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AEROBEE PARACHUTE RECOVERY PACK MODIFICATIONS

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SUMMARY

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This report describes mechanical and electrical modifications to the Aerobee Sounding Rocket's parachute recovery pack. The adaptations were performed by personnel of the Sounding Rocket Instrumentation Section.

Improvements in both mechanical and electrical modifications provided pressurized parachute recovery packs to meet experimenters' requirements and a higher degree of reliability.

AUTHOR

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AEROBEE PARACHUTE RECOVERY

PACK MODIFICATIONS

INTRODUCTION

These modifications deal with all Aerobee parachute recovery packs. Mr. Flynn was responsible for the mechanical modification that entailed the adaptation of the Aerobee parachute recovery pack from a non-pressurized unit to a pressurized one, meeting experimenters prerequisite. The prerequisite was that no outgassing or contamination from batteries or any other materials used in the payload that might ruin emulsion packs, film, or other essential data be used in recovering units. Mr. Groves was responsible for the electrical modification that changed the actuator box within the parachute recovery pack, making the unit more accessible from the outside of the parachute recovery pack canister.

PARACHUTE RECOVERY PACKS

Parachute recovery packs perform the necessary function of preventing high-impact damage to vital instrumentation aboard rocket vehicles. Without some means of slowing the free-fall of such vehicles, the deceleration and shock of earth impact would result in virtual destruction of the most rugged equipment, completely destroying the value of fragile items such as cameras and electronic gear.

As the parachute recovery pack is comparatively simple in design and operation, its reliability is high. By either ground-controlled or automatic command, the parachute is deployed, and the vehicle instrumentation gently floats to earth. In some cases, a radio beacon in the instrumentation container aids the direct search operation and speeds recovery.

The facet of reliability adds to the chances of attaining a successful mission and recovering data that would be otherwise lost. Further, the number of launchings required is reduced by recovery techniques since more complete information can be obtained from a specific firing. When recovery methods are not used, the flight value is greatly reduced.

The aforementioned factors indicate the importance of recovery and immeasurably justify the cost of development and utilization of a parachute recovery pack in each launching.

PRESSURIZING FORWARD BULKHEADS

The parachute extensions are received from the manufacturer in an unpressurized condition. The forward end has a 2-inch diameter hole; four (4) 0.406-inch diameter holes; and four (4) 1/4-28 Rosan studs are installed, drilled, and tapped through the bulkhead. All of these openings must be sealed.

To obtain the pressurized condition of the parachute canister required by the scientist or experimenter, such that no outgassing or contamination from batteries or other materials used in the payload occurs, the forward bulkhead was modified by incorporating the following mechanical adaptations:

1. A threaded adapter O-ring nut (D.R.AZ-4-008), designed to fit the four 3/8-24 studs that carry the main chute load through the four (4) 0.406-inch diameter holes, is installed on each stud to seal the bulkhead at each hole. The heights of the adapters are minimized to avoid any interference with a payload located over the parachute bulkhead (see Figure 1).

2. A plate, designed with an O-ring seal, is used, as shown in Figure 2, employing a design which allows sealing of the 2-inch diameter hole and, at the same time, installation of a through-bulkhead fitting to carry through all electrical connections. Holes are match-drilled through this plate, into the chute extension, and then are blind-drilled and blind-tapped.

3. The 1/4-28 Rosan studs are sealed inside and outside of the extension with G. E. Glyptol, No. 1201, or Loctite.

4. At least two antenna (UG-492) coaxial feed-through connectors are installed.

5. In machining the above openings (modification 4), they are back-bored on the inside of the parachute extension to allow mating of the pressurized fittings and connectors.

6. The holes are spot-faced and ready to be blind-drilled and blind-tapped around the 2-inch diameter hole, as shown in Figure 3.

7. With the parachute installed, the 2-inch diameter hole is sealed with the plate through-bulkhead fitting installed, as shown in Figure 2.

Figure 1. Parachute installed. Technician installing O-ring nut to hold parachute in place; nut holds 4 studs to carry main load of parachute.

