tribution when a high explosive (HE) type warhead is used. The three batteries are of nickel-cadmium construction, insuring long operating life. The battery box is heated during the prelaunch period by external power (phase A) which is applied to the battery heater in the battery box. The heater maintains the temperature at a level for maximum battery efficiency. During flight, the heat generated by normal battery discharge keeps the batteries warm.

(*a*) During the prelaunch period, missile heat phase A power is applied from connector P8-58 (D2) through battery box connector J510-R (B2) to one side of the battery box heater circuit consisting of the battery heater element and thermostatic switch S24. The energizing path of the heater circuit is completed through J510-P (B2) and P8-32 (C2) to ground (ac power). Thermostatic switch S24 closes when the battery box temperature falls slightly below +75°F, and opens when the temperature becomes slightly greater than +75°F, assuring that the battery temperature does not fall below +75°F. Thermostatic switch S25 provides a means of monitoring the heater circuit by closing when the temperature falls below +50°F. This action is monitored at heater monitor connector P8-75 (D2) through external circuitry located in the launching area.

(*b*) Battery voltage of the guidance set battery and the two warhead batteries (1 and 2) may be monitored at guidance set battery meter P8-7, warhead battery No. 1 meter P8-8 (D2), and warhead battery No. 2 meter P8-9. The three batteries may be charged by applying charging current through guidance set battery P8-31 (C2), warhead battery No. 1 charge P8-23 (D2), and warhead battery No. 2 charge P8-12 (D2). Warhead batteries No. 1 and No. 2 cannot be monitored or charged until their respective circuit paths are completed through connectors J500 and J501 located in the warhead section (A6 to B6). This is accomplished by connecting a shorting plug between connectors J500 and J501, thereby completing the circuit path from P8 to the battery box connector J510.

(3) *Safety and arming inertia switch S30.* Safety and arming inertia switch S30 (C6) closes at lift-off, supplying a preset relay ground to connector P1-6 (C5) on the missile guidance set. Inertia switch S30 functions as part of the steering control circuit described in paragraph 3-6*b* (stovepipe) or paragraph 3-7*b* (mushroom). The function of S30 is identical for both stovepipe and mushroom guidance sets.

Section III (C). THEORY OF THE MISSILE GUIDANCE SET (MUSHROOM)

3-7 (C). Block Diagram Analysis

a. General. The mushroom missile guidance set (fig. 3-13) consists of four functional circuits: the receiving and decoding circuit, the steering control circuit, the beacon transmitting circuit, and the detonation command circuit. The missile guidance set receives guidance signals from the missile tracking radar (MTR) system and transmits beacon response signals back to the MTR system so that the MTR can track the missile. The guidance set controls the positioning of the missile elevons to steer the missile according to received guidance commands and to keep it from rolling from its present reference position. The guidance set also generates a burst impulse for detonating the missile warhead when burst commands are received. If no signal is received from the MTR or if the missile guidance set does not function properly, a fail-safe burst impulse is generated by the missile guidance set and the missile is destroyed. The four functional circuits of the missile guidance set are covered in *b* through *e* below.

b. Receiving and Decoding Circuits.

(1) The receiving and decoding circuit (fig. 3-13) consists of the radio receiver, amplifier-decoder, delay line driver, missile-code delay line, RF detector, P-Y-burst delay network, command signal decoder, P command signal converter, Y command signal converter, sweep generator, and pulse delay oscillator. These units function to assure that only guidance signals from the missile's own MTR will be effective. The receiving and decoding circuit receives pulses of RF energy (guidance signals) from the MTR and converts these signals into a form which can be used by the other circuits of the missile guidance set.

(2) The pulses of RF energy are received in groups of four or five pulses (fig. 3-4) coded to contain the missile code and the missile command. The coding is contained in the time interval between various pulses in each group of pulses received (refer to para 3-3 for discussion of missile coding). The receiving and decoding circuit detects, amplifies, and decodes the received energy and supplies P and Y commands (dc voltages) to the steering control circuit, beacon trigger pulses to the beacon transmitting circuit, and P and Y 5-microsecond pulses and burst commands to the detonation command circuit.

(3) Pulses of RF energy received by the receiving antennas (No. 2 and No. 4) are detected by crystal diodes in the radio receiver. These video pulses from the radio receiver consist of groups of four or five pulses (para 3-3) at a 500-pulse group per second rate which are applied to the video amplifier section of the amplifier-decoder.

(4) The video amplifier section sums the video pulse groups from the two RF detectors in the radio receiver into one composite pulse train, amplifies the video pulse train and applies it to the decoder section of the amplifier-decoder and the delay line driver.

(5) The delay line driver converts the undelayed video pulse train into amplified 15-megacycle output pulses that are applied to the missile code delay line. The undelayed video pulse train is also applied through the delay line driver to the command signal decoder and the command detonation electronic switch in the detonation command circuit. The 15-megacycle pulses drive the missile-code delay line which delays each pulse by a time interval corresponding to the missile code. The delayed 15-megacycle pulses from the missile-code delay line are detected and amplified by the RF detector. The delayed video pulse train output of the RF detector is applied to the decoder section of the amplifier-decoder and to the P-Y-burst delay network.

(6) The decoder section compares this delayed video pulse train with the received undelayed video pulse train. If the No. 1 pulse of the delayed video pulse train and the No. 2 pulse of the undelayed video pulse train are properly coded, i.e., coincidental in time, the decoder produces a decoded pulse output which is applied to the pulse delay oscillator. Negative pulses in the decoded pulse output will not affect the pulse delay oscillator.

(7) The decoded pulse triggers the pulse delay oscillator which generates a burst enable pulse and an 80-microsecond gate pulse. The 80-microsecond gate pulse is generated 50 microseconds after the pulse delay oscillator is triggered and applied to the sweep generator. The burst enable pulse, which is in time coincidence with the No. 2 pulse of the undelayed video pulse train, is applied to the command detonation electronic switch in the detonation command circuit.

(8) The P-Y-burst delay network utilizes the delayed video pulse train from the RF detector to provide three outputs

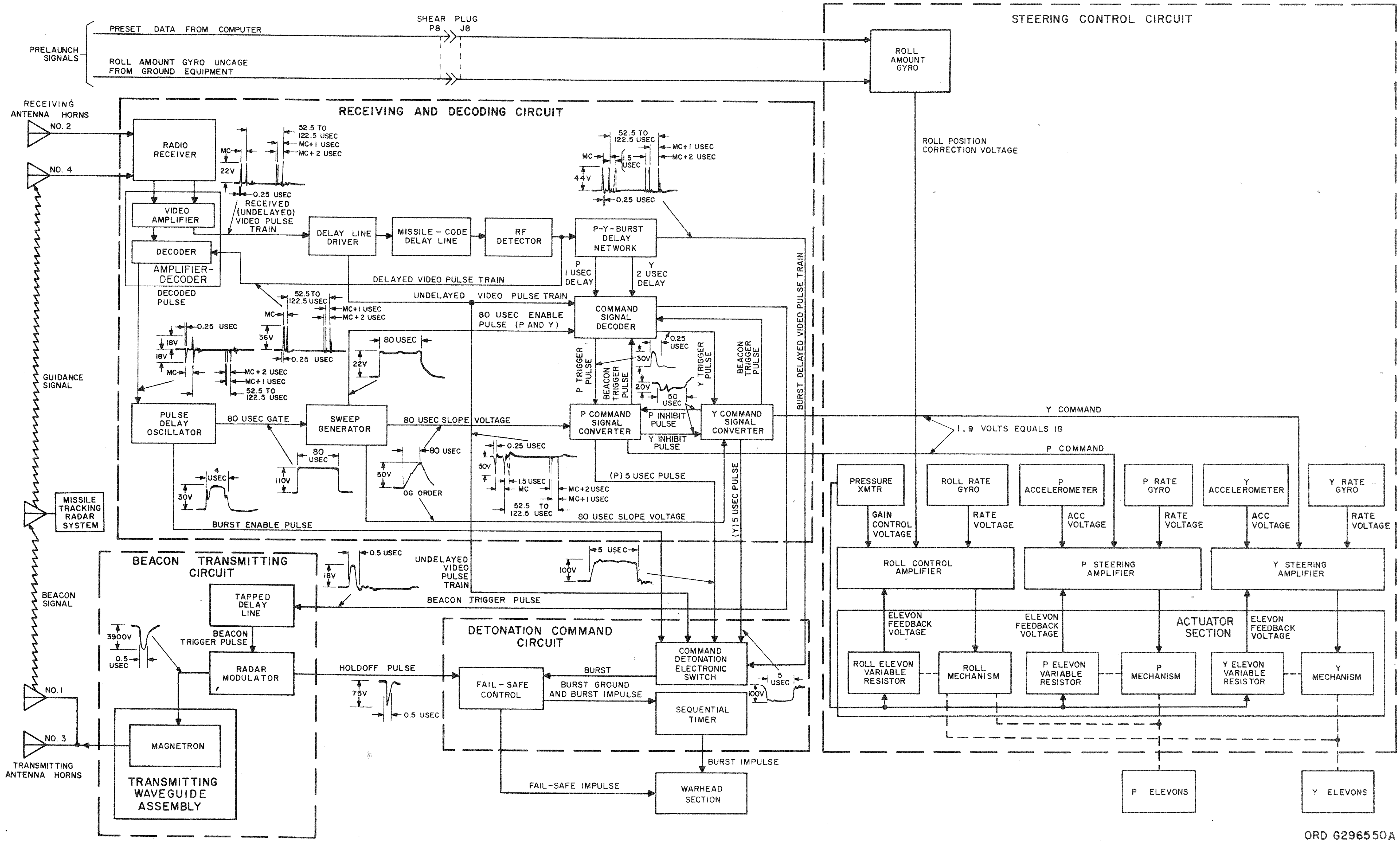

Figure 3–13 (C). Missile guidance set (mushroom)—block diagram (U).

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with additional delays of 1, 2, and 1.5 microseconds. These outputs are the P delayed video pulse train, delayed by 1 microsecond; the Y delayed video pulse train, delayed by 2 microseconds; and the burst delayed video pulse train, delayed by 1.5 microseconds. The P and Y delayed video pulse trains are applied to the command signal decoder. The burst delayed video pulse train is applied to the command detonation electronic switch in the detonation command circuit.

(9) The command signal decoder has six inputs: the P and Y delayed pulses from the P–Y–burst delay network; the undelayed video pulse train from the delay line driver; beacon trigger pulses from the P and Y command signal converters; and the 80-microsecond P and Y enable pulses from the sweep generator. The undelayed video pulse train is also applied to the command detonation electronic switch in the detonation command circuit. Within the command signal decoder, the 80-microsecond P and Y enable pulses, the P and Y delayed video pulse train, and the undelayed video pulse train are applied to the P and Y channels. The 80-microsecond enable pulse prepares both channels for operation. If the No. 3 pulse in the P delayed video pulse train is coincident with the No. 4 pulse in the undelayed video pulse train and the 80-microsecond enable pulse, the command signal decoder generates a P trigger pulse which is applied to the P command signal converter. The operation of the Y channel is identical to the P channel except for the time coding. The three pulses which must be in coincidence in the Y channel for the generation of a Y trigger pulse are the 80-microsecond enable gate, the No. 3 pulse of the Y delayed video pulse train, and the No. 4 pulse of the undelayed video pulse train. The Y trigger pulse is applied to the Y command signal converter. The beacon trigger pulses from the P and Y command signal converters are combined in the command signal decoder and applied to the tapped delay line in the beacon transmitting circuit.

(10) The P and Y command signal converters receive trigger pulses from the command signal decoder and 80-microsecond slope voltage pulses from the sweep generator. When a trigger pulse is received, the P or Y command signal converter generates the following pulses: a beacon trigger pulse to the command signal decoder; a P or Y command voltage to the steering control circuit; a P or Y 5-microsecond pulse to the command detonation electronic switch in the detonation command circuit; and a P or Y inhibit pulse to the P or Y command signal converter.

c. Steering Control Circuit. The steering control circuits in the mushroom and stovepipe missile guidance sets are identical. Refer to section II, paragraph 3–5*c*, for block diagram analysis of the steering control circuit.

d. Beacon Transmitting Circuit.

(1) The beacon transmitting circuit consists of a tapped delay line, radar modulator, and magnetron. This circuit transmits beacon response pulses from the missile to the MTR so that the MTR can track the missile. A beacon response pulse is transmitted after the receipt of each steering order. The beacon transmitting circuit receives beacon trigger pulses at a rate of 500 pps as long as the missile is receiving steering orders. It uses these pulses to control the generation of beacon response pulses of RF energy which are transmitted through transmitting antenna horns (No. 1 and No. 3) to the MTR. Holdoff pulses are generated simultaneously and applied to the detonation command circuit.

(2) The tapped delay line receives the beacon trigger pulse from the command signal decoder. The tapped delay line is adjusted to delay the beacon trigger pulse so that the delay in all missiles between receipt of the No. 4 pulse and the transmission of a beacon response pulse will be the same. This delay must be the same for all missiles because the MTR considers this delay in determining radar to missile range. The beacon trigger pulse from the tapped delay line triggers the radar modulator.

(3) The radar modulator generates a high voltage pulse which is applied to the magnetron and a holdoff pulse which is applied to the fail-safe control of the detonation command circuit to prevent fail-safe detonation of the missile.

(4) The high voltage pulse from the radar modulator drives the magnetron into oscillation. The RF pulse generated by the magnetron is the beacon response pulse which is radiated by transmitting antenna horns (No. 1 and No. 3) to the MTR.

e. Detonation Command Circuit.

(1) The detonation command circuit consists of the command detonation electronic switch, fail-safe control, and sequential timer. The detonation command circuit receives burst enable pulses, the undelayed video pulse train, positive P 5-microsecond pulses, negative Y 5-microsecond pulses, and the burst delayed video pulse train from the receiving and decoding circuit. Negative holdoff pulses are received from the beacon transmitting circuit. The detonation command circuit detonates the missile warhead when burst commands are received or when holdoff pulses are not received.

(2) The positive P 5-microsecond pulse and the negative Y 5-microsecond pulse from the P and Y command signal converters are applied alternately to the command detonation electronic switch. While both pulses are applied, no burst command will be accepted. This prevents jamming signals from detonating the missile. When the missile is conditioned for burst, only the positive P 5-microsecond pulse is received. After a series of at least 25 positive P 5-microsecond pulses, the command detonation electronic switch will accept a burst command.

(3) The undelayed video pulse train, burst delayed video pulse train (video pulse train delayed by the missile code plus 1.5 microseconds), and the burst enable pulses are applied to a coincidence gate in the command detonation electronic switch. When a burst command (see fig. 3–7 for relationship of burst command pulses)is received, the coincidence gate will pass the burst command. After a series of 10 consecutive burst commands, the command detonation electronic switch produces a burst output which is applied to the fail-safe control. This burst output causes the fail-safe control to apply a burst ground to the sequential timer. After a delay of 0.33 second, the sequential timer connects the burst impulse from the fail-safe control to the warhead section, causing the missile to detonate.

(4) Holdoff pulses from the radar modulator in the beacon transmitting circuit are applied to the fail-safe control at a rate of 500 pps. As long as these pulses are present, the fail-safe control will not destroy the missile. If the holdoff pulses are absent or the guidance set does not function properly for a period of 1 to 3 seconds, the fail-safe control will send a burst impulse to the warhead section and the missile will be destroyed.

3–8 (C). Functional Description (Mushroom)

a. Receiving and Decoding Circuit (Fig. 4–7). The circuit consists of two receiving antenna horns, the radio receiver, the amplifier-decoder, the delay line driver, the missile-code delay line, the RF detector, the P–Y–burst delay network, the command signal decoder, the P and the Y command signal converters, the pulse delay oscillator, and the sweep generator. These units receive, amplify, and decode the guidance commands from the MTR system. The guidance commands consist of groups of RF pulses transmitted at a rate of 500-pulse groups per second. Each pulse group consists of four or five RF pulses which are detected and converted into a video pulse train and applied to the steering control circuits. Video pulse trains produced by incorrectly coded guidance commands are not accepted by the receiving and decoding circuits. For each correctly coded guidance command received, the receiving and decoding circuit produces a beacon trigger pulse which is applied to the beacon transmitting circuit.

(1) *Antenna horns.* The antenna horns used on the mushroom guidance set are identical to those used on the stovepipe model. Refer to paragraph 3-6*a*(1) for the functional description.

(2) *Radio receiver.* The radio receiver (A2) operates in the 8,600- to 9,400-megacycle frequency range. It contains two crystal detectors used to rectify the RF signal energy from the two receiving antenna horns. The crystal detectors convert the received RF signal energy into dc pulses. The resulting dc voltages are applied to the amplifier-decoder as dual video pulse train inputs.

(3) *Amplifier-decoder, delay line driver, missile-code delay line, and RF detector.*

(*a*) The amplifier-decoder, delay line driver, missile-code delay line, and the RF detector are interdependent components that amplify the incoming video and reject false (incorrectly coded) signals. The amplifier-decoder accepts the dual video pulse train inputs from the radio receiver and applies these detected, positive pulses across an RC network. This network averages the applied signals and forms a composite video pulse train. The output of the RC network is amplified by five video amplifiers, V1 through V5. The amplified negative pulses at the output of V5 are inverted by transformer T1 and applied to coincidence gate diode CR3 (C5) and to cathode follower V8B as the undelayed video pulse train. The output of cathode follower V8B is simultaneously applied to AGC coincidence amplifier V6 and to the delay line driver.

(*b*) The delay line driver, missile-code delay line, and RF detector incorporate a fixed time delay which delays the applied video pulse train by an amount equal to the assigned missile code. The undelayed video pulse train from the amplifier-decoder is applied to video amplifiers V1A and V1B. The negative output from video amplifier V1A is applied to the command signal decoder and the command detonation electronic switch (C2, fig. 4-10).

(*c*) The amplified negative pulses at the output of V1B (A7, fig. 4-7) are applied to the input of ringer V2, driving V2 to cutoff. When cutoff occurs, inductance coil L1 attempts to maintain current flow through V2. The inductive action of L1 produces oscillations at a 15-megacycle rate. These 15-megacycle ac oscillations are amplified by IF amplifier V3 and applied through transformer T1 to the missile-code delay line. An input transducer in the delay line converts the amplified ac oscillations into 15-megacycle mechanical vibrations. The mechanical vibrations are transmitted through a quartz crystal in the delay line. This crystal provides a time delay equal to the missile code. An output transducer in the delay line reconverts the mechanical vibrations into 15-megacycle ac oscillations. The heater and thermostatic switch S1 heat and stabilize the temperature of the missile-code delay line. The ac oscillations are applied through transformer T1 in the RF detector to a diode bridge detector consisting of diodes CR1 through CR4. The diode bridge detects the 15-megacycle pulses, thereby restoring the delayed signals to the original video pulse train form. The negative pulse train at the output of the diode bridge is amplified and inverted by video amplifier V1 to provide a positive pulse train that is applied to cathode follower V2. The missile code delayed video pulse train is applied to the P-Y-burst delay network, and to AGC coincidence amplifier V6 and coincidence gate diode CR4 in the amplifier-decoder.

(*d*) The two inputs to coincidence gate circuit consisting of CR3, CR4, and resistor R43 in the amplifier-decoder are the undelayed and the delayed video pulse trains. When the undelayed No. 2 pulse at CR3 and the delayed No. 1 pulse at CR4 arrive in time coincidence, the coincidence gate conducts and develops a decoded output pulse that is applied to the pulse delay oscillator to control generation of enabling pulses which allow operation of steering and burst order circuits. In addition to its primary function, the delayed video No. 1 pulse enables the AGC circuit in the amplifier-decoder. The AGC circuit consists of AGC coincidence amplifier V6, video amplifier V7, cathode follower V8A, diode CR2, transformers T2 and T3, and associated circuitry. The undelayed video No. 2 pulse, taken from cathode follower V8B and applied to V6, has sufficient amplitude to trigger V6 into conduction when combined with the delayed video No. 1 pulse. AGC adjust variable resistor R44 is used to adjust the AGC level. Negative output pulses from V6 are inverted by transformer T2 and applied to video amplifier V7, and inverted by V7. The negative outputs from V7 are applied through transformer T3 to crystal detector CR2. Detector CR2 develops a negative dc bias which is applied to cathode follower V8A. AGC voltages are applied from V8A to the input of video stages V1, V2, and V3. The application of AGC voltage to these stages reduces the noise level and also results in truer reproduction of input signals.

(*e*) The time relationship between the undelayed video No. 2 pulse, the delayed video No. 1 pulse, and the decoded pulse is shown in figure 3-4. The decoded pulse can be generated only by received signals which carry the correct missile code. An incorrect missile code causes the delayed video No. 1 pulse to arrive at the coincidence gate either before or after the undelayed video No. 2 pulse. When this occurs, the coincidence gate cannot conduct and the resulting lack of the decoded pulse causes the erroneous signals to be rejected.

(4) *Pulse delay oscillator.*

(*a*) Input signals to the pulse delay oscillator are decoded pulses from the amplifier-decoder. Each time a properly coded pulse group is received by the missile receiving antenna horns, an output pulse from the amplifier-decoder is fed to the pulse delay oscillator. Output signals from the pulse delay oscillator consist of an 80-microsecond enable gate pulse sent to the sweep generator and a burst enable pulse sent to the command detonation electronic switch.

(*b*) Positive decoded pulses from the amplifier-decoder are applied to trigger generator V1B. The positive pulse is inverted by V1B, and applied to the primary of transformer T1. Transformer action inverts the pulse and a positive pulse taken from the secondary of T1 is applied to blocking oscillator V1A. There are two positive outputs from V1A. One is applied through R2 to the command detonation electronic switch as the burst enable pulse (C2, fig. 4-10). The other output is applied through diode CR2 to phantastron V2 (C7, fig. 4–7). Diode CR2 prevents V1A from being retriggered by V2. Phantastron V2 supplies a positive output pulse after a 50-microsecond delay, which triggers one-shot multivibrator V3. The phantastron delay time can be adjusted ±1 microsecond by delay time adjust variable resistor R13. Triggering of V3 supplies an 80-microsecond enable gate pulse to the sweep generator.

