32150K 04 7808

CDC 32150K

BOMB NAVIGATION SYSTEMS MECHANIC

(ASB 9A/16)

(AFSC 32150K)

Volume 4

RDPS and Radar

Extension Course Institute

Air University

Prepared by

Msgt JAMES F. BENNETT
3450th Technical Training Group (Avionics)
3400th Tech Tng Wing (ATC)
Lowry AFB, Colorado 80230

Reviewed by

Daniel H. McCalib, Education Specialist
Extension Course Institute (AU)
Gunter AFS, Alabama 36118

PREPARED BY
3450TH TECHNICAL TRAINING GROUP
3400TH TECHNICAL TRAINING WING (ATC)
LOWRY AIR FORCE BASE, COLORADO

EXTENSION COURSE INSTITUTE, GUNTER AIR FORCE STATION, ALABAMA

Preface

THIS FOURTH volume of CDC 32150K has been designed to incrase your knowledge of the bomb navigation radar data presentation set and radar. The areas included are the power distribution, signal generation and control, display circuits, transmitter circuits, receiver circuits, terrain avoidance, and the various normalization circuits. In each of these areas, as appropriate, you will learn the theories, data flow, alignment, and maintenance of the system.

This information will expand your knowledge of the BNS system. It is not designed to replace the technical order but to enhance your ability to use relevant technical manuals. Extra emphasis has been placed on those areas of the system which have been identified as having increased workloads or weak knowledge areas by personnel in your career field.

Please note that in this volume we are using the singular pronoun *he, his,* or *him* in its generic sense, not its masculine sense. The word to which it refers is *person.*

Foldout 1 is printed and bound at the back of this volume.

If you have questions on the accuracy or currency of the subject matter of this text, or recommendations for its improvement, send them to 3400 TCHTW/TTGOX, Lowry AFB CO 80230. NOTE: Do not use the suggestion program to submit corrections for typographical or other errors.

If you have questions on course enrollment or administration, or on any of ECI's instructional aids (Your Key to Career Development, Behavioral Objective Exercises, Volume Review Exercise, and Course Examination), consult your education officer, training officer, or NCO, as appropriate. If he can't answer your questions, send them to ECI, Gunter AFS AL 36118, preferably on ECI Form 17, Student Request for Assistance.

This volume is valued at 36 hours (12 points).

Material in this volume is technically accurate, adequate, and current as of January 1978.

Contents

NOTE: In this volume, the subject matter is developed by a series of Learning Objectives. Each of these carries a 3-digit number and is in boldface type. Each sets a learning goal for you. The text that follows the objective gives you the information you need to reach that goal. The exercises following the information give you a check on your achievement. When you complete them, see if your answers match those in the back of this volume. If your response to an exercise is incorrect, review the objective and its text.

Power Distribution

THE RADAR data presentation set (RDPS) and radar set combine in enabling a B-52 to see. There are other systems which aid in this respect, but their range is more limited.

In the G3ABR32130K Course you have been taught the fundamentals of the RDPS and radar. In this volume you will study more of the operation of these circuits. Since you are on OJT and now working with the system itself, you should find the data explained here much more job related.

First to be discussed is power development and distribution. Second, we take up the RDPS; third, the radar transmitter and receiver circuits; and fourth, the terrain avoidance (TA) system.

Planned modifications to the B-52 avionics systems call for the basic radar system currently in use to be retained. A large portion of the typical BNS workload falls in this area. You should, therefore, strive for an understanding of the theory and operation of the circuits discussed in this volume.

1-1. RDPS and Radar Power Supplies

The RDPS and radar power supplies provide the necessary dc voltages for the various radar and RDPS units. The power supplies can be grouped into two groups: (1) the oil-cooled power supplies, used with the ASB-16 bombing navigational systems (BNS), and (2) the air-cooled power supplies, used with the ASB-9A bombing navigational system.

Although most of the power supplies are labeled RDPS or presentation, you should realize they also provide the necessary dc voltages for the radar system. The only exception is the radar 120-volt power supply, which will be discussed later in the text.