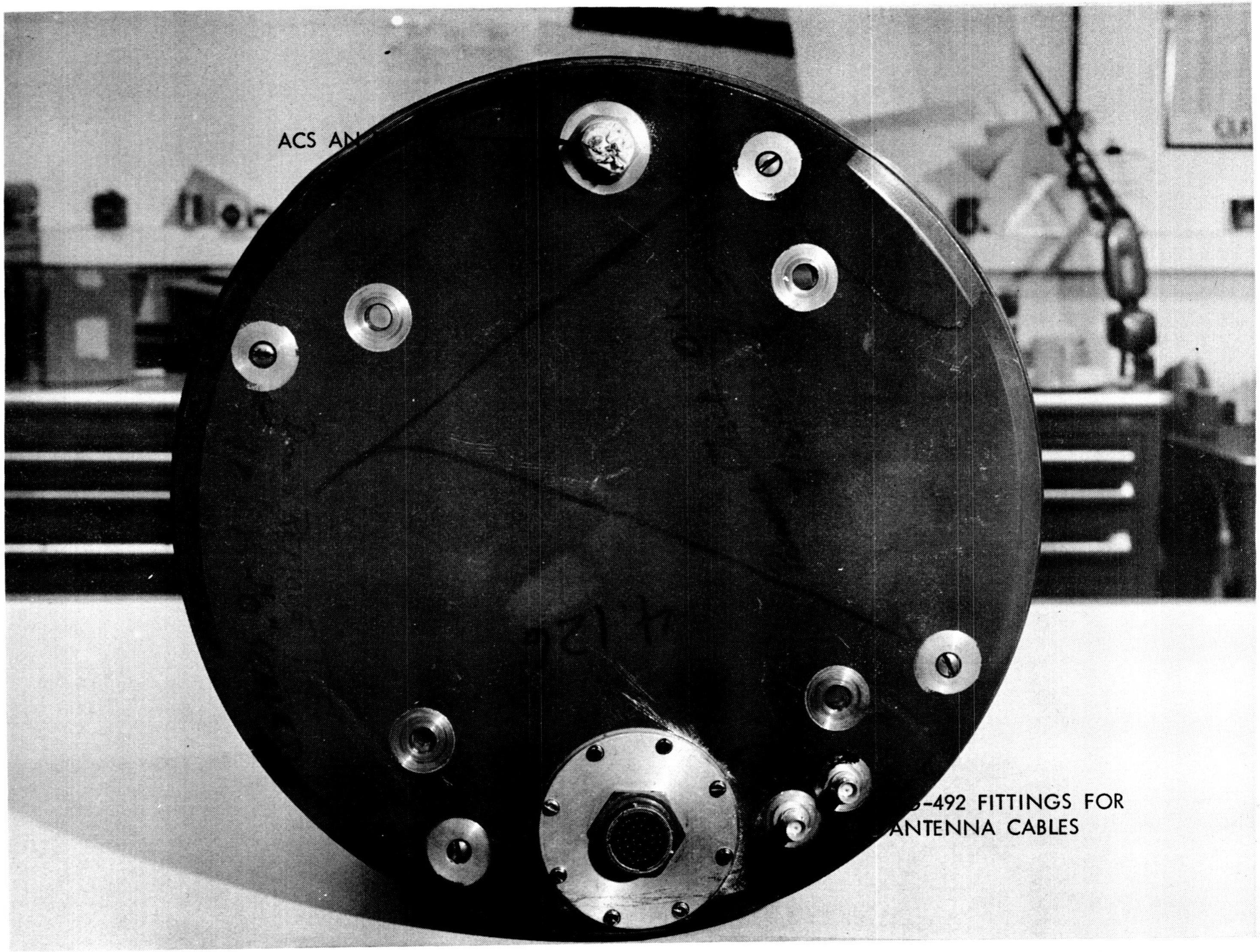


Figure 2. View of Top Surface of Parachute Extension, ready for installation of parachute. The 2-inch hole at the bottom center, for the electrical male plug, has been sealed with plate and O-ring to hold the through bulkhead connector (TBF).