(5) *Sweep generator.*

(*a*) The sweep generator receives the 80-microsecond enable gate pulse from the pulse delay oscillator. It supplies 80-microsecond slope voltages to the P and Y command signal converters and 80-microsecond P and Y enable pulses to the command signal decoder. The sweep generator has a P channel and a Y channel. Since the operation of the P and Y channels is identical, only the P channel will be discussed.

(*b*) The 80-microsecond enable gate pulse is applied to power amplifier V1 which is a cathode follower in the sweep generator. Power amplifier V1 supplies two positive outputs. One positive output is the 80-microsecond P enable pulse developed across R3 and applied to the command signal decoder. The other 80-microsecond positive output is applied to diode CR1. Before the 80-microsecond pulse is applied to CR1, diodes CR1 and CR2 are conducting, and current flows from the –28 volt to the +28 volt CS voltage. At this time, capacitor C2 is negatively charged. The 80-microsecond positive pulse cuts off conduction of CR1, and C2 begins to charge positively. The positive-going pulse on C2 is applied to bootstrap V2A which operates as a cathode follower. The output of V2A is the 80-microsecond P slope pulse which is applied to the P command signal converter. In addition, the positive output of V2A is coupled as a feedback voltage through C3 to the cathode of CR2. This feedback voltage adds to the cathode voltage and cuts off CR2. This increasing voltage at CR2 gives an almost constant voltage across variable resistors R5 and R6, resulting in a constant charging current for C2 and a linear slope voltage from V2A. Slope adjust variable resistor R5 varies the rate of charge on C2, thereby varying the slope of the output waveform of V2A.

(6) *P–Y–burst delay network.*

(*a*) Input signals to the P–Y–burst delay network (A13) are supplied from the RF detector. Signals applied to the delay network have been delayed by a period of time corresponding to the missile code. Because all the pulses were previously delayed by the same amount of time, the pulses arriving at the pulse delay network remain in the same relative positions they occupied when received at the missile antenna horns.

(*b*) For each train of pulses entering the P–Y–burst network, three trains of pulses leave, each with a different delay time. One output from the delay network is a train of pulses delayed 1 microsecond and fed to the P "and" gate of the command signal decoder. Another output is delayed an additional 0.5 microsecond, or a total of 1.5 microseconds, and is applied to the command detonation electronic switch as the burst delayed pulse train. A third output, a train of pulses delayed still another 0.5 microsecond, or a total of 2 microseconds, is fed to the Y "and" gate of the command signal decoder.

(7) *Command signal decoder.*

(*a*) The command signal decoder receives the following inputs: the undelayed video pulse train from the delay line driver, the missile code plus 1-microsecond and plus 2-microsecond delayed video pulse trains from the P–Y–burst delay network, and the 80-microsecond P and Y enable pulses from the sweep generator. It supplies P and Y trigger pulses to the P and Y command signal converters. The command signal decoder has two "and" gates, a P "and" gate, and a Y "and" gate. (The "and" gate is a circuit that will supply an output pulse only when three input pulses are applied simultaneously.) The operation of the P and Y "and" gates is almost identical. The slight differences in operation of the two channels result from differences in signal inputs to the "and" gates. In the P "and" gate, the significant delayed pulse is the No. 3 pulse which has been delayed by the missile code plus 1 microsecond; in the Y "and" gate, the significant delayed pulse is the No. 3 pulse which has been delayed by the missile code plus 2 microseconds. Only the operation of the P channel will be discussed.

(*b*) Before the arrival of pulses at the inputs of the P "and" gate, diodes CR1, CR2, and CR3 comprising the "and" gate are conducting. Whenever a positive signal appears, the diode in the circuit which receives the signal is cut off during the period of time the signal is present. The negative undelayed pulses are inverted by transformer T3 so that positive pulses are applied to the cathode of CR3. When one or two of the diodes is cut off, the voltage at the junction of the three diodes rises slightly, but the amplitude of the voltage is not sufficient to drive amplifier V1A into conduction. It is only when three positive signals arrive at the same time that the output is sufficient to cause CR7 to cut off, thus producing a positive pulse to overcome the bias on V1A and produce an output to trigger the P command signal converter.

(*c*) The three significant signals (fig. 3–5) applied to the P "and" gate are the No. 3 pulse in the pulse train delayed by the missile code plus 1 microsecond from the P–Y–burst delay network, the 80-microsecond P enable pulse from the sweep generator, and the No. 4 pulse in the undelayed video pulse train from the delay line driver. When these three pulses arrive in coincidence, a positive pulse is applied to amplifier V1A (C15, fig. 4–7). The output of V1A is a negative pulse which is inverted by transformer T6 and applied as the P trigger pulse to the P command signal converter.

(8) *Command signal converters.*

(*a*) There are two command signal converters in the radio set (A18). P command signal converter A9 is for P commands and Y command signal converter A11 is for Y commands. The operation of the P and Y command signal converters is identical. Only the operation of the Y command signal converter will be discussed. The inputs to the Y command signal converter are the Y trigger pulse from the command signal decoder and the 80-microsecond Y slope voltage from the sweep generator. The outputs of the Y command signal converter are the decoded Y command and the Y flip-over command ground applied to the steering control circuit, the Y 5-microsecond pulse applied to the detonation command circuit, and the Y beacon trigger applied through the command signal decoder to the beacon transmitting circuit.

(*b*) Y trigger pulses from the command signal decoder are applied to amplifier V1A (B19) and cathode follower V1B. The output of V1B is applied to the beacon transmitting circuit as the Y beacon trigger pulse. Amplifier V1A amplifies and inverts the input Y trigger pulse. The negative output from V1A is developed across the primary of transformer T1. This pulse is coupled to secondary winding 9–10 of T1 and a positive pulse is applied to trigger blocking oscillator V2. The duration of this pulse is adjusted to 5 microseconds by 5 microseconds adjust variable resistor R8.

(*c*) Before blocking oscillator V2 is triggered, diodes CR3 and CR4 in the secondary circuit of T1 are conducting. Conduction through these diodes establishes a positive voltage at the junction of diodes CR5 and CR6, and a negative voltage at the junction of diodes CR7 and CR8. These voltages cause the bridge circuit, composed of inductor L1, resistor R12, and diodes CR5, CR6, CR7, and CR8 to present a high impedance path for the charge or discharge of capacitor C6. When V2 is triggered, secondary winding 7–8 of T1 produces a negative pulse which cuts off conduction of diode CR4; secondary winding 3–4 of T1 produces a positive pulse which cuts off conduction of diode CR3. Diode bridge CR5 to CR8 then appears as a low impedance path for the charge or discharge of C6. Capacitor C6 charges or discharges to a value corresponding to the instantaneous value of the 80-microsecond Y slope voltage applied through the diode bridge. The resultant voltage of the 80-microsecond Y slope voltage developed across C6 is applied through resistor R15 and scale factor adjust variable resistor R10 to the steering control circuit as a dc voltage representing the Y command. To prevent false operation of the P channel when a Y order is being received, a negative disabling pulse (inhibit pulse) from T1–7 is applied through resistor R9 to the P command signal converter.

(*d*) Scale factor adjust variable resistor R10 is set for an output of 1.9 volts per G for the Y command. Each time blocking oscillator V2 is triggered, the negative pulse at T1–1 appears at T1–5. This negative pulse is approximately 100 volts in amplitude and 5 microseconds in duration and is applied to the command detonation electronic switch. During the normal steering phase of missile flight, the positive pulse from the P command signal converter and the negative pulse from the Y command signal converter are combined in the command detonation electronic switch. When the burst enable command is sent by the ground guidance system, the P and Y command signal converters do not operate alternately. Instead, the P command signal converter operates continuously and conditions the command detonation electronic switch for burst command.

(*e*) The flipover command ground is not electrically associated with the other command signal converter circuits and is utilized only for surface-to-surface firings. On surface-to-surface firings, the Y flipover command ground is applied to the steering control circuit at missile flipover (receipt of burst order) to give a 0G missile order.

b. Steering Control Circuit.

(1) *General.*

(*a*) The steering control circuit (fig. 4–8) receives roll amount gyro positioning signals from the launching area during the prelaunch phase. These signals cause the roll amount gyro to be positioned so that the initial dive of the missile will be toward the predicted intercept point. The steering control circuit receives P command and Y command signals from the receiving and decoding circuit (fig. 4–7) during flight. These signals indicate necessary missile maneuvers and cause the steering control circuit to position the missile elevon for the received order. The steering control circuit also controls elevon position to keep the missile oriented according to the preset position of the roll amount gyro.

(*b*) The steering control circuit consists of three electronic units plus their associated flight control instruments and the relays and switches which perform the switching functions. (The basic theory of operation of the flight control instruments is described in paragraph 3–4.) Also included in the steering control circuit, but external to the missile guidance set, are three hydraulic mechanisms and three feedback variable resistors in the actuator section. These steering control circuit components are divided into four functional systems. These systems are the gyro preset system, the P control servo system, the Y control servo system, and the roll control system. These systems are discussed in (2) through (5) below.

(2) *Gyro preset system.*

(*a*) *General.* The gyro preset system consists of the A_G data converter (B1, fig. 4–8) and the gyro preset servo amplifier (B1) located externally to the missile, and the roll amount gyro (C10), preset relay K2 (C8), and associated circuitry located in the missile. During prelaunch, the gyro preset system uses externally derived reference voltages to preset the roll amount gyro to the A_G (gyro azimuth) angle indicating the direction of the predicted intercept point. At lift-off, internally derived reference voltages are applied to the roll amount gyro variable resistor and are used after rocket motor cluster separation to roll-stabilize the missile.

(*b*) *Roll amount gyro.* The roll amount gyro is sensitive to missile roll and provides a fixed space reference for the roll position servo system. The inner gimbal of the roll amount gyro is mechanically limited in its motion to prevent gimbal lock (para 3–4*b* (2)). To avoid approaching the gimbal lock condition during missile maneuvers, the roll amount gyro is caged, preset toward the predicted intercept point, and uncaged before launch. In the caged condition, the inner and outer gimbals of the roll amount gyro are locked together and move as a unit. When caged, the roll amount gyro is in a condition to be preset. Presetting orients the roll amount gyro toward the predicted intercept point. Uncaging releases the inner and outer gimbals allowing the gyro to maintain a fixed space reference. The missile then has the widest latitude for target maneuvers without approaching gimbal lock.

(*c*) *Caging.* During prelaunch, –28 volt cage relay power is applied from the launching area through P8–28 (B3), through the missile distribution box, and through contacts 1–9 of deenergized gyro protect relay K5 to energize cage solenoid L2 (B10) in the roll amount gyro. Energizing cage solenoid L2 operates the caging mechanism. When the caging mechanism cages, roll amount indicator switch S1 is operated to the cage position. The –28 volt power applied through contacts 8–6 and 4–2 of cage control relay K6 to one side of relay K5 energizes K5 when its ground return is completed through switch S1 in the cage position. Contacts 1–9 of energized relay K5 remove –28 volt cage relay power applied to cage coil L2, and contacts 4–10 of K5 apply –28 volt uncage relay power to uncage coil L1. The roll amount gyro remains caged until uncage coil L1 is energized. Energizing of L1 operates the caging mechanism which uncages the roll amount gyro.

(*d*) *Presetting.* Data concerning the predicted intercept plane (gyro azimuth) is originated in the ground guidance equipment. This data consists of preset voltages 1, 2, 3, and 4 (C2). These preset voltages are supplied from the A_G data converter located in the Hercules section-simulator group through contacts 1–9, 3–10, 5–11, and 7–12 of deenergized preset relay K2 (C8) in the flight control group to the terminals of roll amount variable resistor R1 in the roll amount gyro. An error existing between the actual position of the gyro spin axis and the predicted intercept plane is picked off as a roll position error voltage (C10) by the arm of roll amount variable resistor R1 and applied to gyro preset servo amplifier located in Hercules section-simulator group (B1). The roll position error voltage may be monitored at test connector J2–F (B15). This error voltage represents a displacement to the right or left of a null point. The error voltage is amplified by the gyro preset servo amplifier (A1) and applied through closed contacts 8–12 and 6–11 (B9) of energized gyro protect relay K5 to gyro preset motor B2 in the roll amount gyro. The presence of an error voltage causes preset motor B2 to drive roll amount variable resistor R1 arm in the proper direction to reduce the error. When the wiper arm of R1 reaches the null of zero error point, the spin axis of the gyro rotor is perpendicular to the predicted intercept plane.

(*e*) *Uncaging.* At fire command, the gyro preset circuit is fixed so that there are no more changes in gyro azimuth. At launch order, the roll amount gyro is uncaged. In the uncaged condition, the gimbals are free to operate independently, permitting the gyro to maintain its rotor spin axis perpendicular to the fixed gyro azimuth plane. The —28 volt uncage relay power is applied from the launching area through P8–6 (B3), through the missile distribution box, and through contacts 4–10 of energized gyro protect relay K5 to uncage coil L1. (A second circuit, inertia switch S2 (B5), operates at missile lift-off to assure —28 volt power to uncage the roll amount gyro if the external circuit is defective.) Uncage coil L1 is energized and releases the caging mechanism. When the caging mechnism has completed the operation of uncaging the roll amount gyro, indicator switch S1 (C11) is operated to the uncage position. Gyro protect relay K5 is deenergized by the opening of its ground return through switch S1. Open contacts 4–10 of deenergized relay K5 remove the application of the —28 volt uncage relay power from uncage coil L1, protecting it from overload. Open contacts 8–12 and 6–11 of deenergized relay K5 open the preset servo circuit and prevent operation of preset motor B2. Cage control relay K6 (B8) functions to supply —28 volt power to one side of relay K5 whenever cage relay power is applied or when either heater and gyro or battery power is applied. This is accomplished by the application of —28 volt cage relay power through contacts 4–2 and 8–6 of deenergized relay K6 or by the application of external heater and gyro —28 volt power (taken from contacts 3–7 of deenergized transfer relay K3 (A8)) through contacts 5–2 and 1–6 of energized relay K6.

(3) *P control servo system.*

(*a*) *General.* The P control servo system consists of contacts 3, 4, and 14 of flipover relay K1 (C12), P steering amplifier (C20), P rate gyro (A10), P accelerometer (C13), P hydraulic mechanism (B25), and P elevon feedback variable resistor R1 (C27) of the actuator section. Variable resistor R2 of the pressure transmitter (C13) in the missile guidance set controls the input to the P elevon feedback variable resistor.

(*b*) *Inputs.* The P command voltage received from the P command signal converter (C5) is a dc voltage representing the magnitude and direction of the received P command. This voltage has a scale factor of 1.9 volts per G of order and causes the P control servo system to position the P elevons to produce a P maneuver. Flight control instruments determine when the missile is performing the received command and cause the missile to execute the command as received.

(*c*) *Steering amplifier operation.* The P command from the P command signal converter (C5) is applied through contacts 4–14 of energized flipover relay K1 (C12). Flipover relay K1 is energized before launch by B+ activate —28 volt power applied through contacts 4–8 of deenergized transfer relay K3 (A8) and deenergized arm and closed contacts of burst relay K1 (C5, fig. 4–10) in the command detonation electronic switch to the coil of flipover relay K1. This power is maintained at launch order when transfer relay K3 (A8, fig. 4–8) is energized and its contacts 12–8 close to apply —28 volt battery power to the coil of flipover relay K1. Flipover relay K1 is deenergized when burst relay K1 on the command detonation electronic switch is energized. Deenergizing flipover relay K1 opens its contacts 4–14, removing the P command, and closes its contacts 3–14 to apply a P flipover command ground (0G order) from the P command signal converter. The P command voltage applied through contacts 4–14 of energized flipover relay K1 is applied through terminal 5 of the P steering amplifier and through an RC network which proportions the inputs to amplifier V1B. For testing, a P command calibrate input is applied at J2–K (D15). Amplifier V1B (C20) is directly coupled to amplifier V1A by common cathode resistor R12. Amplifiers V1B and V1A produce a push-pull output which drives push-pull power amplifiers V2 and V3. A P command input voltage (if not zero volt) causes an unbalance in the output currents of V2 and V3. This unbalance in output currents flowing through control solenoid windings of the P hydraulic mechanism (B25) causes motion of the solenoid core.

(*d*) *Elevon feedback circuits.* These solenoids control a hydraulic system which positions the P elevons and the arm of P elevon feedback variable resistor R1 (C26). P elevon feedback variable resistor R1 receives minus elevon feedback voltage and plus elevon feedback voltage from variable resistor R2 of the pressure transmitter (C13). The P elevon voltage for a given displacement of the arm of P elevon feedback variable resistor R1 varies directly with the pressure sensed by the pressure transmitter. If the missile flies faster or in a denser atmosphere, the output voltage is greater, and the voltage taken from P elevon feedback variable resistor R1 will be greater for a given elevon deflection. During testing, transfer relay K4 (B14) is deenergized and the P elevon feedback voltage representing elevon deflection for a given pressure is applied through contacts 3–10 of K4, terminal 14 of the P steering amplifier, and an RC network which proportions and smooths the signal to the input of amplifier V1A. Transfer relay K4 is energized at the time of missile launch order. Contacts 6–8 of energized K4 open, removing the short across capacitor C7 so that the P elevon feedback voltage passes through C7. Capacitor C7 filters the dc component from the elevon feedback voltage. This filtering prevents a bias voltage which will affect missile flight if there is an error in initial orientation of the elevons. The elevon feedback voltage functions to cancel all or a portion of the P command input and stop elevon deflection. The deflected P elevons cause the missile to turn.

(e) *Rate gyro operation.* The turning motion of the missile is sensed by the P rate gyro (A10) which positions the arm of its variable resistor R1 in accordance with the direction and rate of turn. The −28 volt and +28 volt control signal voltages are applied across R1. The speed of gyro motor B1 is held constant by the use of 3-phase ac power. The P rate feedback voltage (0.18 volt per degree of turn per second), which can be monitored at J2–H (A15), is applied through terminal 13 of the P steering amplifier (C20) and through an RC network to amplifier V1B. This rate gyro signal is in opposition to the P command voltage and causes a current output from power amplifiers V2 and V3 which reduces elevon deflection.

(f) *Accelerometer operation.* A centrifugal force exists as the missile changes course. This force is an indication of the missile P maneuver and is sensed by the P accelerometer (C13). The force is indicated by a displacement of the arm of variable resistor R1 in the P accelerometer. Variable resistor R1 is connected between the −28 volt and +28 volt control signal voltages. The voltage at the resistor arm represents the centripetal acceleration and can be monitored at J2–J. This accelerometer voltage has a scale factor of 2.8 volts per G of maneuver and is applied through terminal 6 of the P steering amplifier and an RC network which proportions the signal to amplifier V1B. The signal is coupled to amplifier V1A and a push-pull driving signal is applied to power amplifiers V2 and V3. The output currents of V2 and V3 change to cause further reduction in elevon deflection. When the missile is performing the received order, the feedback signals from the P rate gyro, the P accelerometer, and the P elevon feedback variable resistor exactly cancel the P command signal. The output currents from power amplifiers V2 and V3 are balanced and the elevon position is stationary. This condition will be maintained until the P command is removed or changed. If the command is quickly removed, the feedback signals, which are degenerative, will still exist and will quickly stabilize the missile on the new heading with little overshoot.

(g) *P and Y steering and roll control amplifier adjustments.* The amplifier bias control (B17) supplies the P, Y, and roll centering and buzz voltages to the P steering amplifier of the P control servo system, the Y steering amplifier of the Y control servo system, and the roll control amplifier of the roll control servo system. As the function of the centering and buzz voltages applied to each amplifier is the same, only the application of the P centering and P buzz voltage to the P steering amplifier will be described. The 250-cps P buzz voltage is applied from the amplifier bias control to the P steering amplifier. The P buzz voltage is amplified by V1A and V3 and then applied to the control solenoid in the P hydraulic mechanism. The buzz voltage causes a jitter in the control solenoid which overcomes static friction. P buzz variable resistor R21 on the amplifier bias control is adjusted to obtain a 65 to 75v ac potential across the control solenoid. The P centering voltage is applied from the amplifier bias control to amplifier V1B in the P steering amplifier. The P centering voltage compensates for any tube or component variations in the P steering amplifier. P centering variable resistor R19 on the amplifier bias control is adjusted (−2 to +4 volts) to balance the output currents of V2 and V3 in the P steering amplifier under static conditions.

(4) *Y control servo system.*

(a) *General.* The Y control servo system functions exactly as the P control servo system. Therefore, this subparagraph gives only overall operation of the Y control servo system. Refer to (3) above for more detailed coverage. The Y control servo system controls the Y elevons in accordance with Y commands received, and its flight control instruments are physically oriented to monitor Y maneuvers. The Y command servo system consists of contacts 1, 2, and 13 of flipover relay K1 (D12), Y steering amplifier (B20), Y rate gyro (A12), Y accelerometer (B13), Y hydraulic mechanism (B25), and Y elevon feedback variable resistor R1 (B26) of the actuator section of the missile. Variable resistor R2 of the pressure transmitter (C13) in the missile guidance set controls the input to the Y elevon feedback variable resistor.

(b) *Inputs.* The Y command from the Y command signal converter (D5) is applied through contacts 2 and 13 of energized flipover relay K1 (D12) to the Y steering amplifier. This signal will unbalance the −Y valve and the +Y valve output currents of the amplifier and cause the Y hydraulic mechanism to position the Y elevons. The elevon positioning will produce a Y elevon feedback from Y elevon feedback variable resistor R1. This signal with the Y rate feedback voltage from the Y rate gyro and the Y accelerometer feedback voltage from the Y accelerometer causes the missile to maneuver in accordance with the received Y command.

(5) *Roll control servo system.*

(a) *General.* The roll control servo system generates its own control signal and causes the P and Y elevons to be positioned to keep the missile oriented at its reference position. The roll control servo system consists of the roll amount gyro (C10), preset relay K2 (C8), flipover relay K1 (C12), roll control amplifier (D20), and roll rate gyro (A9) in the missile guidance set, and the roll hydraulic mechanism (C25) and roll elevon feedback variable resistor R1 (C27) of the roll actuator assembly. Variable resistor R2 of the pressure transmitter (C13) controls the input to the roll elevon feedback variable resistor R1, and variable resistor R1 of the pressure transmitter controls the gain of the roll control amplifier. The gain varies inversely with pressure.

