally-open contacts of Ry-2, through the coil of Ry-2, to the negative battery terminal, and this circuit will not break until the obstruction is removed from the light beam.

The time-delay circuit, which holds the trigger circuit inoperative until the flash unit recharges, is activated by the same brief pulse which energizes the solenoid. A storage capacitor (C-1) is discharged through D-2, through the normally-open contacts of Ry-1 and the normally-closed contacts of Ry-2 and through D-1. When this circuit is broken by Ry-2, C-1 begins recharging through R-6 and R-7 and through the base of Tr-3. Tr-3 conducts, cutting off Tr-4 by shorting base to emitter, and subsequently Ry-3 is de-energized. A circuit is made from the positive battery terminal, through the normally-closed (upper) contacts of Ry-3, through the coil of Ry-2, to the negative battery terminal. Ry-2 remains energized, and the trigger circuit inoperative, as long as the delay circuit is complete. When C-1 is recharged, Tr-3 is cut off and a forward bias is again applied (through R-8) to Tr-4. Tr-4 conducts, Ry-3 is energized, the circuit through the coil of Ry-2 is broken, and the time-delay cycle is complete.

Alternate triggers (Sw-2), such as the clock contacts or the optional manual control switch, trigger the circuit by shorting the junction of PC and R-3 to positive, which produces the same effect on Tr-1 as the above-mentioned disruption of the light beam.

3. CONSTRUCTION DETAILS

3. (a) The Solenoid Assembly

The solenoid mechanism (Figs. 6, 8) and its electronic circuit (Figs. 5, 18, 21) have been designed to depress and release the camera start button so fast that only one frame is exposed. Although the mechanism is rather crudely constructed with common shop scraps, it should provide trouble-free service indefinitely because it is non-adjustable and movements are minimal. The assembly must be custom-fitted to the camera, with primary concern given to the following; synchronizing the action of the micro-switch with the camera start button; keeping the solenoid slug travel at a minimum; and aligning the parts so the slug pulls straight and will not eventually bind.

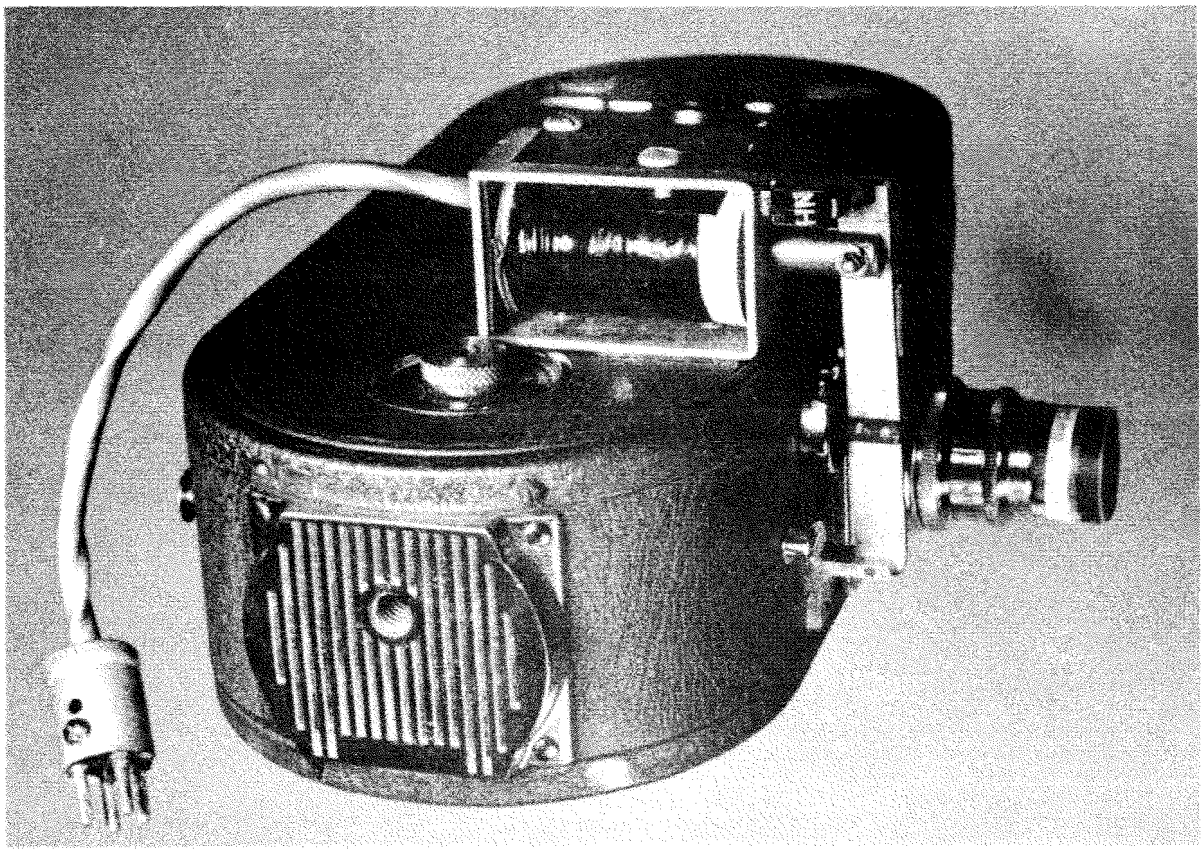


Fig. 6 The solenoid assembly.

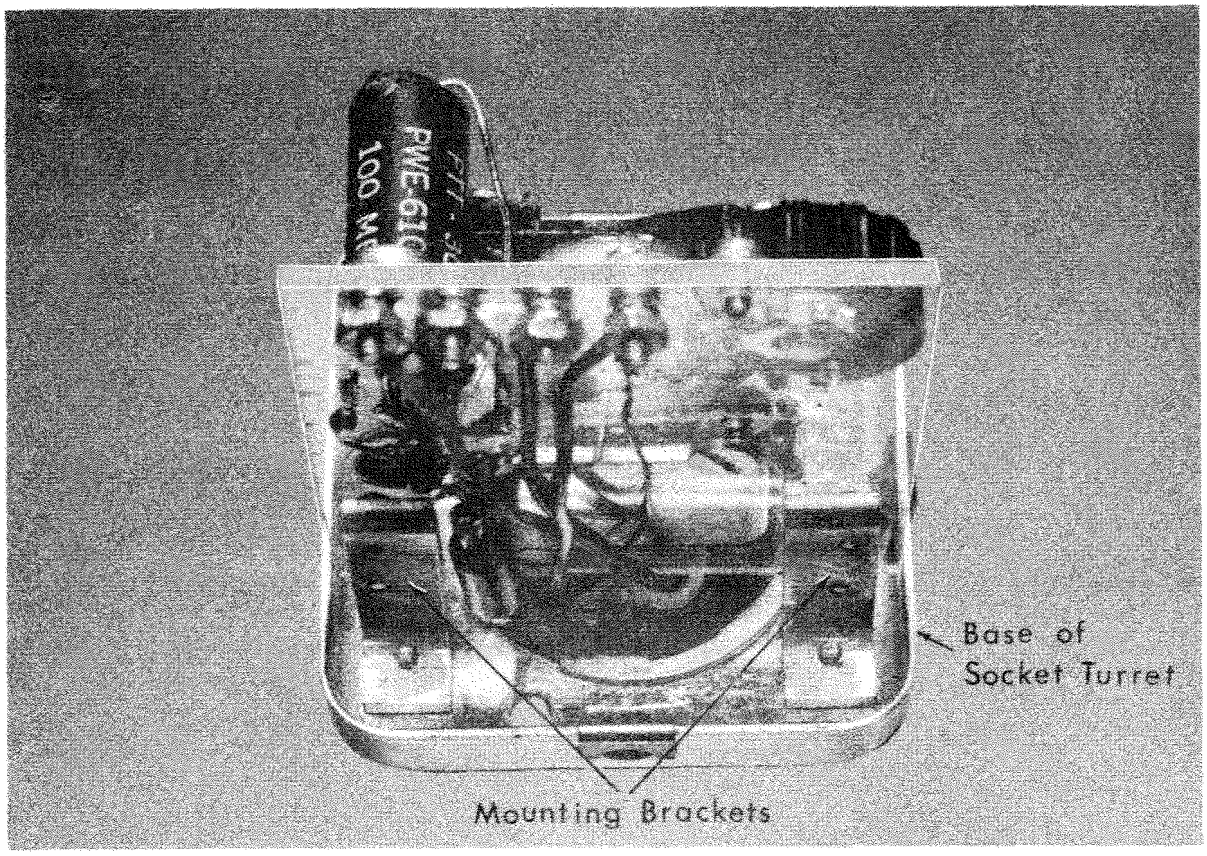


Fig. 7 Arrangement for mounting the circuit-boards.

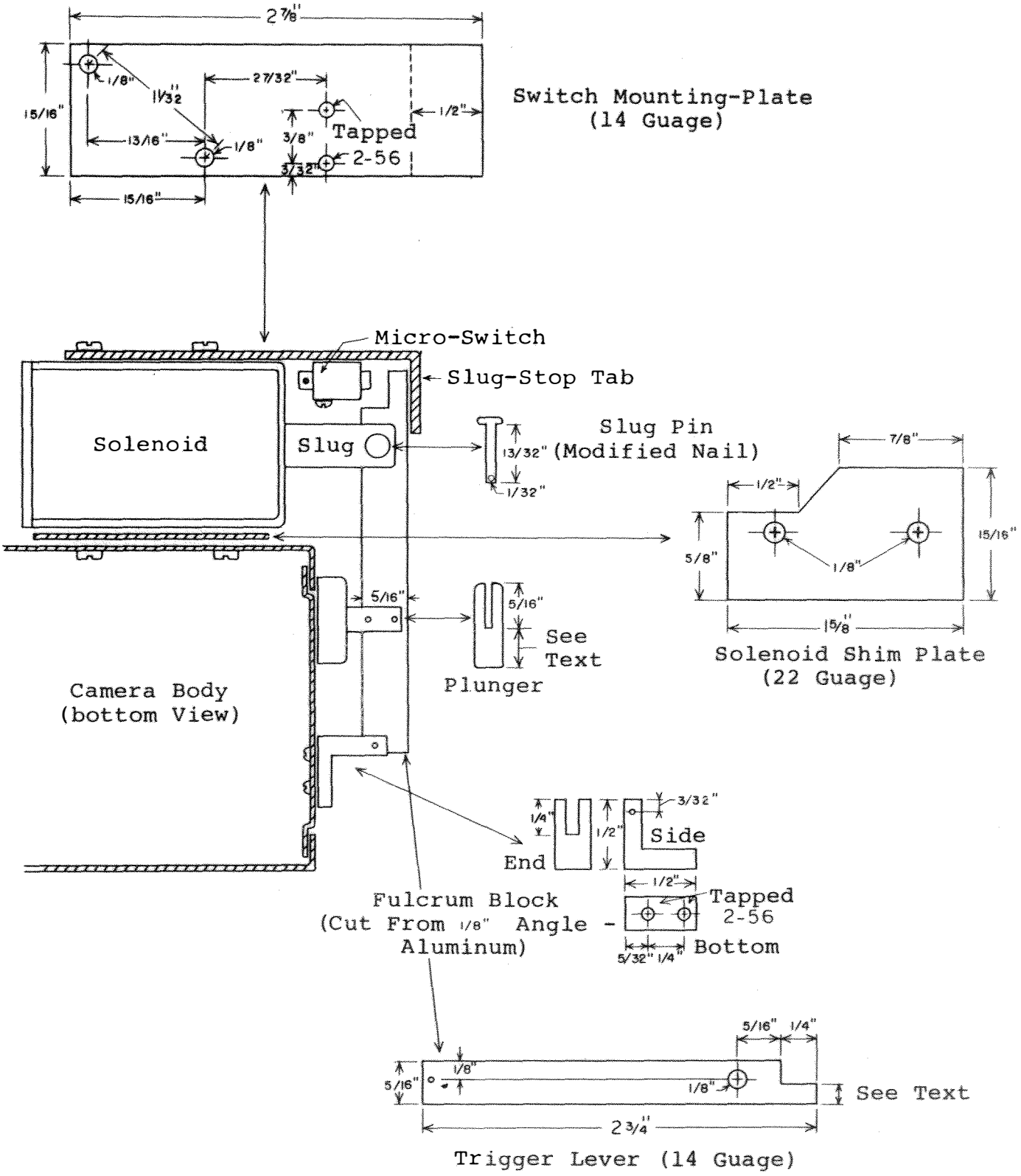


FIG. 8 THE SOLENOID ASSEMBLY.

Attaching the Micro-switch

Cut, bend, drill and tap the switch mounting plate. (Fig. 8) Use a drill-guide as described in 3. c. Solder two 3-inch insulated leads (22-26 guage) to the "C" (common) and "N-O" (normally-open) terminals of the microswitch, keeping connections as compact as possible, and coat these connections with silicone resin laquer. Attach the switch to the mounting plate, and using 6-32 x 1/8" binder head steel screws (longer screws may damage the coil windings) attach the mounting plate to the solenoid.

Wiring the Solenoid Assembly

Following the schematics in Fig. 21, attach an 8-inch, 4-conductor lead (use four 18-guage stranded leads braided or wrapped) to the solenoid and micro-switch and terminate this lead in an Amphenol 91MPM4S plug. Keep the wiring at the solenoid as short as possible. Solder all connections and coat them with silicon resin laquer. Wrap this wiring tightly to the solenoid core with a strong layer of insulating tape.

Assembling the Trigger Lever

Cut and drill the trigger lever to the specifications in Fig. 8, but do not cut the 1/4-inch wide notch deeper than 1/8-inch to begin. Cut, drill and tap the fulcrum block from a 1/4-inch length of 1 x 1 x 1/8" angle aluminum, and with a hacksaw cut the 1/4-inch deep slot just wide enough to accomodate the width of the 14 gauge trigger lever. Drill the 1/32-inch hole for the hinge pin and fit the trigger lever in place. Drive a 19 gauge finishing nail (should fit tightly) through the 1/32-inch hole, cut both ends flush with the aluminum, and flare the ends of the pin with a center-punch to keep it in place.

The pin fastening the trigger arm to the solenoid slug is made from any common nail which fits in the hole in the solenoid slug. Cut it to length and drill it as specified in Fig. 8.

The trigger lever must be a loose fit in the solenoid slug or it will cause the slug to bind. If necessary, file or grind the lever until it swivels freely in the slug.

Synchronizing the Micro-switch with the Camera Start Button

The finger on the end of the trigger arm must trip the micro-switch just before (1/32-inch or less) the slug is completely withdrawn into the core, and the camera must start before the microswitch is tripped; but the total travel of the solenoid cannot exceed 1/8-inch.

The 1/4-inch wide notch on the end of the trigger arm must be gradually filed down until the remaining finger trips the microswitch (a tiny audible click is produced when the switch trips) when the solenoid is 1/32-inch to 1/64-inch from the end of its travel. The trigger lever must be held perpendicular (exactly 90°) to the slug and the slug should be depressed while the trigger lever is subjected to a slight upward tension. This tension is required to eliminate the free-play in the purposely-loose connection of the lever with the slug.

The solenoid and trigger a m are mounted with the trigger arm horizontal, parallel with the front of the camera, and passing directly over the center of the camera start button.

While holding the solenoid against the side of the camera (as shown in Fig. 8) align the trigger arm perpendicular to the camera axis, directly over the center of the camera start button. Temporarily clamp the fulcrum in place. Lift the slug 1/16-inch out from the "stop" inside the core, and align the solenoid body so that with the previously-mentioned free-play taken up, the trigger arm is parallel to the front panel of the camera and perpendicular to the slug. Trace the outline of the solenoid body on the camera panel, and on a line perpendicular to the camera axis and in line with the center of the camera start button, locate and drill the two holes for the 6 - 32 x 1/8" Binder-head screws. (Remove the panel before drilling to avoid damage to the camera.) Insert the 22 gauge metal shim, fasten the solenoid to the panel (from the inside) and replace the panel.

Align the trigger arm so the pin passes through the center of the 1/8-inch hole leaving free-play on either side. Mark and drill the 3/32-inch holes for the two 2 - 56 x 3/16" screws which fasten the fulcru block in place.

A test lamp will be needed to determine when the switch trips because the tiny click cannot be heard above the noise of the camera motor. Materials needed for the test lamps are: the GE #10 6-volt 2-pin lamp; a 6-volt battery; and two 2-foot lengths and one 6-inch length of light gauge solid insulated wires with all ends stripped 1/2-inch. Fig. 21-A is the schematic of this test circuit. Connect (by wrapping) one contact of the bulb with a 2-foot wire to the positive battery terminal. Connect the negative battery terminal by a 2-foot wire to the #2 terminal of the 4-prong plug from the camera, and connect the 6-inch wire from the #3 contact of the plug to the remaining bulb contact. When the micro-switch is tripped, the bulb should light.

Bend the 1/2" slug-retaining tab of the micro-switch mounting plate until the slug-travel is limited to 1/8-inch when the free-play is eliminated at the slug and arm connection (pull up on the arm and down on the slug).

Now the camera start button may be synchronized with the micro-switch. To make the plunger for the trigger arm, (shown in Fig. 8) cut a 5/16-inch deep slot (to tightly accommodate the 14 guage trigger arm) in a length of 3/16-inch soft-iron rivet or nail, and cut this plunger to a length of about 9/16-inch. Make certain the trigger arm fits properly in the slot so the plunger will not shift under pressure. Gradually reduce the length of the solid end of the plunger until, when force is exerted on the slug (not the arm), the camera starts at 1/16-inch, and the switch trips at 3/32-inch, of slug-travel. Permanently fasten the plunger on the trigger arm by two rivets made from lengths of 19 gauge finishing nail in 1/32-inch holes (Figs. 6, 8).

3. (b) Flash Synchronization Switch

The flash-synchronization switch is easily installed with a single screw, on the base of the pressure plate. It is tripped by the returning film-advance claw when the shutter has fully opened.

To remove the pressure plate, (Figs. 9 and 10) remove the two screws at the base, and while drawing the film-advance claw from the slot in the plate, lift the pressure plate out.

Drill and tap a #2-56 hole (Figure 11) in the base of the pressure plate for the sync-switch mounting screw. Enlarge the mounting hole in the sync-switch with a 5/64-inch or a #44 drill to accept a #2 screw. Slenderize the heads of two #2-56 x 1/4 screws (Figure 12). Use one of these to screw the sync-switch in place, then cut the screw flush with the underside of the plate. Replace the pressure plate with conventional #6-32 x 3/16 Fillister Head screws, replacing the thin washers between the pressure plate and the camera body.

It may be necessary to trim the length of the sync-switch lever if the film advance claw encounters it during both the up and the down stroke. The claw mechanism should contact this lever on the return or up stroke only.

Synchronization of the sync-switch with the shutter should be checked to prove that shutter gearing has not been altered. Remove the camera lens and visually verify that the switch contacts close only after the shutter has fully opened.

The flash sync-terminal (Fig. 10 and 12) is a modified sync-switch, mounted inside on the back of the camera case with the receptacle protruding through the case. Before mounting the sync-switch as directed in Figure 12, enlarge the mounting hole with a 5/64" or #44 drill, cut off the switch lever, and solder a 6-inch length of phono-arm cable to the remaining contact post (Figure 12).

Lead the phono-arm cable from the rear-mounted outlet to the flash sync-switch and tape it in place (Figure 10). Make a pin-plug for insertion in the sync-switch outlet from a 1/4-inch length of 18 gauge bare copper wire. Reduce the diameter until the pin is a tight fit in the socket. Trim the phono-arm cable to the required length, solder the end to the pin-plug and plug the pin into the sync-switch.

3. (c) The Control Unit

The control unit consists of three parts: a chassis which serves to interconnect all the electrical parts; a trigger unit which amplifies the signal from the photocell, and controls the solenoid action; and a timer unit which serves as a timer-delay mechanism to hold the trigger unit inactive while the electronic flash recharges.