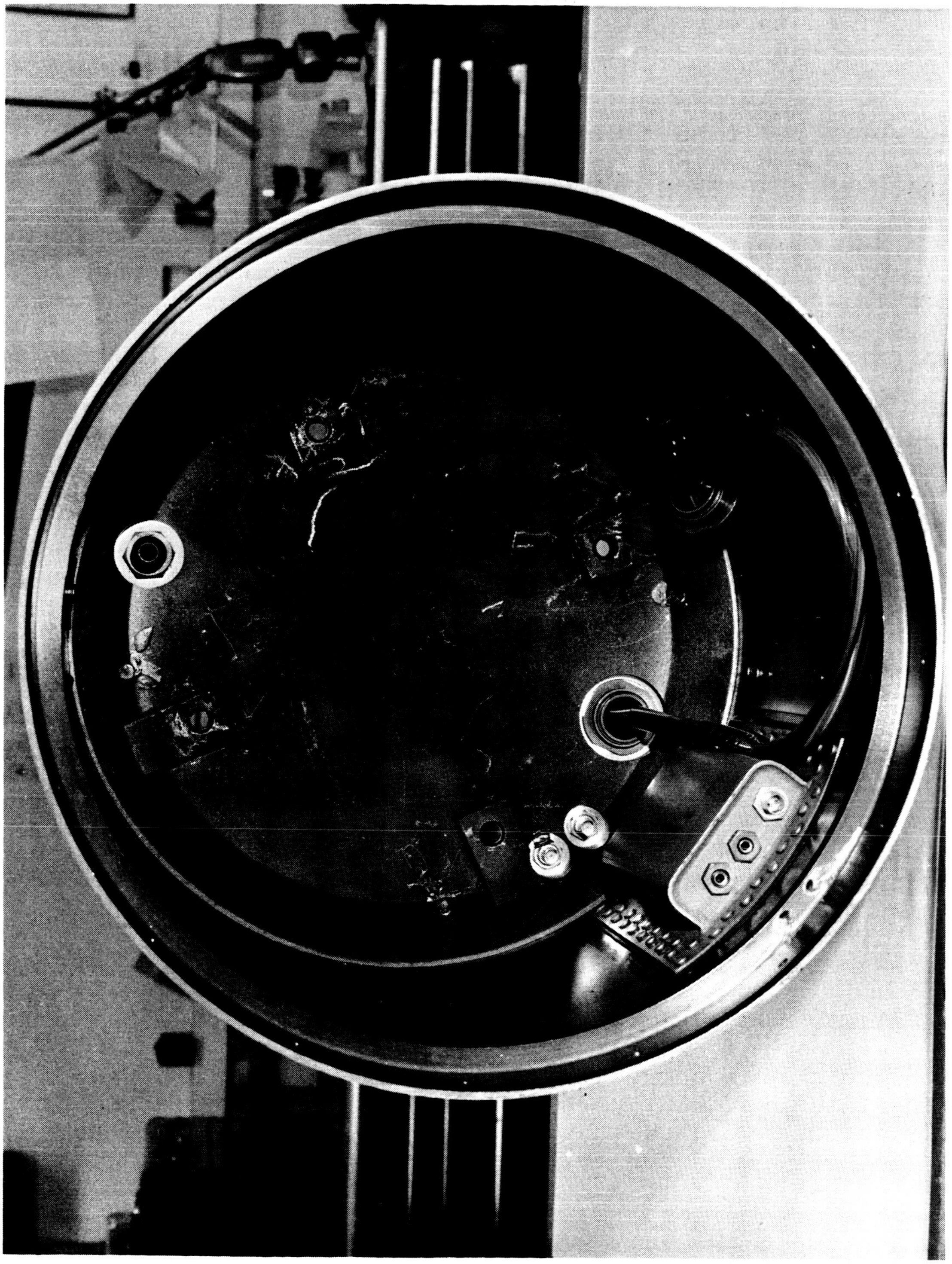


Figure 3. Inside view, or bottom, of top bulkhead after all machining has been done and fittings have been installed.

8. When an Attitude Control System AN fitting is used, feed-through hole must also be spot-faced and back-counterbored (as shown in Figure 2).

This completes the modification to the forward bulkhead, pressurizing it to meet experimenters' requirements.

PARACHUTE ACTUATION CIRCUITRY

The primary function of the actuation circuit is to initiate the primacord which severs the parachute cover assembly. When this cover is pulled away from the payload by aerodynamic drag, the pilot chute is extracted. This sequence occurs at approximately 18,000 feet on the downward leg of the trajectory.

The former actuation circuit, as supplied by Space-General Corporation under P/N 2-070408, is shown in Figure 4. It was contained in a metal box, the dimensions of which were 2 x 4 x 6 inches, with a shielded insulated firing cable with connector, and a receptacle for checkout and telemetry. The previous circuit consisted of eight (8) barometric pressure switches (four (4) 20,000-foot and four (4) 50,000-foot) Erickson Type ES-4; two relays, General Electric Type 3S2791G210; five (5) Eveready Mercury cells, Type E12, series connected (6.75 volts) for squib power; and a 33-volt Burgess Dry Battery, Type XX22 for relay power.

SQUIB FIRING CIRCUIT

In addition, an investigation was made of the former circuit to determine the ability of the mercury battery to meet a 1-amp all-fire current per bridge, as recommended by the ordnance manufacturer, Beckman and Whitley. Calculations confirmed that the mercury battery would not provide the 1-amp all-fire current per bridge, as required. Figures 5 and 6, and the associated calculations, illustrate this point.

ACTUATION CIRCUIT

The former actuation circuit was utilized in the general over-all improvement program. Several component changes were made which increased the reliability. The 33-volt Burgess XX22 Dry battery, used for relay power, was replaced with a nickel cadmium battery. It is not considered good engineering practice to use a dry battery as a power source for space payload applications, because dry batteries are not designed to withstand the environment encountered in space vehicles. Nickel cadmium