(b) *Roll amount variable resistor.* At launch, contacts 1 and 2 of inertia switches S1 and S2 (C5) close to complete the energizing path for preset relay K2 (C8). The preset relay K2 can also be energized during tests through J2–d (C6). Normally closed contacts 1–9, 3–10, 5–11, and 7–12 of energized K2 open to break the gyro preset circuit, and normally open contacts 2–9, 4–10, 6–11, and 8–12 close to connect reference voltages and ground to roll amount variable resistor R1 (C10) in the roll amount gyro. Terminal 1 of R1 is grounded through contacts 2–9 of energized K2 and terminal 3 of R1 is grounded through contacts 6–11 of energized K2.

Normally, −28 volt control signal voltage is applied to terminal 2 of R1 and +28 volt control signal voltage is applied to terminal 4 of R1. The −28 volt input to terminal 2 of R1 is applied through contacts 10–17 of energized flipover relay K1 (C12) and through contacts 4–10 of energized K2. The +28 volt input to terminal 4 of R1 is applied through contacts 12–8 of energized flipover relay K1 and through contacts 8–12 of energized preset relay K2. Flipover relay K1 is energized during prelaunch phase by external power and is kept energized during flight by internal battery power. When a burst order is received, relay K1 is deenergized. During the time K1 is energized, −28 volts is applied to terminal 2 of R1 and +28 volts is applied to terminal 4 of R1. When relay K1 is deenergized, contact 17 of flipover relay K1 switches from contact 10 to 9 and changes the voltage on terminal 2 of R1 in the roll amount gyro from −28 volts to +28 volts, and contact 18 switches from contact 12 to 11 and changes the voltage on terminal 4 of R1 from +28 volts to −28 volts. Switching these voltages causes the stable null to be at terminal 3 of R1 rather than at terminal 1. This change will cause the missile to roll 3,200 angular mils to the new null position, terminal 3.

1. The roll position output voltage from the arm of roll amount variable resistor R1 (C10) is zero volt if the missile is correctly oriented. If the missile is rolled from its reference position, a roll position error voltage will be taken from variable resistor R1. During the missile flight phase (preset relay K2 and flipover relay K1 energized) if the missile rolls clockwise as viewed from the rear from its reference position, the roll position error voltage will be negative; if the missile rolls counterclockwise, the roll position error voltage will be positive. The value of this voltage is 0.31 volt per degree of roll error. The roll position voltage can be monitored at J2–F (B15). This roll position error voltage is applied through terminal 6 of the roll control amplifier (D20) and through an RC network which proportions the signal to amplifier V1B. Amplifier V1B is directly coupled to amplifier V1A by common cathode resistor R12. Amplifiers V1A and V1B produce a push-pull output which drives push-pull power amplifiers V2 and V3. A roll position error voltage causes an unbalance in the output currents of V2 and V3. The gain of V2 and V3 and, hence, the magnitude of the unbalance in currents for a given error is controlled in accordance with the resistance of variable resistor R1 of the pressure transmitter (C14). The gain of V2 and V3 varies inversely with pressure. The unbalance in output current because of the error voltage causes motion of the cores of the control solenoids in the roll hydraulic mechanism (C25). These solenoids control a hydraulic system which positions the P and Y elevons to cause the missile to roll back toward its reference position and also positions the arm of roll elevon feedback variable resistor R1 (C27). The roll elevon feedback variable resistor receives minus elevon feedback voltage and plus elevon feedback voltage from variable resistor R2 of the pressure transmitter (C13). The roll elevon voltage for a given displacement of the arm of roll elevon feedback variable resistor R1 varies directly with pressure sensed by the pressure transmitter and can be monitored at J2–U (C22). The roll elevon voltage is applied through terminal 13 of the roll control amplifier and through an RC network which proportions and smooths the input to amplifier V1A. The roll elevon feedback functions to cancel the roll error input and stop elevon deflection. Deflection of the elevons by the roll hydraulic mechanism causes the missile to roll toward its reference position. Any roll of the missile produces a roll rate feedback voltage from the roll rate gyro (A9). The roll rate gyro is similar to the P and Y rate gyros but is less sensitive. The sensitivity is 0.072 volt per degree of roll per second. The output roll rate feedback voltage from variable resistor R1 of the roll rate gyro is applied through terminal 11 of the roll control amplifier (D20) and through an RC network which proportions and smooths the rate voltage to amplifier V1A. The roll rate feedback voltage can be monitored at J2–E (A15). The roll rate feedback input to the roll control amplifier always produces a change in output current which will cause the elevons to be positioned to slow down the roll. The roll rate feedback signal is especially effective during the roll stabilization phase of flight when the roll rate might be too large for the roll position signal from the roll amount gyro to control. The roll rate signal can never completely stop missile roll, but it does greatly reduce the rate of roll.

2. Flipover relay K1 (C12) is deenergized at burst order. When flipover relay K1 deenergizes, its contacts 8–16 open to remove the −100 volt charging voltage from C5 and C1, and contacts 7–16 close to apply the stored voltage across C5, C1, and limiting resistor R3 as an input to the roll control amplifier. This input is applied at the same time that the polarities of the reference voltages applied to roll amount variable resistor R1 in the roll amount gyro (C10) are changed. The negative voltage charge across C5 and C1, when applied to the roll control servo system, causes the missile to roll in a counterclockwise direction. This motion moves the missile away from its now unstable null (terminal 1 of R1 in the roll amount gyro) toward the flipover reference position (terminal 3 of R1). Missile flipover occurs on each missile firing but is ineffective on surface-to-air missions because the missile is detonated 0.33 second after receiving the burst order. On surface-to-surface missions, the burst order does not control detonation of the missile warhead, but conditions the missile for an unguided portion of flight. Flipover of the missile (3,200-mil rotation) reduces missile drift for increased accuracy.

c. Beacon Transmitting Circuit.

(1) *General.* The relatively small size of the missile makes it difficult to obtain a satisfactory reflection of the signal transmitted by the missile tracking radar system. To insure more positive tracking of the missile, a beacon signal is sent back to the missile tracking radar system. Each time the No. 4 pulse of the coded pulse group (fig. 3–4) is received by the missile receiving and decoding circuit, the beacon transmitter is triggered by a pulse from either the P or Y command signal converter and sends back a beacon signal. The units which comprise the beacon transmitting circuit (fig. 4–9) are located in the radio set. These units consist of the P and Y command signal converters, command signal de-

coder, tapped delay line, trigger amplifier and blocking oscillator, radar modulator, magnetron V1, and transmitting waveguide assembly.

(2) *Command signal decoder.* Positive 22 volt beacon trigger pulses from the Y command signal converter (A1) and the P command signal converter (D1) are developed across resistor R2 in the command signal decoder. These pulses occur alternately and produce a train of decoded beacon trigger pulses at a 500-pulse per second rate so there will be a return pulse for each pulse series received. These pulses pass through dc blocking capacitor C5 of the command signal decoder to the tapped delay line in the radio transmitter.

(3) *Tapped delay line.* The decoded beacon trigger pulses from the command signal decoder are delayed by the tapped delay line by an interval of from 0 to 0.2 microsecond in 0.02-microsecond steps. The pulses are delayed in an inductive-capacitive circuit. The inductor is tapped so that different values of delay can be selected by response time switch S1 (B3). Switch S1 permits the delay time of the tapped delay line to be varied so that the overall response time (the time between receipt of a No. 4 pulse and transmission of a pulse of RF energy by the beacon transmitting circuit) is 0.85 microsecond within 0.01 microsecond. This time must be a known fixed time in order for the MTR system to determine missile range accurately and consistently with different missiles. The delayed beacon trigger pulses from the tapped delay line are applied to the trigger amplifier and blocking oscillator circuit.

(4) *Trigger amplifier and blocking oscillator circuit.* Delayed beacon trigger pulses from the tapped delay line are applied to the trigger amplifier section of tube V1 (B5) in the trigger amplifier and blocking oscillator circuit, causing conduction through the amplifier section of V1. A resulting amplified negative pulse output from the amplifier section is applied to primary winding 1-2 of transformer T1 located in the radar modulator (A6). A positive pulse from secondary winding 3-6 of transformer T1 is fed back to trigger the blocking oscillator section of V1. The monostable blocking oscillator section of V1 produces a positive pulse of 225 volt amplitude which is fed to the radar modulator as a trigger pulse. This trigger pulse may be monitored at test point TP1 (spring clip).

(5) *Radar modulator.* The radar modulator produces a high voltage pulse to trigger the magnetron, which generates an RF pulse called the beacon signal. This signal is sent back to the MTR to acknowledge the receipt of orders sent to the missile by the MTR. The radar modulator also provides a dc holdoff pulse which is sent to the fail-safe control. This dc pulse acts as a bias voltage which holds the fail-safe circuit inoperative unless the command signals fail. If command signals fail, the fail-safe control is activated within 3 seconds, causing the missile to detonate.

(*a*) *Pulse forming network Z1.* The trigger pulse from the blocking oscillator section of VI (B5) causes thyratron modulator V1 to fire. When modulator V1 fires, network Z1 discharges. Discharge of network Z1 produces a negative pulse of 275 volts in amplitude across the primary of transformer T3 and also supplies a 75 volt, 0.5-microsecond negative holdoff pulse which is applied to the fail-safe control. Network Z1 is recharged through diodes CR3, CR2, and CR1, inductor L1, parallel-connected contacts 7-12, 5-11, and 1-9, 3-10, and the coil of deenergized overload relay K1 to the +300 volt dc power supply. Because of the resonant characteristics of inductor L1 and the capacitors of Z1, the network will charge to approximately 550 volts. The reverse breakdown voltage of diodes CR4, CR5, and CR6 prevents the dc voltage supplied to modulator V1 from reaching a value high enough to fire V1 without a trigger pulse.

(*b*) *Overload relay K1.* The normal charging current developed across network Z1 is not sufficient to energize overload relay K1. However, if modulator V1 fails to deionize after Z1 discharges, the current flow through the coil of relay K1 will increase sufficiently to energize K1, and energized contacts of K1 will open the power circuit and force deionization of V1.

(6) *Magnetron V1.* Magnetron V1 (B9) is a cavity-resonant magnetron using a grounded anode and a negative-pulsed cathode. The magnetron is tunable to any frequency between 8,900 and 9,400 megacycles. Tuning is accomplished by mechanically varying the dimensions of the cavity with magnetron adjust control. The negative 3,900 volt, 0.5-microsecond pulse from the radar modulator is applied to the cathode of the magnetron. The RF output of the magnetron is coupled directly to the waveguide by means of an exponential coupling which is part of the magnetron. The output coupling matches the output impedance of the magnetron to that of the waveguide. Ferrite isolator A4 (C9) allows RF energy to pass from the magnetron with little loss, but prevents any reflected energy from re-entering the magnetron and causing frequency shifting by changing the magnetron load.

(7) *Pattern modulator.* A pattern modulator (D9) is used to vary the relative phase radiation of one antenna horn with respect to the other at an 80 to 90 cps rate. Varying the relative phase radiation of one antenna horn with respect to the other rapidly shifts the radiation pattern so that any dead spots in the radiation pattern will be shifted at a rate sufficient to allow the MTR to track the missile.

d. Detonation Command Circuit.

(1) *General.* Missile detonation is controlled by the detonation command circuit (fig. 4-10) consisting mainly of the command detonation electronic switch in the radio set of the transponder-control group and the fail-safe control and sequential timer located in the warhead section. Detonation commands are received from MTR (command detonation) or are generated by the fail-safe control circuit (fail-safe detonation) in the missile. Command detonation is initiated by a burst order (para 3-3*h*) from the MTR at about 0.35 second prior to intercept. Upon receipt of the burst order, the command detonation electronic switch, the fail-safe control, and the sequential timer which introduces a 0.33-second delay activate the detonation devices in the warhead section, and the missile warhead detonates. The fail-safe control will initiate warhead detonation whenever ground guidance ceases or a malfunction occurs within the missile guidance set. The theory of command detonation is discussed in (2) below. The theory of fail-safe detonation is discussed in (3) below. This subparagraph covers detonation of a high explosive warhead. The operation of the detonation command circuit is the same for a prime warhead but the wiring from the detonation command circuit is different. With a prime warhead, the fail-safe and command outputs are separated. The fail-safe output controls a small explosive charge which will destroy the missile without detonating the prime warhead. The command detonation output controls the prime warhead detonating mechanism.

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(2) *Command detonation.* Command detonation of the missile is controlled by signals from units of the receiving and decoding circuit (fig. 4–7). These signals are applied to the command detonation electronic switch (C5, fig. 4–10) and consist of the following inputs: the positive P 5-microsecond pulse from the P command signal converter (A2), the negative Y 5-microsecond pulse from the Y command signal converter, the positive burst enable pulse from the pulse delay oscillator, the negative undelayed video pulse train from the delay line driver, and the positive burst delayed video pulse train delayed by the missile code time plus an additional 1.5 microseconds from the P–Y–burst delay network. The command detonation electronic switch produces a current pulse that is applied through burst relay K1 (D10) in the burst pulse forming network and burst relay K1 (C5) in the command detonation electronic switch. These burst relays control operation of the sequential timer (C15) and flipover relay K1 (B7). The sequential timer, after a 0.33-second delay, energizes the detonators of the missile warhead. Flipover relay K1 functions to disable the receiving circuit and to cause the missile to roll 3,200 angular mils. Figure 4–10 shows arming mechanisms connected for a high explosive warhead.

(*a*) *Command detonation control.* The command detonation electronic switch consists of an integrating circuit, "and" gate, two multivibrators, a control enable relay stage, a relay control stage, and two relays. The integrator circuit consists of resistors R14, R15, and R16; capacitors C9A and C9B; and diodes CR12, CR13, and CR9. The integrating circuit, multivibrator V3, control enable V4, and burst enable relay K2 form an enabling circuit and are controlled by the P and Y 5-microsecond pulses. The enabling circuit prevents acceptance of a burst order during the steering phase of flight when alternate positive P and negative Y pulses are received. The enabling circuit allows the burst circuit to accept burst orders when only positive P 5-microsecond pulses are received (time-to-intercept less than 0.5 second or just before guidance cutoff on surface-to-surface firings). The "and" gate consists of transformers T1, T2, and T3; diodes CR1, CR2, and CR3; and biasing network resistors R2, R3, R24, and R25; and diode CR11. The "and" gate; multivibrator V1; clamping diode CR6; diode CR7; filter resistor R9 and capacitor C6; relay control V2 and burst timing adjustment circuit R10, R11, and R12 with bypass capacitor C7; storage capacitor C8; and burst relay K1 form the burst channel of the command detonation electronic switch. Burst relay K1 (D10) and storage capacitor C2 and its associated charging circuit in the burst pulse forming network and the sequential timer function with the burst channel and control the arming mechanism.

(*b*) *Enabling circuit.* Positive 18 volt P 5-microsecond pulses (A2) are applied through R14 and CR12 to capacitors C9A and C9B. Negative 18 volt Y 5-microsecond pulses (B2) are applied through R15 and CR13 to C9A and C9B. As long as the P and Y pulses arrive alternately, as they do during the steering phase of missile flight, the voltage across C9A and C9B will be very near zero volt. The relative resistances of R14 and R15 assure that the negative pulse will always cancel the positive pulse. With zero volt applied, multivibrator V3 will be conditioned so that its output will be –25 volts. Diode CR9 prevents any negative voltage across C9A and C9B. Resistor R16 is a high resistance discharge path for C9A and C9B. The –25 volt output of V3 disables multivibrator V1 and control enable V4. When the missile is to be conditioned for burst, only the positive 18 volt P 5-microsecond pulses will be received and a positive voltage will build up across C9A and C9B. After 25 consecutive P pulses, the voltage across C9A and C9B causes multivibrator V3 to change state, and the output voltage changes from –25 volts to +12 volts. The positive voltage causes control enable V4 to energize burst enable relay K2. Contacts 1–5 and 2–6 of K2 close to apply operating voltage to relay control V2. The positive output of V3 also removes the disabling bias on multivibrator V1. Diode CR10 blocks any positive voltage to multivibrator V1.

(*c*) *Burst channel operation.* The 4-microsecond burst enable pulse is applied to "and" gate transformer T2. The negative undelayed video pulse train is applied to T1 which is connected to invert the input pulse and the burst delayed video pulse train delayed by the missile code time plus 1.5 microseconds is applied to T3. Refer to paragraph 3–3 for a discussion of missile orders. The transformers provide impedance matching and isolate bias current flowing in the "and" gate from the input circuit. When no positive pulses are applied through the transformers, bias current is flowing from –107 volts through R2, the three transformer secondary windings 3–4, and "and" gate diodes CR1, CR2, and CR3, and R3 to ground. Voltage dividers R24, C11, R25, and CR11 keep the voltage across R3 constant for small changes in bias current. If a positive pulse is applied to the cathode of one of the "and" gate diodes, there will be no significant change in the bias current because the three diodes are in parallel. Even if two positive pulses are applied simultaneously to two of the diodes, there will be no significant change in bias current. If three positive pulses (fig. 3–7) are applied simultaneously to all three of the diodes, then the bias current will be cut off and the voltage across R3 will become less negative. The voltage across R3 will change in a positive direction until the anode to cathode potential causes one of the diodes to conduct. This conduction will stop the positive voltage change and maintain this voltage until one of the coincidence signals is removed. The positive change in voltage (burst pulse) is coupled through C3 and triggers multivibrator V1 (D4, fig. 4–10). Multivibrator V1 is monostable and produces a positive 150-microsecond pulse each time it is triggered. The negative portion of the 150-microsecond pulse is clamped to ground by diode CR6. Diode CR7 allows the positive signal to pass to filter R9 and C6 without allowing C6 to discharge. Resistor R9 is a high resistance discharge path for C6. Ten 150-microsecond pulses from multivibrator V1 build up a positive voltage across C6 sufficient to fire thyratron relay control V2. Burst time variable resistor R11 is adjusted so that ten burst pulses at 2-millisecond intervals (500 pulse groups per second) cause V2 to fire. Capacitor C7 bypasses the burst timing circuit. When relay control V2 fires, it acts as a switch to discharge storage capacitor C8. Capacitor C8 discharges through series-connected coils of burst relay K1 (D10) in the burst pulse forming network and burst relay K1 (C5) in the command detonation electronic switch and through bypass capacitor C7, relay control V2, contacts 2–6 and 1–5 of energized burst enable relay K2, and back to C8.

(*d*) *Burst relays.* Contacts of burst relay K1 on the command detonation electronic switch open to deenergize flip-over relay K1 (B7) of the flight control group and close to provide a holding circuit for the burst relays. Parallel contacts of energized burst relay K1 (D10), in the burst pulse forming network close to complete the ground path for energizing the arming mechanisms. The arming mechanisms are normally in their safe condition, preventing premature detonation of the missile during the prelaunch period. With the arming mechanisms in their safe condition, the detonators within the arming mechanisms are not alined to receive the ignition charge. After the period of sustained acceleration at launch, the detonators within the arming mechanisms are rotated into position by inertia switches. As an added precaution, shorting plug P8 prevents detonation of the missile before launch should the mechanism be armed. When contacts of K1 close, the ground paths for the sequential timer are completed. The parallel ground paths are from J1–P and G of the sequential timer, through parallel contacts of burst relay K1 of the burst pulse forming network, to J1–D and E on the sequential timer. This ground completes the energizing path for input transfer relay K2 (D15) of the sequential timer.

(*e*) *Sequential timer.* Contacts of energized relay K2 perform switching to energize output control relay K1 and change the input to the time delay network from reset to operate condition. The time delay network uses the time required for saturation of an inductor to introduce a 0.33-second delay. The exact delay is set by adjustment of time adjust variable resistor R5. At 0.33 second after ground is applied, saturation of the time delay network is such that Q1 and Q2 are forward biased and conduct sufficiently to energize output control relay K1 and to complete the path for energizing the arming mechanisms. When parallel contacts 6–1 and 2–5 of energized relay K1 in the sequential timer close, an electrical charge on capacitor C2 (C10) of the burst pulse forming network sends current through resistors R3 and R4 on the burst pulse forming network, through the two parallel connected arming mechanisms, and through parallel contacts of energized output control relay K1 in the sequential timer back to C2. This current pulse activates the two arming mechanisms, causing the missile warhead to burst.

(*f*) *Burst pulse forming network.* Capacitor C2 (C10) of the burst pulse forming network is charged to almost 300 volts. The charging path for C2 is from detonator ground through parallel resistors R3 and R4, C2, diode CR1, and resistor R1, all in the burst pulse forming network, through connecting wiring and circuitry to +300 volts. Diode CR1 insures an electrical charge on C2 even if the +300 volt supply fails in flight. This assurance is necessary because this electrical charge is also used for fail-safe operation. Contacts of connector J2 (C9) allow monitoring of command burst circuit operation.

(3) *Fail-safe detonation.*

(*a*) *General.* Fail-safe detonation of the missile is controlled by negative 75 volt holdoff pulses from the radio transmitter (C6). As long as these negative pulses are present, the missile will not be destroyed. A negative holdoff pulse is normally generated for each correctly coded pulse group received. If no signals are received for a period of 1 to 3 seconds or if the guidance set does not function properly, the fail-safe circuit will operate to destroy the missile. The fail-safe portion of the detonation command circuit consists of three electronic switches Z1, Z2, and Z3, and a portion of burst pulse forming network Z4, all in the fail-safe control located in the warhead section.