In this section you will learn the operating principles and the theory of operation of both the oil-cooled and the air-cooled power supplies. The importance of the power supplies is much greater than the simple circuits used would indicate. Why? Because none of the circuits to be discussed in this volume could operate without the power from these power supplies. You should also keep in mind that the loss of a single dc power voltage results in many units failing to perform their required functions. For this reason, when many system units appear to have failed, you should first check the system power supply outputs.

600. Clarify the circuits and operation of the oil-cooled power supplies used on the ASB-16 by identifying specific voltage changes and components involved in or parts of these power supplies.

Oil-Cooled Power Supplies. The oil-cooled presentation power supplies are: (1) the +150-and +300-volt power supply, (2) the –150-and –300-volt power supply, and (3) the 600-volt power supply. These power supplies provide plate, screen, and grid bias voltages used throughout the RDPS and radar sets of the ASB-16 bombing navigational systems.

+150- and +300-volt power supply. This unit consists of a power supply section for both the +150 and the +300-volt outputs and two filter amplifier sections. One filter amplifier is used with the +150-volt output, while the other filter amplifier is used with the +300-volt output. A liquid-cooled rectifier well separates the two power supplies. Each power supply (see fig. 1-1) has its own transformer, saturable reactor, rectifier, filter, buck-booster transformer, electronic filter, and control amplifier. However, both power supplies receive 3-phase unregulated input power through contacts of the –150-volt interlock relay, K201 within the power supply.

When –150 vdc is applied to interlock relay K201, 115 vac, 3-phase, 400 Hz power is applied through K201's energized contacts to the primaries of transformers T201 and T202. Transformer T201 provides 3-phase input power through reactance windings of L203 to the +300-volt full-wave bridge rectifier. The output of the +300-volt full-wave bridge rectifier is filtered by an LC filter and then applied to

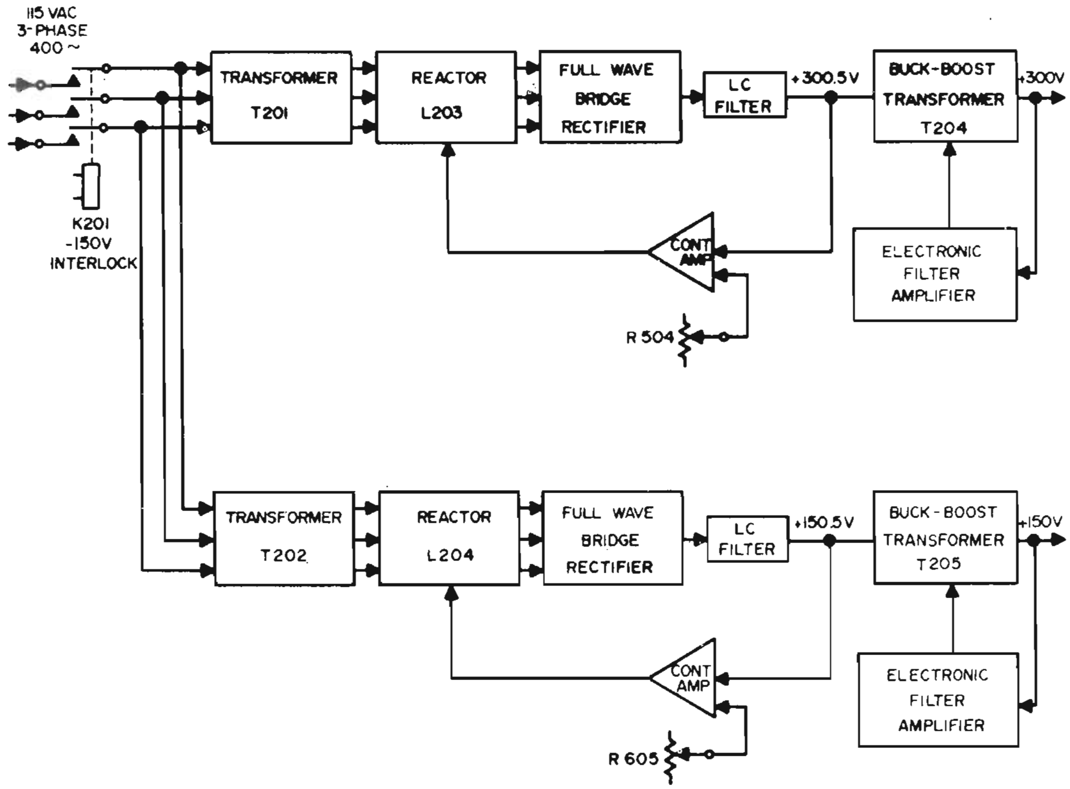

Figure 1-1. +150- and +300-volt power supply.