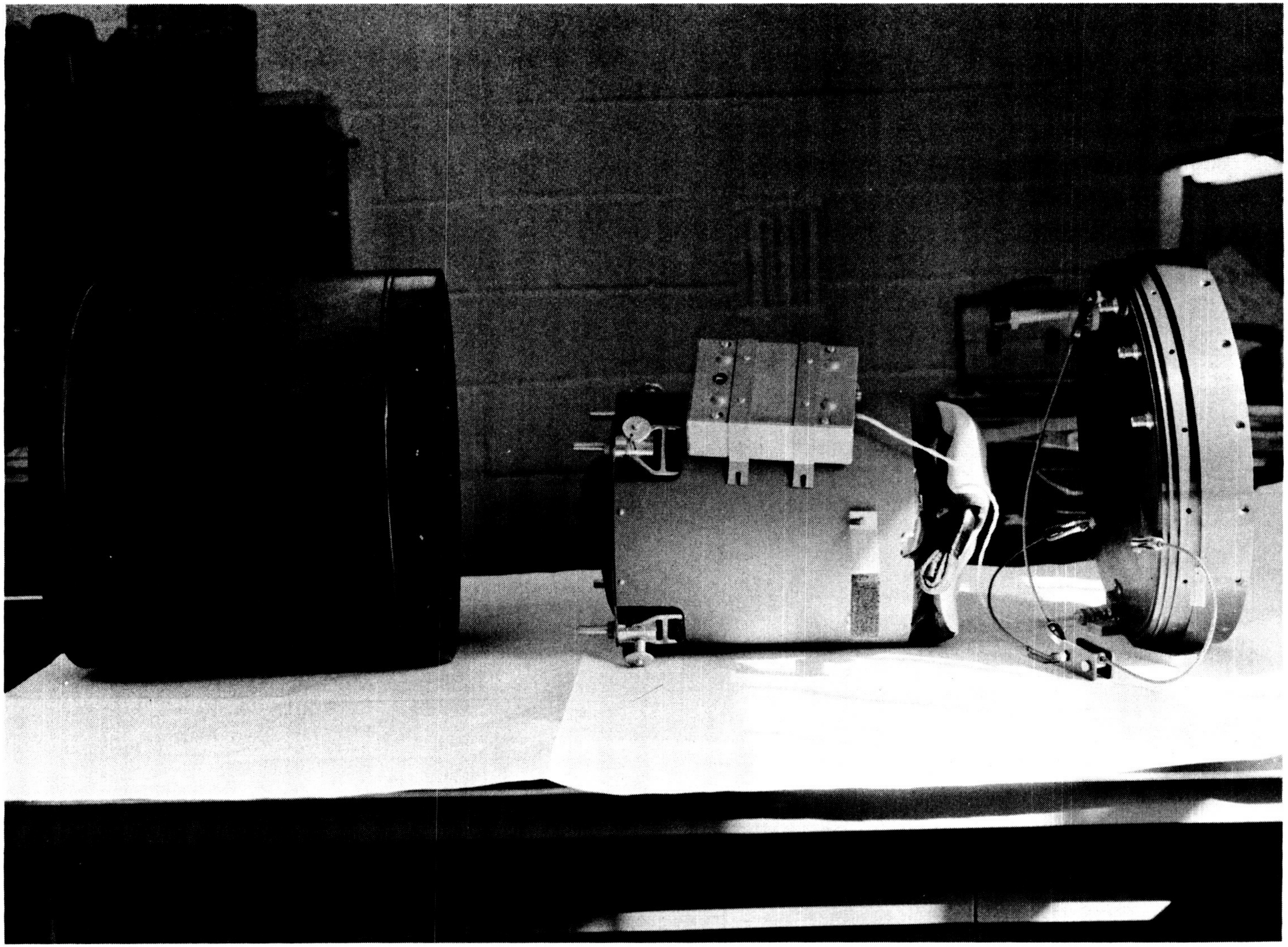
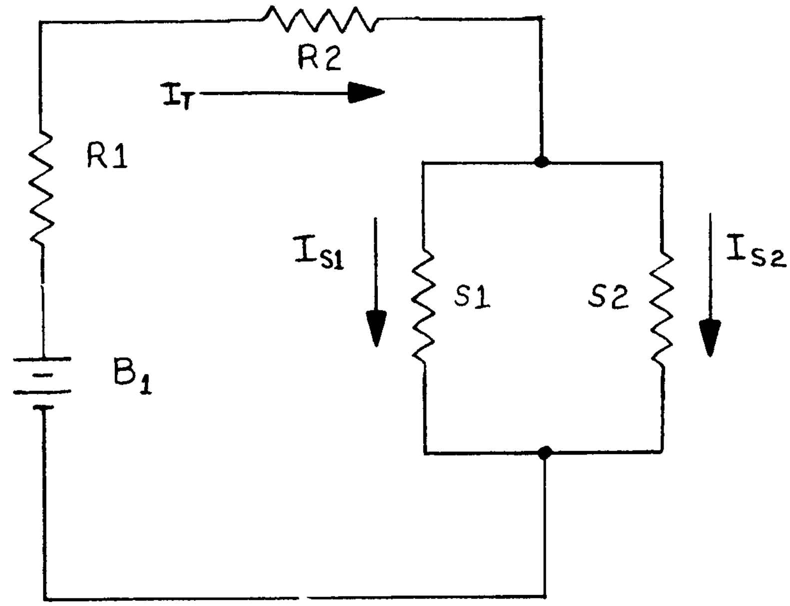


Figure 4. Former Parachute Actuator Configuration.



B1 (SQUIB BATTERY) 5 RM-12 CELLS = 6.75 VOLTS
R1 (INTERNAL RESISTANCE) = 2.5 OHMS
R2 (CIRCUIT RESISTANCE) = LESS THAN 1 OHM, USE 1 OHM
S1/S2 (SQUIB RESISTANCE) = 3 to 7 OHMS EACH

1. $$I_t = \frac{B1}{R1+R2+\frac{S1 \times S2}{S1 + S2}} = \frac{6.75}{2.5 + 1 + 1.5} = \frac{6.75}{5} = 1.35 \text{ AMPS}$$

$$I_{s1} = I_{s2} = 0.675 \text{ AMPS}$$

2. S1 = S2 = 7 OHMS

$$I_t = \frac{6.75}{2.5+1+3.5} = 0.964 \text{ AMPS}$$

$$I_{s1} = I_{s2} = 0.482 \text{ AMPS}$$

3. S1 = 3 OHMS, S2 = 7 OHMS

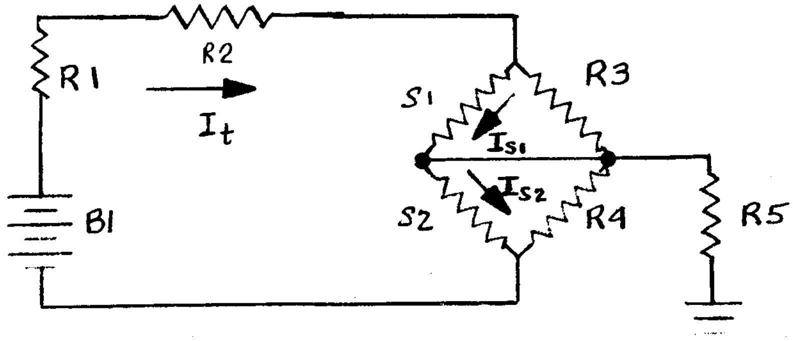
$$I_t = \frac{6.75}{2.5+1+2.1} = 1.225 \text{ AMPS}$$