(*b*) *Electronic switches Z1, Z2, and Z3.* The —75 volt holdoff pulse at a +300 volt level from the radio transmitter is applied to terminal 12 of the burst pulse forming network (D10). The —75 volt holdoff pulse passes through capacitor C1 which blocks the +300 volts. The holdoff pulse is applied to terminal 7 of all three electronic switches. A —28 volt bias is also applied to terminal 7 through resistor R2 in the burst pulse forming network. The holdoff pulse applied to blocking oscillator Q1 produces a negative pulse at terminal 4 of winding 4–3 of transformer T1 which induces a negative pulse at T1–6. This negative pulse is passed by diodes CR3 and CR7 to storage capacitors C2 and C3. As long as holdoff pulses are received, these capacitors will be charged sufficiently negative to prevent any output from amplifier Q2 and electronic switch Q3 will conduct sufficiently to energize fail-safe relay K1. The contacts of all fail-safe relays in the three electronic switches will then be open. The six sets of relay contacts form part of a circuit consisting of storage capacitor C2 and its associated components in the burst pulse forming network, the fail-safe relay contacts, and the two parallel arming mechanisms. The six sets of relay contacts are interconnected in a series parallel arrangement so that contacts in two of the three electronic switches must be closed to complete the circuit between C2 and the arming mechanisms. Capacitor C2 is kept charged to +300 volts by +300 volts from the radio transmitter. Diode CR1 prevents discharge of C2 should the +300 volts fail. If for any reason the holdoff pulse is not present for a period of from 1 to 3 seconds, storage capacitors C2 and C3 of the electronic switches will discharge sufficiently so that the output of amplifier Q2 will cause conduction through electronic switch Q3 to decrease and fail-safe relay K1 to deenergize. Contacts of the fail-safe relays close and C2 of the burst pulse forming network discharges through the two parallel arming mechanisms causing the missile to be destroyed. The discharge path for C2 is through resistors R3 and R4 of the burst pulse forming network, the detonator ground circuit, the two parallel arming mechanisms, through series-parallel connected contacts of the fail-safe relays of the three electronic switches (six possible paths exist, each involving two sets of relay contacts), and back to C2 in the burst pulse forming network. The use of three electronic switches improves reliability. The series arrangement of relay contacts prevents a faulty electronic switch which allows its relay contacts to close from destroying the missile. This parallel arrangement of relay contacts assures that a faulty electronic switch with contacts that do not close will not prevent the fail-safe circuit from destroying the missile. Contacts of test connector J2 allow monitoring of fail-safe circuit operation. No operating connections are made to connector J2.

e. Power Supply Distribution Circuits.

(1) *General.* All operating voltages required by the missile in flight are produced by the radio set power supply with its associated direct current power filter and the transistor oscillator inverter. Electron tube filament voltage is supplied from a 120 volt, 1,700-cps transistor saturable-reactor circuit in the radio set power supply. All dc voltages and a 45 volt pattern modulator motor and buzz voltage are produced from a separate transistor saturable-reactor circuit within the radio set power supply. The two circuits operate independently of each other and are energized at separate times. The transistor oscillator inverter supplies 3-phase, 120 volt, 400 cps power to all gyro motors. During the prelaunch period, various external voltages are applied to the missile for test purposes and as warmup power. The sequence in which these voltages are applied is given in (2) below.

(2) *Power application sequence.* Delay line heater power of 120 volts ac is applied through contacts 1–5 of deenergized transfer relay K3 (B2, fig. 4–11) in the flight control group to the delay line heater (B4) in the missile-code delay line. The thermostatically controlled heater maintains the missile-code delay line at a constant temperature through the operation of thermostat switch S1. The heater circuit may be monitored at test connector J2–B. External —28 volt heater and gyro power is applied through contacts 3–7 of deenergized transfer relay K3 to the transistor oscillator inverter and to the filament voltage producing circuit in the radio set power supply; it is also applied to the fail-safe control and the sequential timer.

(*a*) *External input power.* B+ activate —28 volt power is applied through contacts 4–6 of deenergized transfer relay K8 to the dc and 45 volt ac-producing circuit of the radio set power supply. This action applies operation dc voltages to all units within the guidance set. Flipover relay K1 (B2) in the flight control group is also energized at this time by B+ activate —28 volt power applied through the closed contacts of deenergized burst relay K1 (A4) in the command detonation electronic switch. Burst relay K1 remains deenergized until a burst order is received. When a burst order is received, burst relay K1 becomes energized removing the —28 volt supply to flipover relay K1 (*b*(3) (*c*) above). Deenergizing flipover relay K1 removes the receiver B+ (+150 volt) supply fed through contacts 6–15 of flipover relay K1 to the amplifier-decoder (C4).

(*b*) *Internal power.* At launch order the guidance set is transferred from external power to internal power supplied from a —28 volt battery. External to internal power transfer is accomplished by applying (as initial energizing power) external —28 volt transfer relay power to transfer relays K3 and K4 (B2). Relays K3 and K4 are locked up by the application of internal battery power through resistor R5 and contacts 11–6 of energized relay K4. Deenergizing K3 and K4, after internal battery power is applied, is accomplished by shorting through external circuitry the —28 volt external transfer power lead to ground. Resistor R5 in the circuit prevents a direct short of the —28 volt battery to ground when relays K3 and K4 are being deenergized.

1. Relay K3 when energized applies —28 volt dc internal battery power through contacts 12–8, replacing external B+ activate power; through contacts 9–5, replacing external delay line heater power; and through contacts 11–7, replacing external heater and gyro power.

2. At lift-off, inertia switch S1 (A1) closes, supplying —28 volt battery power to relays K3 and K4, insuring that they are energized. Inertia switch S2 (B1) also closes at lift-off applying —28 volt uncage power to the uncage solenoid of the roll amount gyro in the steering control circuit (B10, fig. 4–8).

(3) *Radio set power supply.* The radio set power supply (A5, fig. 4–11) consists of a 120 volt, 1,700-cps filament voltage supply, a separate dc voltage supply, and 45 volt, 250-cps supply. The pattern modulator motor and buzz voltages are supplied from the 45 volt output. The two circuits operate independently of each other and are energized at separate times.

(*a*) Application of —28 volt heater and gyro power energizes the 120 volt ac transistor converter. This power is applied through shunt resistor R2 (B4), through series regulator Q1, through transformer T1 located on radio set power supply subassembly A2, and to 120 volt ac transistor converters Q4 and Q5. Because of the saturation characteristics of transformer core T1, Q4 and Q5 conduct alternately at 1,700 cps, producing a square-wave voltage across T1 of 120 volts, 1,700 cps used as electron tube filament power.

1. Regulation is provided by applying a feedback control voltage from transformer T1 to voltage regulators Q1, Q2, Q3, and Q11. This voltage is rectified as it passes through bridge rectifiers CR3, CR4, CR5, and CR6, and appears as a negative control voltage across variable resistor R4. Variable resistor R4 provides a sensitivity adjustment of the voltage regulator by determining the amount of control voltage applied. An increase in —28 volt heater and gyro voltage or an increase in the 120 volt ac output load causes a corresponding increase or decrease in the amount of control voltage induced across T1.

2. An increase in —28 volt heater and gyro power or a decrease in output load results in an increase of control voltage applied to the voltage regulator from variable resistor R4. As the control voltage applied to the voltage regulator increases, an increase in impedance across shunt resistor R2 and series regulator Q1 takes place. This results in an increase of the —28 volt heater and gyro power dropped across shunt resistor R2 and series regulator Q1, thereby compensating for the original increase in —28 volt heater and gyro power or decrease in output load. An increase in the 120 volt ac output load or a decrease in —28 volt heater and gyro power results in a decrease of impedance across shunt resistor R2 and series regulator Q1, resulting in an increase of —28 volt heater and gyro power applied from the voltage regulator, thereby compensating for the original increase in output load or decrease in —28 volt heater and gyro power.

(*b*) Application of —28 volt B+ activate power energizes the dc voltage transistor converter and 45 volt ac transistor converter. This power is applied through shunt resistor R8, through voltage regulators Q8, Q9, Q10, and Q12, and transformers T2 and T3 located on radio set power supply subassembly A2, to transistor converter Q1 and Q2 (dc voltage), and to transistor converters Q6 and Q7 (45 volt ac). Transistor converters Q6 and Q7 produce a 45 volt ac output across transformer T3. AC voltages from dc producing converters Q1 and Q2 developed across transformer T2 are rectified by bridge-rectifier circuits. Operation of the dc voltage and 45 volt ac circuits is identical to the 120 volt ac circuit; however, voltage regulators Q8, Q9, Q10, and Q12 function primarily to regulate dc outputs.

1. AC voltages induced in transformer T2 are applied to their respective rectifiers. Rectifier Z1 supplies unfiltered +300 volts dc when combined with a filtered +150 volt input from the direct current power filter. Rectifier Z2 supplies unfiltered +150 volts dc; rectifier Z3 supplies unfiltered +200 volts and —100 volts dc. In addition, the ac voltage applied to Z3 from T2 is fed through series-connected half-wave rectifiers CR1, CR2, and CR3, and through resistor R2 (B8) on A3 as unfiltered +230 volts. Rectifier Z4 supplies unfiltered —107 volts dc.

2. Rectifier Z5 supplies —28 volt and +28 volt control signal voltage (monitored at test connector J2–f and J2–h (C17)). CS bal adjust variable resistor R5 allows the control signal output voltages to be balanced. All dc voltage outputs from the radio set power supply are applied to the direct current power filter, with the exception of —28 volt and +28 volt control signal voltages and the unfiltered +230 volt output.

(4) *Direct current power filter.* The direct current power filter (A9) consists of RC filter networks used to provide filtering of unfiltered dc inputs from the radio set power supply. Filtered dc outputs from the direct current power filter include filtered +300 volts dc; filtered +200 volts dc, monitored at test connector J2–k (C17); filtered —107 volts dc, monitored at test connector J2–p (D17); filtered +150 volts dc, monitored at test connector J2–m (C17); and —100 volts dc, monitored at test connector J2–c (C17).

(5) *Transistor oscillator inverter.* The transistor oscillator inverter (D5) produces regulated 3-phase, 120 volt, square-wave gyro motor power. The unit is energized whenever external —28 volt dc heater and gyro power is applied and remains energized in flight from internal battery power. Energizing —28 volt power is applied to voltage regulators Q1, Q2, and Q3, and to a frequency adjust network across voltage regulators Q1, Q2, and Q3, consisting of resistor R4, frequency adjust variable resistor R5, and resistor R6.

(*a*) The operating frequency of the transistor oscillator is dependent upon the value of —28 volt power (heater and gyro) applied to three converters (phase A, B, and C). Frequency adjust variable resistor R5 adjusts the operating frequency by controlling the amount of —28 volt power dropped across the voltage regulator circuit, thereby controlling the voltage input to phase A, B, and C converters. Approximately —18 volts of the original —28 volt input power is supplied from the voltage regulator circuit to the three converters controlling the output frequency at 400 cps.

(*b*) The frequency control voltage of —18 volts from the voltage regulator is applied to phase A converters Q1 and Q2; to phase B converters Q3 and Q4; to phase C converters Q5 and Q6; and to transformers T4, T5, and T6, one for each phase converter, located on transistor oscillator inverter subassembly A2.

(*c*) Transistors Q1 and Q2 in the phase A converter conduct alternately, producing a 120 volt square-wave output across T4 at 400 cps. This voltage is fed to phase A push-pull power amplifiers Q4 and Q5. The increased power output from Q4 and Q5 is developed across transformer T1, one of three used with the three push-pull power amplifiers located on the transistor oscillator inverter subassembly and applied to all gyro motors.

(*d*) Operation of phase B and C converters with their associated power amplifiers is identical to the phase A producing circuit. Saturable-reactors L1 and L2 within the transistor oscillator inverter subassembly are so designed to cause phase B to lag phase A by 120 degrees and saturable-reactors L3 and L4 cause phase C to lag phase B by 120 degrees.

(*e*) Should the phase angle of any of the three phases differ more or less than 120 electrical degrees from the other two phases, a correction voltage from the transistor oscillator inverter subassembly is applied through a rectifier bridge to the respective phase converter. This action causes a phase angle change in the converter output, thereby compensating for the original error. Bridge rectifiers, through which correction voltage is applied to the phase converters, consists of CR1 through CR4, CR5 through CR8 (C6), CR9 through CR12, and CR13 through CR16.

(*f*) Delay circuits Q7 and Q8 function to provide a high impedance ground path, preventing the three-power amplifier stages from drawing large currents before the receipt of phase A, B, and C converter voltages. A feedback voltage from phase C output transformer T3 is applied through bridge rectifier CR17 through CR20 to delay transistors Q7 and Q8. Upon the receipt of this voltage, Q7 and Q8 conduct, providing a low-impedance conduction path from the three power amplifiers.

f. —28 Volt and Ground Distribution Circuit. The —28 volt and ground distribution circuits are identical for both mushroom and stovepipe guidance sets except in missiles using mushroom guidance sets there is no connection to safety and arming inertia switch S30 (C4, fig. 4–5). A functional description of the —28 volt and ground distribution circuits is given in paragraph 3–6*e*.

Section IV (C). THEORY OF THE MISSILE (LESS THE MISSILE GUIDANCE SET)

3–9 (C). Propulsion System

a. General. The propulsion system consists of a rocket motor cluster (booster) (fig. 2–2) and a missile rocket motor (fig. 2–7). The rocket motor cluster contains four rocket motors (fig. 3–14) that are ignited simultaneously to provide the initial (boost) thrust. The missile rocket motor (fig. 3–15) is ignited after rocket motor cluster separation to provide the final thrust.

b. Rocket Motor.

(1) The rocket motor (fig. 3–14) consists of a steel head, a steel combustion chamber, and a steel nozzle. The combustion chamber contains a solid propellant cast in a symmetrical pattern forming nine gas passengers. To insure uniform propellant burning, each gas passage contains a resonance rod. A liner of inhibited cellulose acetate around the propellant prevents burning on the outside of the propellant. An insulating coating on the inside surface of the combustion chamber protects the thin metal wall from the high heat of combustion. A nozzle closure provides a cemented seal that protects the propellant prior to ignition. When the propellant is ignited, the gases produced expel the nozzle closure. The escape of the gases through the nozzle produces the thrust required to propel the missile during the boost period.

(2) Ignition of the propellant in the rocket motor is accomplished one-fourth of a second after the launch order by applying 120 volts ac to the rocket motor igniter circuit. This action applies current through the rocket motor igniter

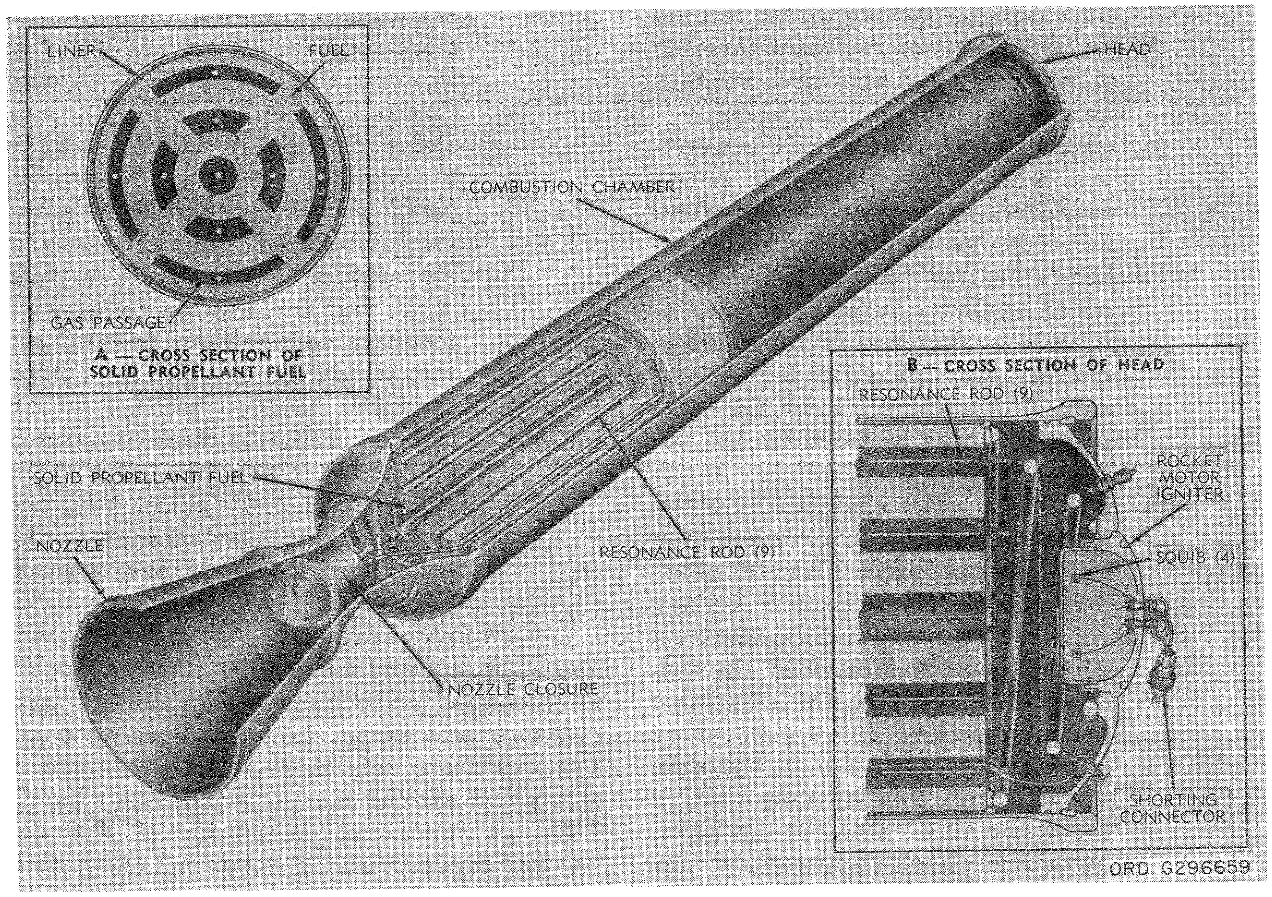

Figure 3–14 (U). Rocket motor—cutaway view (U).

cable to each rocket motor igniter (B, fig. 3–14) in the head of the rocket motor. The current fires four squibs in each of the rocket motor igniters, thereby igniting an explosive charge in the rocket motor igniter. The charge then ignites the propellant in the rocket motor. Approximate burn time of the propellant is 3.4 seconds at 70°F.

(3) Accidental ignition of the propellant in the rocket motor during shipment and storage is minimized by removal of the igniter and installation of a plastic shipping plug in the igniter receptacle. If accidental ignition does occur, the gases produced expel both the plastic shipping plug and the nozzle closure. The resultant diminished internal pressure causes the rocket motor to expend itself without creating thrust. To prevent stray voltages from accidentally firing the rocket motor igniter, a shorting connector is inserted during shipment and storage in the connector on the free end of the cable protuding from the igniter.

c. Missile Rocket Motor M30 Series.

(1) The missile rocket motor consists of a gas generator (igniter) (fig. 3–15), a steel combustion chamber, a blast tube, a blast tube nozzle, and two missile rocket motor initiators. The combustion chamber contains a solid propellant cast in a symmetrical gas passage. A liner of inhibited cellulose acetate around the propellant prevents burning on the outside of the propellant. An insulating coating on the inside surface of the combustion chamber protects the thin metal wall from the high heat of combustion. When the propellant is ignited, the gases produced escape through the blast tube and the blast tube nozzle, thereby producing the thrust required to propel the missile.

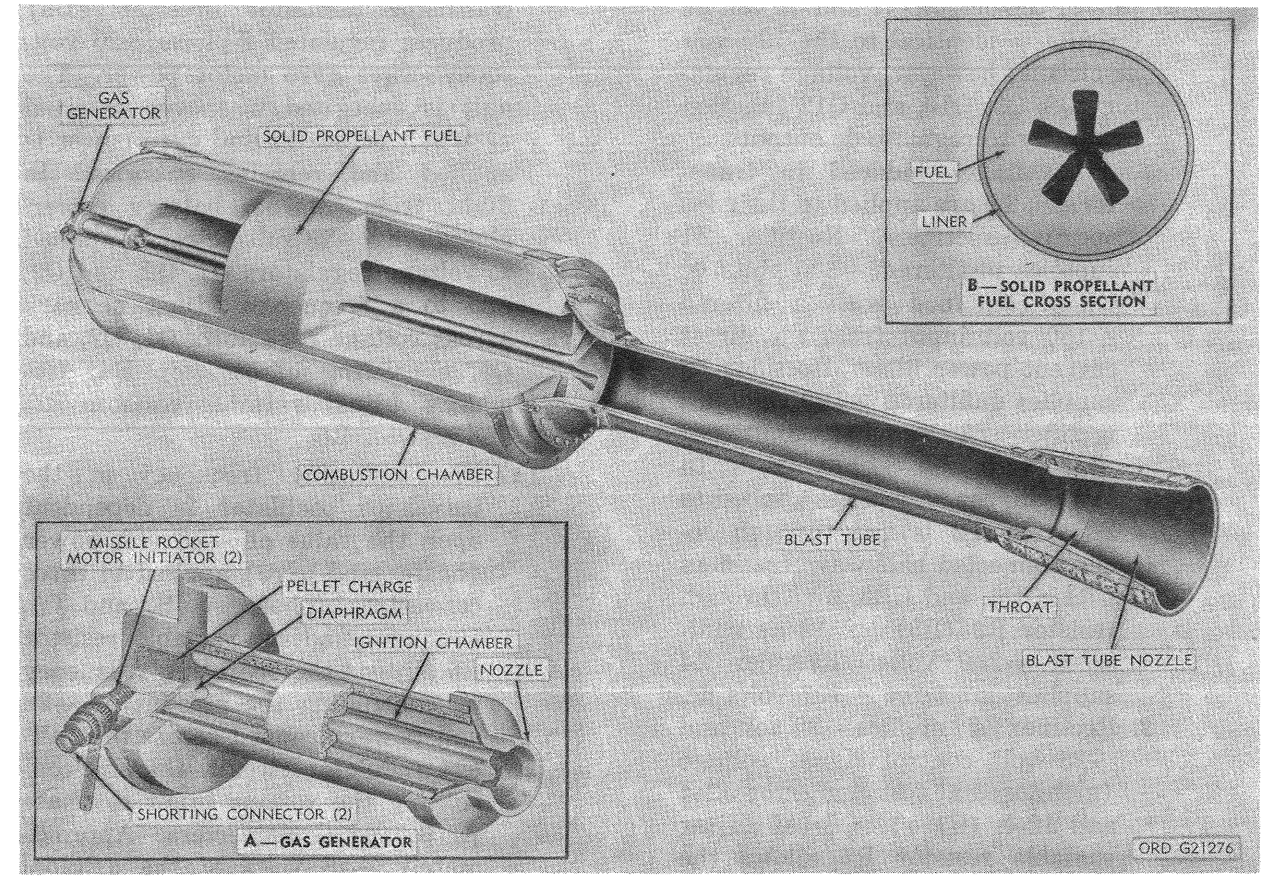

Figure 3–15 (U). Missile rocket motor M30—cutaway view (U).