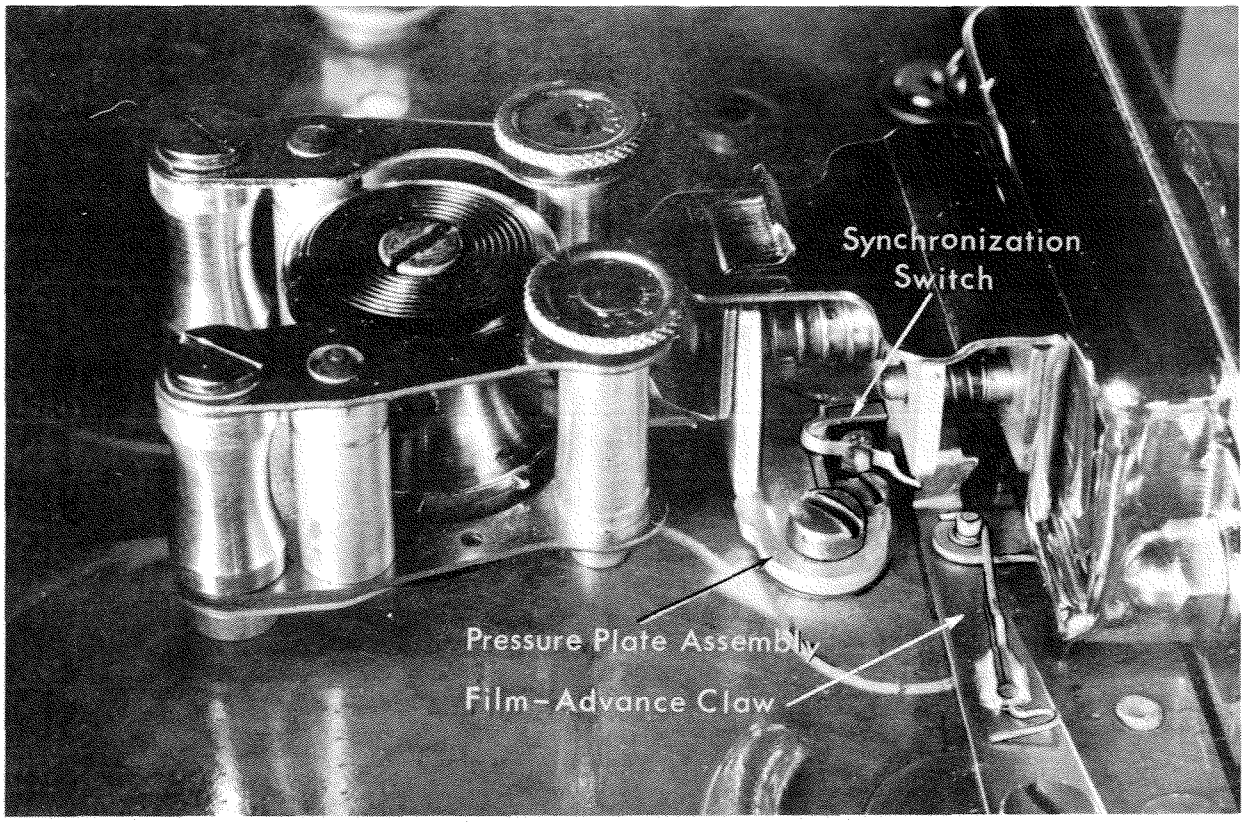


Fig. 9 The flash synchronization switch.

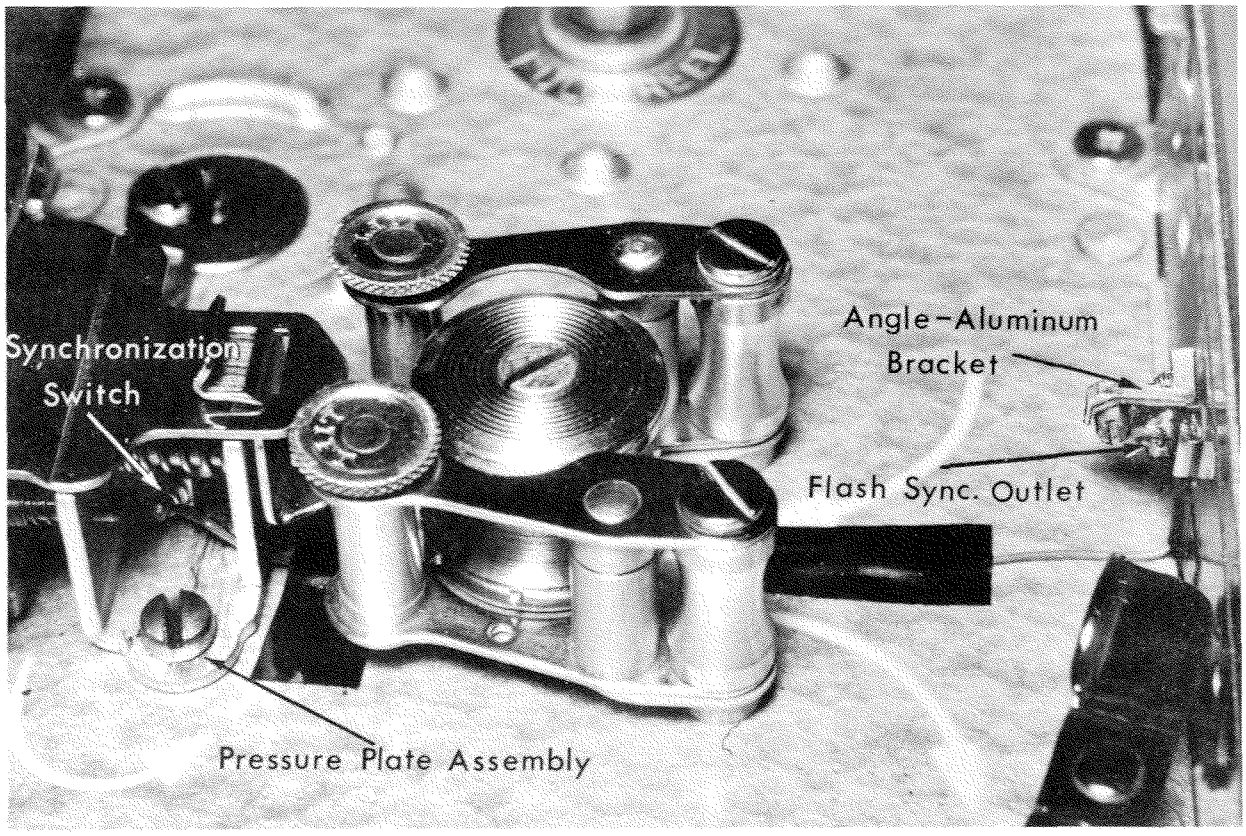


Fig. 10 Wiring and mounting of the flash synchronization outlet.

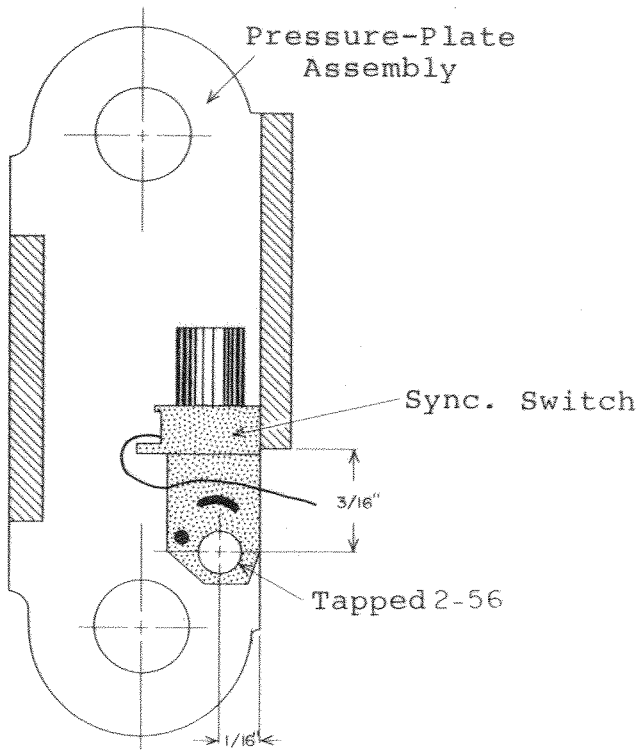


FIG. 11 INSTALLATION OF FLASH-SYNCHRONIZATION SWITCH.

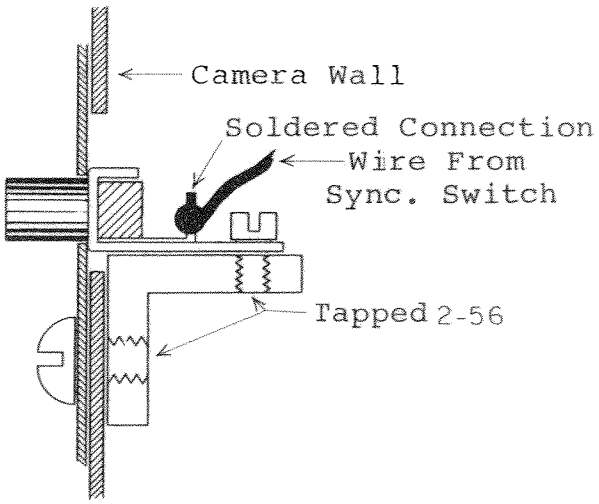


FIG. 12 INSTALLATION OF FLASH-SYNCHRONIZATION OUTLET.

The chassis (Fig. 16) is constructed from a ready-built miniature aluminum box $4\frac{1}{4}$" x $2\frac{1}{4}$" x $1\frac{1}{2}$" and wired as indicated in Figure 17. Two octal sockets are mounted on the top for the trigger and timer socket turrets. Three sockets are mounted on the front of the chassis: a 4-contact outlet for the solenoid assembly; a 3-contact outlet for the photocell assembly; and a 2-contact outlet for manual control (optional). A fuseholder and a grommet-protected outlet for the power cord are provided on the rear panel of the chassis.

Cut the large holes in the top of the chassis with a $1\frac{1}{4}$" round radio chassis punch. Cut the two 5/8-inch holes in the front of the chassis with a 5/8-inch round punch. The 1/4-inch hole in the chassis front, and the 1/2-inch and the 5/16-inch holes in the end of the chassis should be drilled on a drill press with a wood block inserted within the chassis for support. Finally, the four 3/32-inch holes are drilled for the octal socket mounting screws, and a 1/8-inch hole is centered in the top and bottom of the chassis for a #8 screw which fastens the chassis to the floor of the camera case

When mounting the two octal sockets, orient them similarly to avoid confusion in wiring. When installing the two 5/8-inch sockets on the chassis front, orient them so that when the plug is inserted, the retaining screw on the metal cap faces up. This will eliminate unnecessary fumbling during use. Mount the phono jack in the 1/4-inch hole on the front with a soldering tab on the inside located for easiest access with the solder gun.

The trigger and timer units are built into socket turrets, to permit circuit substitution in the event of breakdown. The components are mounted on scraps of plexiglass which are fastened by small aluminum brackets to the base of the socket turrets. (Fig. 7). Figures 18 and 19 are the wiring schematics of the trigger and time delay turrets, and Figures 23 and 24 show the arrangement of parts.

Use a drill guide when drilling the plastic circuit boards to ensure accuracy. For each size hole to be drilled, drill a hole in a scrap of 14 gauge sheet metal. Mark holes to be drilled with a center-punch and center the drill guide over the mark and clamp it in place. The guide will prevent the drill bits from "wandering" in the plastic.

After drilling all the holes in the circuit boards (Figs. 13 and 14) tap the holes at the top of the boards for the wiring terminals, and also tap the holes for mounting the potentiometer in the timer circuit.

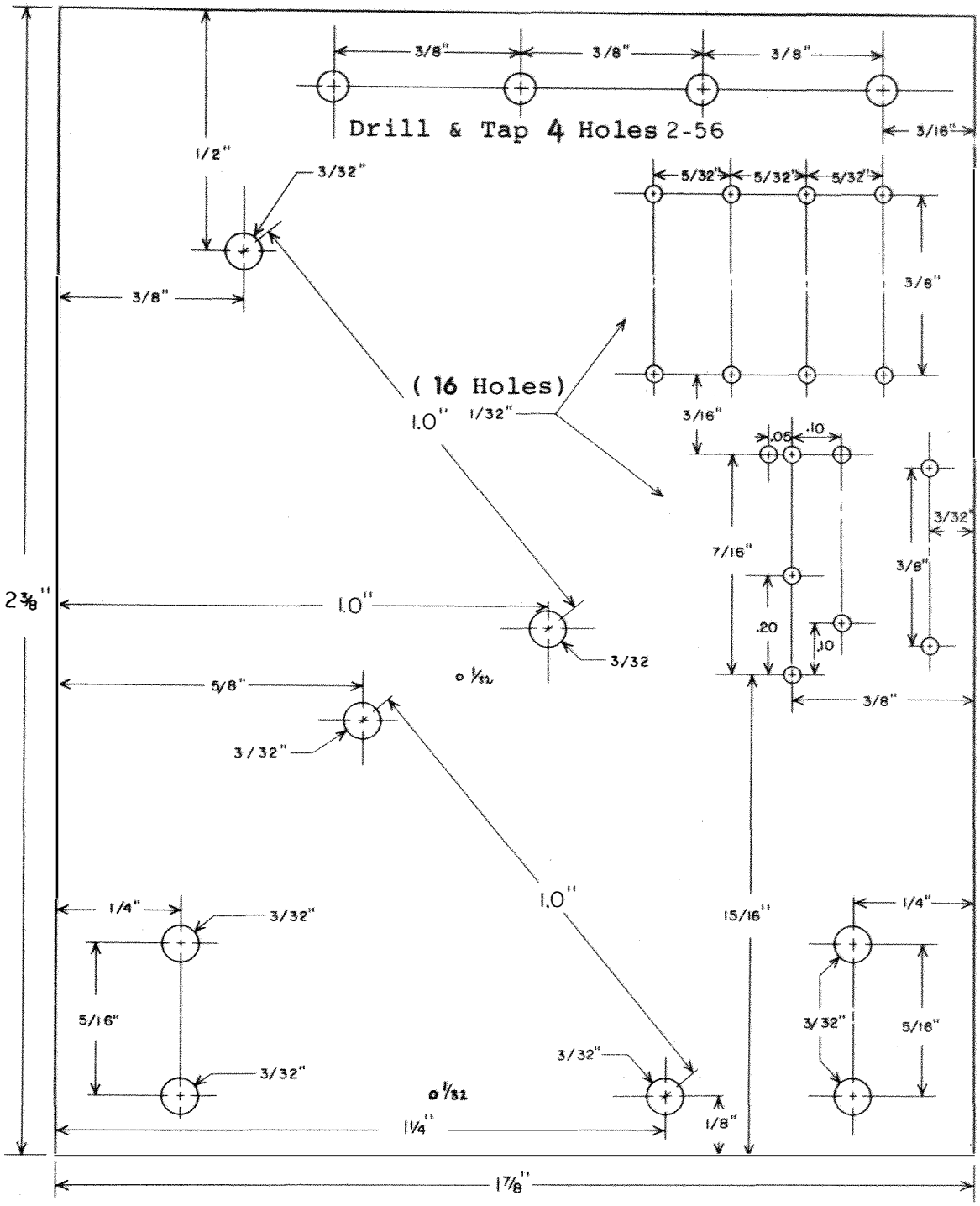


FIG. 13 TRIGGER CIRCUIT-BOARD DRILLING DETAILS.

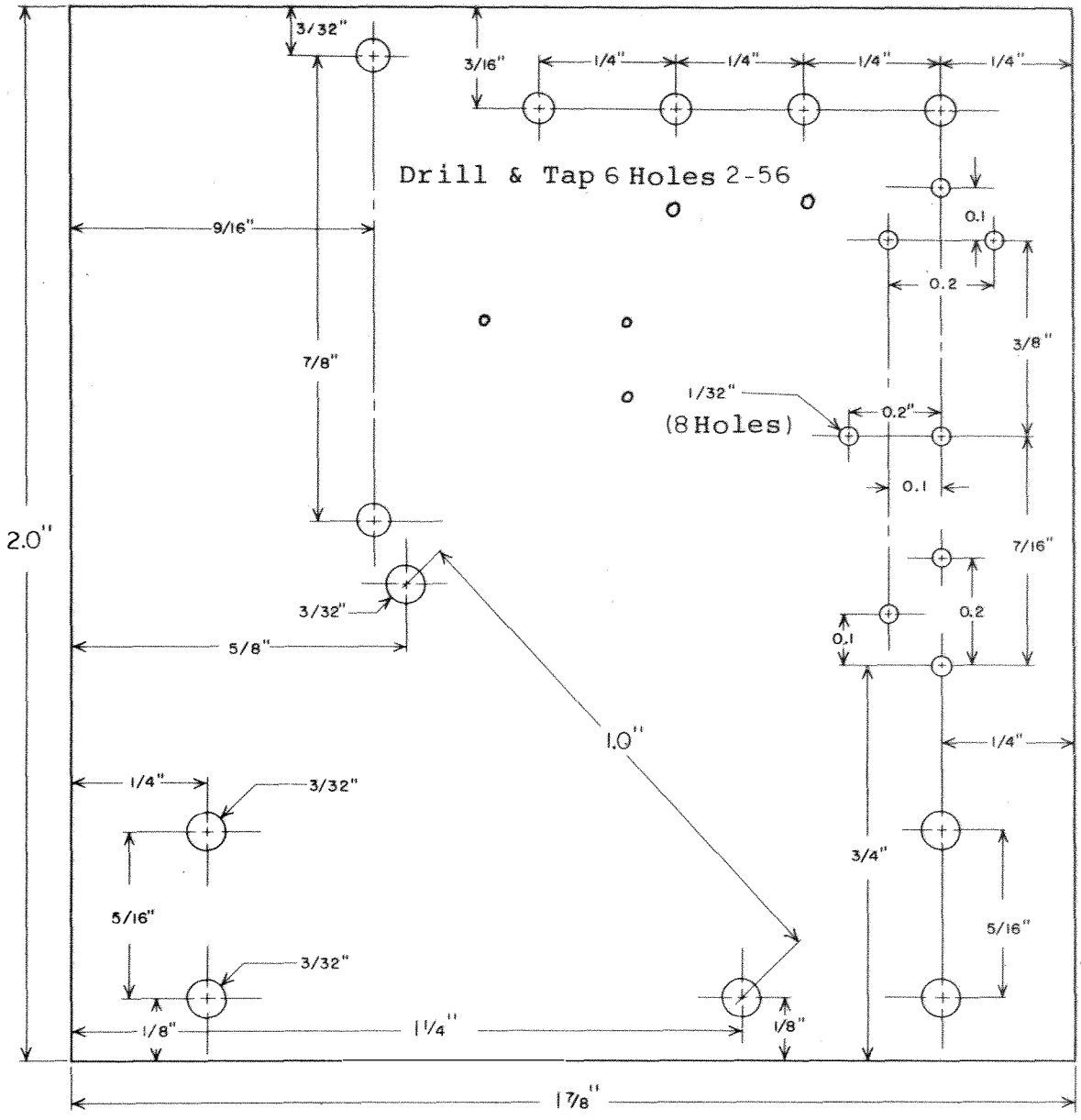


FIG. 14 TIME-DELAY CIRCUIT-BOARD DRILLING DETAILS.

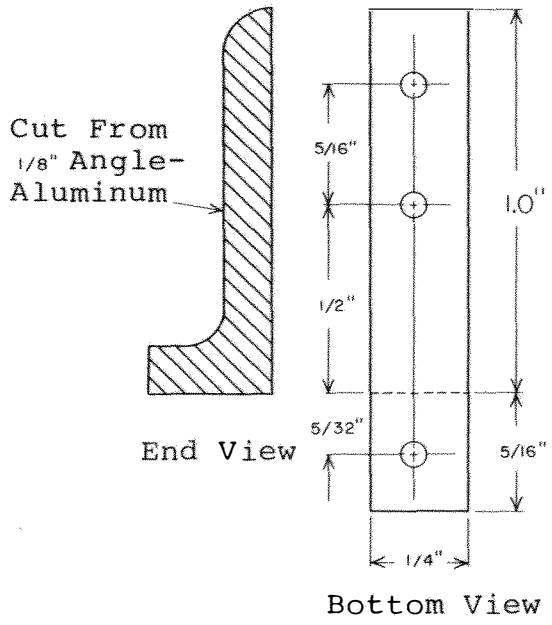


FIG. 15
MOUNTING BRACKETS FOR CIRCUIT-BOARDS.

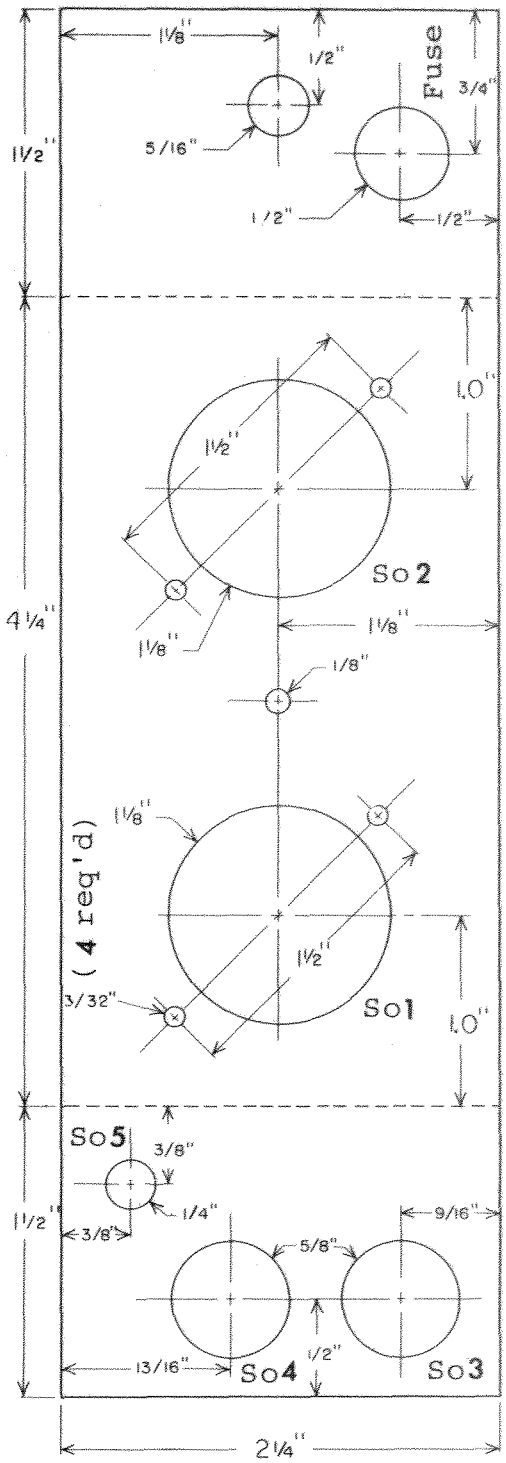


FIG. 16 CHASSIS DRILLING DETAILS.