$$V_{squibs} = 6.75 - V_{R1+R2} = 6.75-(1.225 \times 3.5) = 6.75 - 4.28 = 2.47 \text{ VOLTS}$$

$$I_{s1} = \frac{2.47}{3} = 0.82 \text{ AMPS}$$

$$I_{s2} = \frac{2.47}{7} = 0.35 \text{ AMPS}$$

Figure 5. Squib Firing Circuit Schematic and Calculations



ALTERNATE FIRING CIRCUIT SCHEMATIC (WHITE SANDS)

B1 (SQUIB BATTERY) 5-RM-12R CELLS = 6.75 VOLTS
R1 (INTERNAL RESISTANCE) = 2.5 OHMS
R2 (CIRCUIT RESISTANCE) = LESS THAN 1 OHM, USE 1 OHM
R3/R4 (EXTERNAL BRIDGE) = 10 OHMS EA.
R5 (STATIC CHARGE GND) = 100K OHMS
S1/S2 (SQUIB RESISTANCE) = 3 to 7 OHMS EA.

CALCULATIONS OF FIRING CURRENT

1. S1 = S2 = 3 OHMS

$$I_t = \frac{B1}{R1+R2+\frac{(S1+S2)(R3+R4)}{S1+S2+R3+R4}} = \frac{6.75}{2.5+1+\frac{6 \times 20}{26}} = 0.831 \text{ AMPS}$$

$$V_{s1} + V_{s2} = E_{B1} - I_t(R1+R2) = 6.75-(0.831 \times 3.5) = 3.84 \text{ VOLTS}$$
$$V_{s1} = V_{s2} = 1.92 \text{ VOLTS}$$
$$I_{s1} = I_{s2} = \frac{1.92}{3} = 0.640 \text{ AMPS}$$

2. S1 = S2 = 7 OHMS

$$I_t = \frac{6.75}{2.5+1+\frac{(14 \times 20)}{34}} = \frac{6.75}{11.74} = 0.575 \text{ AMPS}$$

$$V_{s1} + V_{s2} = E_{B1}-I_t(R1+R2) = 6.75-(0.575 \times 3.5) = 5.74 \text{ VOLTS}$$
$$V_{s1} = V_{s2} = 2.87 \text{ VOLTS}$$
$$I_{s1} = I_{s2} = \frac{2.87}{7} = 0.41 \text{ AMPS}$$

3. S1=0, S2= 7 OHMS (S1 shorted)

$$I_t = \frac{B1}{R1+R2+\frac{(S2 \times R4)}{S2+R4}} = \frac{6.75}{7.62} = 0.887 \text{ AMPS}$$

$$V_{s2} = E_{B1}-It(R1+R2) = 6.75-(0.887 \times 3.5) = 3.65 \text{ VOLTS}$$
$$I_{s2} = \frac{3.65}{7} = 0.521 \text{ AMPS}$$

4. **S1 = , S2 = 7 OHMS (S1 Open)**

$$I_t = \frac{B1}{R1+R2+R3+\frac{(S2 \times R4)}{S2+R4}} = \frac{6.75}{2.5+1+10+\frac{70}{17}} = 0.383 \text{ AMPS}$$

$$V_{s2} = E_{B1}-I_t(R1+R2+R3) = 6.75-(0.383 \times 13.5) = 1.58 \text{ VOLTSX}$$
$$I_{s2} = \frac{1.58}{7} = 0.224 \text{ AMPS}$$

Figure 6. Alternate Firing Circuit Schematic and Calculations

batteries were chosen because of their ability to deliver higher current at stable voltages over a wide range of temperature, vibration, and shock; also, their recharging ability and a minimum amount of maintenance required was advantageous. The two General Electric relays, Type 3S2791G210 were replaced with Filtor relays, Type V14WDK18A. The General Electric relays are double-pole, double-throw types with 2-amp contact rating and will withstand the following environment:

Vibration - 20 g's at 55--2000 CPS
Shock - 50 g's
Operate over the temperature range of -65°C to +125°C.

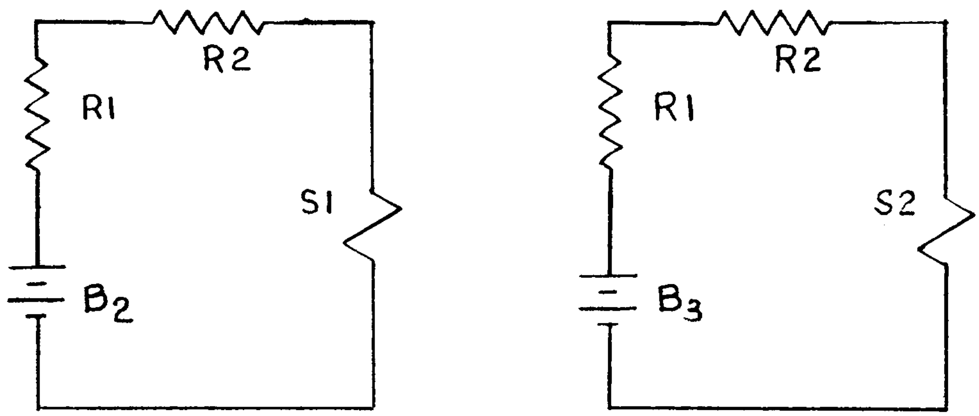
The Filtor relay is a six-pole, double-throw relay with 5-amp contacts and will withstand the following environment:

Vibration - 30 g's at 5--3000 CPS
Shock - 100 g's
Operate over the temperature range of -65°C to +125°C.