(2) Firing of the missile rocket motor initiators is prevented before the boost period by safety and arming switch S31 (C5, fig. 4–12), which applies a short across the two missile rocket motor initiators and opens the circuit from the thermal battery assembly. During the boost period, the force of acceleration arms the switch, thereby removing the short from the two initiators and completing the circuit from the thermal battery assembly. At rocket motor cluster burnout, separation occurs and the propulsion arming lanyard (fig. 3–16), which extends from the thermal battery assembly in the actuator section of the missile body to a bracket on the forward end of the rocket motor cluster, mechanically activates the two thermal batteries, by pulling the lanyard, which releases the initiator pin. The striker arm then strikes the percussion cap, activating the batteries. These batteries develop sufficient voltage in about three-fourths of a second to cause a flow of current to ignite the missile rocket motor initiators (A, fig. 3–15) in the gas generator of the missile rocket motor. When a normal surface-to-air mission is designated, the current from the batteries passes through normally closed contacts of the motor start delay timer relay (F5,

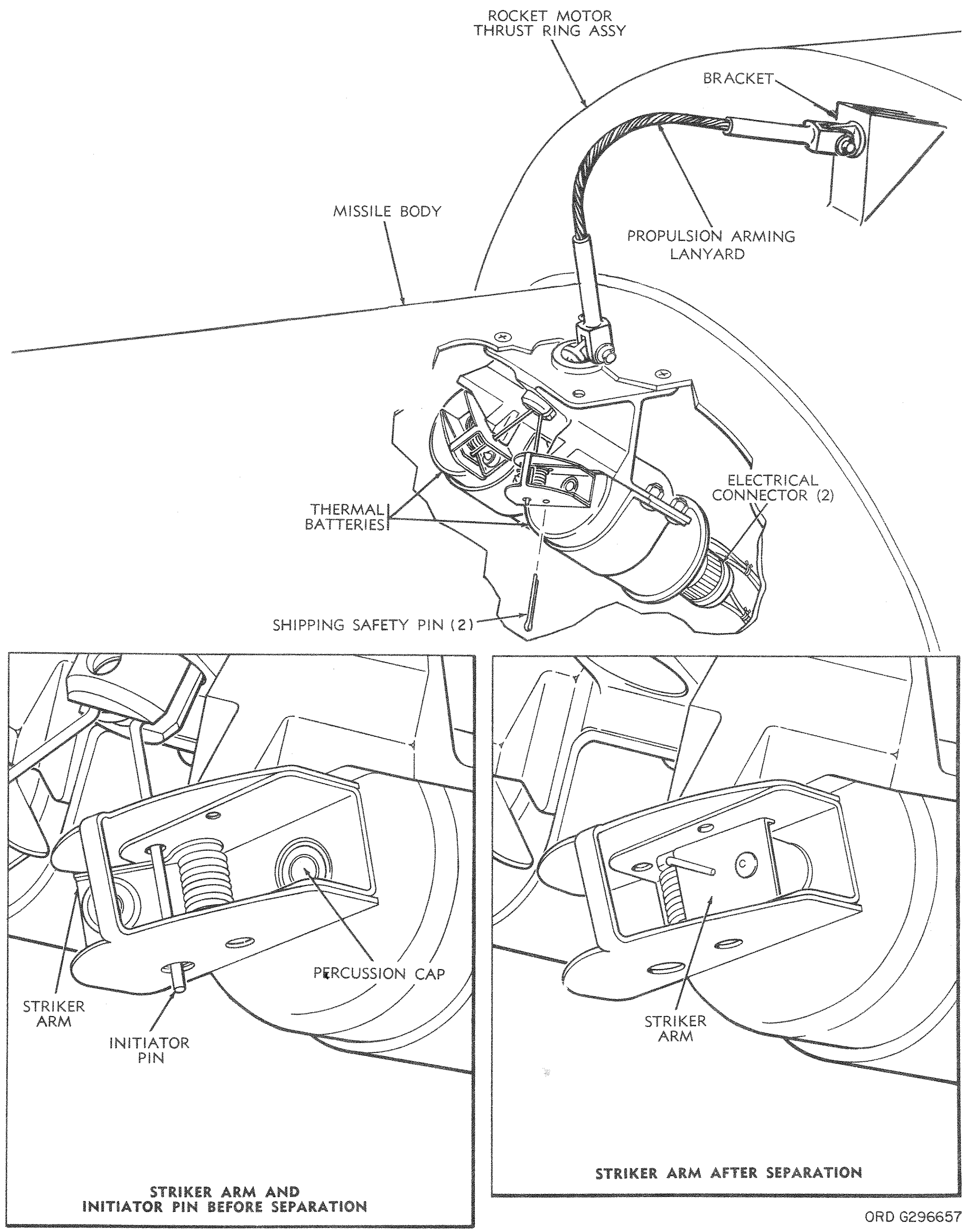

Figure 3–16 (U). Thermal battery assembly—activation (U).

fig. 4–12) (deenergized) or through the dummy connector assembly, and through safety and arming switch S31 to the initiators. The motor start delay timer relay remains deenergized during this type of mission and does not delay the completion of the initiator circuit.

(3) When activated by the current from the thermal battery assembly, the two missile rocket motor initiators (A, fig. 3–15) ignite the pellet charge in the forward end of the gas generator. The pressure caused by the ignition of the pellet charge breaks a diaphragm in the gas generator, and the combustion spreads to the ignition chamber. The gas generator forces hot, burning gases from the ignition chamber through the nozzle onto the solid propellant fuel. At this time, burning of the fuel commences. Approximate burn time of the fuel is 29 seconds.

(4) Accidental ignition of the propellant in the missile rocket motor during shipment and storage is minimized by removal of the two missile rocket motor initiators. To prevent stray voltages from accidentally firing the initiators, a shorting connector (A, fig. 3–15) is installed on each initiator during shipment and storage.

3–10 (C). Hydraulic System

a. General.

(1) The hydraulic system consists of the P, Y, and roll actuator assemblies (fig. 3–17), a mechanical linkage, and an accessory power supply (APS) or hydraulic pumping unit (HPU). The hydraulic system, operating under the direction of guidance commands from the missile guidance set, positions the elevons in order to produce the required maneuver. The P and Y elevons are positioned independently by identical servo loops that include electrical hydraulic, and mechanical components. The roll stabilization servo loop operates independently of the P and Y servo loops, and moves all four elevons by means of a separate mechanical linkage.

(2) When a steering order is applied to the P or the Y steering amplifier in the missile guidance set, unequal output currents unbalance the two solenoids of a missile control valve in the P or the Y actuator assembly, respectively. The missile control valve governs the flow rate of hydraulic oil to an actuator in the actuator assembly. As hydraulic oil flows to the actuator, a piston in the actuator connected to the mechanical linkage is displaced and moves a pair of elevons. Movement of the elevons produces aerodynamic forces that maneuver the missile. The maneuver is sensed by the P and Y accelerometers and rate gyros in the missile guidance set. These flight-control instruments produce feedback voltages that are applied to the P or Y steering amplifier. An elevon feedback voltage from the elevon variable resistor in the actuator assembly is also applied to the steering amplifier. When the required maneuver is achieved, the total feedback voltage and the steering voltage balance the outputs from the steering amplifier. The currents in the two solenoids of the missile control valve are equal, and the hydraulic system holds the elevons in position.

(3) A mechanical linkage between the P, Y, and roll actuator assemblies and the elevons is capable of combining simultaneously P, Y, and roll orders that require a different angle between each elevon (fig. 3–18) and the associated main fin. When a P steering order is received, both P elevons (No. 2 and No. 4) rotate through the same angle about the P elevon axis. When a Y steering order is received, a similar rotation of the two Y elevons (No. 1 and No. 3) about the Y elevon axis occurs. A roll stabilization order causes a rotation of all four elevons

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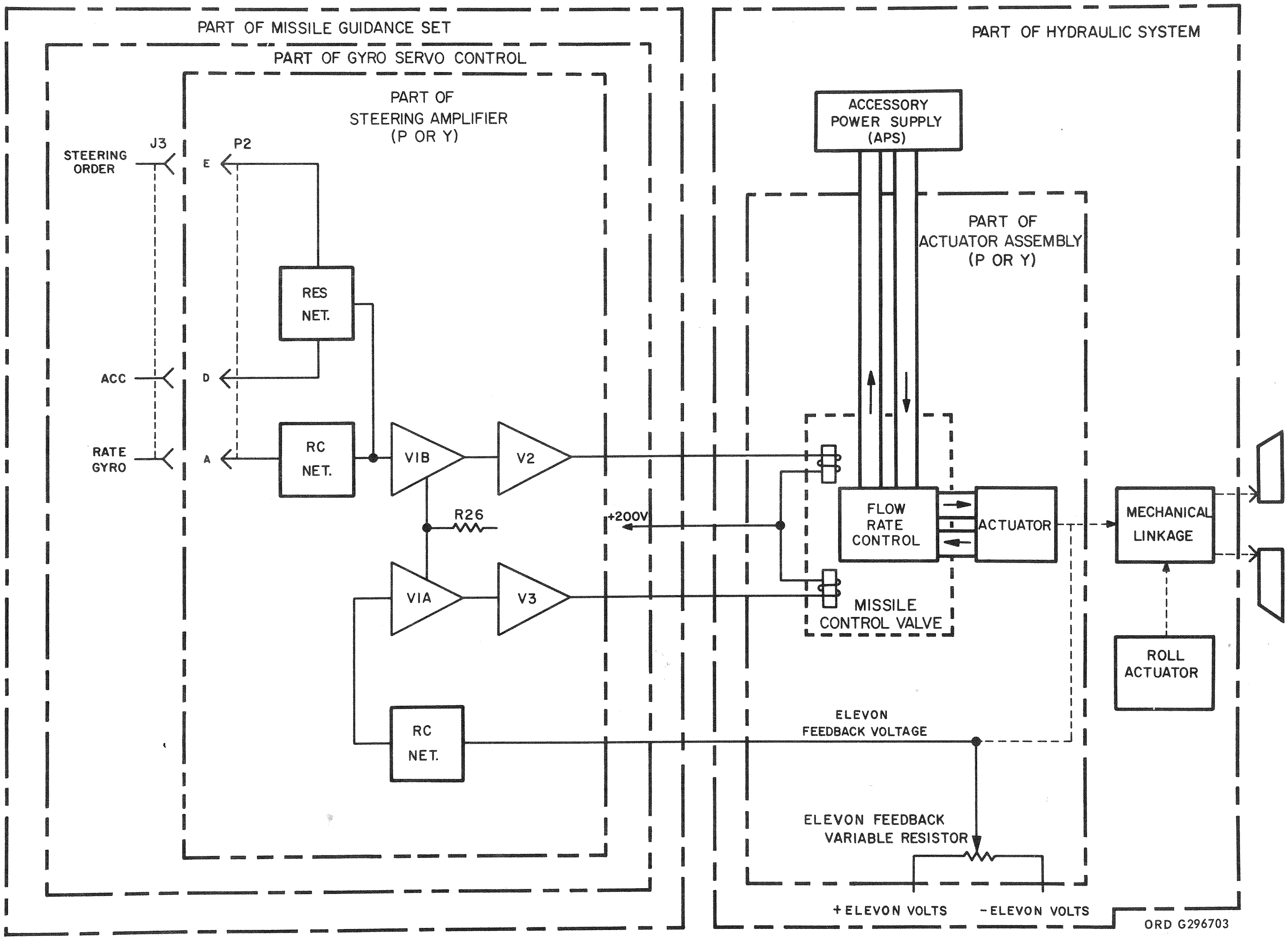

Figure 3-17 (U). Hydraulic system—P or Y servo loop—block diagram (U).

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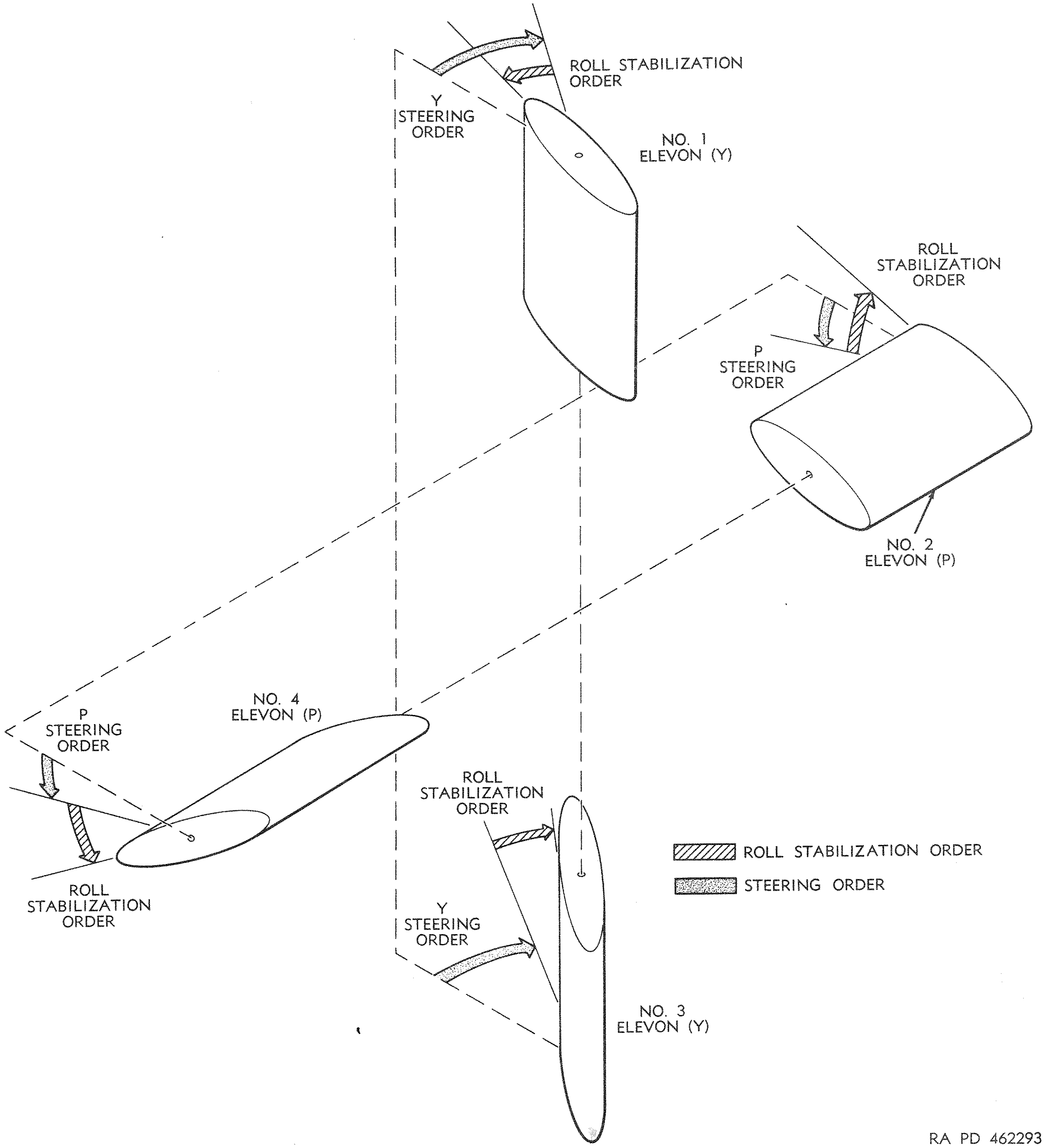


Figure 3-18 (U). Elevon positions—combined P, Y, and roll orders (U).

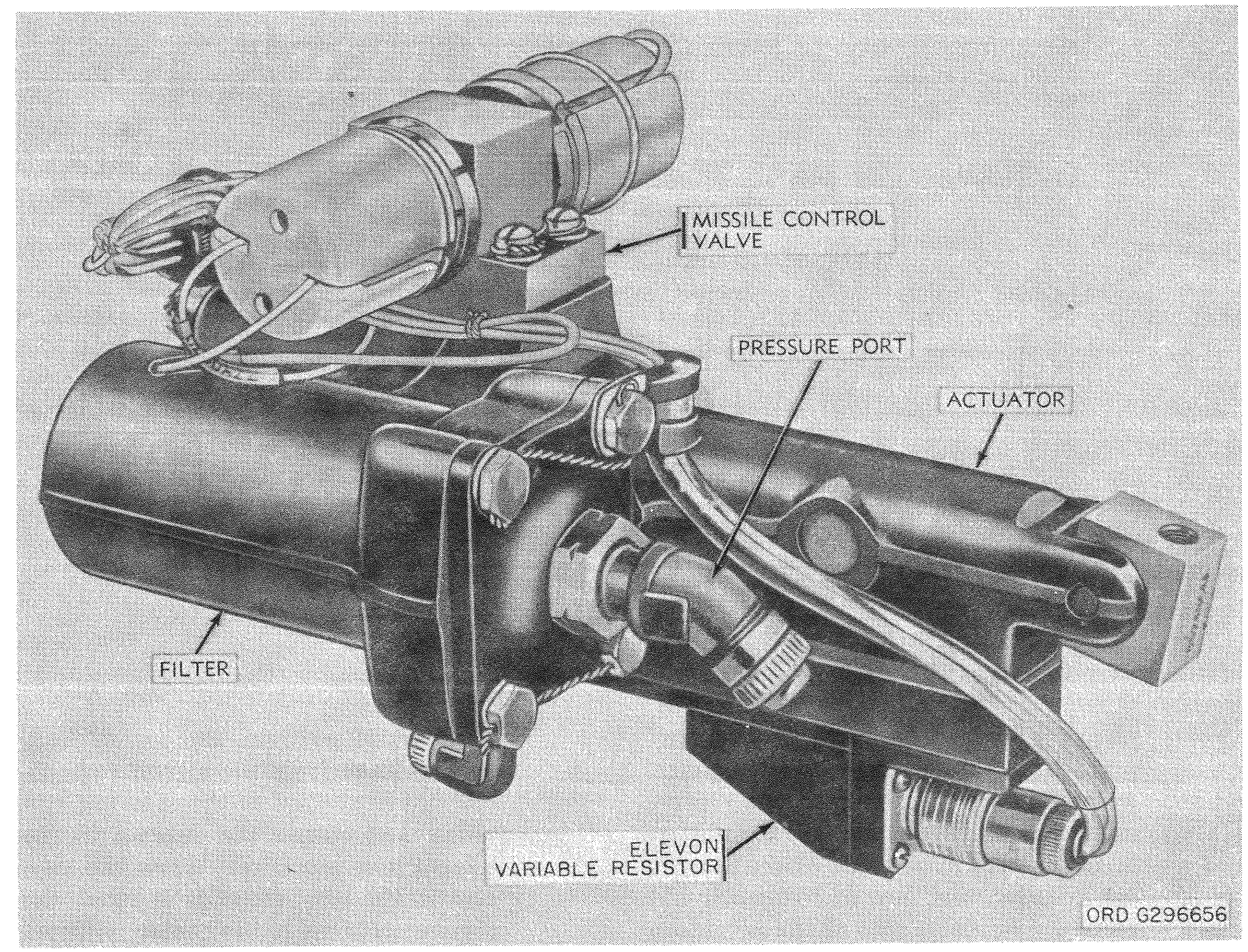


Figure 3-19 (U). P, Y, or roll actuator assembly (U).

in such a manner that any pair of elevons rotate through equal angles in opposite directions about their common axis. Any combination of angles within the physical limits of elevon travel may occur.

b. Actuator Assemblies.

(1) Each of the three actuator assemblies (fig. 3-19) consists of a missile control valve, an elevon variable resistor, and an actuator. The P and the Y actuator assemblies are identical. The roll actuator assembly differs only in the amount of travel of the actuator piston and the roll elevon variable resistor pickoff arm. Each actuator assembly converts electrical signals into mechanical displacements by controlling the flow of hydraulic oil. This oil enters each actuator at a pressure port (fig. 3-20) and passes through a filter to the missile control valve. The oil from the missile control valve returns to the APS through a return port in the actuator.