Legend of Figures 17 - 19

R1, 2	330 ohm $\frac{1}{4}$ watt
R3	18,000 ohm $\frac{1}{4}$ watt
R4	5,600 ohm $\frac{1}{4}$ watt
R5, 7	1,000 ohm $\frac{1}{4}$ watt
R6	500,000 ohm potentiometer
R8	10,000 ohm $\frac{1}{4}$ watt
Ry-1, 2, 3	Potter & Brumfield RS5D-6V-SPDT
Tr-1	2N1102
Tr-2, 3, 4	2N508
C1	100 Mfd. 6V
D1, 2	Sarkes-Tarzian F4-1N2483
So1, 2	Amphenol 77M1P8 octal socket
So3	Amphenol 78S3S miniature socket
So4	Amphenol 78S4S miniature socket
So5	Midland 14-251 phono jack
PL1, 2	Vector octal socket-turrets

(For colour coding on resistors, see footnote on page 56)

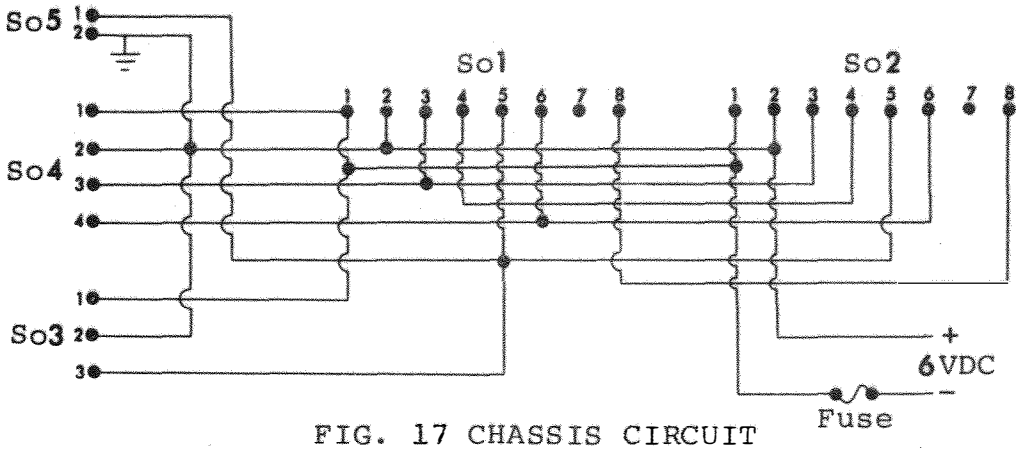


FIG. 17 CHASSIS CIRCUIT

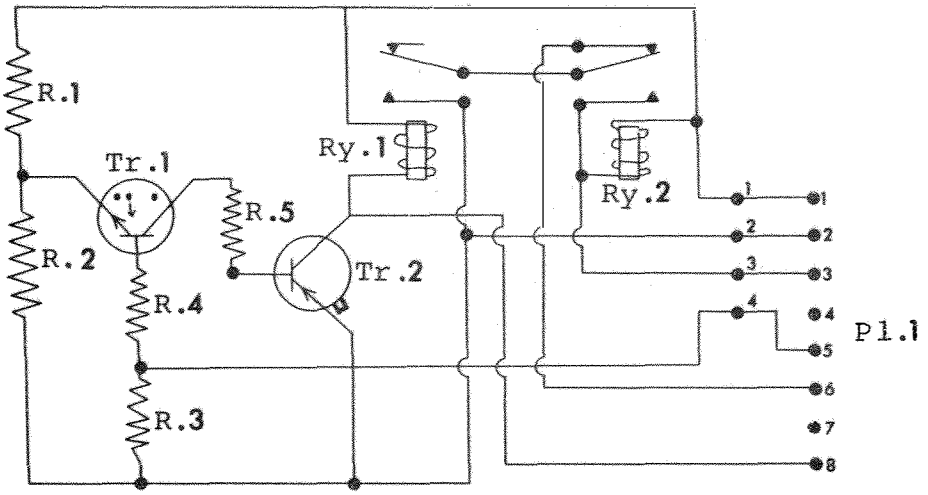


FIG. 18 TRIGGER TURRET CIRCUIT

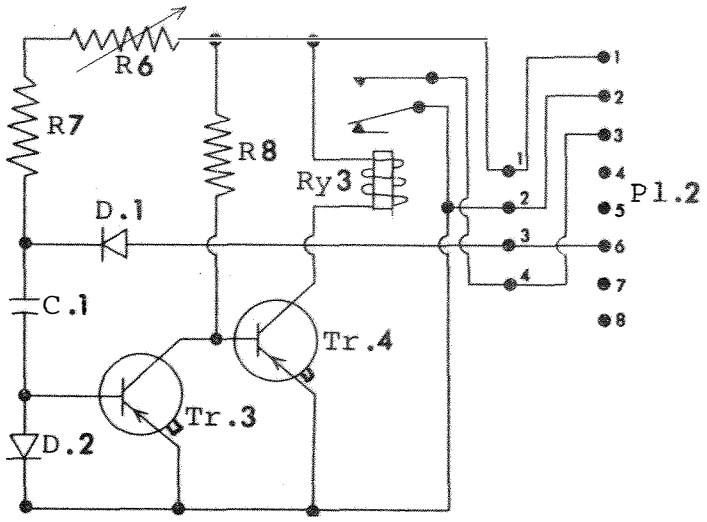


FIG. 19 TIME-DELAY TURRET CIRCUIT.

Legend of Figures 20 - 22

R9	5,000 ohm $\frac{1}{4}$-watt resistor
Sol.	Guardian #11-Cont. 6VDC
Lamp	GE #12, 6.3 volts, 0.15 amps, 5,000 hour
Pc	Lafayette #19G2101 cadmium-sulphide photocell
PL3, PL3A	Amphenol 91MPM3S
PL4	Amphenol 91MPM4S
So6	Midland 14-227 miniature phone jack
Sw 1	Unimax USM5L microswitch
Sw 2	Contacts on clock
Sw 3	Any momentary, normally-open switch

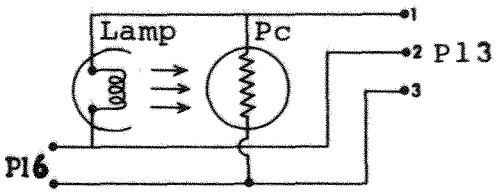


FIG. 20
PHOTOCELL ASSEMBLY CIRCUIT

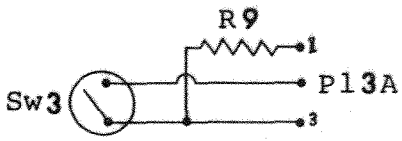


FIG. 20A
ALTERNATE TRIGGER CIRCUIT

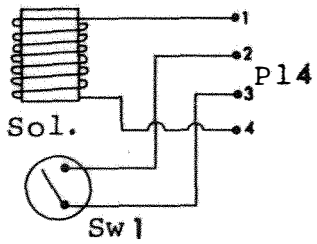


FIG. 21
SO NOID ASSEMBLY CIRCUIT

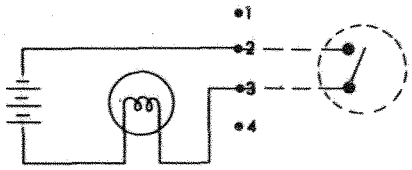


FIG. 21A
SOLENOID ASSEMBLY TEST CIRCUIT

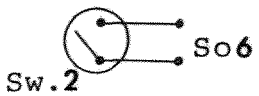


FIG. 22
CLOCK CONTACT CIRCUIT

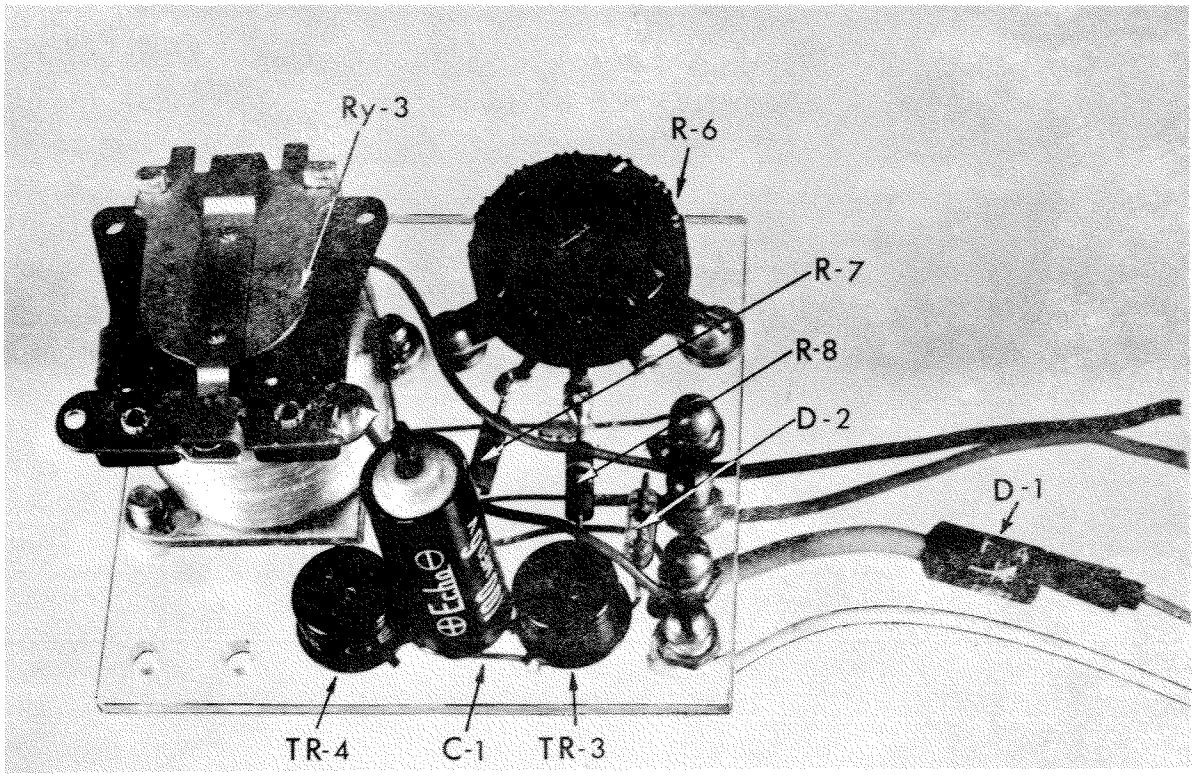


Fig. 23 The time-delay turret circuit-board.

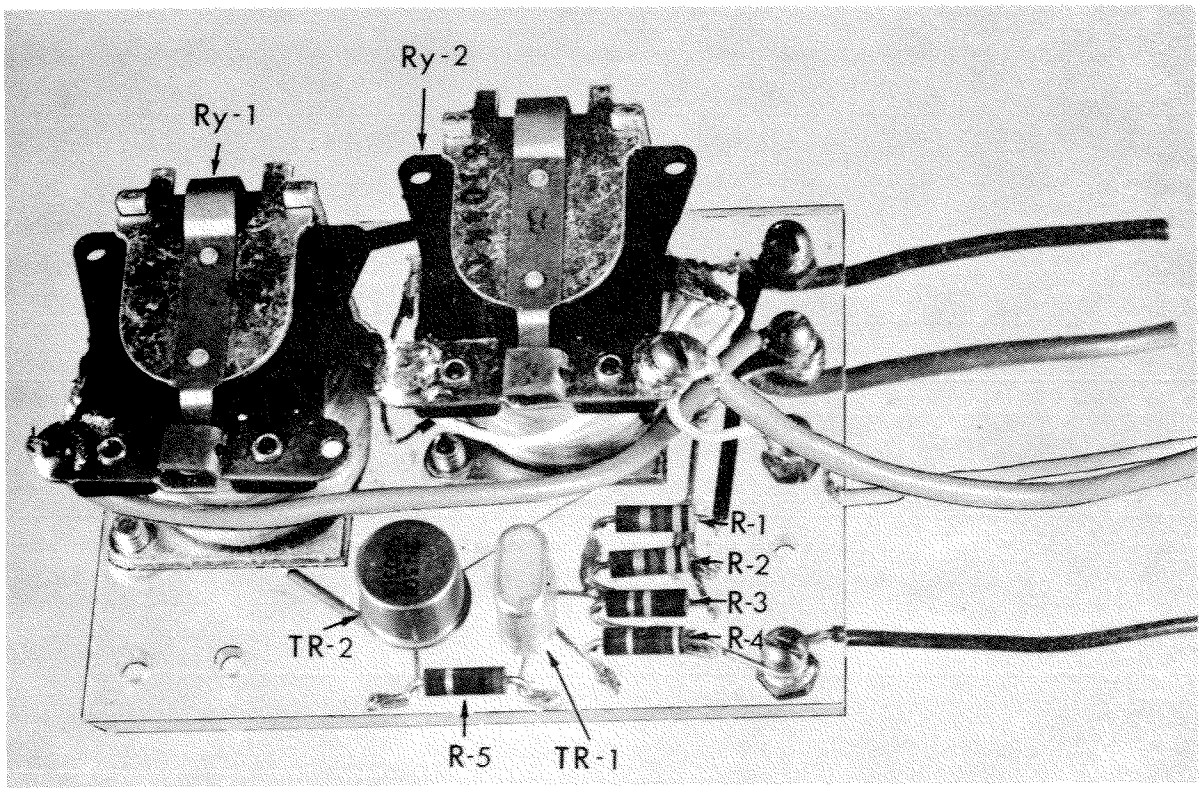


Fig. 24 The trigger turret circuit-board.

When mounting the components on the circuit boards, care must be exercised in soldering the leads to the transistors and rectifiers. A soldering iron of 100 watts or less should be used, and connections should be made as quickly as possible. It is advisable to clamp pliers on the wire leads between the soldering iron and the transistor case to dissipate the heat. Overheating will ruin these components.

An alternate trigger circuit is provided for test purposes and for triggering the apparatus by timing devices, remote control, etc. Wire this alternate trigger as shown in Fig. 20A. Install the 1000 ohm 1/4-watt resistor inside the case of the plug and attach the two leads from the plug to any momentary-contact switch.

3. (d) The Photocell Assembly

The photocell mounting block and the lamp housing are mounted at opposite ends of a 4 x 9 x $\frac{1}{2}$-inch (two $\frac{1}{4}$-inch layers) plywood base with a 1 x 2 x $\frac{1}{4}$-inch deep depression (for bait) between them (Fig. 3). The unit is designed to be recessed into a permanent platform, or for greater versatility, it becomes a lightweight accessory for a variety of uses in the field or laboratory. The permanent mounting arrangement eliminates problems due to mis-alignment.

Mounting the Photocell

Using the dimensions of Fig. 25, cut the two 4 x 9-inch pieces of plywood, and in the top layer, drill two 1-inch holes on 1-inch centers. Chisel away the remaining wood to form an oval shaped hole. Cut a slot $\frac{1}{2}$ x $1\frac{1}{4}$-inch in the top layer as shown in Fig. 25.

Cut the photocell mounting block to the specifications of Fig. 26 and fasten it to the top layer of the base with woodscrews from beneath (Fig. 25).

Drill a 3/32-inch channel for the wiring (Fig. 26B) from the bottom of the 9/16-inch hole, down through the block and through the base. Using as little heat as necessary, and making the protrusion from the photocell as short as possible, solder a 6-inch length of phono-arm cable to the photocell, cut off the excess photocell lead wires, and coat the connections with silicon resin laquer. Pass the cable through the 3/64-inch channel and fit the photocell in place using builder's caulking compound to keep it permanently in place and weatherproofed.

The Lamphousing

Cut and bend the metal envelope (Fig. 27A) and fasten the $\frac{1}{2}$ x $1\frac{1}{4}$-inch window and end panel in place with epoxy glue. Glue the envelope in place in the $\frac{1}{2}$-inch slot in the plywood base. (The glue should set in about 30 minutes at 120°F under a 60-watt desk lamp.)

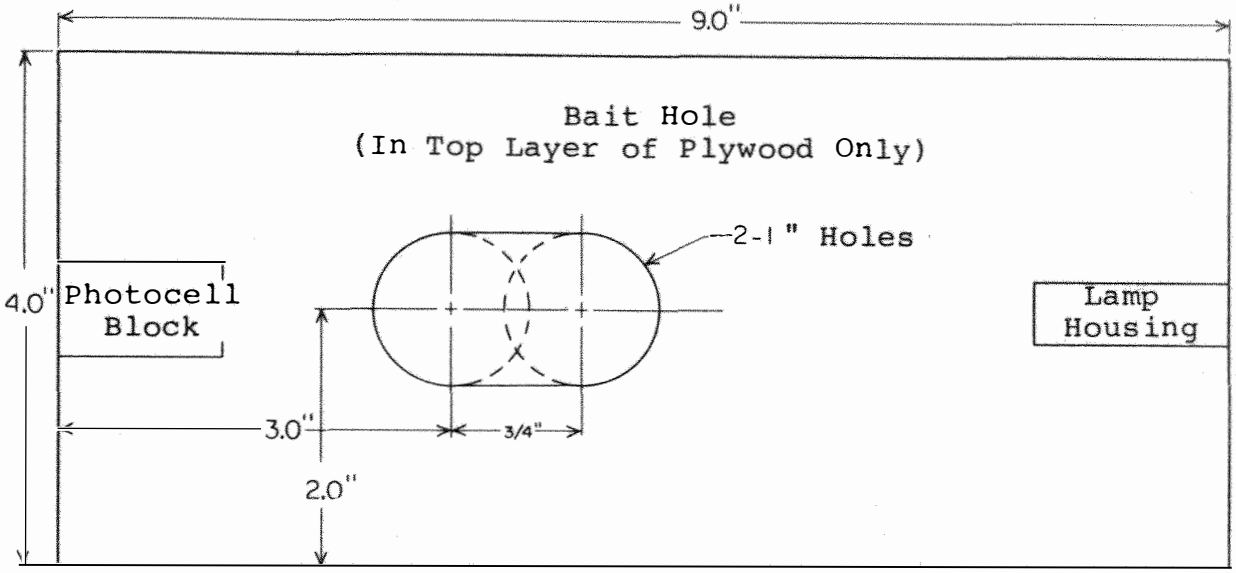


FIG. 25 PHOTOCELL ASSEMBLY.

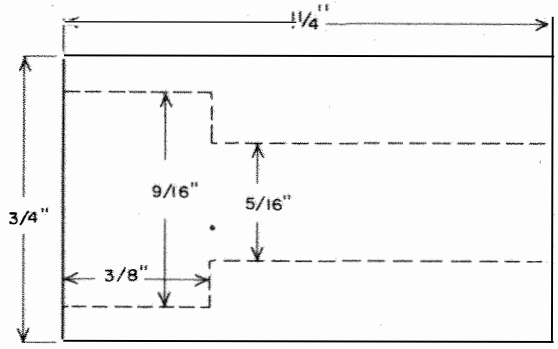


FIG. 26A TOP VIEW OF PHOTOCELL BLOCK.

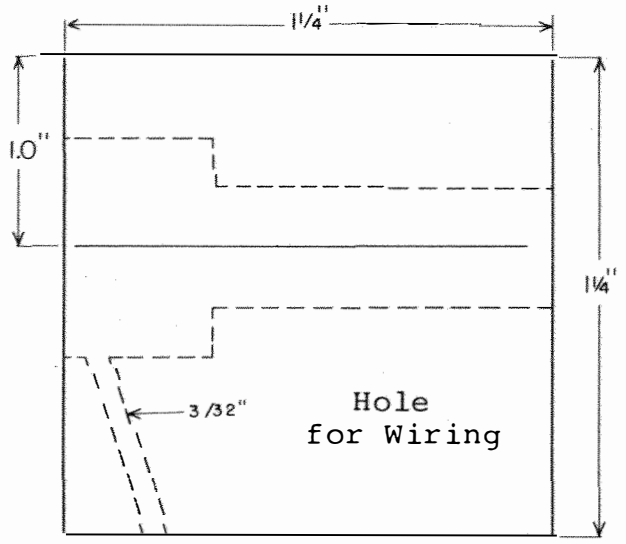


FIG. 26B SIDE VIEW OF PHOTOCELL BLOCK.