By using the Filtor relay, two sets of contacts are used in parallel for redundancy. The mercury battery, 5 cells in series (6.75 volts, 3600 milliamp-hour capacity at a 62 milliamp discharge rate), previously used to fire both squibs, was replaced by two nickel cadmium batteries, Gulton No. 10V0.250, (12-volt, 250 milliamp-hour capacity at a 250 milliamp discharge rate). The nickel cadmium battery was chosen because the results of a 1-amp discharge rate on both batteries showed that the mercury battery had less than a 16 milliamp-hour capacity at a 1 ampere discharge rate. In comparison, the nickel cadmium battery had a 285 milliamp-hour capacity at a 1 ampere discharge rate. This test conclusively showed that the capacity of the mercury battery broke down considerably faster than the nickel cadmium battery.

In the former circuit, both squibs were fired by one battery; in the present circuit, each squib is fired by a separate battery, thereby increasing system reliability through redundancy. Figure 7 illustrates the modified parachute assembly actuation box squib firing circuit.

The former actuation circuit was housed in a metal box 2 x 4 x 6 inches, weighing 2 pounds 16 ounces (see Figure 4). This box was mounted on the parachute cylinder, which was installed in the extension assembly. After the recovery system was integrated with the complete rocket payload, it was impossible to check the actuation circuit for proper operation. This check is necessary to determine operation of the circuit, which



B2 - B3 (SQUIB BATTERY) Gulton 10V0.250, 12 VOLTS
250 MILLIAMP-HOUR CAPACITY
R1 (INTERNAL RESISTANCE) = 1.8 OHMS
R2 (CIRCUIT RESISTANCE) = LESS THAN 1 OHM, USE 1 OHM
S1 - S2 (SQUIB RESISTANCE) = 3 to 7 OHMS

1. $S1 = \frac{B_2}{R_1 + R_2 + S_1} = \frac{12}{1.8+1+3} = 2$ AMPS

2. $S_2 = 7$ OHMS $I_t = \frac{B3}{R_1+R_2+S_1} = \frac{12}{9.8} = 1.2$ AMPS

Figure 7. Modified Parachute Assembly Actuation Box Squib Firing Circuit

is accomplished by simulating switch closure. Simulation is fulfilled by a switch placed in parallel with the altitude switches. Battery load check is accomplished in a similar manner, by simulating squib actuation.

In order to gain access to the former actuator circuit box, it was necessary to disassemble the parachute cylinder assembly from the payload. This was not practical as the complete payload was jeopardized, and a considerable amount of time was involved.

The modified (present) actuation circuit box (see Figure 8) is fabricated on an access door which is mounted on the extension cylinder. This allows the actuation circuit to be removed intact without separating the payload (see Figure 9). Easy access permits complete checkout of the actuation circuit, battery charging, or complete replacement of the actuation box. The modified parachute actuation circuit schematic diagram is shown in Figure 10.

CONCLUSION

As a result of these mechanical and electrical modifications, 12 successful rockets have been flown. The mechanical adaptation has proven itself to meet the experimenters' requirements of pressurized payloads. The electrical adaptation has provided easy access, more reliable components, and checkout capability, without compromising space or weight. In both cases, 100% success has been achieved and both modifications now appear on all Aerobee rockets.