(2) The missile control valve is a spool valve that regulates the direction and rate of flow of hydraulic oil to the actuator in response to electrical signals from an associated steering amplifier in the missile guidance set. Two solenoids, located at opposite ends of a plunger in the missile control valve, form the plate load for the P or Y steering amplifier (fig. 3-17). When the current in the two solenoids (fig. 3-20) is unequal, the plunger moves toward the solenoid that has the larger current; when the current flow in each solenoid is equal, a centering spring centers the plunger. The flow of hydraulic oil through the missile control valve is regulated by the position of the plunger with respect to five inlets. There is an inlet to the pressure port, an inlet to each side of the actuator

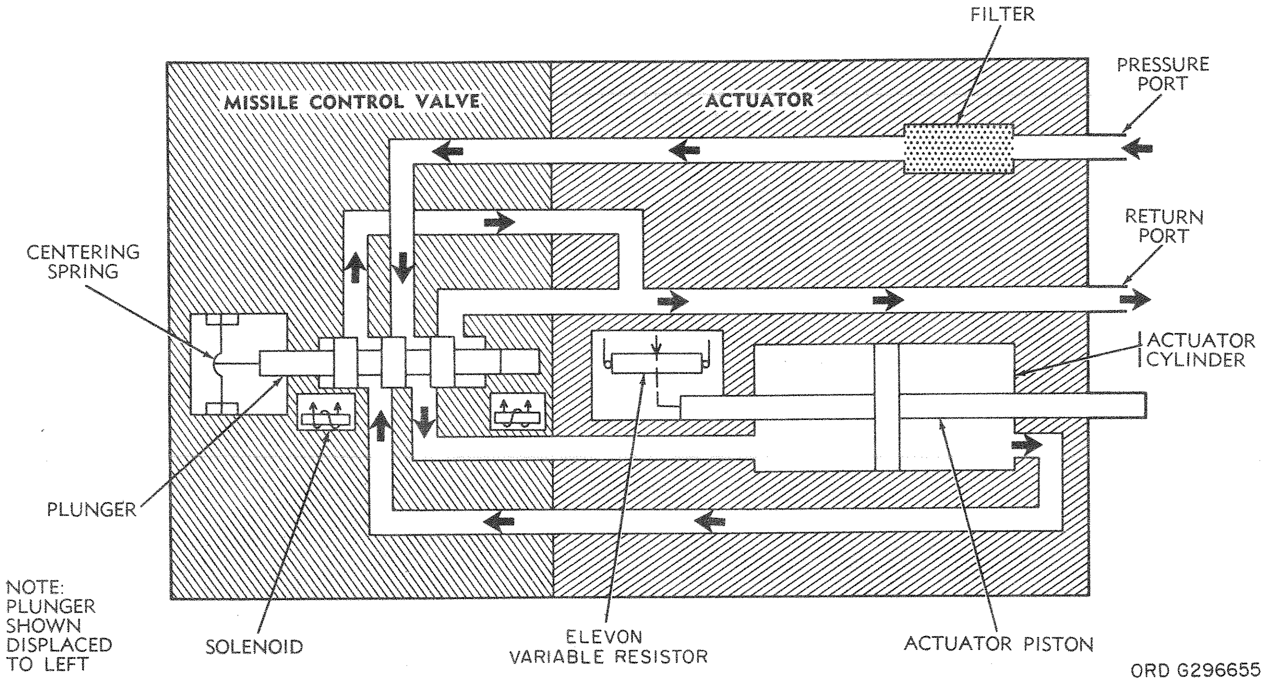


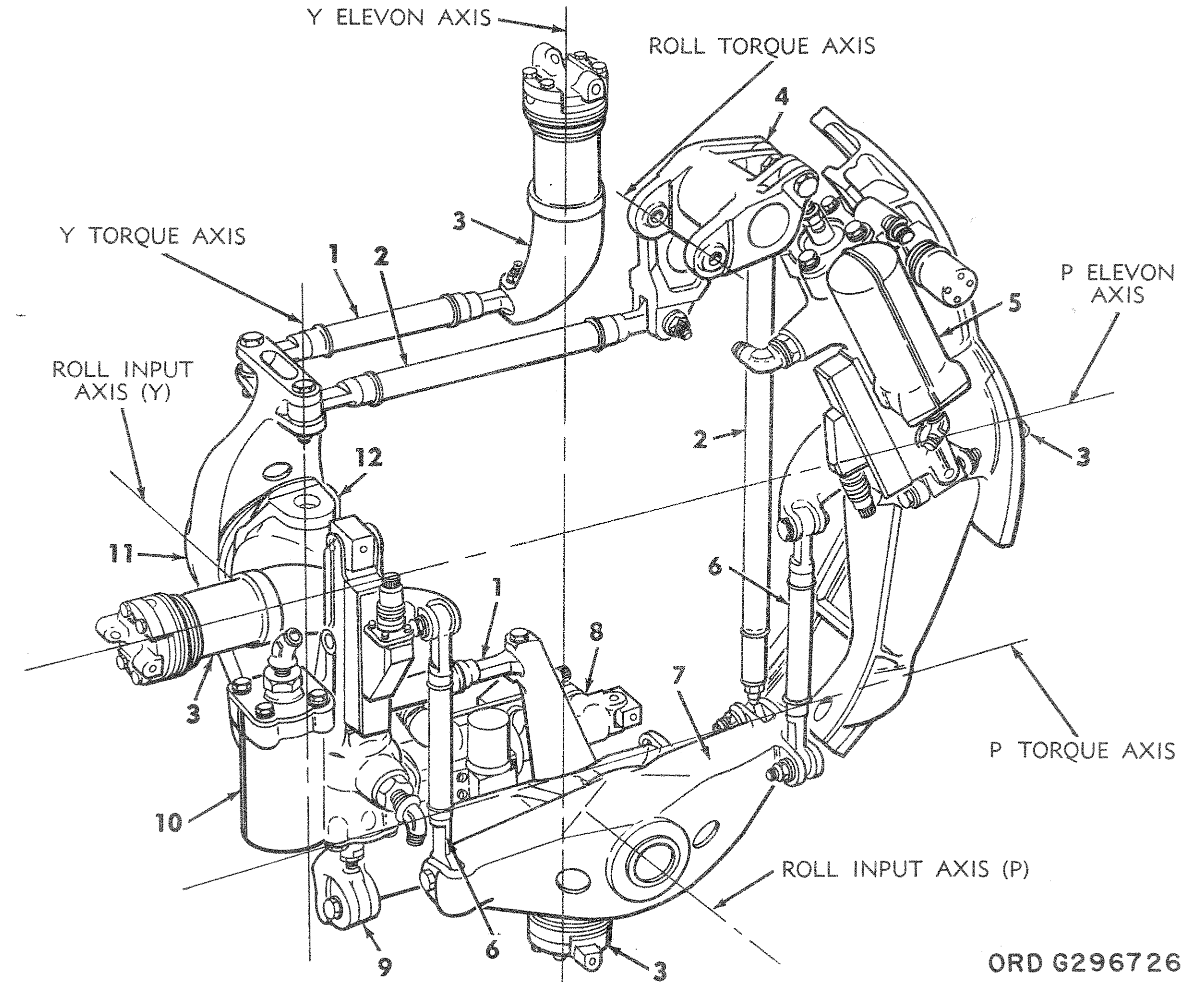
Figure 3-20 (U). P, Y, or roll actuator assembly—hydraulic schematic (U).

piston, and two inlets to the return port. The plunger is so shaped that, when displaced, it simultaneously permits flow of hydraulic oil from the pressure port to one side of the actuator cylinder, and flow of hydraulic oil from the opposite side of the actuator cylinder to the return port. As hydraulic oil enters one side of the actuator cylinder, the actuator piston moves, thereby forcing hydraulic oil from the other side of the actuator cylinder through the missile control valve to the return port. As the actuator piston moves, it moves the pickoff arm of the elevon variable resistor. The voltage picked off by the arm is the elevon feedback voltage.

(3) In actual operation, a steering order applied to the P or Y steering amplifier (fig. 3-17) in the missile guidance set produces unequal currents in the two solenoids (fig. 3-20) in the missile control valve. This action causes the plunger in the missile control valve to move to one side, thereby allowing hydraulic oil flow to move the actuator piston. As the piston approaches the commanded position, the elevon feedback voltage from the elevon variable resistor is applied to the steering amplifier and causes the current in the solenoids to equalize. When the current in the two solenoids is equal, the plunger returns to the center position, the oil flow ceases, and the actuator piston stops.

c. Mechanical Linkage.

(1) The mechanical linkage (figs. 3-21 and 3-22) converts motion of the actuator pistons in the P, Y, and roll actuator assemblies into corresponding motion of the P and Y elevons. When the actuator piston in the P actuator assembly (10) moves, both the P bar (9) and P beam (7) rotate about the P torque axis. This rotation causes both P pushrods (6) to move an equal amount in the same direction. Since the two P pushrods are connected to the two P elevons by two shafts, (3), both P elevons move through the same angle. A similar linkage converts the motion of the actuator piston in the Y actuator assembly (8) into corresponding motion of the two Y elevons.

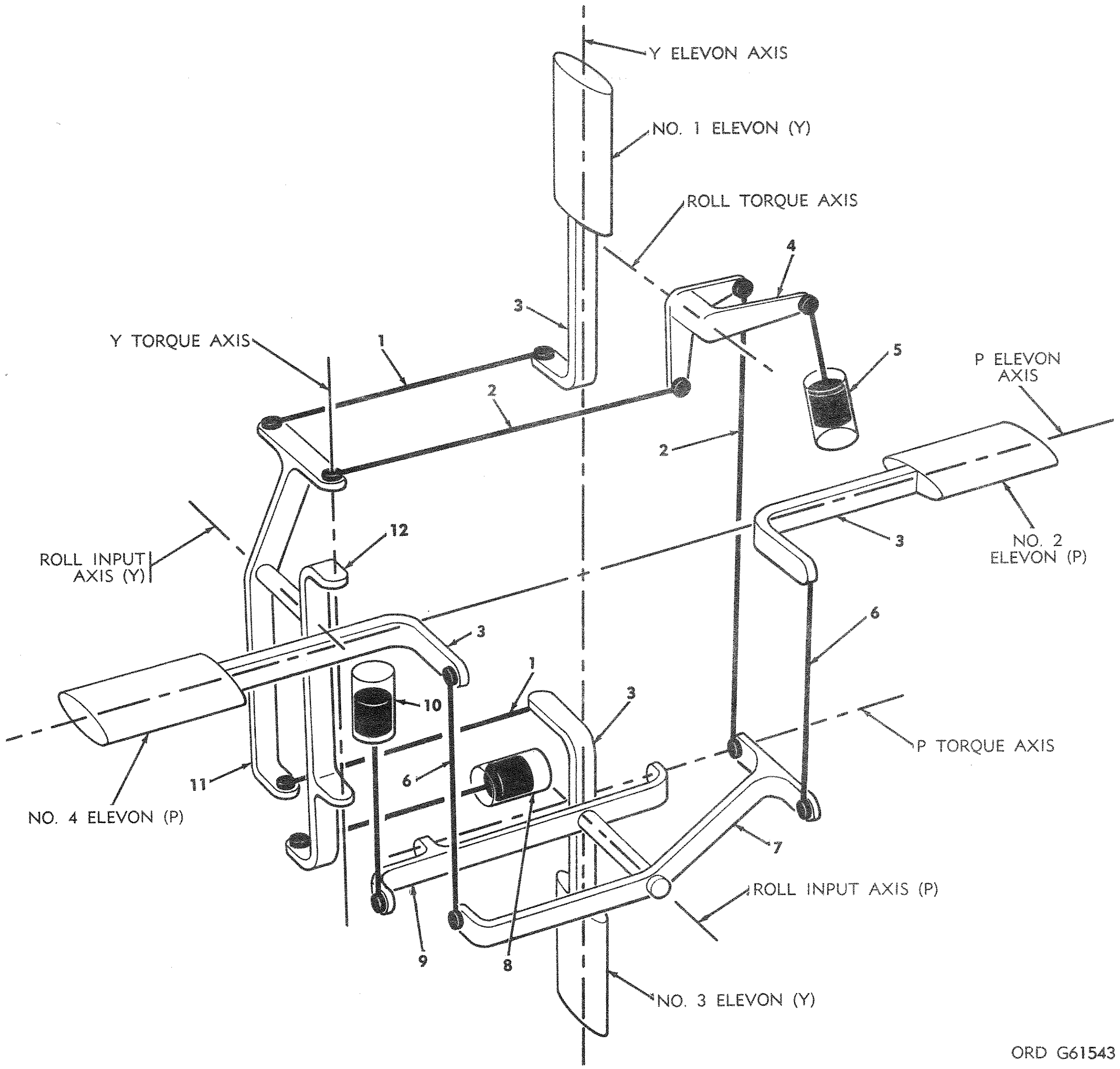


1—Y pushrod (2)
2—Roll pushrod (2)
3—Shaft (4)
4—Roll bell crank
5—Roll actuator assembly
6—P pushrod (2)
7—P beam
8—Y actuator assembly
9—P bar
10—P actuator assembly
11—Y beam
12—Y bar

Figure 3-21 (U). Mechanical linkage—structure (U).

(2) When the actuator piston in the roll actuator assembly (5) moves, the roll bell crank (4) rotates about the roll torque axis. This rotation causes the two roll pushrods (2) to move the same amount but in opposite directions. The two roll pushrods rotate both the P beam (7) and the Y beam (11) about their respective roll input axis. This action causes the two P pushrods (6), and the two Y pushrods (1), to move in opposite directions, thereby rotating opposite elevons of each elevon pair (P and Y) through the same angle, but in opposite directions.

(3) During actual flight of the missile, P and Y steering orders and roll stabilization orders are applied simultaneously to the mechanical linkage. In this condition, the P bar and beam, and the Y bar and beam act as double linkage differentials (two inputs and two outputs). The two inputs are the steering order (P or Y) and the roll stabilization order. These orders are



1—Y pushrod (2)
2—Roll pushrod (2)
3—Shaft (4)
4—Roll bell crank
5—Roll actuator assembly
6—P pushrod (2)
7—P beam
8—Y actuator asembly
9—P bar
10—P actuator assembly
11—Y beam
12—Y bar

Figure 3-22 (U). Mechanical linkage—simplified schematic (U).

mechanically combined so that one output is the steering order plus the roll stabilization order, and the other output is the steering order minus the roll stabilization order. These two outputs are the motions of the pushrods that position the elevons.

d. Accessory Power Supply (APS).

(1) *General.* The accessory power supply (fig. 3-23) is a gas operated, electrically controlled mechanism that provides hydraulic power for operation of the P, Y, and roll actuator assemblies. APS start, stop, and glow are applied automatically through the launching set during a firing sequence, and manually through the launching set or assembly area electrical test set group for test. The operating systems of the APS are: APS power system, which utilizes an ET_hO decomposition reaction to drive a turbine and, through reduction gearing, a hydraulic pump and an alternator; hydraulic system, which regulates hydraulic pressure developed by the pump; and APS electric control system, which provides circuits for starting, stopping, and regulating the operation of the APS.

(2) *APS power system.*

(*a*) The APS power system transforms the energy of ET_hO decomposition to furnish high-pressure oil to the APS hydraulic system and to provide the ac voltage for operation of the APS electrical control system.

(*b*) Glow plug power to preheat the gas generator (NN, fig. 4-13) is applied from external equipment a minimum of 45 seconds prior to applying the APS start command ((4) (*d*) below). When the APS start command is given, the boost fuel valve (MM) and the run fuel valve (LL) are opened ((4) (*b*) and (*c*) below), permitting ET_hO to flow from the fuel reservoir (V) through the fuel filter (KK) into the gas generator (NN). The large quantities of gas that are generated expand through the turbine nozzle against the blades of the turbine (PP). The turbine drives both the alternator (A) and the hydraulic pump (C) through a gear train in the gear box (B). As hydraulic pressure is developed by the hydraulic pump (C), the fuel pressurization check valve (CC) permits oil flow from the high pressure line to the fuel pressurization reservoir (BB) in the fuel reservoir assembly. (Refer to (5) below for additional functions of the fuel pressurization check valve (CC) and the fuel pressurization reservoir (BB); also for the functions of the fuel pressure differential valve (U) and the TRANSFER valve (T).) The ET_hO in the fuel reservoir (V) is compressed by the action of the fuel reservoir piston (W), thereby maintaining a constant flow of fuel to the gas generator (NN). An air vent eliminates air pressure buildup behind the piston. When the alternator (A) attains normal operating speed, the boost fuel valve (MM) and the fuel run valve (LL) are closed ((4) (*f*) and (*h*) below), stopping the flow of ET_hO to the gas generator. When the alternator drops below normal operating speed, the fuel run valve reopens, accelerating the turbine back to normal operating speed, and then closes again. When the APS stop command is given, the fuel run valve remains closed ((4) (*g*) and (*i*) below), preventing further flow of ET_hO to the gas generator.

(3) *APS hydraulic system.*

(*a*) The APS hydraulic system regulates the flow of high-pressure hydraulic oil between the hydraulic pump (C) and the P, Y, and roll actuator assemblies, maintaining the oil flow at a pressure between 2,800 and 3,200 psi.

(*b*) When the APS start command is given, the pump bypasses valve (JJ) is opened ((4) (*b*) and (*c*) below), and oil flows from the high-pressure side of the hydraulic pump (C) through the pump bypass valve and the accumulator oil reservoir (R), to the low-pressure side of the hydraulic pump. This action allows the APS to start in an unloaded condition.

(*c*) Once the hydraulic pump attains operating speed, the pump bypass valve is closed ((4) (*f*) and (*h*) below), and high-pressure oil is applied to the high-pressure switch (D) and the unloader valve (E). If

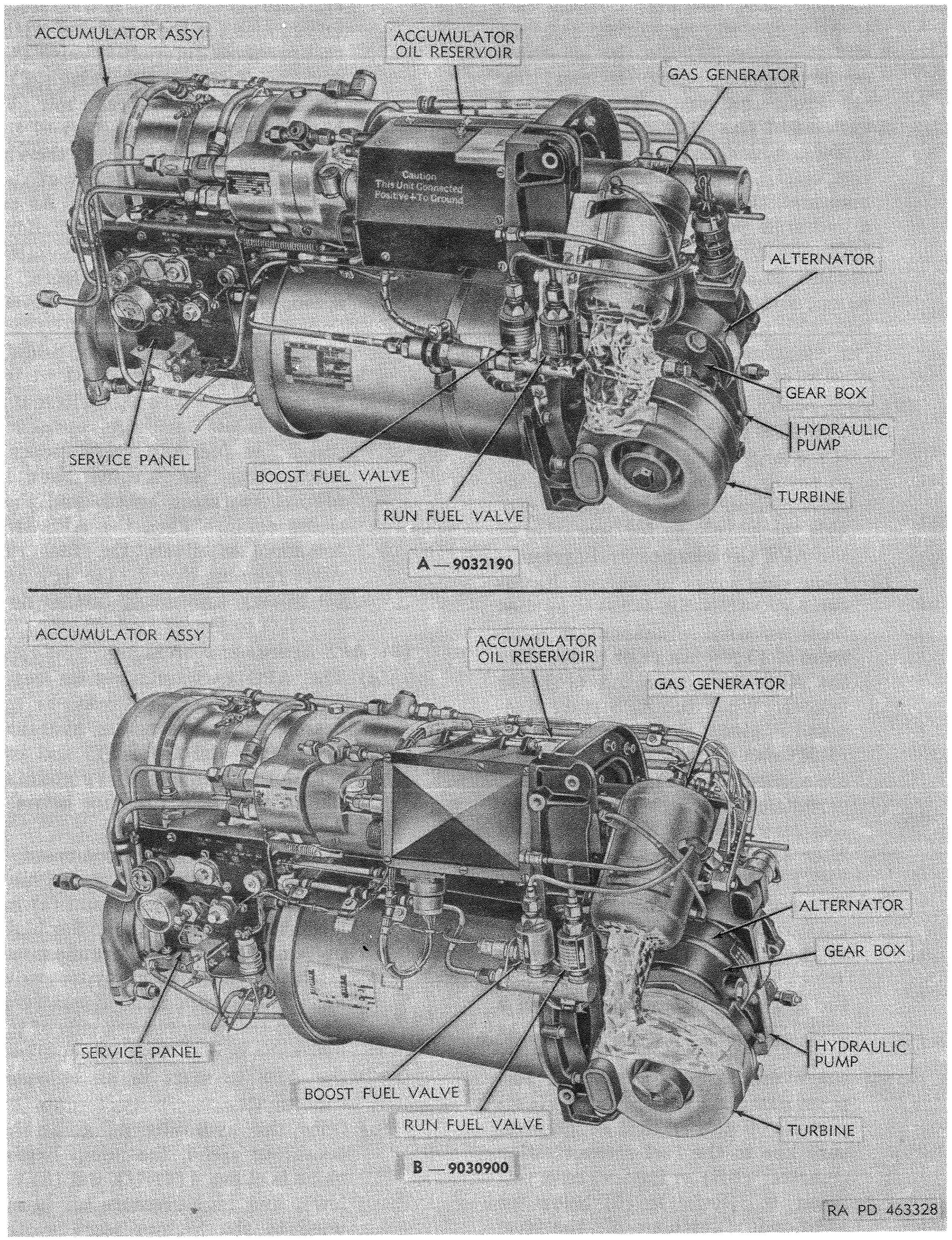


Figure 3-23 (U). Accessory power supply (U).

the oil pressure becomes greater than 3,200 psi, the high-pressure path through the unloader pilot valve (G) is closed, and the low-pressure path through the unloader pilot valve is opened, permitting low-pressure oil to enter the spring side of the unloader valve. The high-pressure oil on the other side of the unloader valve forces the unloader valve open, and the pressure is reduced by the flow of oil through the oil filter (HH) to the low-pressure line. If the oil pressure decreases to 2,800 psi, the high-pressure path through the unloader pilot valve is opened and the low-pressure path through the unloader pilot valve is closed, permitting high-pressure oil to enter the spring side of the unloader valve. The unloader valve closes and forces oil to be pumped into the oil accumulator (EE) until the oil pressure reaches 3,200 psi and the unloader valve opens as described above. If the oil pressure becomes greater than 3,450 psi, the high-pressure relief valve (H) bypasses oil to the low-pressure line through the oil filter. Thee high-pressure check valve (F) prevents backflow of oil. The function of the high-pressure switch is described in (4) (*l*) below.

(*d*) High-pressure oil from the unloader valve assembly is applied to the accumulator assembly. When the APS start command is given, the pilot valve lock (N) releases the accumulator shutoff pilot valve (M) which is closed ((4) (*b*) below), and held closed by the spring (QQ). This action relieves pressure from the spring side of accumulator shutoff valve A (K). When oil pressure on the high-pressure side of the valve is great enough, accumulator shutoff valve A is forced open, and oil flows to the oil accumulator (EE). The oil accumulator is a reserve source of high-pressure oil for peak load requirements. The pressurized air in the air accumulator (FF) acts as a surge absorber. A transfer passage through the accumulator piston (Q) passes high-pressure oil from the oil accumulator (EE) to a cavity between the rod of the accumulator piston (Q) and the differential piston (P). The differential piston keeps the oil in the accumulator oil reservoir (R) under constant pressure. The accumulator oil reservoir stores low-pressure oil for supply to the hydraulic pump (C). High pressure oil from the oil accumulator (EE) forces accumulator shutoff valve B (L) open, making high-pressure hydraulic oil available to the P, Y, and roll actuator assemblies. The low-pressure return path from the actuator assemblies is through the oil reservoir (AA) in the fuel reservoir assembly and the accumulator oil reservoir (R) to the low-pressure side of the hydraulic pump (C).