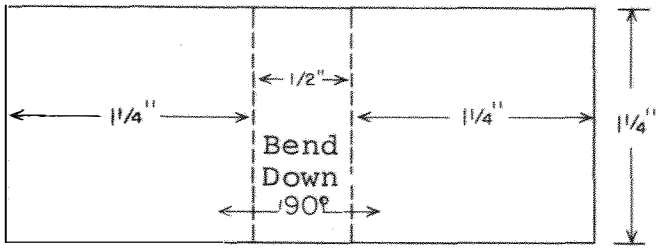


FIG. 27A LAMPHOUSING ENVELOPE.

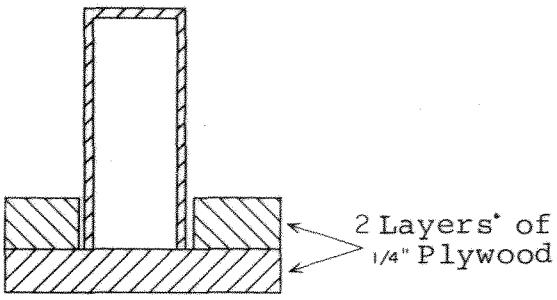


FIG. 27B END VIEW OF MOUNTED LAMPHOUSING.

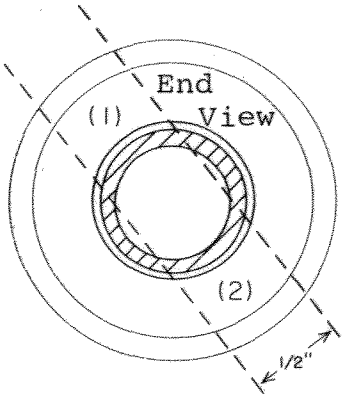


FIG. 27C METHOD OF CUTTING TWO MODIFIED REFLECTORS FROM AN F-780 FLASHLIGHT REFLECTOR.

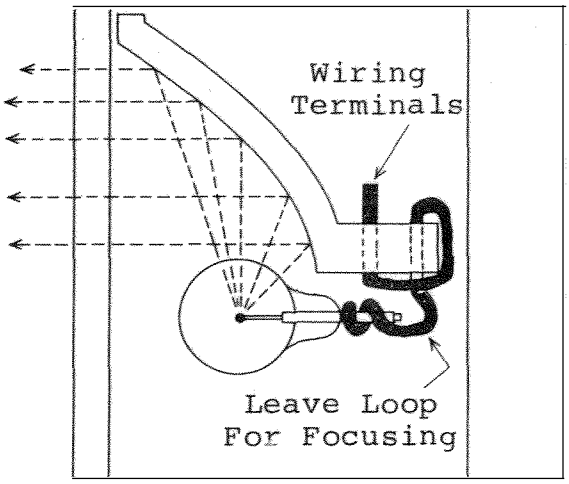


FIG. 27D SIDE VIEW OF LAMPHOUSING.

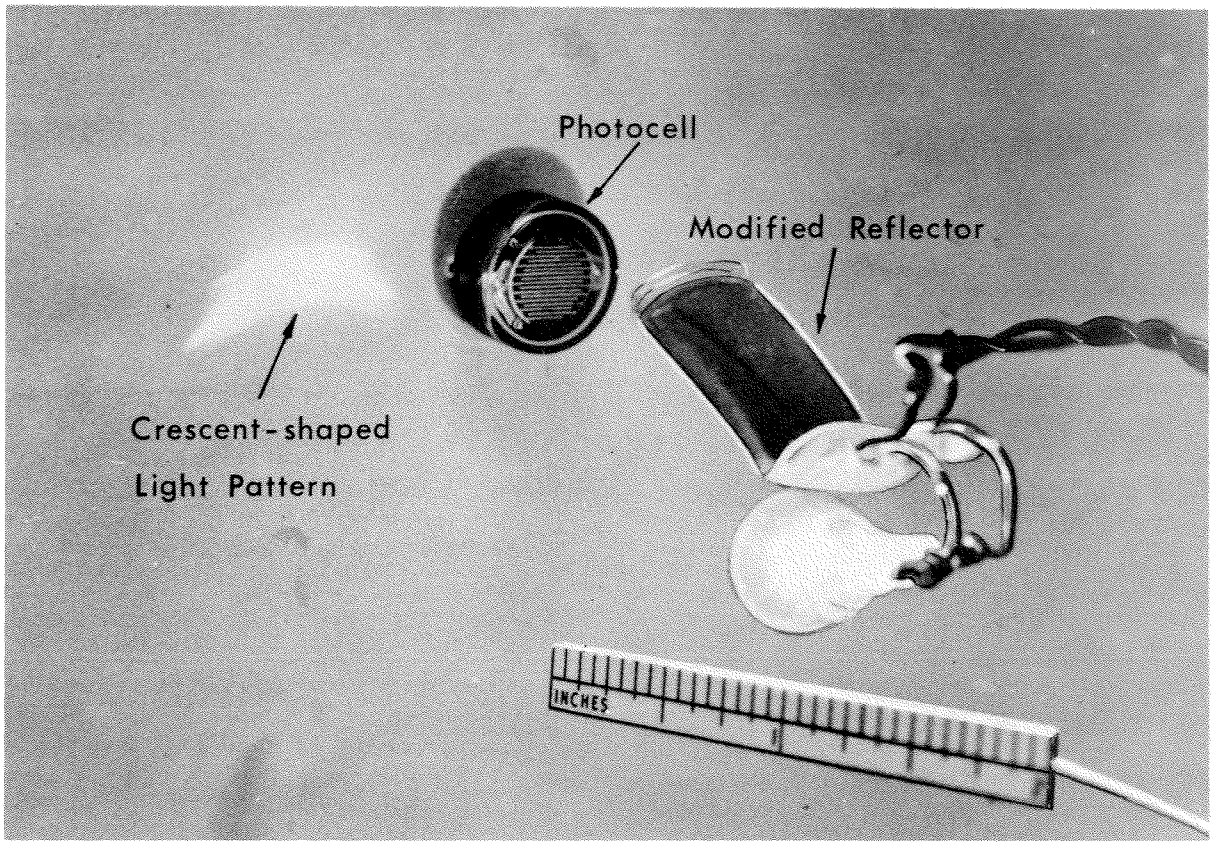


Fig. 28 Focusing the lamp.

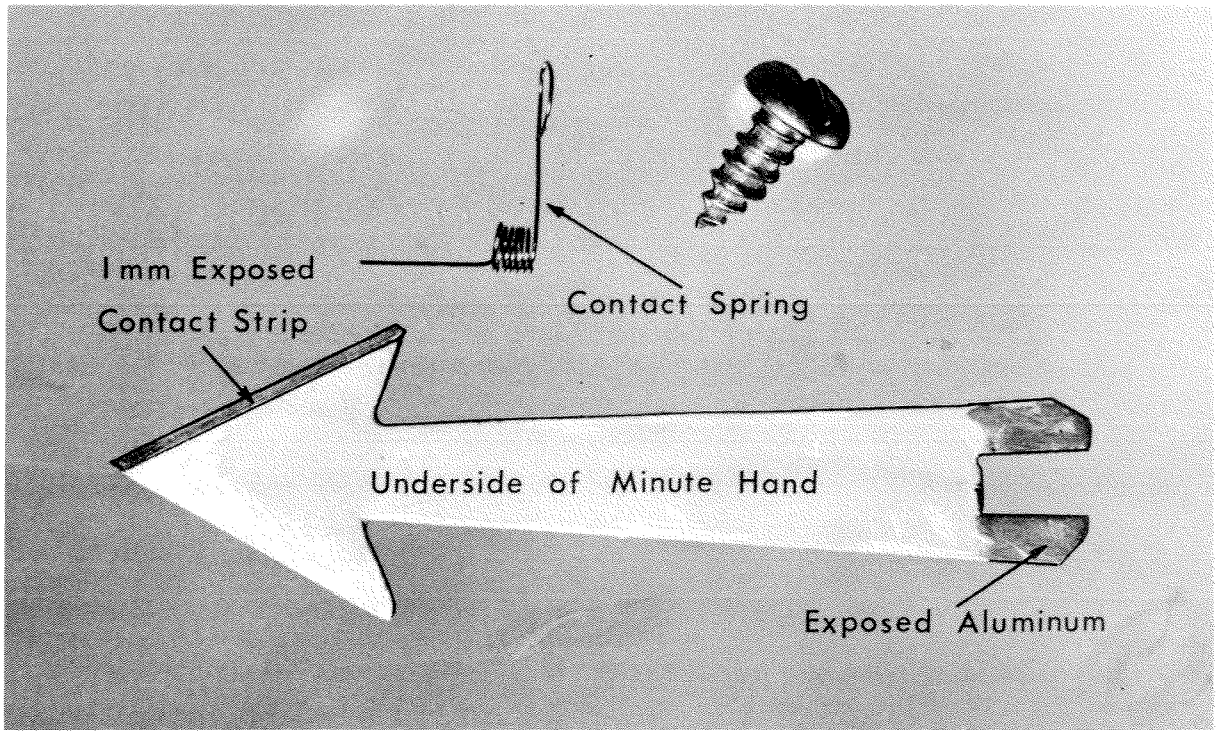


Fig. 29 The clock switching components.

Cut the ½-inch wide section from the flashlight reflector as shown in Fig. 27C, by holding the reflector firmly in place in a mitre-box and making the cuts with a fine toothed saw, preferably a jeweller's hacksaw. Solder 3-inch leads of bare 22-gauge solid copper wire to the bulb, and clean the bulb terminals using flux, as the terminals are not tinned. Drill four 1/16-inch holes in the reflector extension (Figures 27D and 28) and pass the wire through these holes, leaving a small loop to facilitate focusing. Make certain the physical attachment of the bulb to the reflector is tight enough to eliminate "wobbling". Attach a 6-inch length of phono-arm cable to the reflector assembly and connect the assembly temporarily to the 6-volt battery.

Orient the bulb in a horizontal position to obtain the most intense crescent of light (Fig. 28) on a card set at a distance of 12 inches, and mentally note the position of the bulb in the reflector. Apply epoxy glue to the edges of the reflector (keep it off the reflecting surface) and brush a very thin layer on the inside of the metal envelope where the reflector will rest. Slide the reflector in place. Focus the bulb again to obtain the most intense crescent of light, then move the reflector assembly until this crescent falls upon the photocell. Cure the epoxy glue at about 120°F under a desk lamp for 30 minutes.

Following the schematics of Fig. 20, attach a 42-inch 3-conductor cable terminating in an Amphenol 91MPM3S plug, and an 18-inch 2-conductor cable terminating in a miniature phone plug, to the photocell unit. (See also Fig. 3).

Recess the wiring into the plywood and coat all wiring with silicon resin laquer. Finally, attach the bottom layer of plywood in place with ½-inch wood screws at 1½-inch intervals around the outside edge. Be careful not to damage the wiring.

3. (e) The Flash Unit

EXTREME CAUTION must be exercised when working with the flash unit because, when the flash unit is charged to its full 300 volts, it retains this potentially lethal charge in a storage capacitor after the power source has been disconnected; and even after the flash tube has been fired, the storage capacitor retains a charge of about 50 to 75 volts. For these reasons, it is advisable to read the instructions through first, and follow them step by step.

The flash unit operates on 110 VAC with a transformer cord, or when line current is not available, a standard high-voltage photographic dry battery is used. For reasons of simplicity and overall economy, a 225 volt battery was chosen which will provide 4000 flashes during its lifetime.

To increase the performance of this flash unit during the rather adverse conditions under which it must usually be operated, minor modifications are recommended which may be made as follows;

a) Discharge the flash capacitor by stripping the ends of the replacement cord (see Parts List, page 55) inserting the 1500 ohm 2-watt resistor between these ends, and plugging this cord into the flash head. Leave this connected as long as the flash head is dismantled.

b) Remove the two diagonally opposite screws on the bottom of the case and pull the case apart, being careful not to dislocate any of the parts.

c) Using a single strand of fine wire (from a scrap of 18 gauge stranded line cord) wrap the flashtube as shown in Fig. 32. Tie both ends of this wire to the metal band wrapped around the tube. Keep this wire away from the terminals at the base of the tube.

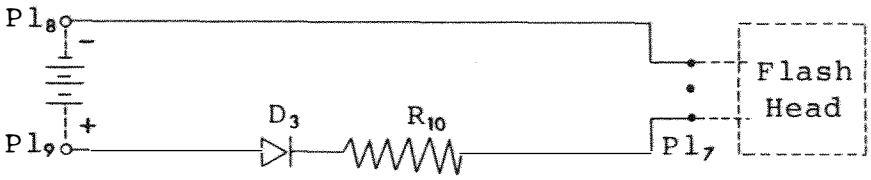
d) To reduce needless battery drain, disconnect one terminal of the neon indicator lamp. Snip with wire cutters and tape ends.

e) Coat all connections except those at the flashtube itself with a moisture resistant layer of silicone resin laquer, especially the trigger coil.

f) Reassemble the case, making sure the small white plastic "open flash" button is properly inserted in its hole, and test the unit with the transformer cord. Detach the resistor from the connecting cord.

A safe but convenient method was devised for connecting the 120-volt AC flash-head to high-voltage dry batteries where the voltages are at lethal levels. A replacement connecting cord, originally designed for use with an optional transistor power pack, was modified for connecting the flash head directly to a standard 225-volt photoflash battery. (Fig. 30). A current-limiting resistor and a shock-eliminating rectifier are wired into this connecting cord and a pair of high voltage banana plugs serve as safe, positive connection to the battery. For simplicity, both the resistor and the rectifier are inserted in the positive lead near the battery. The rectifier prevents this lethal voltage from discharging back through the disconnected exposed banana plugs. It also prevents damage caused by reversed battery polarity.

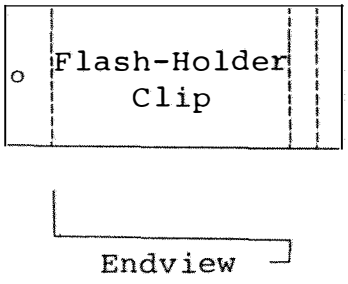
The overall length of the cord from the photoflash battery need be only 12 inches when the battery is used within the camera case, but where necessary, the length of this cord may extend hundreds of feet without affecting the efficiency of the unit. (For example, in sub-zero weather, the battery may be buried for warmth). However, when extensions are used, consideration must be given to hazards created by gnawing rodents, effects of weather, etc.



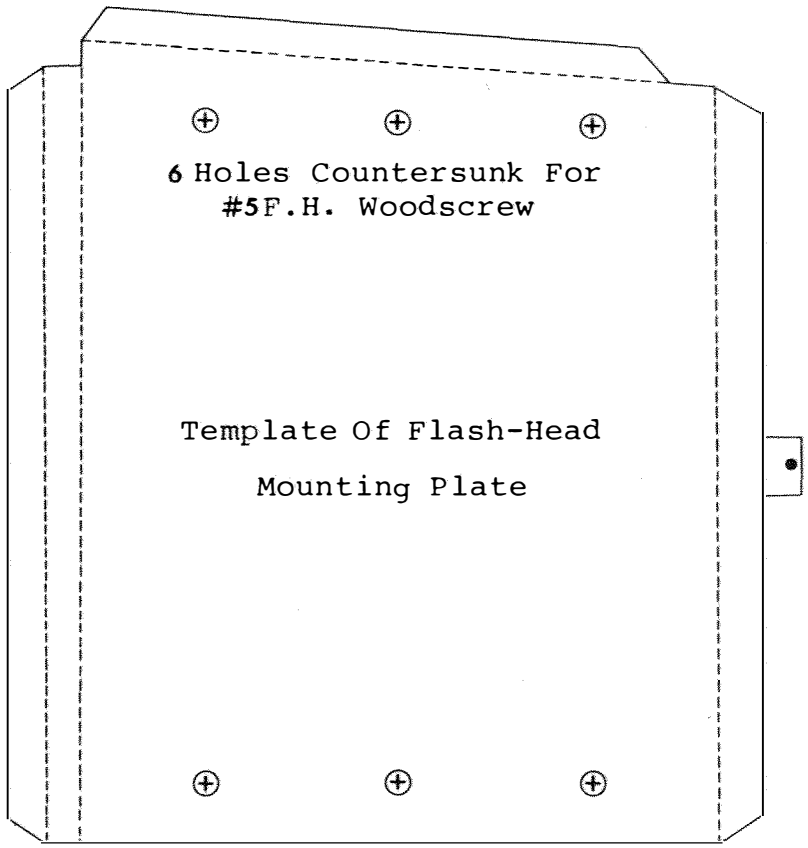
Pl_7- Plug on End of Special Power-Pack Supply Cord (See Parts List).
Pl_8- Banana Plug (Black).
Pl_9- Banana Plug (Red).
D_3 - 1N2483 Silicon Rectifier.
R_{10} - 1500 Ohm 2Watt Resistor.

FIG. 30 CIRCUIT OF BATTERY POWER SUPPLY CORD.

FIG. 31 THE FLASH-HOLDER.



Actual Size



End View of Finished Mounting Plate

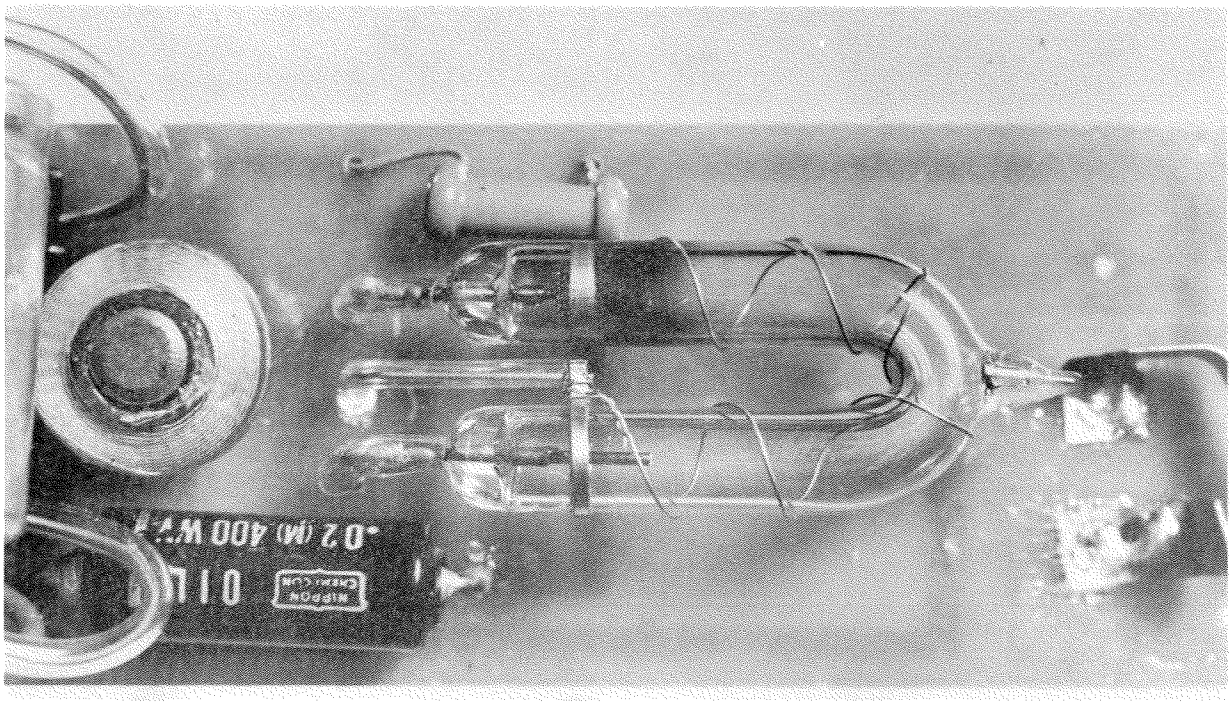


FIG. 32 FLASH TUBE WRAPPED WITH WIRE TO INCREASE IONIZATION.