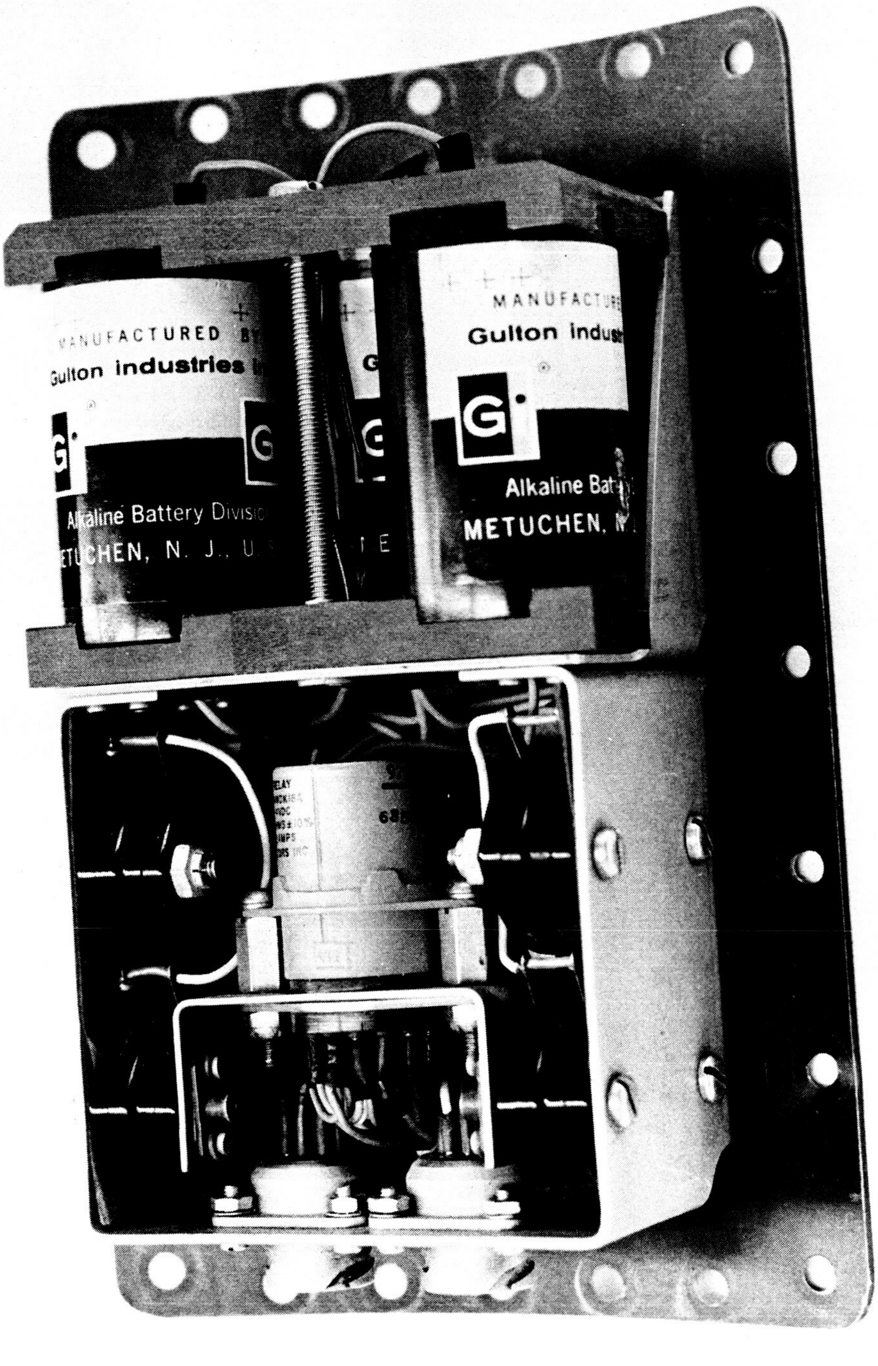


Figure 8. Present Parachute Actuator Box.