(*e*) When the APS stop command is given, the accumulator shutoff pilot valve (M) opens and is held open by the pilot valve lock (N) ((4) (*g*) and (*i*) below), allowing high-pressure oil to flow to the spring side of both accumulator shutoff valves (K and L). This action equalizes the pressure on both sides of the accumulator shutoff valves (K and L) permitting the springs to close the valves, thereby stopping the flow of oil through the oil accumulator (EE) to the P, Y, and roll actuator assemblies.

(4) *APS electrical control system.*

(*a*) The APS electrical control system (figs. 4-15, 4-16, or 4-17) controls the operation of the APS power system and the APS hydraulic system, and holds the frequency of the atternator at 400 ±40 cps after operation has begun. The APS start and stop commands applied to the

APS electrical control system originate in external equipment. Minor circuit differences between models exist, but operation is not affected. Unless otherwise stated, all information in subsequent paragraphs describing operation of the electrical control system applies to all three models.

Note. Paragraph (*b*) below applies to APS 9032190 and APS 9030900 prior to serial number 69–3632.

(*b*) When the APS start command is given, —28 volts is applied from external equipment to pilot valve lock solenoid L2 (D4, figs. 4–15 and 4–16). This action releases the accumulator shutoff pilot valve, which is then held closed by the spring ((3) (*d*) above). The APS start command also applies —28 volts through arm SAFETY SWITCH S1 and the closed contacts of relays K2 and K3 (deenergized) to run fuel valve solenoid L3, boost fuel valve solenoid L4, and pump bypass valve solenoid L5. Solenoids L3 and L4 open the run fuel valve and the boost fuel valve causing ET_hO to be sprayed into the gas generator ((2) (*b*) above). Solenoid L5 opens the pump bypass valve, permitting unloaded start of the APS ((3) (*b*) above).

Note. Paragraph (*c*) below applies to APS 9030900, serial number 69–3632, and subsequent.

(*c*) When the APS start command is given, —28 volts is applied from external equipment to pilot valve lock solenoid L2 (D4, fig. 4–17). This action releases the accumulator shutoff pilot valve, which is then held closed by the spring ((3) (*d*) above). The APS start command also applies —28 volts through arm SAFETY SWITCH S1, diode CR14, and then closed contacts of relays K1, K4, and K2 (deenergized) to run fuel valve solenoid L3, boost fuel valve solenoid L4, and pump bypass valve solenoid L5. Diode CR14 permits application of the APS start —28 volts to solenoids L3, L4, and L5 while blocking the APS internal —28 volts from the start circuit in the external equipment. Solenoids L3 and L4 open the run fuel valve and the boost fuel valve, causing ET_hO to be sprayed into the gas generator ((2) (*b*) above). Solenoid L5 opens the pump bypass valve, permitting unloaded start of the APS ((3) (*b*) above).

(*d*) Prior to the APS start command, 120 volts ac from the APS glow plug circuit in the external equipment is applied to the coil of glow plug relay K5 (B3, fig. 4–15, B3, fig. 4–16, and B3, fig. 4–17). In APS 9032190, the 120 volts ac is applied through glow plug thermal switch TS1. In APS 9030900, ac power ground is applied through the closed contacts of glow plug thermal switch TS1 and arm SAFETY SWITCH S1. In either APS, the respective actions energize K5 which applies 120 volts ac to APS glow plug HR1. When the glow plug reaches its operating temperature, glow plug thermal switch TS1 opens, deenergizing K5 and removing the 120 volts ac from the glow plug. At lift-off, all electrical power is removed from the glow plug; however, the heat generated by the decomposition of ET_hO within the gas generator during operation is sufficient to maintain the temperature of the glow plug.

(*e*) When the gases from the gas generator drive the turbine at its normal operating speed, a 3-phase ac voltage is developed by the alternator (A1, fig. 4–15, A1, fig. 4–16, and A1, fig. 4–17). The alternator supplies all internal voltages for operation of the APS electrical control circuit. Phase A is used within the frequency sensor, phase B is not used, and phase C is applied to the primary of stepdown transformer T1. The secondary of T1 is rectified by a bridge rectifier. The positive output of the rectifier is returned to control power ground and the negative output (—28v) supplies the operating voltage for the APS electrical control circuit.

Note. Paragraphs (*f*) and (*g*) below apply to APS 9032190, and APS 9030900 prior to serial number 69–3632.

(*f*) After the APS is started, the frequency sensor energizes frequency sensor relay K4 (B6, fig. 4–15, and B6, fig. 4–16) when the frequency of the alternator approaches 440 cps and deenergizes K4 when the frequency falls toward 360 cps ((*j*) through (*l*) below). When relay K4 is energized for the first time, relays K2 and K3 are energized and locked up through the contacts of K3. Relay K3 (energized) opens the circuit to boost fuel valve solenoid L4 and pump bypass valve solenoid L5, closing both valves for the remainder of the APS run ((2) (*b*) and (3) (*c*) above). Relay K2 (energized) removes run fuel valve solenoid L3 from the start circuit, and inserts L3 in the circuit through the normally closed contacts of relay K1 and frequency sensor relay K4. Thus, relay K4 controls the operation of L3 so that, before the alternator frequency reaches 440 cps, L3 is deenergized, closing the run fuel valve, and thereby causing turbine speed to decrease. Since alternator frequency is directly proportional to turbine speed, this action causes a decrease in alternator frequency. Before frequency falls to 360 cps, relay K4 causes L3 to again be energized, opening the run fuel valve, and thereby causing turbine speed and alternator frequency to increase. This cycle continues until the APS stop command is given.

(*g*) When the APS stop command is given, —28 volts is applied from external equipment to accumulator shutoff pilot valve solenoid L1 (D4, fig. 4–15 and D4, fig. 4–16), opening the accumulator shutoff pilot valve which is held open by the pilot valve lock, ((3) (*e*) above). Simultaneously, relay K1 is energized and locked up through its own contacts. Additional contacts of K1 open the circuit of run fuel valve solenoid L3 closing the run fuel valve, and stopping all flow of ET_hO to the gas generator ((2) (*b*) above).

Note. Paragraphs (*h*) and (*i*) below apply to APS 9030900, serial number 69–3632, and subsequent.

(*h*) After the APS is started, the frequency sensor energizes frequency sensor relay K4 (B6, fig. 4–17) when the frequency of the alternator approaches 440 cps, and deenergizes K4 when the frequency falls toward 360 cps ((*j*) through (*l*) below). When relay K4 is energized for the first time, relay K2 is energized by the APS start —28 volts and is locked up by the APS internal —28 volts through its own contacts. Relay K2 (energized) opens the circuit to boost fuel valve solenoid L4 and pump bypass valve solenoid L5, closing both valves for the remainder of the APS run ((2) (*b*) and (3) (*c*) above). Closed contacts of relay K2 (energized) also apply to APS internal —28 volts to the moveable contact of frequency sensor relay K4 through normally closed contacts of relay K1. Thus relay K4 controls the operation of L3 so that before the alternator frequency reaches 440 cps, L3 is deenergized, closing the run fuel valve, and thereby causing turbine speed to decrease. Since alternator frequency is directly proportional to turbine speed, this action causes a decrease in alternator frequency. Before frequency falls to 360 cps,

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relay K4 causes L3 to again be energized, opening the run fuel valve, and thereby causing turbine speed and alternator frequency to increase. This cycle continues until the APS stop command is given.

(*i*) When the APS stop command is given, —28 volts is applied from external equipment to accumulator shutoff pilot valve solenoid L1 (D4), which actuates the pilot valve lock, opening the accumulator shutoff pilot valve which is held open by the pilot valve lock ((3) (*e*) above). Simultaneously, relay K1 is energized only as long as the —28 volts is applied from external equipment. Additional contacts of K1 open the circuit of run fuel valve solenoid L3, closing the run fuel valve and stopping all flow of ET_hO to the gas generator ((2) (*b*) above). The holddown circuit of K2 is also opened by additional contacts of K1, which prevents —28 volt internal power from being applied to L3 after the stop command is released.

(*j*) The frequency sensor forms part of a closed loop automatic control system that holds the frequency of the alternator within 360 to 440 cps. The inputs to the frequency sensor are alternator frequency and oil pressure. As frequency sensor relay K4 is alternately energized and deenergized, the circuit of run fuel valve solenoid L3 is alternately opened and closed ((*f*) and (*h*) above). This action alternately opens and closes the run fuel valve, which governs the flow of ET_hO to the gas generator, and thereby the speed of the turbine and the frequency of the alternator.

(*k*) The phase A voltage of the alternator is applied across a tuned circuit formed by capacitor C1, inductor L1, and isolation resistor R3. The voltage developed across L1 is detected by diodes CR5 and CR6 and applied to input winding Z1 of the magnetic amplifier through an input network formed by resistor R4 and capacitor C2. The circuit described above forms a slope detector that causes the dc voltage applied to Z1 to be directly proportional to the alternator frequency. The phase A voltage of the alternator is also applied to the primary of transformer T2. The two secondaries of T2 provide a bias voltage for bias winding Z2 and a supply voltage for output winding Z4 of the magnetic amplifier. The bias voltage for Z2 is rectified by diode CR13, filtered by capacitor C3, and applied through variable resistors R1 and R2 and fixed resistor R5. The ac supply voltage for Z4 is applied directly to the center tap of Z4. Diodes CR11 and CR12 cause the current flow through Z4 to be in one direction only. However, the output of Z4 applied to the junction of diodes CR7 and CR10 is an alternating current, since the cathode of CR11 and the plate of CR12 are connected to the junction of diodes CR7 and CR10. Due to the action of the magnetic amplifier, the current flow in Z4 is directly proportional to the frequency of the voltage applied to the slope detector. The output current of Z4 is rectified by the bridge rectifier formed by diodes CR7 through CR10, and applied to the coil of frequency sensor relay K4. Feedback is provided from the bridge rectifier through resistor R6 to winding Z3 of the magnetic amplifier. The voltage applied to frequency sensor relay K4 is thus determined by the frequency of the input voltage to the slope circuit (alternator output voltage).

(*l*) Since the frequency sensor must hold the alternator frequency within limits, both when the hydraulic pump is loaded and when it is unloaded, the bias voltage of the magnetic amplifier is adjusted for both these conditions by means of variable resistors R1 and R2. In the APS hydraulic system, the high-pressure switch (D, fig. 4–13) is actuated by oil pressure between the hydraulic pump (C) and the unloader valve (E). As pressure increases, the switch is closed; when the unloader valve bypasses oil, pressure at the switch decreases, and the switch is opened. Variable resistors R1 and R2 (B5, fig. 4–15, 4–16, or 4–17) are adjusted so that when both are in the bias circuit (high-pressure switch open), the frequency sensor will hold within limits for the unloaded condition. Variable resistor R2 is thus the electrical equivalent of the loaded hydraulic pump, and is removed from the bias circuit by the high-pressure switch when the pump is actually in the loaded condition.

(5) *APS controls and indicators.* All controls and indicators of the APS are located on the service panel. The FUEL FILL, OIL FILL, and AIR FILL fittings are used during servicing of the APS. The ACC. AIR PRESS. gage indicates pressure in the air accumulator (FF, fig. 4–13). The lower scale of the gage is calibrated in psi and is used during operation to indicate the hydraulic pressure developed by the APS. The upper scale is calibrated in degrees Fahrenheit, and is used during air servicing to indicate when the air accumulator is pressurized to the required value for the existing ambient temperature. The HYD. RES. LEVEL indicator is calibrated in degrees Fahrenheit, and is used during oil servicing to indicate when the accumulator oil reservoir is filled to the required amount for the existing ambient temperature. The FUEL LEVEL indicator indicates the quantity of fuel in the fuel reservoir. The TRANSFER valve provides means of manually unloading the APS. When the TRANSFER valve is depressed, high-pressure oil flows from the fuel pressurization reservoir (BB, fig. 4–13) through the fuel pressure differential valve (U) to the low-pressure line. The decrease in pressure in the fuel pressurization reservoir (BB) causes the fuel pressurization check valve (CC) to open, allowing high-pressure oil to flow from the high-pressure line through the fuel pressurization reservoir (BB) and the fuel pressure differential valve (U) to the low-pressure line. This flow continues until the pressure differential across the fuel pressure differential valve falls to approximately 600 psi. The OIL BLEED valve provides means of removing hydraulic oil from the APS.

(6) *APS safety features.*

(*a*) Excessive pressure in the high-pressure hydraulic line is prevented by the high-pressure relief valve (H) which opens at 3,450 psi ((3) (*c*) above). Excessive pressure in the low-pressure hydraulic line is prevented by the oil relief valve (X) which opens at 170 psi and allows hydraulic oil from the low-pressure line to flow through the overboard dump. Excessive pressure in the fuel reservoir (V) is prevented by the fuel relief valve (Y) which opens at 900 psi and allows ET_hO to flow through the overboard dump.

(*b*) Arm SAFETY SWITCH S1 located on the service panel, is a 3-position, plunger-type interlock switch, spring loaded from the fully depressed position to center (safe) position. On APS 9032190, S1 is a single-pole switch; but on APS 9030900, S1 is a double-pole switch. When the APS SERVICE DOOR is properly closed, the shaft of S1 is in armed (fully depressed) position, closing the circuit to pump bypass valve solenoid L5 (D6, fig. 4–15, D6, fig. 4–16, and D6, fig. 4–17), boost fuel valve solenoid L4 and run fuel valve solenoid L3. On APS 9030900, with the shaft of S1 in the armed position, the circuit to glow plug relay K5 (C3, fig. 4-16 and C3, fig. 4-17) is also closed. When the APS SERVICE DOOR is opened, the plunger of S1 returns to the center (safe) position, opening the circuits described above. This action prevents the APS glow plug on APS 9030900 (B3, fig. 4-16 and B3, fig. 4-17) from being energized and on all three models, prevents the APS start command from opening the pump bypass valve (D6, fig. 4-15, D6, fig. 4-16, and D6, fig. 4-17), the boost fuel valve, and the run fuel valve. The maintenance (fully out) position of S1 completes the same circuits as in the armed (fully depressed) position, and allows the operational test (hot-run) of the APS with the APS SERVICE DOOR open.

e. Hydraulic Pumping Unit (HPU).

Note. Refer to figure 4-14 for the hydraulic schematic of the HPU.

(1) *General.* The hydraulic pumping unit (HPU) is a battery-powered mechanism that provides hydraulic power for operation of the P, Y, and roll actuator assemblies. The HPU start command is applied automatically through the launching set during the firing sequence. The HPU power system utilizes an HPU squib battery (4, fig. 3-24) to power a dc motor (3). The motor, in turn, drives a hydraulic pump (2). The power system also provides circuits to start the HPU, to monitor battery temperature, and to provide for ground operation of the unit. The HPU hydraulic system regulates hydraulic pressure developed by the pump.

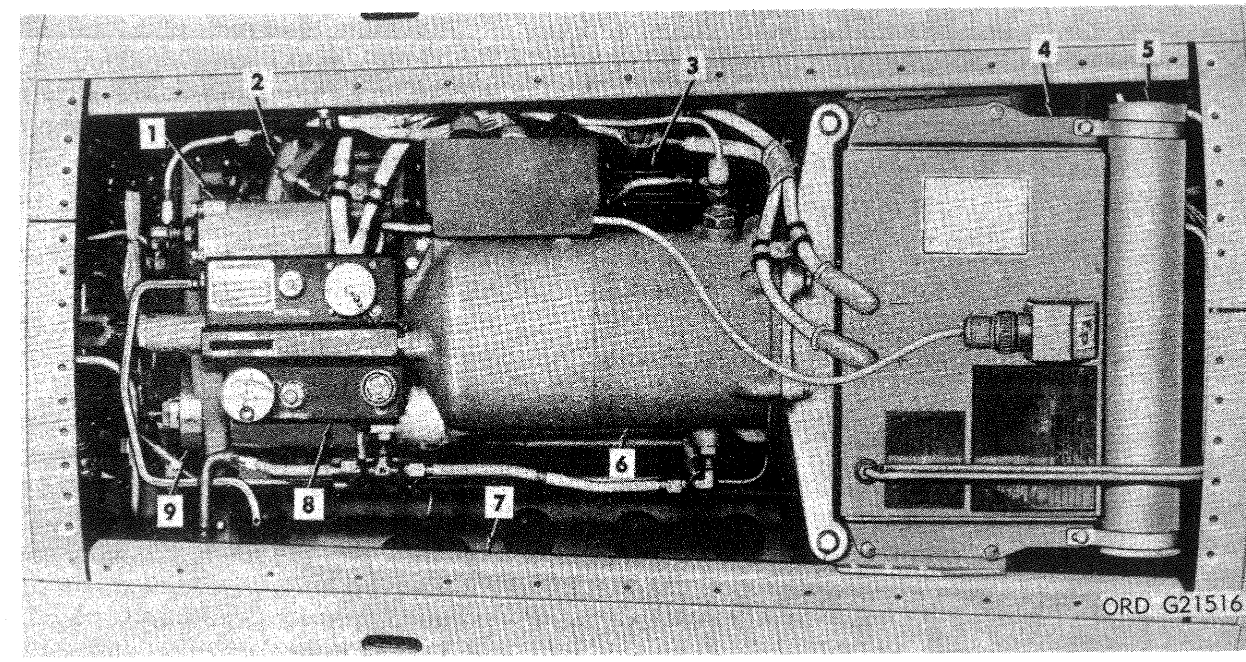
(2) *HPU power system.*

(*a*) The HPU utilizes a 28 volt dc HPU squib battery (4), capable of supplying a maximum of 200 amperes at 31.5 volts to operate a dc motor (3) which drives a hydraulic pump (2). The battery squibs (D7, fig. 4-18), are activated by 120 volt, 400-cps power from the launching set when the fire command has been given. Upon activation of the squibs, gas-generated pressure ruptures discs inside the battery and forces electrolyte through a manifold into the cells, activating the battery. Within 1.5 seconds after the battery is activated, full power is supplied to the motor.

(*b*) The 28 volt dc start command is supplied through pin A of connector P143, closing the contacts of relay K513. The battery squibs are activated by 120 volt, 400-cps power applied through pin D of connector P143. Battery current actuates the squib-activated switch inside the battery, completing a circuit to illuminate the appropriate HEAT MONITOR indicator light on both the launcher control-indicator and the section control-indicator.

(*c*) Current to power the heaters is supplied by an external power source. The heater thermostats maintain the electrolyte container temperature at 115° ±8°F. The heater thermostats close when the electrolyte container temperature decreases to 100° ±8° F. If the temperature decreases to 100° ±8° F, the appropriate HEAT MONITOR indicator light illuminates on both the launcher control-indicator and the section control-indicator.

(*d*) During ground operation, the HPU is supplied power from an external power source through connector J546. A motor temperature switch and an oil temperature switch in the low-pressure accumulator (6, fig. 3-24) are also provided for ground operation. If the oil temperature exceeds 195° ±5°F, the oil temperature switch opens, automatically turning off the external power. If the motor temperature exceeds the



1—Manifold assembly
2—Pump
3—Motor
4—HPU squib battery
5—Ventilator assembly
6—Low-pressure accumulator
7—Equipment section
8—Indicator panel
9—High-pressure accumulator

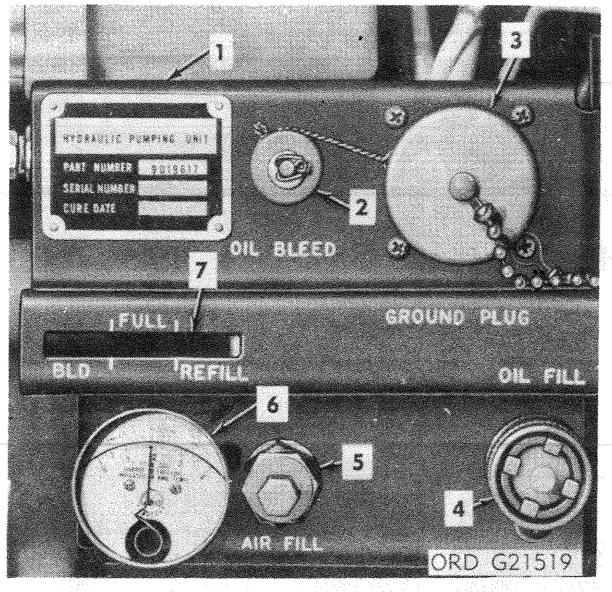
Figure 3-24 (U). Hydraulic pumping unit (HPU) (U).

motor temperature switch cut-in temperature (302°F minimum), the motor switch opens, automatically turning off the external power.

(3) *HPU hydraulic system.*

(*a*) The hydraulic system of the HPU (fig. 4-14) regulates the flow of high-pressure oil between the hydraulic pump (2) and the P, Y, and roll actuator assemblies maintaining the oil flow at a pressure of 2,700 to 3,200 psi.

(*b*) The low-pressure accumulator (6) contains a differential area piston (air on one side, oil on the other) which provides the pump (2) with a pressurized oil supply. The hydraulic oil in the low-pressure accumulator absorbs a portion of the heat generated by the hydraulic system during HPU operation. Immediately after the HPU is started, oil is transferred by the pump (2) from the low-pressure accumulator (6) to the high-pressure accumulator (9), making high-pressure oil available to the P, Y, and roll actuator assemblies. The hydraulic reservoir level indicator (7, fig. 3-25) moves from the FULL to the REFILL area, and the accumulator air pressure gage (6) indication increases from the initial precharge pressure to 2,700 to 3,200 psi; the hydraulic reservoir level indicator (7) remains in the REFILL area during HPU operation. The high-pressure accumulator (9, fig. 3-24) stores hydraulic oil under pressure generated by the pump (2) so that oil pressure demands by the actuators may be satisfied. The high-pressure accumulator (9) also dampens pressure surge occurring



1—Indicator panel
2—OIL BLEED valve
3—GROUND PLUG
4—OIL FILL valve
5—AIR FILL valve
6—Accumulator air pressure gage
7—Hydraulic reservoir level indicator

Figure 3-25 (U). Hydraulic pumping unit—indicator panel (U).

from the pump (2). The high-pressure relief valve (fig. 4-14) relieves the pressure of the pump (2, fig. 3-24) if the pressure compensator, which maintains the pump (2) outlet pressure between 2,700 and 3,200 psi, fails to function properly. In case of pump (2) malfunction, the high-pressure relief valve (fig. 4-14) provides a 3,750-psi differential pressure at 2.5 gpm flow, bypassing oil to the low-pressure accumulator (6, fig. 3-24). The low-pressure relief valve (fig. 4-14) prevents oil pressure in the reservoir from exceeding 160 psi during servicing operations. The check valve prevents the high-pressure oil in the high-pressure accumulator (9, fig. 3-24) from rotating the pump (2) in reverse. After unit shutdown, the oil flows from the high-pressure accumulator (9) through the actuators to the low-pressure accumulator (6) by the application of buzz voltage; the hydraulic reservoir level indicator (7, fig. 3-25) moves to the FULL area and the accumulator air pressure gage (6) indicates the air precharge pressure, when the high-pressure accumulator (9, fig. 3-24) is completely depleted of oil.