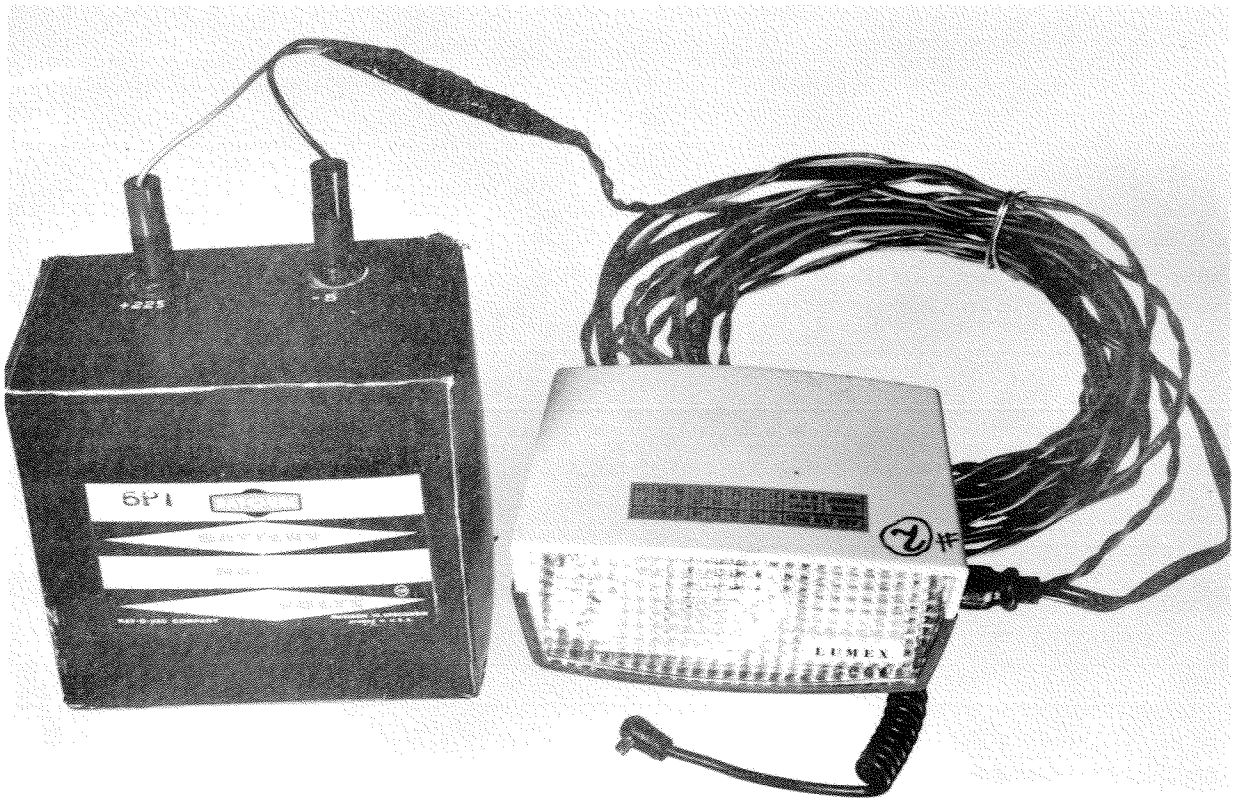


FIG. 33 FLASH-HEAD, BATTERY AND POWER CORD.

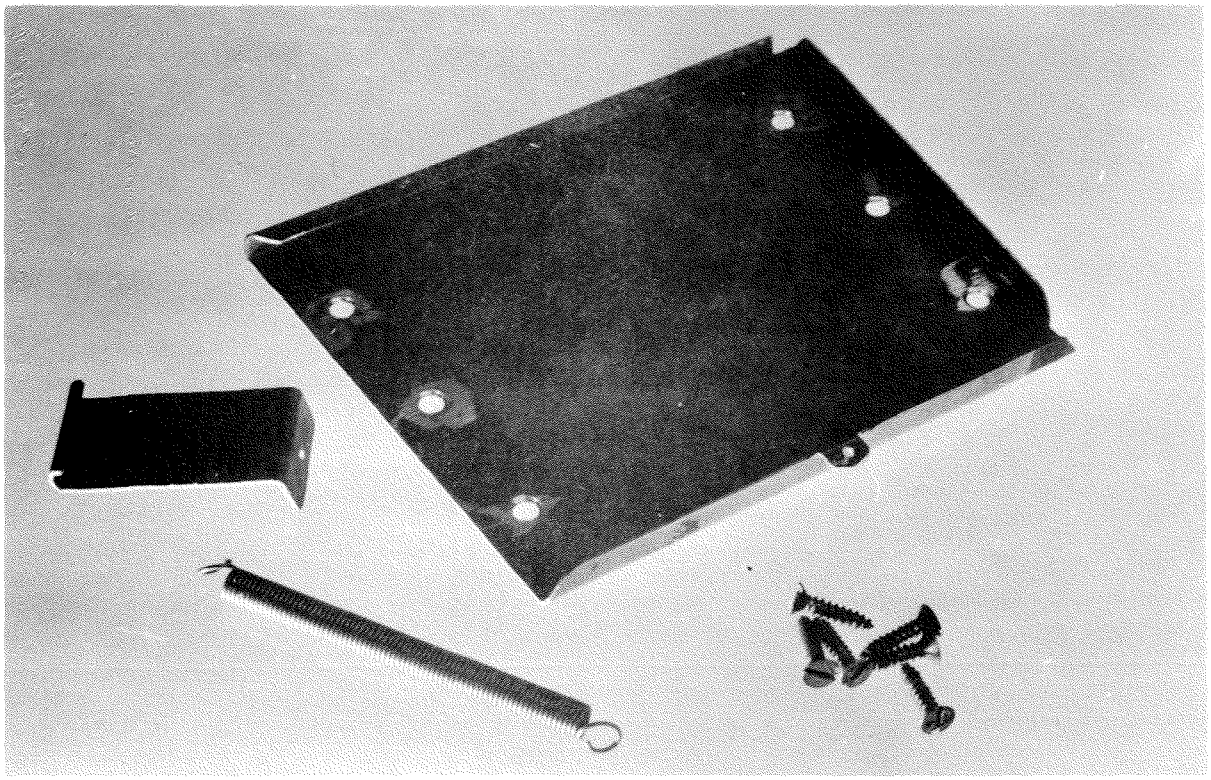


FIG. 34 PARTS OF THE FLASH-HOLDER

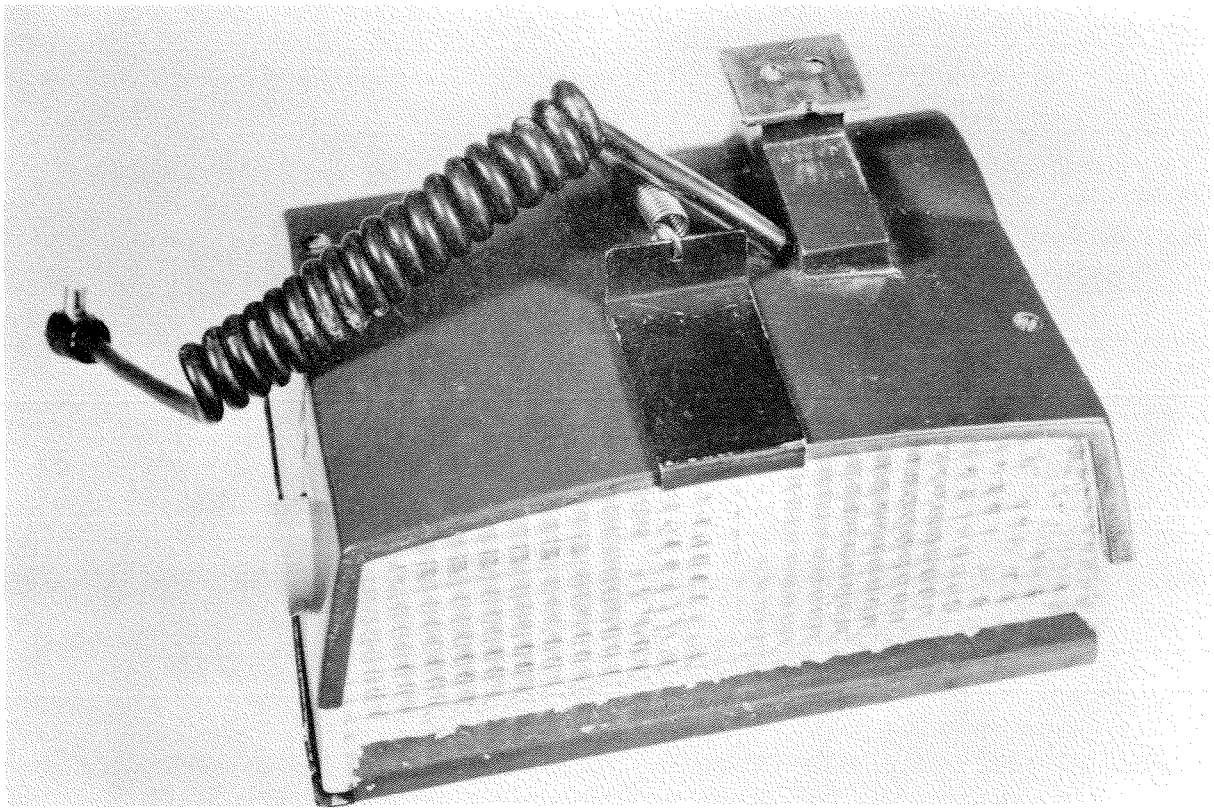


FIG. 35 FLASH-HEAD MOUNTED IN THE FLASH-HOLDER.

To determine the polarity of the leads of this modified cord, observe the following procedure: attach the two leads of the disconnected replacement cord to a voltimeter set at "500 Volts D.C." and wrap these temporary connections with insulating tape to prevent shock or short circuit; using the transformer cord, charge the flashhead, then disconnect the transformer cord and trigger the flash; connect the cord from the meter to the flash head and observe the direction of needle deflection. If the needle moves up the scale slightly, the positive (red) lead of the meter has been connected to the positive lead from the flash head, and if the needle is deflected downward, the negative (black) lead from the meter has been connected to the positive lead from the flash head. Disconnect the cord from the flash head immediately but do not disconnect the leads from the meter until they are properly labelled with a "+" and "-".

In the interests of safety, it is imperative that certain precautions be taken before construction and use of this cord as noted below:

(a) The symbol of a rectifier (Fig. 30) is a triangle with a short perpendicular bar across its apex: be sure that the rectifier is oriented so that the apex of the triangle marked on it points AWAY from the positive battery terminal, regardless of any other markings.

(b) To avoid damaging the rectifier with heat, clamp the lead between the rectifier and the solder joint with a pair of pliers to dissipate the heat, and use as little heat as necessary when soldering. As soon as the components are soldered in place, temporarily wrap the exposed wiring with insulating tape.

(c) Test the completed cord by connecting the leads of a voltmeter set at "500 Volts DC" to the banana plugs and wrap these connections with insulating tape. Charge the flash head fully with the transformer cord, then remove it and attach the newly wired battery cord to the flash head. If the meter needle moves at all, the rectifier was connected wrong or it was damaged by heat, in which case a new rectifier must be installed. If the meter-needle does not move at 500 volts, reset the meter for "10 Volts DC"; if the needle still does not move, disconnect the meter from the cord and as a final test to ensure that the meter was not at fault: using two moist fingers of the same hand and with a slapping motion touch both exposed banana plugs simultaneously. If you notice any unpleasant sensation whatsoever, begin the tests again with another meter.

To insulate these components, paint all exposed wiring with silicone resin laquer. Then slip an adequate length of $\frac{1}{4}$" Alphlex shrinkable plastic tubing over them and, using a flame, shrink it to a tight fit.

Make the flashhead mounting plate of 22 gauge sheet metal, drilled and bent to the specifications of Fig. 31. See also Figs. 34 and 35. To avoid damaging the flashhead, countersink the six mounting holes to accept #5 x $\frac{1}{2}$ flat head wood screws so the top of the screw is flush with the plate.

3. (f) The Instrument Panel

Note: Data from the instrument panel must be read 4000 times from each roll of film. Attention given to making the panel as neat and pleasant in appearance and as readable as possible will promote accuracy and reduce tedium and eyestrain during data recovery. Hence, the colours used on the prototype (chosen for maximum contrast) are mentioned here only as suggestions.

Cut the instrument panel to the specifications of Fig. 36A but the hole for the barometer should be cut slightly undersize and gradually enlarged with a wood file until the barometer fits tightly and requires no other support. Avoid shock - the barometer is a delicate instrument.

Fasten the top panel to the front with wood glue and 3/4-inch finishing nails (at about 3/4-inch intervals) for rigidity. To avoid splitting the 1/4-inch plywood front panel, hold it about 1/16-inch above "flush" in a wood vise while nailing.

After the glue has set (about four hours) dip the panel in clear Pentox wood primer and when dry (24 hours) apply three or more coats of white Varathane plastic paint for maximum durability. Allow 24 hours between each coat and prepare the surface with fine sand paper prior to painting. When the final coat has dried, paint the 3/8-inch numerals (Fig. 4) on 1 5/8-inch radii with black Humbrol plastic model enamel.

Cut the socket mounting bracket (Fig. 37) from 22 gauge sheet metal and the panel support (Fig. 38) from 14 gauge sheet metal. Paint these parts with Humbrol plastic enamel and when dry (four hours) mount them with #4 x 1/4-inch binder head self-threading metal screws on the panel as shown in Figure 36C.

Make the minute hand of 20 gauge aluminum to reduce corrosion of the exposed contact-strip. Cut the hand as shown in Figure 39 and coat the leading edge and the underside of the arrowhead with two or three thin layers of epoxy glue. Each layer should be dried for about 20 minutes at 120°F under the heat of a desk lamp. The epoxy is used here as a sturdy insulation coating to ensure that the aluminum of the hand does not prematurely make contact with the spring wire. (Softer insulations such as paint or enamel would likely scratch away during the 9000 contacts of a year's operation. The contact strip, (Fig. 29) a 1 mm strip of exposed aluminum along the trailing edge of the underside of the arrowhead, is made simply by cutting and scraping away a 1 mm-wide strip of the epoxy insulation coat. Paint the minute hand bright red or, ideally fluorescent red-orange.

The hour hand may be easily made by merely shortening one of the two hour hands which are supplied with the clock movement kit, or by cutting one from light gauge aluminum as shown in Fig. 40. Paint this hand black.

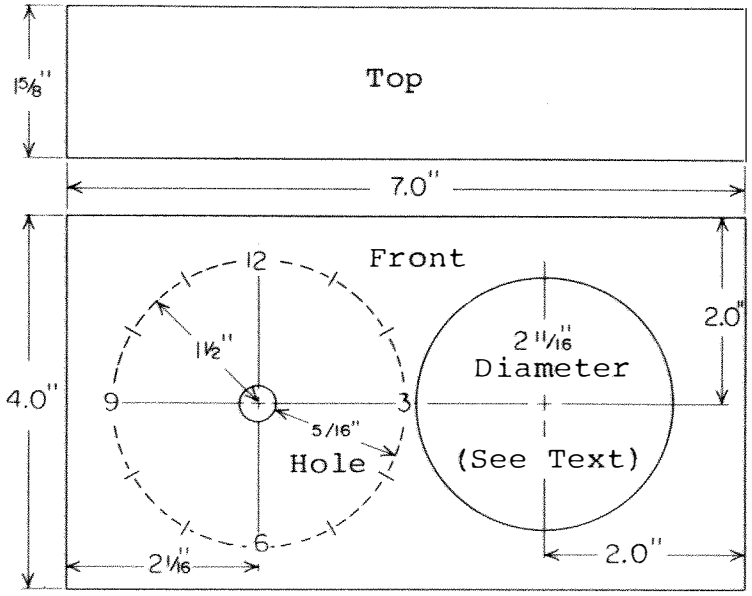


FIG. 36A INSTRUMENT PANEL DIMENSIONS

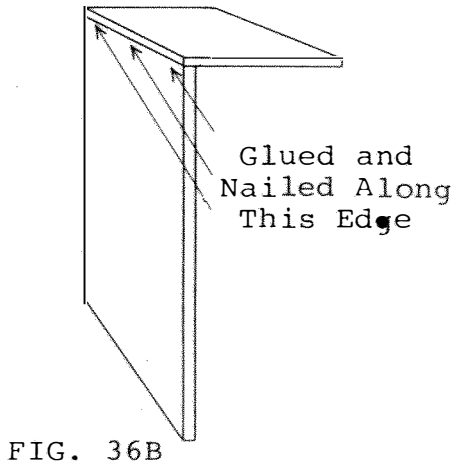
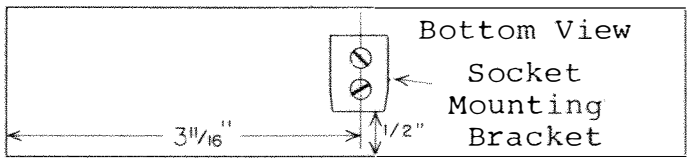


FIG. 36B
PANEL CONSTRUCTION



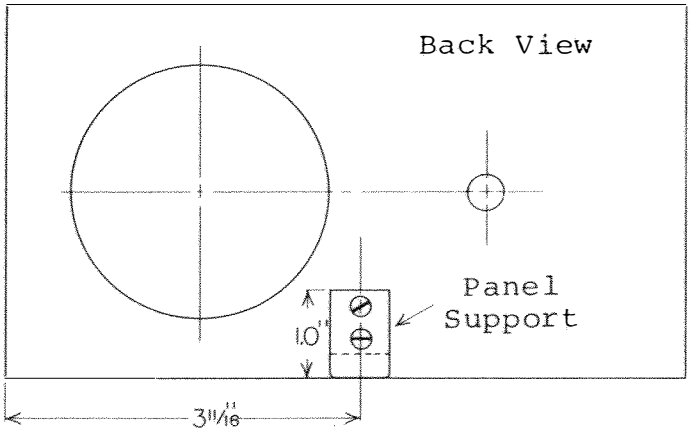


FIG. 36C LOCATION OF PARTS ON PANEL.

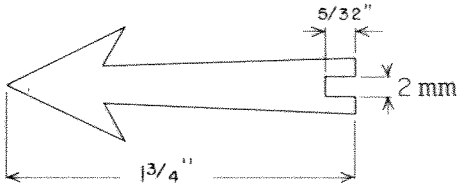


FIG. 39 MINUTE HAND.

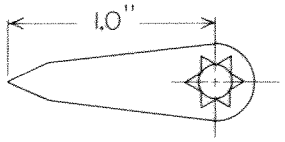


FIG. 40 HOUR HAND.

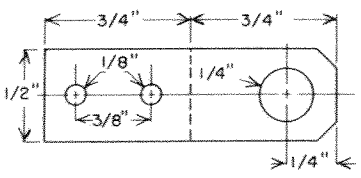


FIG. 37 SOCKET MOUNTING BRACKET.

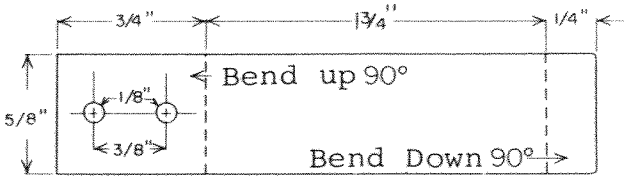


FIG. 38 PANEL SUPPORT

Make the clock contact spring from a 2 1/2-inch cleaning wire for a 26 gauge syringe needle. Wrap about eight turns around the shank of a 1/16-inch drill and form the ends as shown in Figure 29. Fasten the spring in place on the clock face with a #4 x 1/4-inch binder-head self-threading metal screw so the center of the exposed strip on the underside of the hand will make contact with the spring just as the hand passes the "12" position. (Also see Figs. 4 and 41). The mounted spring contact should stand about 1/16-inch above the minute hand.

Attach a 4-inch lead of light gauge wire to the contact spring mounting screw and pass it through the plywood face as near to the screw as feasible. Solder it and a second 4-inch lead (the latter for connection to the clock body mounting-bushing) to the two terminals of the miniature phone jack which make contact with the shank and the tip of the plug. Do not install the clock yet.

Cut out and drill the modified wet-dry bulb temperature scale panels as shown in Figure 43. The columns must be removed and when the panels have been modified, should be tied in place with a few loops of fine gauge wire. A single strand from multi-stranded household lamp cord is ideal.

Cut and drill the 22 gauge metal for the water-reservoir holder as shown in Figure 44. Roll it to an inside diameter of about 9/16-inch (use the shank of a 1/2-inch drill) so it holds the delicate glass reservoir firmly but without risk of breaking. Modify the glass reservoir by bending over a Bunsen burner to the specifications of Figure 45.

Mount the modified wet and dry bulb panels and the water-reservoir holder on the plywood frame with #4 self-threading metal screws (Figs. 41 and 42).

The *manganese alkaline "C-size" dry cell should be attached to the clock with short, soldered leads before clipping it in place, to eliminate any chance of faulty connections. The surface of the battery must be roughed with a file before soldering, and heat should be used sparingly.

Install the barometer and the clock. Connect the lead from the miniature phone jack to the threaded bushing of the clock during installation.

The columns of the wet and dry thermometers can only be read from a narrow angle, and therefore must be aimed at the camera lens and fastened in that position permanently with epoxy glue. Taking into account the 1/2-inch floor of the camera case, and the half-inch floor of any instrument shelters used, the thermometer columns should be "aimed" at a point 24 inches from the lens and 4 3/4 inches above the bottom edge of the instrument panel.

---

*Manganese-alkaline cells have a longer life and are far more efficient at low temperatures than zink-carbon cells.