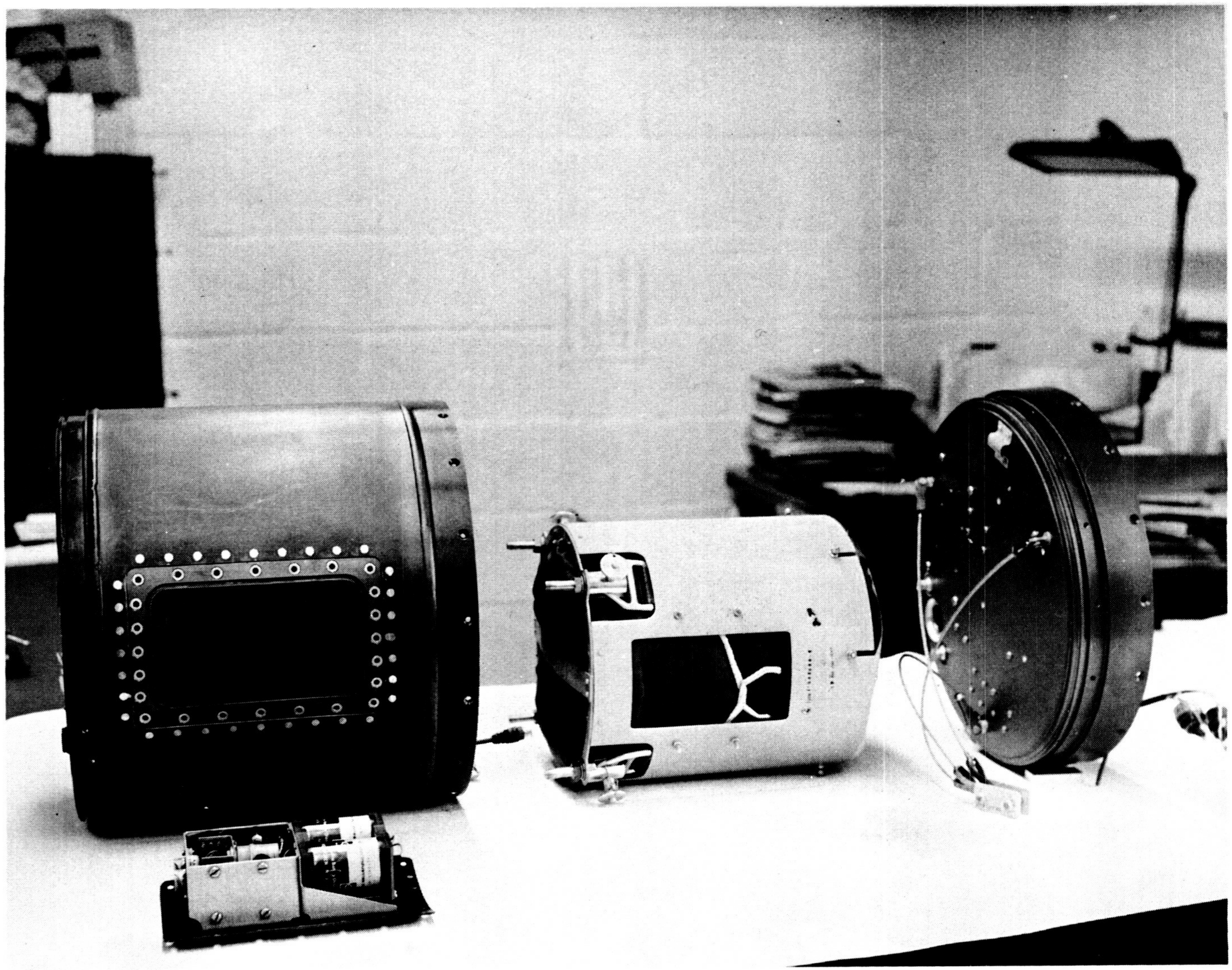


Figure 9. Present Actuator Box Configuration.

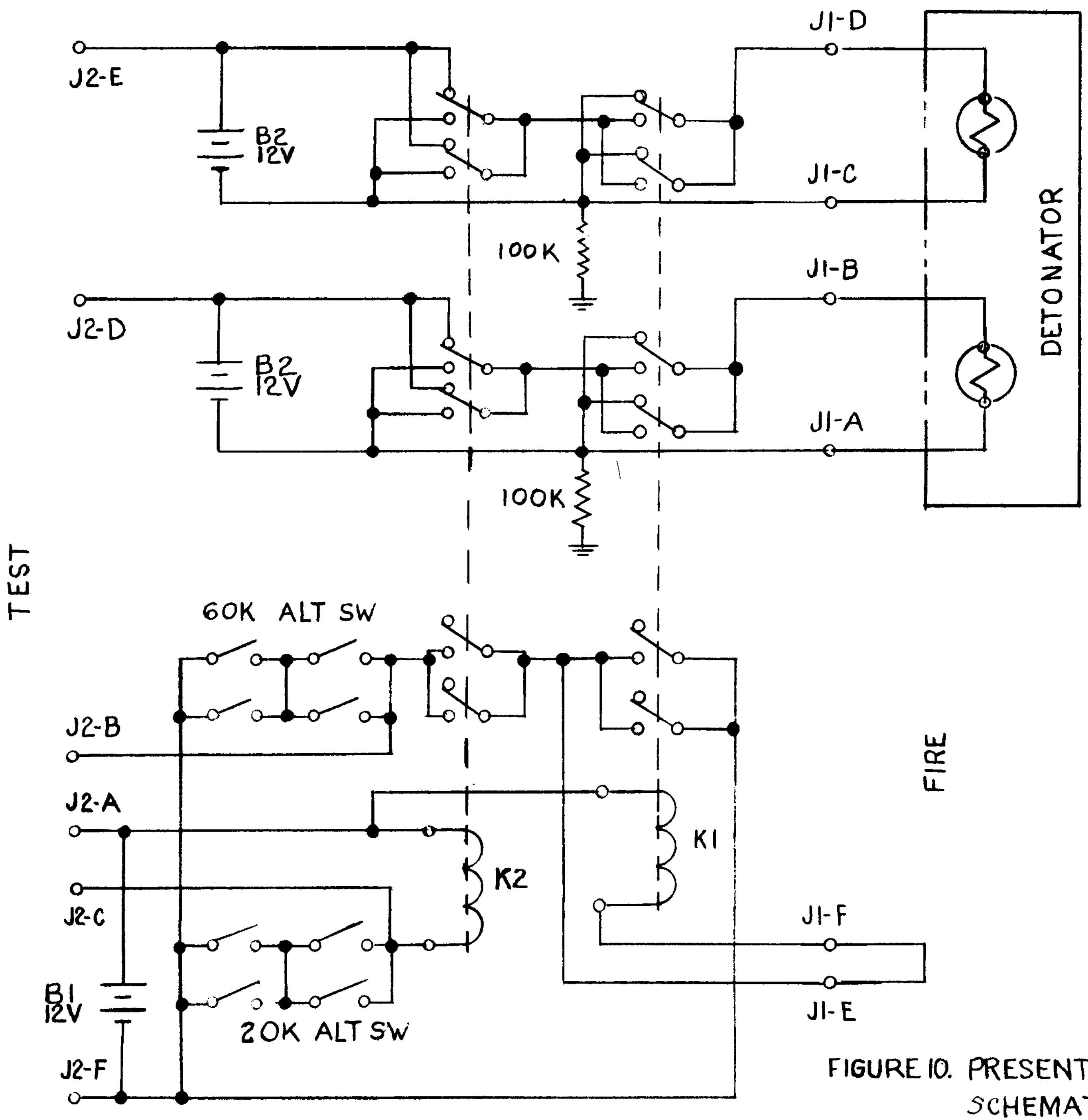


FIGURE 10. PRESENT PARACHUTE ACTUATOR
SCHEMATIC DIAGRAM