(4) *HPU controls and indicators.* All controls and indicators for servicing and inspecting the HPU are located on the indicator panel (1, fig. 3-25). The accumulator air pressure gage (6) indicates the pressure of the air contained in the high- and low-pressure accumulators. The lower scale of the air pressure gage is calibrated in pounds per square inch and is used during operation to indicate the hydraulic pressure developed by the HPU. The upper scale is calibrated in degrees Fahrenheit and is used during air servicing to indicate when the air accumulator is pressurized to the required value for the existing ambient temperature. The hydraulic reservoir level indicator (7) indicates the quantity of oil in the air reservoir. It is divided into three areas: BLD, FULL, and REFILL. The OIL FILL valve (4) is used to connect an external oil supply for oil servicing. The OIL BLEED valve (2) is used during air and oil servicing to bleed air from the oil system and drain excess oil from the oil side of the low-pressure accumulator (6, fig. 3-24). The AIR FILL valve (5, fig. 3-25) is used to connect an air supply to precharge the HPU accumulators. The GROUND PLUG (3) is used to connect an external power supply to the HPU for ground operation.

3-11 (C). Warhead System

a. General. The warhead system consists of two safety and arming devices (fig. 3-26), an explosive harness, and a warhead. All detonations of the warhead are initiated by a burst voltage from the guidance set. Two identical paths are provided from the fail-safe control to the warhead, thereby increasing overall reliability of the warhead system.

b. Safety and Arming Device M30A1.

(1) The safety and arming device (fig. 3-26) is a plug-in, fuse-type mechanism that functions as a safety device and a detonator. As a safety device, it prevents detonation of the warhead until the missile is a safe distance from the launching area. As a detonator, it initiates detonation of the warhead.

(2) The safety and arming device consists of a delayed inertia switch, an electrical detonator, and a tetryl lead charge. In the disarmed (safe) condition, the delayed inertia switch opens the circuit from the fail-safe control and applies a short across the electrical detonator. This action prevents premature detonation of the warhead by the burst voltage from the fail-safe control or by stray voltages. The safety and arming device is armed during the boost period by the force of acceleration acting on the delayed inertia switch. Approximately 11 G's acceleration sustained for 2 seconds is required for commit to arm. The earliest possible arming time for the safety and arming device is approximately 3.4 seconds after lift-off. In the armed condition, the short is removed from the electrical detonator and the detonator is connected to the fail-safe control. In missiles 10206 through 11935, the explosive charge is ignited by the 240 volt dc burst voltage from the fail-safe control. In missiles 13001 and subsequent, the explosive charge is ignited by the 300 volt dc burst voltage from the fail-safe control. A functional description of the fail-safe control and associated circuits is contained in paragraph 3-6.

c. Explosive Harness. The explosive harness consists of two lead assemblies and each lead assembly contains two PETN relays. Detonation of the electrical detonators and tetryl lead charges in the safety and arming devices ignite the explosive harness. This harness serves as an explosive coupling between the safety and arming devices and the warhead.

d. Warhead T45 (M17). The warhead consists of approximately 20,000 cubical 140-grain steel fragments arranged in single and double layers around a 651-pound explosive charge and a warhead booster. The warhead booster consists of a PETN relay, primer cord lead, and tetryl booster pellets. These charges cause ac-

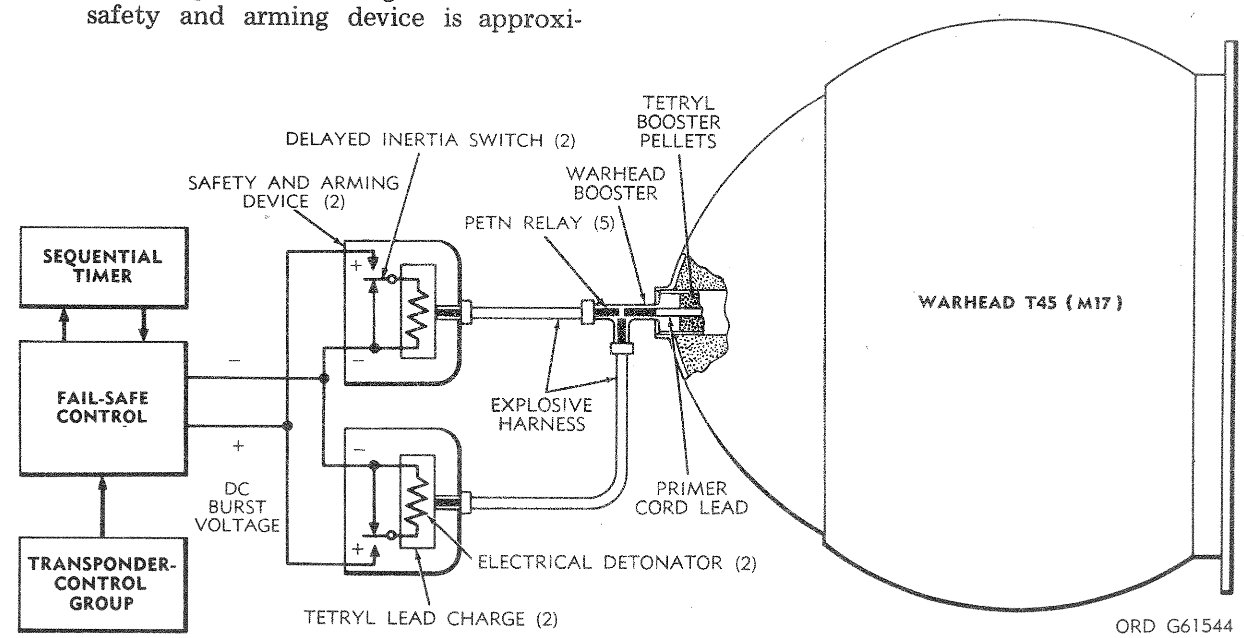


Figure 3-26 (C). Warhead system—block diagram (U).

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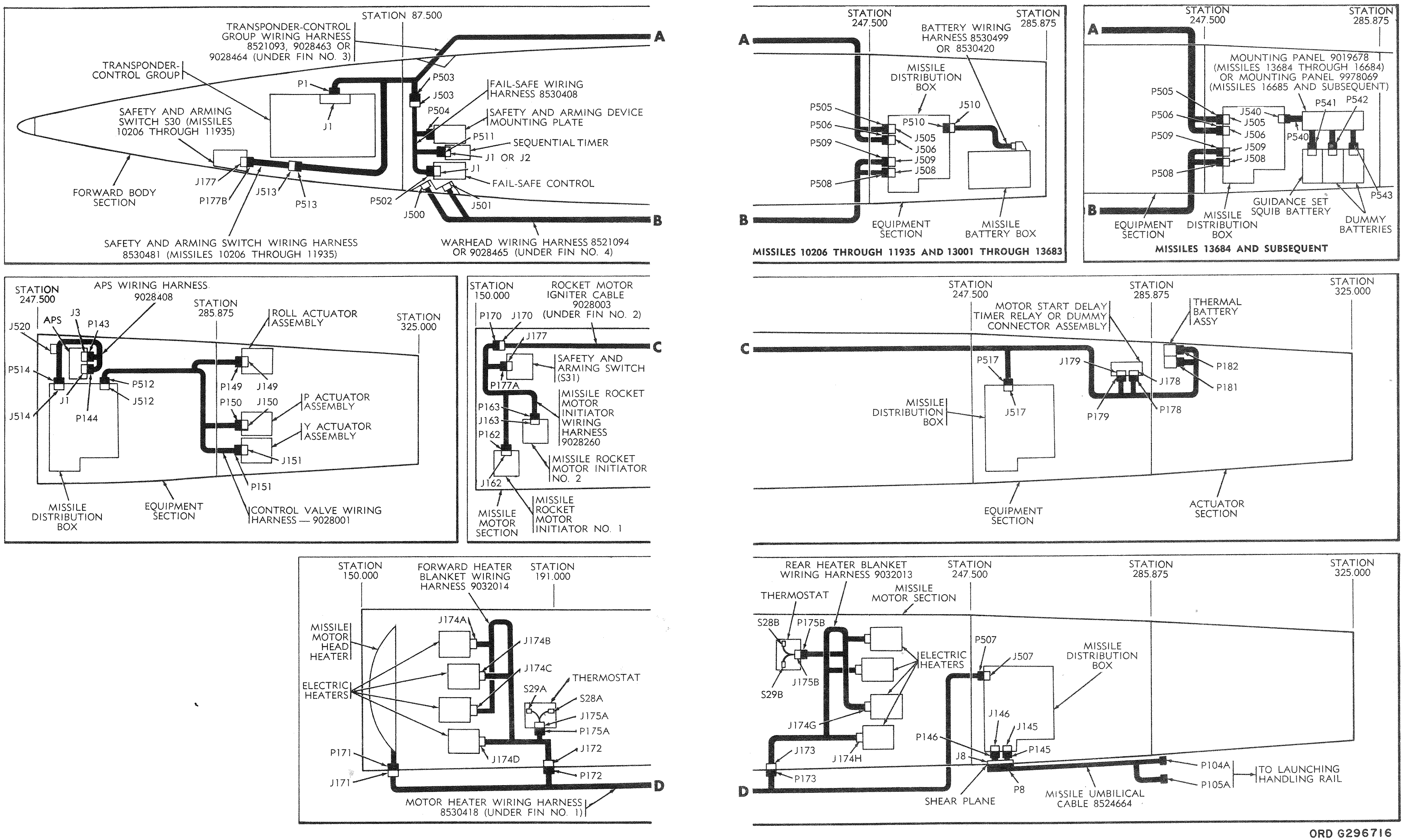

Figure 3-27 (C). Missile wiring harness—location of cables (U).

tual detonation of the warhead. Upon detonation, the fragment distribution is approximately spherical, with a conical dead zone in the rearward direction.

3-12 (C). Missile Guidance Set Batteries and Associated Equipment

a. Wiring Harness. The missile wiring harness provides the electrical connections for operation of the various systems and electrical components of the missile. For locations and connections of the various electrical components comprising the missile wiring harness, refer to table 3-2 and figure 3-27.

b. Missile Guidance Set Battery. In missiles 10206 through 11935 and 13001 through 13683, the missile guidance set battery (C1, fig. 4-19) in the missile battery box supplies −28 volts through the missile distribution box to the transponder-control group. Connectors P104A (A1) and P105A in the missile umbilical cable, connected to the missile guidance set battery through the missile distribution box, permit charging of the battery and monitoring of the battery output voltage.

c. Missile Guidance Set Battery Heater. The missile guidance set battery heater (A2, fig. 4-20) and thermostats S24 and S25 are included in the missile battery box to hold the battery temperature above +75°F, if the ambient temperature is below +75°F. When the temperature within the battery box becomes less than 75°F, thermostat S24 closes and connects the battery heater across phase A power. When the temperature becomes greater than +75°F, the thermostat opens. If the battery heater fails to operate, the temperature falls below +50°F, thermostat S25 closes, and the appropriate HEAT MONITOR indicator light illuminates on both the launcher control-indicator and the section control-indicator.

d. Missile Guidance Set Squib Battery (Missiles 13684 and Subsequent).

(1) The missile guidance set squib battery (B1, fig. 4-21) supplies −28 volts through the missile distribution box to the transponder-control group and to relay coils within the missile distribution box. The battery may be activated only once and supplies −28 volts only after it is activated. Two squibs (D1, fig. 4-22) within the battery provide a means of activating the battery and indicating that the battery has been activated.

(2) To activate the battery, relay K511 (D6) is energized by the external transfer relay power of −28 volts at fire command. Closed contacts 2-3 and 5-6 of relay K511 then apply APS glow plug 120 volt ac through resistor R508 or transformer T502 to the battery squib and to the squib in the squib activated switch. This causes the battery to be activated and the contacts of the squib activated switch to close. The closed contacts of the squib activated switch cause the appropriate HEAT MONITOR indicator light on both the launcher control-indicator and the section control-indicator to illuminate. Closed contacts 12 and 13 of relay K511 apply unfiltered −28 volt dc power from the transponder-control group, through pin 46 of connector P1 and through resistor R520, to provide a holding circuit for relay K511. The −28 volts is also applied directly to the transistor switch of delay timer relay K512. After 1¼ seconds, relay K512 energizes and applies the −28 volts through closed contacts 3-5 and 7-6 to transfer relays K3 and K4 in the transponder-control group (para 3-8*e*(1) (*b*)). The 1¼-second delay permits activation of the battery in an unloaded condition. Diode CR100 permits transfer relays K3 and K4 to be deenergized during missile electrical checkout by application of a ground to the external transfer relay power input.

Table 3-2 (C). Missile Wiring Harness—Cable Connections (U)

Cable	Connections
Missile umbilical cable 8524664	Connectors P104A and P105A connect to launching-handling rail connectors J104A and J105A, respectively, through shear plane connectors P8 and J8. Connectors P145 and P146 connect to missile distribution box connectors J145 and J146, respectively.
Transponder-control group wiring harness 8521093, 9028463, or 9028464	Connectors P505 and P506 connect to missile distribution box connectors J505 and J506, respectively. Connector P503 connects to fail-safe wiring harness connector J503. Connector P1 connects to transponder-control group connector J1. Connector P513 connects to safety and arming switch wiring connector J513 in missiles 10206 through 11935.
Battery wiring harness 8530499 or 8530420	Connects to the missile battery box. Connector J510 connects to missile distribution box connector P510 in missiles 10206 through 11935 and 13001 through 12683.
Warhead wiring harness 8521094 or 9028465	Connectors P508 and P509 connect to missile distribution box connectors J508 and J509, respectively. Connectors J500 and J501 connect to a bracket in the warhead body section (not used with HE warhead).
Rocket motor igniter cable	Connector P517 connects to missile distribution box connector J517. Connectors P178 and P179 connect to motor start delay timer relay connectors J178 and J179, respectively (missiles 10206 through 11935 and 13001 through 17026) or to the dummy connector assembly (missiles 17027 and subsequent). Connectors P181 and P182 connect to two thermal battery assembly connectors. Connector J170 connects to missile rocket motor initiator wiring harness connector P170.
Mounting panel 9019678	Connector P540 connects to missile distribution box connector J540. Connector P541 connects to the connector on the guidance set squib battery. Connectors P542 and P543 connect to connectors on warhead squib batteries or dummy batteries in missiles 13684 and subsequent.
Missile rocket motor initiator wiring harness 9028260	Connector P170 connects to rocket motor igniter cable connector J170. Connector P177A connects to safety and arming switch S31 connector J177A. Connector P162 connects to missile rocket motor initiator No. 1 connector J162. Connector P163 connects to missile rocket motor initiator No. 2 connector J163.
Thrust limiter squib wiring harness 9028027	Connectors are not connected to missiles 10206 through 11935.
APS wiring harness 9028408	Connector P514 connects to missile distribution box connector J514. Connectors P143 and P144 connect to APS connectors J3 and J1, respectively. Connector J520 provides a connection for APS winterization kit.
Control valve wiring harness 9028001	Connector P512 connects to missile distribution box connector J512. Connector P149 connects to roll actuator assembly connector J149. Connector P150 connects to P actuator assembly connector J150. Connector P151 connects to Y actuator assembly connector J151.
Motor heater wiring harness 8530418	Connector P507 connects to missile distribution box connector J507. Connector J171 connects to missile motor head heater connector P171. Connector P172 connects to forward heater blanket wiring harness connector J172. Connector P173 connects to rear heater blanket wiring harness connector J173.
Forward heater blanket wiring harness 9032014	Connector J172 connects to motor heater wiring harness connector P172. Connectors J174A, J174B, J174C, and J174D connect to four forward heater blanket connectors. Connector P175A connects to thermostat S28A and S29A connector J175A.
Rear heater blanket wiring harness 9032013	Connector J173 connects to motor heater wiring harness connector P173. Connectors J174E, J174F, J174G, and

Table 3-2 (C). Missile Wiring Harness—Cable Connections—Continued (U)

Cable	Connections
	J174H connect to four forward heater blanket connectors. Connector P175B connects to thermostat S28B and S29B connector J175B.
Fail-safe wiring harness 8530408	Connector J503 connects to transponder-control group wiring harness connector P503. Connector P504 connects to the safety and arming device mounting plate connector. Connector P511 connects to sequential timer connector J1 or J2. Connector P502 connects to fail-safe control connector J1.
Safety and arming switch wiring harness 8530481	Connector J513 connects to transponder-control group wiring harness connector P513. Connector P177B connects to safety and arming switch S30 connector J177 in missiles 10206 through 11935.

e. Missile Guidance Set Squib Battery Heater. A heater (D2, fig. 4-22), thermostat, and monitor thermostat are included in the guidance set squib battery to hold the battery temperature above +115°F. When the temperature within the battery becomes less than +115°F, the thermostat closes and connects the battery heater across phase A power. When the temperature becomes greater than +115°F, the thermostat opens. If the battery heater fails to operate and the temperature falls below +87°F, the monitor thermostat closes, and the appropriate HEAT MONITOR indicator light illuminates on both the launcher control-indicator and the section control-indicator. Under launching conditions, batteries BA-472 series must be maintained at correct operating temperature in order to supply full rated power when activated. The heating period required to raise the temperature of batteries BA-472 series from various ambient temperatures to the correct operating temperatures is shown in the graph in figure 3-28.

f. Missile Reject Circuit. The missile reject circuit (fig. 4-21) in the missile, in conjunction with the missile reject circuit in the launcher

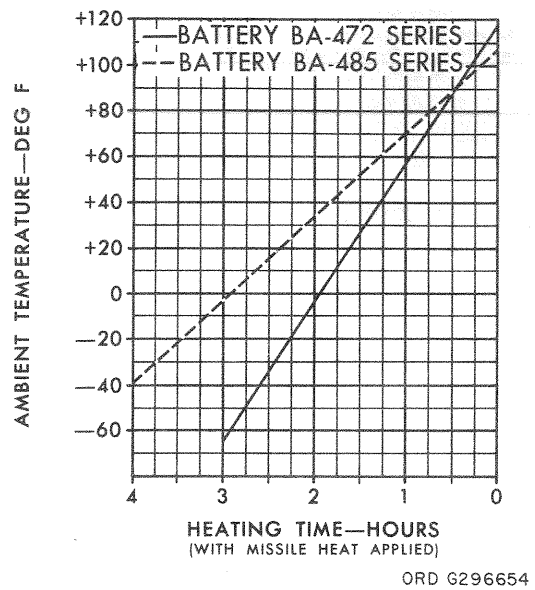

Figure 3-28 (U). Missile squib batteries heating period graph (U).

control-indicator, prevents launch of a missile with an inactive or improperly installed guidance set squib battery or with a malfunctioning APS or HPU.

(1) The −28 volt output of the guidance set squib battery (B1) is applied directly to relay K501, through dummy battery connector J542 (pins K to N) to relay K502, and through dummy battery connector J543 (pins K to N) to relay K510. If any of the three relays fail to energize, the output of the APS or HPU is not applied to the missile reject circuit in the launcher control-indicator. Thus, these relays prevent launching of a missile with an inactive guidance set squib battery or with improperly installed dummy battery connectors J542 and J543.

Note. Step (2) below applies to missiles with an APS only and step (3) below applies to missiles with an HPU only.

(2) With relays K501, K502, and K510 energized, the circuit from the phase A output voltage (D6) of the APS alternator to the missile reject circuit in the launcher control-indicator is completed. If the output voltage of the APS alternator, applied through these relays to the launcher control-indicator, does not reach a specified level within 2 seconds after the fire command, a rejection indication is given.

(3) With relays K501, K502, and K510 energized, the circuit from the pressure switch (A7, fig. 4-18) of the HPU to the missile reject circuit in the launcher control-indicator is completed. If the hydraulic oil pressure output of the HPU does not reach a specific level within 2 seconds after the fire command, the pressure switch is not activated and a reject signal indication is given.

g. HE Prepared Circuit. When the missile guidance set squib battery (B1, fig. 4-21), dummy battery connector J542, dummy battery connector J543, and connectors P540 and P504 (C6) are properly installed in a missile with warhead T45(M17) (HE warhead), the fail-safe ground from the transponder-control group is applied to the launcher control-indicator causing the W. H. TYPE-B-HE indicator light to illuminate. The safety and arming devices need not be installed to enable the W. H. TYPE-B-HE indicator light to illuminate.

h. Rocket Motor Heaters. The rocket motor heaters in the missile heater system hold the temperature of the missile rocket motor above +10°F if the ambient temperature is below +10°F. Eight electric heaters and one missile motor head heater surround the missile rocket motor. Three-phase 120/208 volt, 400-cps power from the launcher control-indicator is applied through the missile umbilical cable (B1, fig. 4-20) to the normally open contacts of heater relay K500 in the missile distribution box. When the temperature falls below +10°F, ac power ground is applied to relay K500 through the closed contacts of either of the parallel connected thermostats S28A and S28B, which are mounted on opposite sides of the missile motor section. Relay K500 then applies power to the rocket motor heaters until the temperature at both thermostats is above +10°F. The cycle will repeat itself as often as required. In order to equalize the load on the power source, three electric heaters are connected across phase A; three electric heaters are connected across phase C; two electric heaters and the missile motor head heater are connected across phase B. If the rocket motor heaters fail to operate, and the temperature falls below −5°F, parallel connected thermostats S29A (C6) and S29B (A6) close, and the appropriate HEAT MONITOR indicator light illuminates on both the launcher control-indicator and the section control-indicator.