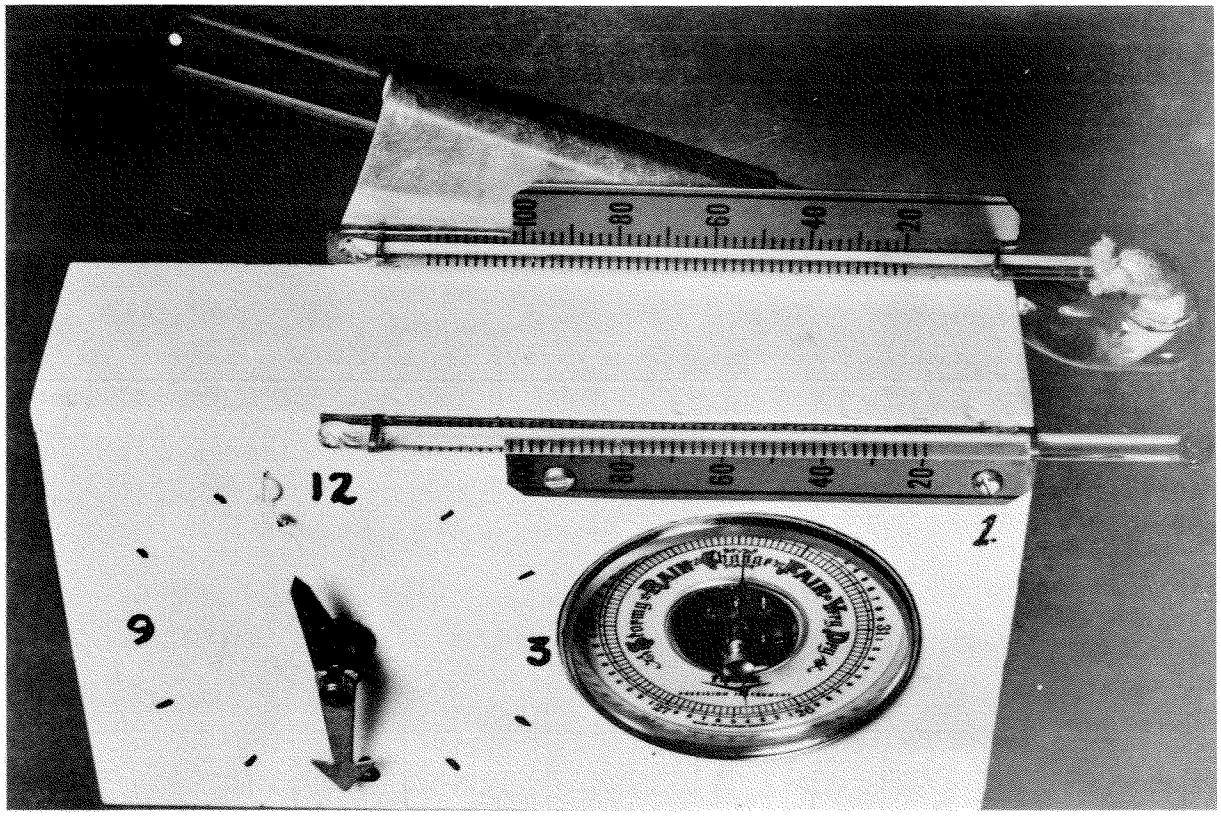


FIG. 41 FRONT VIEW OF INSTRUMENT PANEL.

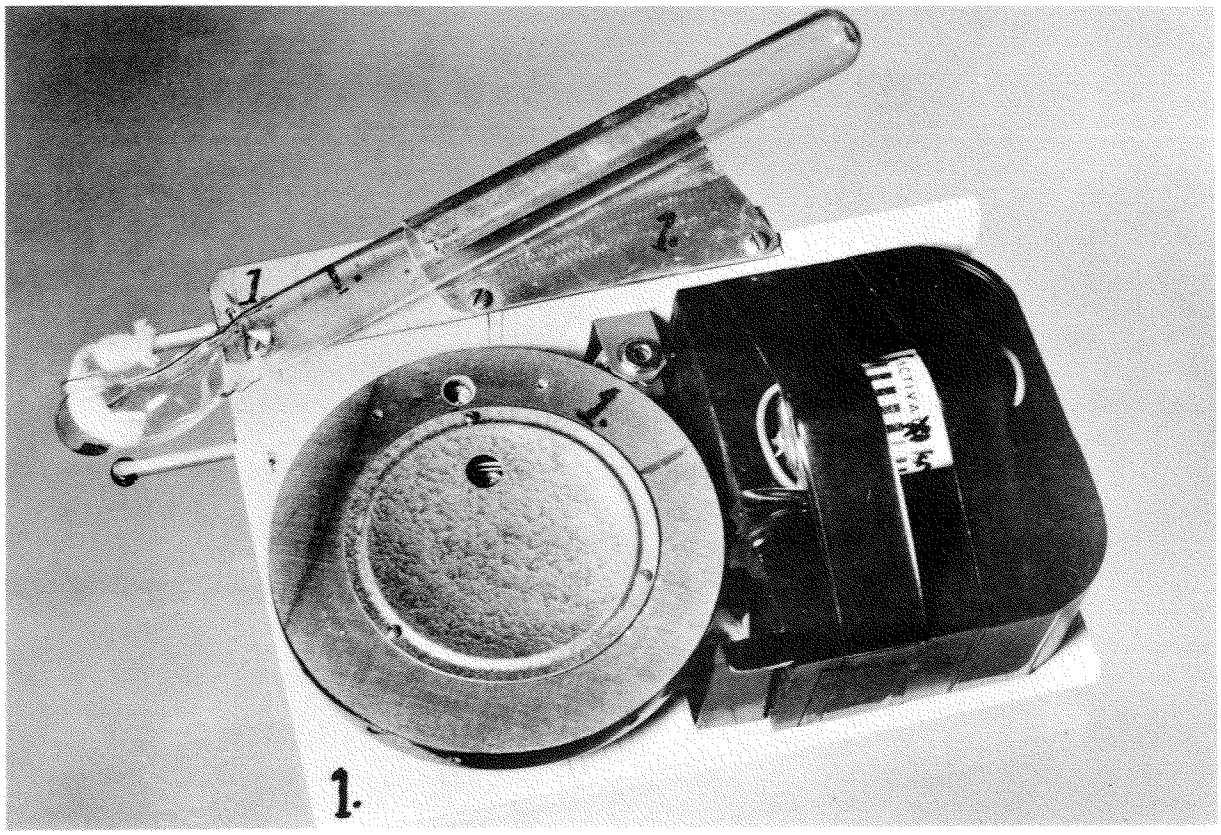


FIG. 42 REAR VIEW OF INSTRUMENT PANEL.

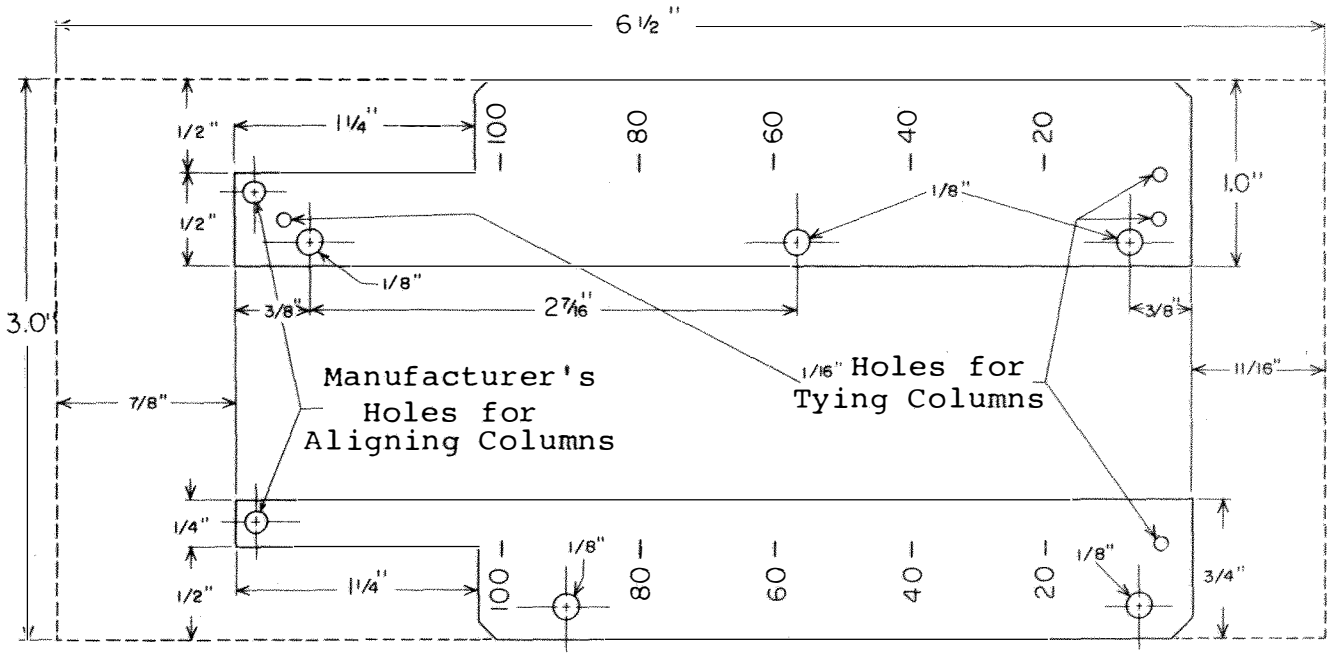


FIG. 43 MODIFICATION OF THERMOMETER SCALE PANEL.

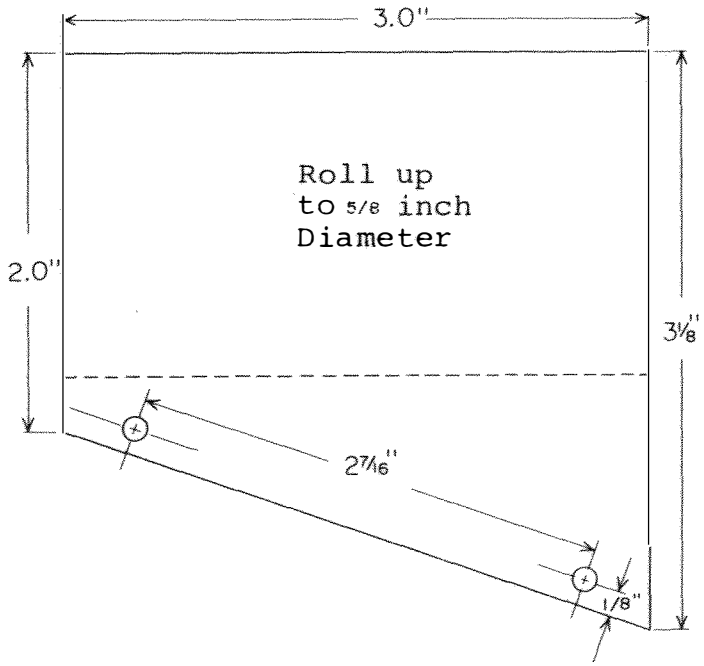


FIG. 44 RESERVOIR HOLDER.

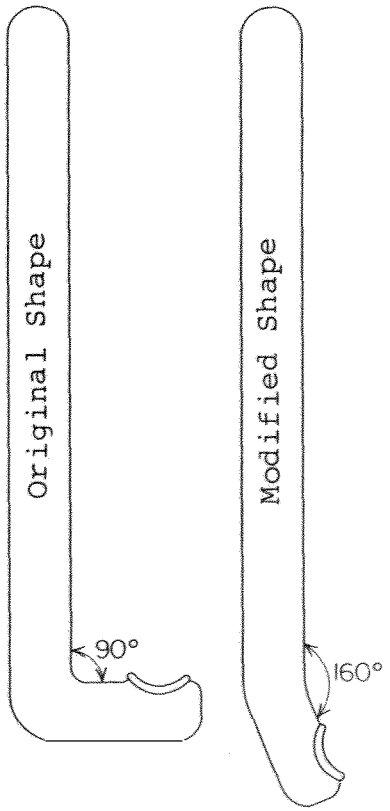


FIG. 45 MODIFICATION OF WATER RESERVOIR.

3. (g) The Camera Case

Cut the 1/2-inch plywood for the camera case (Fig. 46) and the camera-mounting blocks (Fig. 50) as follows:

1 piece 8 x 10" (roof)
1 piece 7 x 9" (floor)
2 pieces 7 1/2 x 10 1/2" (ends)
1 piece 9 x 10 1/2" (back side)
1 piece 10 x 10 1/2" (door)
4 pieces 4 3/4 x 2 1/2" (top block)
4 pieces 4 1/4 x 1 1/2" (bottom block)

Cut the holes for the windows in the front panel as shown in Fig. 46A. Recess an additional 1/4-inch strip around the holes to a depth equivalent to the thickness of the window material used, so the windows will be flush with the plywood surface. Do not install the windows yet. Cut the 1/8-inch "drip-stop" in the top panel and slope the top of the door 30 degrees as shown in Figure 46A. Drill the mounting holes for the lock (Fig. 47), chisel out the slot to receive the catch, cut the 1/4-inch plywood spacer, but do not mount the lock until the case is painted. Assemble the camera case with Lepage's Bondfast wood glue and with 1 1/2-inch finishing nails at 1 1/2-inch intervals. Do not mount the door. File small notches in the edge of the back and bottom panels at the door frame as shown in Figure 2, to permit cables to the photocell and battery to pass without interfering, with operation of the door. Cut the camera mounting blocks with a coping saw, using the patterns of Figure 50, then nail together the four laminations of each block and smooth the cuts with a wood file and sandpaper.

The window for the camera is merely a 3-inch glass flashlight lens but the window for the flash unit, an oval shaped piece of 3/32-inch plexiglass, must be cut to overlap the 2 x 3" oval shaped hole by 1/4-inch.

Prepare the case for painting by filling all the holes and irregularities in the surface with Lepage's Plastic Wood and sand the wood smooth. Thoroughly prime the entire case and the mounting blocks with clear Pentox or Timberlox with particular attention to joints and openings. After this primer coat has thoroughly dried, set the windows in place in a bed of epoxy glue and dry the glue at 120°F. Then fill around the windows with a second application of the glue.

Mask both sides of the windows and prepare the plywood surfaces with a fine grade sandpaper. Cover the interior of the case, the flash-head mounting plate, and the camera-mounting blocks with two coats of flat black enamel. White Varathane plastic paint should be applied in three coats to the exterior. The surface should be lightly sanded prior to painting and each coat allowed at least 24 hours to dry.

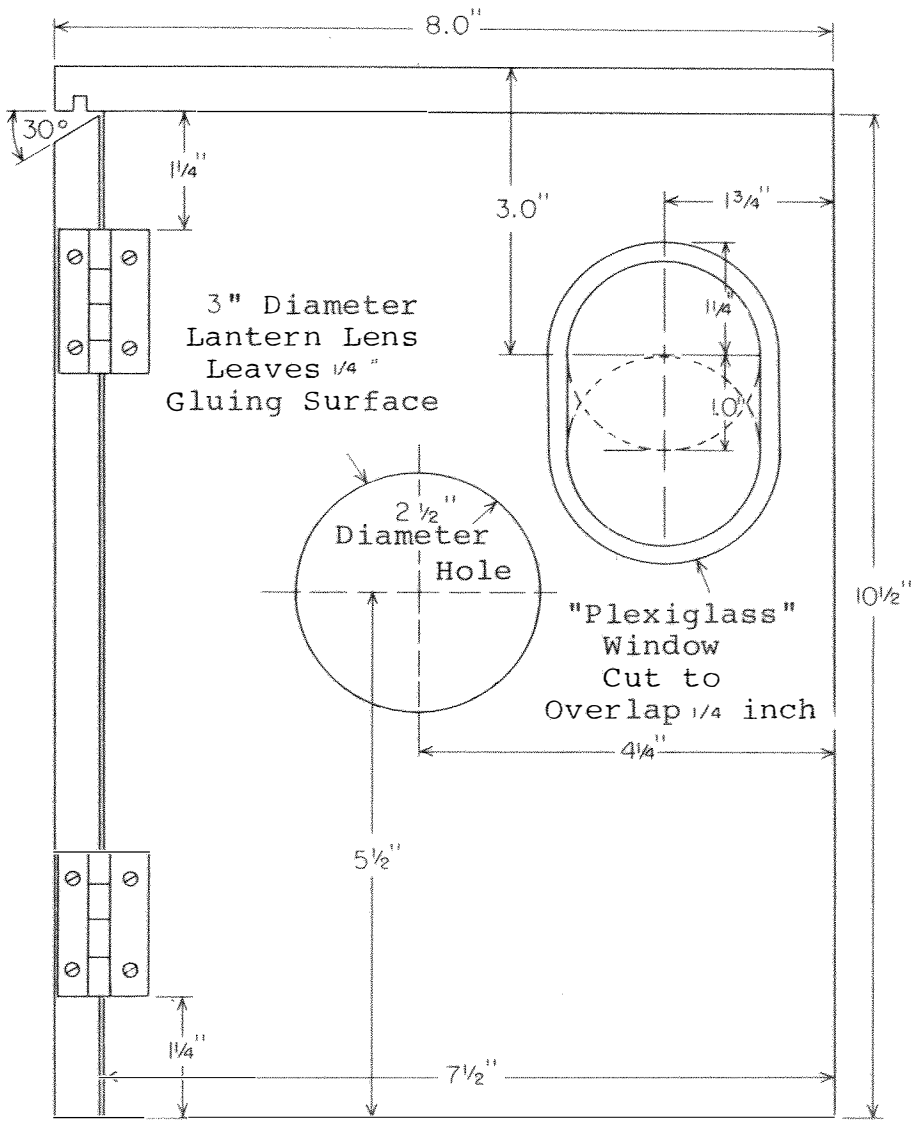


FIG. 46 DIMENSIONS OF CAMERA CASE. (FRONT VIEW)

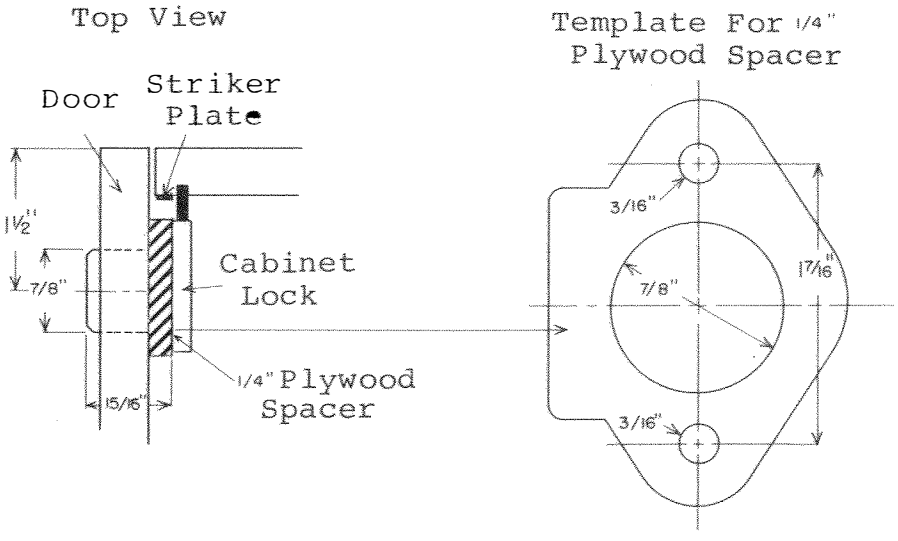


FIG. 47 DETAILS OF THE CAMERA CASE DOOR-LATCH.

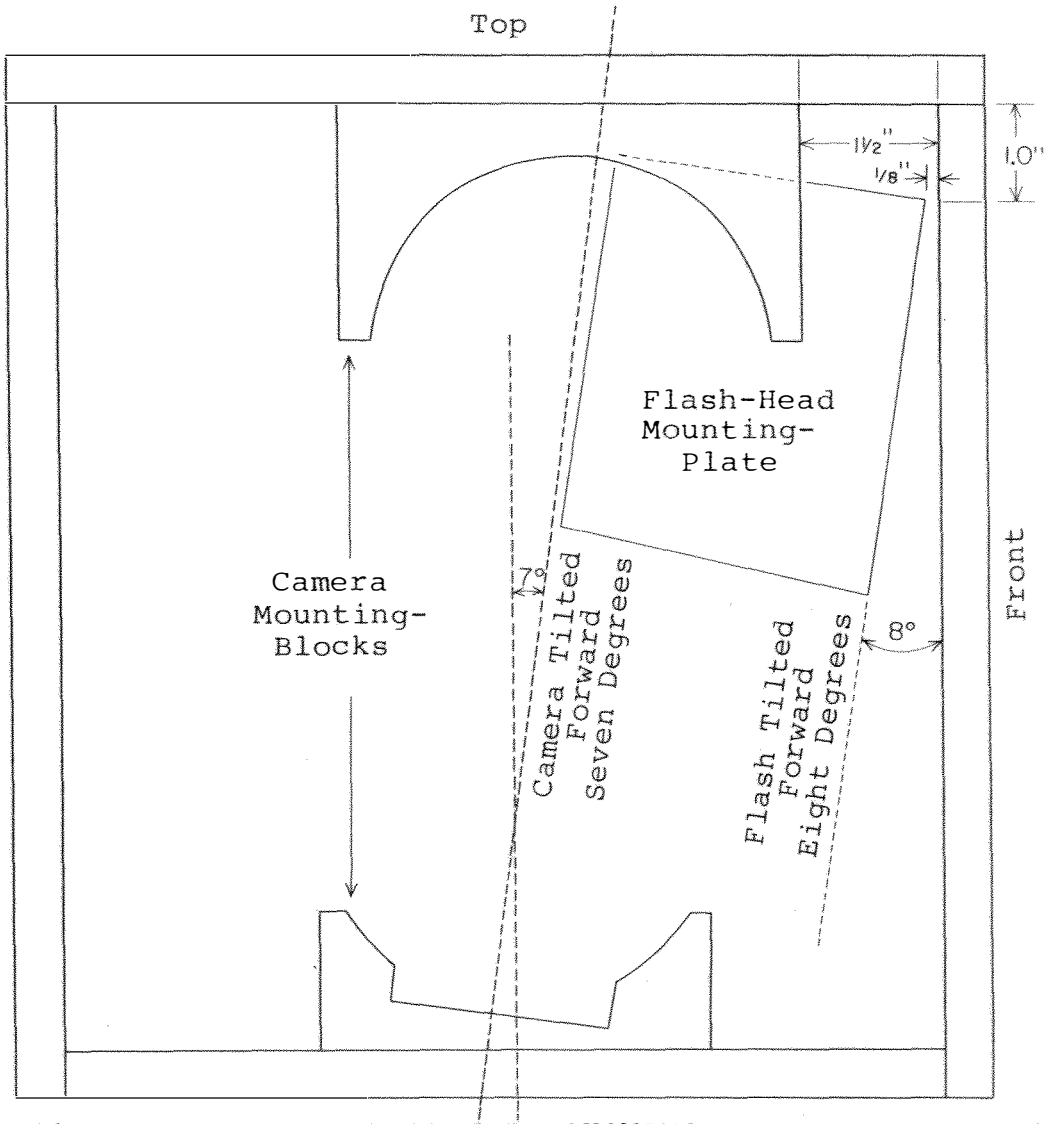


FIG. 48 SIDEVIEW OF CAMERA CASE SHOWING POSITION OF CAMERA MOUNTING-BLOCKS AND FLASH-HEAD MOUNTING-PLATE. NOTE ANGLES OF CAMERA AND FLASH-UNIT.

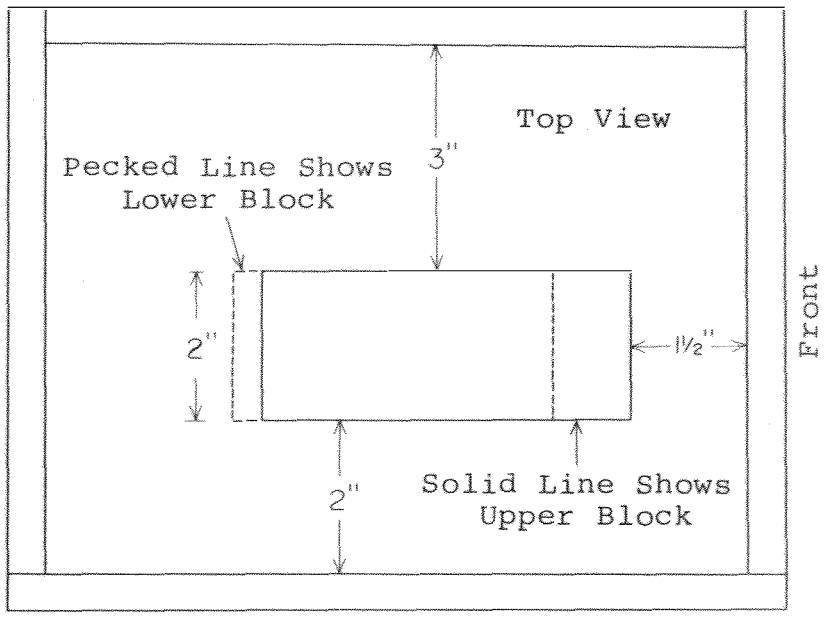
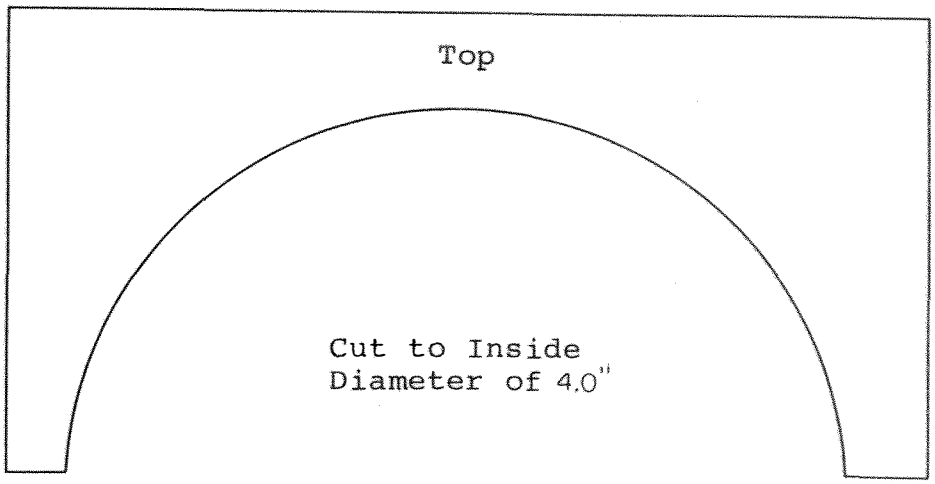


FIG. 49 POSITION OF CAMERA MOUNTING- BLOCKS.



Actual Size

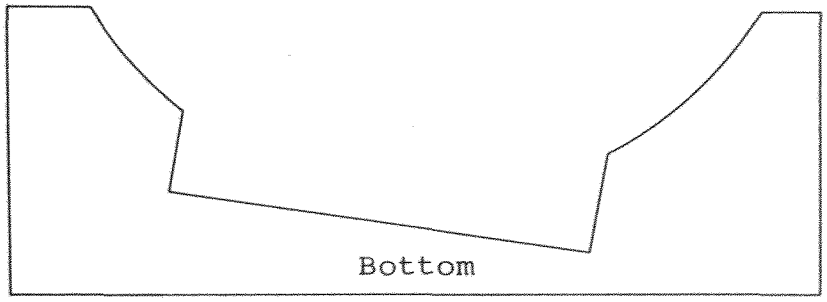


FIG. 50 TEMPLATES FOR CUTTING THE CAMERA MOUNTING-BLOCKS

Install the flash-head mounting plate (Fig. 48) with #5 x 1/2-inch flathead woodscrews on the back side wall with the top forward corner one inch from the roof and 1/8-inch from the front panel. The flash-head mounting plate must tilt forward eight degrees to direct the light between the bait station and the instruments.

The control unit should be located against the back wall of the camera case and fastened to the floor with a #8 x 2-inch round head woodscrew.

Install the camera mounting blocks as shown in Figure 48 so the camera body is tilted forward exactly seven degrees. It will likely be necessary to alter the depth of the top mounting block to obtain the best camera fit at the precise angle required. The depth may be reduced by sanding the block or increased by adding thin metal shims. A large elastic band may be needed to hold the camera in place in the top camera mounting block.

Details for mounting the door hinges are provided in Figure 46A.

3. (h) The Instrument Enclosure

The instruments of the early prototypes were housed in a "Stevenson screen" type of shelter (Figs. 1 and 2) with inside dimensions 12" x 6" x 8½" high, a large sloping roof, and a glass front. This arrangement was most portable, but had disadvantages which led to use of a larger canopy over the entire recorder, eliminating the need for such an elaborate, and difficult to build, instrument enclosure. The plywood canopy, originally designed for protection from snow during winter use, proved most valuable. It sheltered the entire unit from rain, which clouded windows or splashed dirt on them and washed away the bait, as well as warping the unprotected wood of the platform and photocell unit. By shading the unit from direct sunlight, the canopy eliminated the problem of film overexposure, and photocell system malfunction caused by the intense incident light.

If any instrument enclosure is required at all, it would only be to protect the instruments from damage by the wildlife in the area. The author has not found it necessary to protect the instrument panel, and finds the instruments easier to read without the glass window. However, a white background does brighten the film-record considerably.

3. (i) The Battery Case

A plywood battery enclosure (Fig. 2) makes an otherwise awkward and corrosive load fairly easy to handle. It protects the battery from the elements, and protects equipment and furnishings from the battery.

Specifications for the battery case are shown in Figure 52. Construction and painting procedures should follow those described for the camera case.

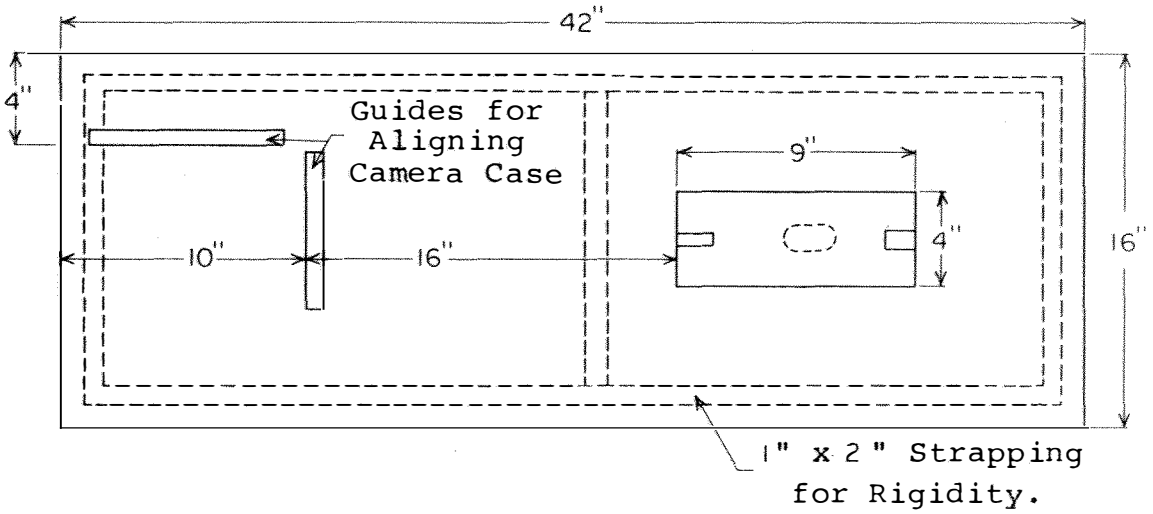


FIG. 51 THE PLATFORM (TOP VIEW)

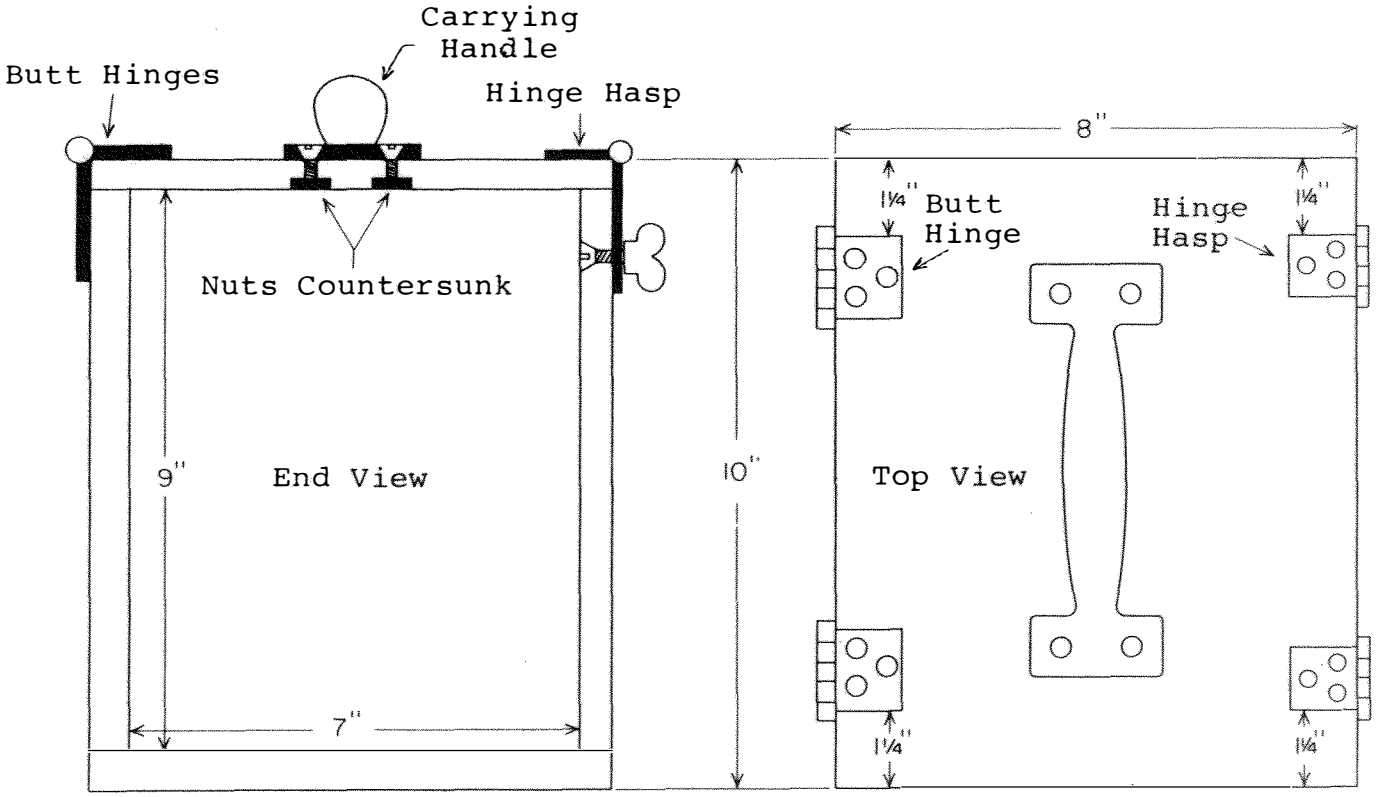


FIG. 52 BATTERY CASE FOR A "GROUP 1", 8⅞" LONG, 6¾" WIDE, 8⅞" HIGH, 6 VOLT, AUTOMOTIVE STORAGE BATTERY.

3. (j) The Platform

The platform consists of a piece of 1/2-inch plywood with 1 x 2" spruce strapping on edge, for rigidity, as shown in Figure 51. A 4 x 9" hole in the platform permits the photocell unit to become part of the platform, thus creating minimal obstruction to the small mammal traffic. Strips of wood nailed to the platform around the camera case following the initial alignment will simplify future alignment. Wood preservatives and paint were not used on the platforms or photocell units of the prototypes to reduce unnatural and possibly repulsive odours, colours and surfaces.

3. (k) The Canopy

A 4 x 8' sheet of 1/2-inch plywood, coated with wood preservative to increase weather resistance, was laid atop four short stakes just higher than the camera case. See Figure 1. The canopy could be hinged to make it more manageable, and in locations where the weight of wet snow would cause it to sag, should be reinforced with 2 x 2" strapping.

4. OPE ATING THE RECORDER

Because the records are made on film, and cannot be verified until the entire roll of film has been developed, it is imperative that the recorder is set up properly before operation. A loose connection or an incorrectly adjusted lens could result in considerable waste of time and money. It is advisable to have a check-list posted at the recorder even though the operator is quite familiar with the operations involved. (During operation of the prototypes, human error greatly exceeded mechanical failure.)

The following suggestions for a "Check-list" are recommended to facilitate trouble-free operation of the recorder.

a) Check the film footage indicator to ensure there is sufficient film for the program. When loading fresh film, check the flash synchronization switch. Replacement may be necessary every five to ten rolls, depending on the degree to which the contacts are burned. Run off a "leader" of ten feet of film at the start of each roll: film developing companies cut off the first few feet and attach a special leader for projection. A "trailer" of three to five feet should be left at the end of the roll. Thread the film very carefully to avoid the all-too-common jamming of film at the gate-mechanism.

b) Check the camera settings. Set the speed at 16 frames per second. Focus the lens at two feet, or if a non-focusing lens is used, be sure the +2 close-up lens is attached. The aperture setting for Kodachrom II film with the Lumex flash unit on 225V battery power is f/5.6; and with the transformer cord and 120V line current, f/9 is optimum. (Glass windows and close-up lenses account for considerable loss of light).

c) Clean the lens with a soft brush, and clean the windows and photocell tube to remove dust, insect webs, etc. Keep the instrument panel clean and bright to enhance readability.

d) Align the camera case and instrument panel and keep the platform clear of debris which would cause the camera to tilt. Turn the instrument panel a few degrees, away from the flash, to avoid glare on the thermometer columns.

e) Always check all the connections. Loose connections may be jarred out of contact during normal operation of the recorder.

Check the battery polarity. The polarity should be marked on both the battery and the battery clips. (The largest battery post is always positive on automotive batteries.)

Maintenance of the storage battery is simple. Do not let the battery go absolutely dead--three weeks operation should be maximum. Do not over-charge the battery or use "fast-charge" techniques: it will last longer if charged slowly, overnight. Maintain the correct water level and use only distilled water. It is advisable to remove the battery caps when charging a battery to prevent damage to the battery and its surroundings.

Winter operation of the recorder is possible and quite practical but some preparations are necessary. Of course, the glass water reservoir for the wet bulb thermometer will burst with the first frosty morning, so must be drained previously. Camera grease becomes quite stiff below 0°F, hence, for use in temperatures below zero, the camera movement and particularly the mainspring, should be lubricated with suitable light grade oils. Photoflash batteries become nearly useless at temperatures lower than about 0°F and therefore, must be water-proofed and buried to a depth where the temperature remains above 25°F. (Tests in a tamarack swamp in southeastern Manitoba showed the minimum temperature at a depth of two feet to be about 25°F while temperatures above the 18-inch (approximate) snow cover dropped below -40°.) Some decrease in the number of frames per winding will result in lower temperatures as the friction increases.

Operation of the recorder in Manitoba's extreme winter temperatures (-40°F) presents a few problems as yet unresolved, but there are no foreseeable, insurmountable obstacles. Operation of the apparatus described herein is quite feasible to 0°F.

5. DETECTION AND CORRECTION OF MALFUNCTIONS

While considerable effort has been expended to keep repairs to a minimum, it would be impractical to omit a guide to follow when trouble is encountered. The following is not a complete guide, but is merely a list of the common problems which may occur and methods of detecting and correcting them without elaborate equipment.

5.1 If nothing works:

a) Make sure battery polarity is correct.

b) Using a hydrometer, make sure the battery is not weak.

c) Check for loose connections.

d) Check for frayed or chewed wiring. If exposed wiring is damaged frequently by gnawing animals, protect it with 1/4" or 3/8" flexible aluminum conduit (available from Northern Electric).

e) Check the fuse. If it is blown, disconnect the camera, photocell unit and both socket turrets from the chassis unit, then replace the fuse. If the fuse blows immediately upon replacement, check for a short circuit within the chassis unit; otherwise connect the alternate trigger (See Sec. 3c) to the chassis unit and observe the following procedure: re-connect one at a time, the trigger turret; the camera assembly; and the time-delay turret and manually trigger the unit for a minute or two following each re-connection in an attempt to locate the short circuit by blowing the fuse. Finally, disconnect the alternate trigger and re-connect the photocell unit. Interrupt the light beam and short the terminals of the miniature phone plug. If the fuse still has not blown, check all wiring and components for obvious shorts. If none, the unit may be returned to normal operation. A faulty fuse or a type of "metal-fatigue" may have been the cause of failure.

5.2 If the photocell lamp is lit, but there is no slight click from the trigger turret when the light beam is interrupted:

a) Check for loose connections or frayed or chewed wiring as in section 5.1 (d).

b) If the photocell is exposed to extremely bright incident light, provide shade.

c) Disconnect the phone plug from the clock. If the unit now operates normally, look for a short circuit in the wiring of the clock.

5.2 d) Clean the photocell tube, clean the lens of the lamp-housing and check that the light is focused properly on the photocell.

e) Try the auxiliary trigger. If the trigger unit now "clicks", the trouble will be within the circuit of the photocell unit itself--most likely a short or open circuit. If the unit still does not "click", remove the time-delay turret and test for a click; then disconnect the camera assembly and test for a click. If there is still no click, the trouble is likely in the trigger turret or in the wiring of the chassis.

5.3 If the photocell lamp is lit and there is a slight click from the trigger turret, but the solenoid is not magnetized, (test with screw-driver etc.), remove the time-delay turret; if the solenoid now operates, the time-delay circuit may be causing the trouble by holding Ry2 (Fig. 5) closed. If the solenoid still does not operate, check the wiring of the camera assembly, the chassis unit and finally, the trigger unit. If relay contacts need cleaning--which would be quite uncommon--use only a fine diamond relay-cleaning spatula, (available from Allied Radio, N.Y.) or replace the relay.

5.4 If the solenoid is energized (magnetized) but the slug does not move:

a) Using a hydrometer, check the level of charge in the battery. The solenoid will not operate if the battery is near exhaustion.

b) Do not oil the solenoid slug but keep it and its brass sleeve smooth and clean.

c) Check the slug alignment and travel. Mis-alignment will cause binding, and the slug will not develop sufficient pull if the stroke is too long. See original construction specifications.

5.5 If the solenoid operates but the camera does not, depress the camera trigger button manually:

a) If the camera now runs, the solenoid arm is not depressing the camera trigger button sufficiently. Install a new, longer plunger on the solenoid arm (Fig. 8). Temporary repairs may be made with a paper shim between the button and plunger.

b) If the camera does not operate when triggered manually, the film may be jammed at the gate mechanism. Open the camera in total darkness only, and re-thread the film.

c) If the camera failure is caused by internal mechanical disorders, take it to a camera-repair shop.

5.6 If the solenoid sticks in, causing multiple exposures:

a) Do not oil the solenoid slug, but keep it and its brass sleeve clean and smooth.

b) Make sure the micro-switch is being tripped. Check the measurements against the original specifications and adjust accordingly.

c) If the solenoid locks on, when the micro-switch is tripped, look for an open circuit in the wiring between the micro-switch and the coil of Ry-2.

d) Cold weather will stiffen camera grease, creating friction at the trigger mechanism. Clean off old grease and oil sparingly with a suitable light grade oil.

5.7 If the time-delay interval between photos is incorrect:

a) Wait a few minutes for the circuit to "warm up" sufficiently.

b) Lengthen or shorten the interval by adjusting the control within the time-delay turret. This should be controllable from no delay at all to longer than thirty seconds.

c) If there is no delay whatsoever, look for loose connections and faulty wiring in the time-delay and trigger turrets, and in the chassis.

5.8 If the flashtube does not discharge with each operation of the camera:

a) Check for poor connections.

b) Test-fire the flash unit by short-circuiting the terminals of the flash sync-plug with a pin. If the unit does not fail when fired manually, but does fail when triggered by the camera, make sure the camera is not jammed; then check for a burned-out sync-switch or faulty wiring within the camera. Remove the film only in total darkness and carefully mark the location on the film with a paper-clip which will be easy to locate in the dark when reloading the film following repairs. When replacing a sync-switch, follow the instructions for the original installation.

c) Try the flash unit with a fresh photoflash battery to determine whether the failure was due to a weak battery, or using extreme caution to prevent shock, partially withdraw the banana plugs from the photoflash battery terminals and measure the voltage of the battery. After a sequence of five flashes at 15-second intervals, a "good" battery should regain over 80% of full voltage within the allotted fifteen second interval at reasonable temperatures.

d) For low temperature operation see Section 5.

e) If batteries are good, but the flash unit misfires or does not fire at all, replace the flashtube. The life expectancy of the flashtube is about 10,000 flashes.

f) If it is necessary to send the flash unit to the distributor (see the parts list for addresses), be sure to re-modify the flash unit before use, as specified in the original instructions.

g) For extensive programs, a spare flash unit would prove valuable. For those who are inclined, a repair depot may be established with a few spare parts from the distributor. The author finds the latter the most satisfactory solution. His supply stocks include:

Carsen's part no.	Part
SA-66	Connecting cord
SA-51	Flash tube
SA-52	Trigger coil

5.9 Poor quality pictures may be the result of any of the following:

a) Too light or "overexposed" pictures are caused by too large an aperture, or direct sunlight, or an extremely slow camera movement. The unit should be shaded by a canopy. The camera normally slows down appreciably only during cold weather, or when it becomes unwound.

b) Too dark or "underexposed" pictures are caused by too small an aperture, a weak photoflash battery, a misfiring flash unit, or an improperly synchronized shutter. To check shutter synchronization, remove the lens and trip the camera. The flash should fire when the shutter is fully open and displaying the full frame of film.

c) Fuzzy pictures likely would be the result of an improperly focused lens, or moisture or dirt on the lens or window.

d) Tilted or poorly centered scenes are caused by a poor alignment initially, a loose fitting camera or mounting blocks, a warped platform, or debris accumulated beneath the camera case or instrument shelter.

6. DISCUSSION AND RECOMMENDATIONS

6 (a) Flash Units.

One of the most difficult problems facing gadgeteers in photographic apparatus for field operation is the scarcity of appropriate electronic flash equipment designed to operate continuously with minimal battery-current waste, having long-life components for trouble free operation, and a low enough price to make it practical. Ideally, such a unit would operate from storage batteries for greatest economy. However, the author has tested a number of commercial hobby units--the only units in the desired price range--and while these are all very compact and light, and most of them do have some sort of "rechargeable" nature, they lack the durability to operate continuously for periods of months. The author's experience with these flash units has been exasperating. Units having mechanical current-monitoring systems are prone to fused relay-contacts, which causes overcharging and literal explosion of the storage capacitor. Another unit which has an all electronic monitor, caught fire and was prone to failure due to weak components. Until a completely reliable unit is discovered or designed, which will operate from economical storage batteries, the most economical operation seems to be the more expensive but more reliable high-voltage storage batteries; the waste of film, labour and transportation involved in flash unit failure of early prototype apparatus was far greater than the subsequent cost of dry batteries in the later units.

Far too frequent are the replacements of flashtube and synchronization-switch in these "single-frame" operations. A flashtube with a life expectancy of 100,000 flashes should be used and a thyratron trigger-tube should be incorporated in the flash trigger circuit to reduce damage to the switch.

A few tips which may lead an experimenter to the eventual design of an optimum flash unit for his particular apparatus are listed below.

The ideal voltage to work with is 450 volts because flashtubes and capacitors are most readily available in this voltage, and the most common and most economical high-voltage photoflash batteries are the largest 225 volt types: Ray-O-Vac N-150, Eveready 492, etc. (Two are used in series to provide the required 450 volts).

Photoflash capacitors are not usually available on the common electronics market because of their limited demand. However, the Mallory Company offers three low-leakage 450-volt photoflash capacitors; the 50-50 Mfd. (two sections of 50 Mfd.may be used in parallel for 100 Mfd.) Model EP240; the 300 Mfd. model HC45003; and the 525 Mfd. model FF45052. The Sprague Company pioneered the low-leakage flash capacitors with their familiar 525 Mfd. model FF-1.

Calculating the power of a flash unit in watt-seconds can be done with the formula $WS = 1/2 \times CE^2$, where C is Mfd's and E is voltage in thousands. For example, the 525 Mfd. capacitor at 450 volts has a watt-second rating of $\frac{525 \times .450^2}{2} = 53$ watt-seconds. (To provide some idea of the light output with relation to watt-seconds, consider that the 40 watt-second Lumex unit has a guide number of 32 for Kodachrome 2 ASA-25 colour film). Thus the flash unit may be built to fulfill most requirements with a range from a feeble 5 watt-seconds to powerful units of 200 watt seconds and greater. Of course, the load capacity of the flash tube must be given strict attention during design.

Flashtubes come in a variety of shapes and sizes and the 450 volt types are most common in the 50, 100 and 200 watt-second sizes, so any power requirement may be met by choosing one of these with a rated capacity greater than the load. Life-expectancy of the flashtube varies from a low 10,000 to a high 100,000 and depends on the load to which it is subjected. A heavy duty tube with a very light load can be operated millions of times. Flashtube manuals are available from General Electric Company, Nela Park, Cleveland, Ohio and also Kemlite Laboratories Incorporated, 1819 W. Grand Avenue, Chicago 60622. Kemlite have the trigger transformers, and also have valuable information on thyratron-trigger circuits.

The basic flash unit is relatively simple, consisting of a flashtube, a trigger-transformer, a flash capacitor, a few miscellaneous resistors, etc., and a power supply. Most flash units appear so frighteningly complex because of the intricacies of the power supply. A high-voltage dry battery power supply is simply that: a battery. Numerous articles have been published on electronic photoflash construction by the various "popular" electronic, photographic, mechanical and science magazines. An excellent booklet costing 35¢ and published by the Sprague Products Company of North Adams, Massachussets, is the "Sprague Electronic Flash Handbook". This presents various circuits for 450-volt flash units. It should be noted here that the 225-volt batteries have developed since the booklet was first published and also that Mallory Company now has the 50 and 300 Mfd. capacitors as well as the 525 Mfd.

One of the cheapest flash units available, and one which is reasonably reliable when powered by high-voltage dry-batteries is the Lumex (Canadian) or, Spiralite (USA) unit. (Figure 33). If modified with a thyratron-triggered circuit, this unit could be quite satisfactory for most operations. It has a flash-tube with an advertised life-expectancy of 50,000 flashes (GE rates their similar-sized tube at only 10,000) and although designed for 300-volt operation, it will operate satisfactorily with a 225-volt battery. A radio B-battery of 45, 67½ or 75 volts could be used in series with the 225-volt battery if necessary. The author builds 300-volt batteries to power the Lumex flash units of the herein described apparatus by cutting apart the 225-volt batteries and producing three 300-volt batteries from every four 225-volt commercial batteries. (A 225-volt battery consists of 150 1.5-volt "wafers" packaged in 25- to 35-volt bundles.) However,

the lethal voltage involved prohibits modification by other than those experienced in high-voltage work - a 225-volt battery can stop a heart just as quickly as a 10,000-volt hydro line.

6 (b) Suggestions For Modifications.

Time-lapse photography of plants, animals, weather conditions, groups of instruments, mechanical functions, etc. is easily made possible by the installation of additional spring contacts on the clock face at the required intervals. This would suffice for intervals between about four minutes and one hour. For periods greater than one hour, use the hour hand as the switch rather than the minute hand and place contacts at appropriate intervals around the face. For periods shorter than four minutes, but longer than 60 seconds, attach the spring contact to the minute hand and have it drag across fine wire terminals partially embedded in epoxy glue. For periods shorter than 60 seconds, either rewire the time-delay circuit to trigger the circuit automatically at regular intervals, by connecting the normally closed (upper) contact of the time-delay relay to the junction of the photocell, R-3 and R-4 (the photocell or the alternate trigger must be plugged in); or for greater accuracy build a time switch from an electric clock having a sweep second hand with a spring contact dragging across wire terminals glued to the face. Dragging-spring contacts are self-cleaning and simplest to build. Construction of spring contacts is described with the description of the instrument panel. The alternate trigger circuit permits attaching the recorder directly to any switching circuit because the current through the contacts would be only 0.001 amperes (maximum).

Remote operation, manual or automatic, is possible up to 10 miles, without the use of relays, with AWG #20 wire. With the wire and a series resistance totalling 10,000 ohms, connect the wire, series resistance and switch between the negative polarity (at the fuse) and the base of Tr-2.

The distance between photocell and lamp may be adjusted to more than eight feet by using the full sized (uncut) flashlight reflector. Adjustment of R-3 (Fig. 18) and/or a more powerful lamp will extend working distances to lengths over 100 feet without circuit alteration. Distances may be reduced also for recording traffic of ants etc., with a thinner light beam.

More than one photocell system may be used simultaneously with minor modification as follows: Each photocell assembly would need a separate circuit with photocell, R-3, R-4, and Tr-1 as described in Figure 5. Each of the transistors would connect from the junction of R-1 and R-2 to R-5 as does Tr-1 so that if any of the light beams were interrupted, a current would be applied to the base of Tr-2, causing Tr-2 to conduct and Ry-1 to close, thus triggering the circuit. Any number of these photocell assemblies could be attached in this manner. The Clairex Co. have economical photocells in a variety of shapes and sensitivities.

The camera may be used as a conventional movie camera by manually depressing the solenoid arm; or electrically by simply applying 6 volts DC to terminals 1 and 4 of the camera assembly plug; or by breaking the line between the micro-switch and the control unit with a switch, the photocell unit or alternative trigger (Sec. 3.c) may be used to control the camera.

Short bursts of frames, of regulated duration, may be triggered by the photocell assembly or by an impulse through the alternative switching circuit with a few minor changes in the original circuits. The time-delay circuit may be used to energize the solenoid for the prescribed interval following the discharge of the time-delay capacitor by the trigger circuit.

REFERENCES

Abbott, Herschel G. and Allyn W. Coombs. 1964. A photoelectric 35 mm camera device for recording animal behaviour. Journal of Mammalogy 45:327-330.

Buckner, C.H. 1964. Preliminary trials of a camera recording device for the study of small mammals. Canadian Field-Naturalist 78: (2), 77-79.

Dodge, Wendell E. and Dana P. Snyder. 1960. An automatic camera device for recording wildlife activity. Journal of Wildlife Management 24:340-342.

Pearson, O.P. 1959. A traffic survey of Microtus-Reithrodontomys runways. Journal of Mammalogy 40:169-180.

8. PARTS LIST*

(The numbers in parenthesis refer to a list of suppliers of these parts which immediately follows this Parts List.)

1	-	Keystone "Criterion" Model A-7 or A-9 16 mm movie camera, used. - (Non-focusing lens must have a "2 portrait lens taped on front)	(1)
1	-	"Lumex" AC-operated electronic flash unit	(2)
1	-	Connecting cord from battery to flash head	(3)
1	-	Photoflash battery, 225 volts, Ray-o-vac # 150	(1)
1	-	Automotive Storage Battery: 6 volt DC, Size 1, 125 Ampere-hour capacity.	(4)
1	-	#314 Weksler wet and dry bulb Hygrometer Mason-style Range 20-120°F.	(5)
1	-	Westclox No. 060 Clock Movement Kit (TT-1 transistor type)	(6)
1	-	Fisher "Ships Wheel" household barometer - body diameter (not including spokes) 4"; outside diameter of face 2 5/8"; depth 1 1/4".	(7)
2	-	"Compur Synchronization Switch - outlet"	(8)
1	-	Lafayette Cat. #19G2101, Cadmium-sulphide resistor photocell, 1/2" diam. by 5/16" thick. (About 75 ohms. at 90 foot-candles.)	(9)
1	-	Guardian #11-Cont-6VDC Solenoid	(10)
1	-	Unimax #USM-5L micro-switch	(10)
1	-	Hammond #1411J 4 1/4 x 2 1/4 x 1 1/2" Aluminum chassis	(10)
1	-	Vector #C-12 socket turret	(10)
1	-	Vector #C-10 socket turret	(10)
2	-	(1 red, 1 black) Johnson #108-301 High-Voltage insulated banana plug	(10)
2	-	Amphenol #77MIP8 socket	(10)
1	-	" #78S3S "	(10)
1	-	" #78S4S "	(10)
2	-	" #91MPM3S Plug	(10)

* Suppliers of electronic parts often send substitutes for parts they do not have in stock; but in this apparatus, substitutes may not fit or function satisfactorily, and are often difficult to identify by the inexperienced builder.

1	-	Amphenol #91MPM4S Plug	(10)
1	-	Midland #14-251 Phono Jack	(10)
1	-	Midland #14-250 Phono Plug	(10)
1	-	Midland #14-227 Miniature phone plug and jack set	(10)
1	-	Buss HJM fuseholder	(10)
1	-	AGX (8AG) 2 Amp 1/4 x 1" fuse, (Pkg. of 5)	(10)
1	-	#112 Rubber Grommet, hole size 5/16", stud size 3/16"	(10)
2	-	Mueller No. 24-A 25 Amp battery clips	(10)
1	-	GE #12, 5,000 hour, 6 volt 0.15 Amp panel lamp	(10)
1	-	Mallory #F-780 C-cell flashlight (Batteries not required)	(10)
3	-	Potter and Brumfield #RS5D-6V SPDT Relay	(10)
3	-	G.E. 2N508 transistor	(10)
1	-	Sylvania 2N1102 transistor	(10)
1	-	Aerovox PWE 6100 100 mfd 6V capacitor	(10)
1	-	G.E. IN34 diode	(10)
2	-	Sarkes-Tarzian (F-4) 1N2483 Silicon rectifier	(10)
1	-	Armaco TV 200 - 500,000 ohm volume control	(10)
1	-	1500 ohm *2-watt resistor	(10)
2	-	330 ohm 1/4-watt resistor	(10)
1	-	22,000 oh 1/4-watt resistor	(10)
1	-	10,000 ohm 1/4-watt resistor	(10)
1	-	4,700 ohm 1/4-watt resistor	(10)
1	-	1,000 oh 1/4-watt resistor	(10)
1	-	"C-sized" 1.5 Volt manganese alkaline dry cell	(10)

---

*Resistors are labelled with colour-coded bands; the colour coding is as follows: 0 = black; 1 = brown; 2 = red; 3 = orange; 4 = yellow; 5 = green; 6 = blue; 7 = violet; 8 = grey; 9 = white; a tolerance of 10% = silver; and a tolerance of 5% = gold. The first two bands from the end are the significant figures, the third band indicates the number of zeros and the fourth band, in silver or gold, indicates the tolerance, e.g.: a resistor marked blue black orange silver would be 6-0-000 (60,000) ohms $\pm$ 10%.

Miscellaneous hardware:

1 - piece plexiglass 1 7/8 x 2 x 5/32" (timer circuit-board).

1 - piece plexiglass 1 7/8 x 2 3/8 x 5/32" (trigger circuit board).

1 - piece plexiglass 2 3/8 x 3 3/8 x 5/32" (window for flash unit).

1 - piece 1 x 1 x 1/8" Angle Aluminum approx. 2" long.

1 - piece 14 gauge sheet metal at least 1 1/2" x 3 1/2"

1 - piece 22 gauge sheet metal at least 6" x 12"

1 - 1" length of 3/16" diam. soft iron rivet.

1 - stainless steel cleaning wire at least 2 inches long for a 26 gauge syringe needle, (clock contact).

1 doz. #4 x 1/2" Binderhead self-tapping sheet metal screws

1 doz. #4 x 1/4" " " " " " "

6 - #5 x 1/2" flat-head wood screws - (flash holder).

3 - 2-56 x 3/16" R.H. brass screw

26 - 2-56 x 1/4" R.H. brass screw

4 - 2-56 x 5/16" R.H. brass screw

6 - 4-40 x 3/16" R.H. brass screw

4 - brass washer for 2-56 screw

12 - brass hex nut for 2-56 screw

2 - 6-32 x 3/16" Fillister-head steel screw

4 - 6-32 x 1/8" Binder-head steel screw

10 - 3/16" x 3/4" flat head stove bolts with nuts

2 - 3/16" wing nuts

8 - #5 - 1" wood screw

2 - #6 - 3/4" wood screw

12 - lineal feet #1 spruce 1" x 2" strapping

2 - sheets 4 x 8 feet 1/2" G.I.S. fir plywood (one for canopy)

1 - piece 8 x 8" 1/4" G.I.S. fir plywood

2 - Ashdown's Cat. #199-307 1 1/2" Middle, Wrought brass butt hinges (11)

2 - Ashdown's Cat. #199-000, 810 x 1 1/4" table butt hinges (11)

2 - Ashdown's Cat. #217-786, 482-J-3, 6 1/2" door pull (11)

1 - Ashdown's Cat. #219-840, Corbin No. 02066 drawer lock (11)

1 - 3" round glass flashlight replacement lens for flashlight Z33RK (11)

2 - Hinge hasp, 3/4" wide x 2-3/4" long #3004 (11)

1 - Ashdown's #623 utility extension spring (11)

1 - #14 - 2 General Cement "Print Kote" Silicon resin laquer (10)

1 - 6" length Alphlex F1T-221 - 1/4" shrinkable tubing (10)

2 feet - fine 2-conductor phono-arm cable (10)

A quantity of 24 or 26 gauge solid hookup wire

1 - #84 elastic band approx. 1/2" wide x 3" diam.

Small amount of caulking compound for photocell

Lepage's Epoxy glue (2 parts)

1 - Quart Flecto Varathane gloss white

1 - Spray bomb of flat black enamel

1 - Small tin - humbrol black plastic model enamel

1 - Spray bomb fluorescent red-orange

Lepage's Bond-fast wood glue

Clear Pentox or Timberlox wood preservative

List of Suppliers

(1) Most camera shops throughout Canada and the United States

(2) Available under the name "Lumex" from camera shops in Canada or from the distributor - W. Carsen & Co., 31 Scarsdale Road, Don Mills, Ontario; or in the United States under the name "Spiralite" from Spiraltone Inc., 369 7th Avenue, New York, N.Y.

(3) Available as "replacement connecting cord from transistor pack to flash head" from the above-named distributors. (Carsen & Co. part number SA-66).

(4) Almost any dealer in auto-accessories

(5) Baker Instruments Limited, 185 Davenport Road, Toronto, Ontario

(6) Westclox Canada Limited, P.O. Box 239, Peterborough, Ontario

(7) Eaton's of Canada Limited, Winnipeg 1, Manitoba

(8) Any photographic repair shop

(9) Lafayette Radio Electronics, 111 Jericho Turnpike, Syosset, L.I., New York 11791

(10) Cam Gard Supply Limited, 397 William Avenue, Winnipeg 2, Manitoba or Electro Sonic Ltd., 543 Yonge St., Toronto 5, Ontario

(11) The J. H. Ashdown Co. Ltd., 157 Bannatyne Ave.East, Winnipeg 2, Manitoba