buck-boost transformer T204. A sample of the LC filter output is supplied as an input to the +300-volt control amplifier the output of which is sent to reactor L203 in figure 1-1. The control amplifier input to L203 controls the reactance of the reactor windings through which the 3-phase power passes. Thus, the 3-phase power input to the bridge rectifier is controlled to provide a constant output of +300.5 volts from the LC filter.

The buck-boost transformer drops 0.5 volt dc and provides an output of +300 volts to the presentation and radar circuits. To further reduce the ripple in the +300 volt output, an electronic filter amplifier samples the ripple content of the +300 volt output and provides an out-of-phase signal to T204. This out-of-phase signal applied to T204 reduces the ripple content in the +300 volt output to provide an almost ripple-free output. Potentiometer R504 provides a means of adjusting the +300 volt output to precisely 300 volts.

The +150-volt power supply circuits operate in an identical manner to that of +300-volt power supply circuits, with the exception of the transformer ratio of T202. The output from T202 is approximately 135 volts RMS, compared to an output of 245 volts RMS from transformer T201. You adjust the +150 volt output with potentiometer R605.

-150- and -300-volt power supply. The -150- and -300-volt power supply unit is almost identical with the +150- and +300-volt power supply unit. The primary differences lie in the component reference designators, the interlock relay circuit, and the output connections.

The reference designators (see fig. 1-2) in the -150- and -300-volt power supply are of the 300 series instead of the 200 series. This means that transformer T301 is the same as transformer T201 in the +150- and +300-volt power supply. The only components that are not renumbered are those on the two filter amplifiers, which remain with 500 series numbers in the 300-volt portion and 600 series numbers in the 150-volt portion.

Interlock relay K301 within the power supply (see fig. 1-2) is operated by the negative 300-volt output voltage through dropping resistor R301. When K301 is energized, 115-vac, 3-phase, 400-Hz power is applied to the -150-volt power supply input power transformer through the energized contacts of K301. Remember that K201 in figure 1-1 was energized by the -150-volt input. Consequently, if the -300-volt power is missing due to malfunction, K301 cannot energize, no -150-volt power is developed, and K201 does not energize. Failure to energize K201 results in no +150 and no +300 voltages. The purpose of these two interlock relays is to prevent damage to radar and RDPS components by preventing application of plate and screen voltages when no negative bias voltages are available.

The last difference existing between the positive and the negative power supplies lies in the output circuit connections. To obtain negative outputs, the ground and output connections are reversed for both the 300-volt and the 150-volt power supplies. Reversing these connections provides −300 volts from the 300-volt power supply and −150 volts from the 150-volt power supply. With the exception of these changes, the circuit operation is identical for both the positive and the negative 150- and 300-volt power supplies.

600-volt power supply. The 600-volt power supply is used to supply plate power to the current deflection amplifier power output stages. The 600 volts is applied to the deflection coils of the topographical comparator and the azimuth and range indicator, while the deflection coils are the plate loads for the current deflection amplifier stages.

The presentation 600-volt power supply provides filtered, bridge-rectified power. Input transformer T101 has a single 3-phase core. The primaries are connected in delta, but the secondaries are connected in wye. This provides a higher voltage output at reduced current. Provisions are made on the secondaries for taps at 570-volt, 620-volt, and 670-volt minimum output.

Three dual, self-saturable reactors (L101A, L101B, and L101C) receive the 3-phase excitation and apply it to a full-wave rectifier bridge CR101. The control windings of one side of these reactors are connected in series with the output load current. Regulation is obtained in this manner for load current changes. The other control windings of reactors L101A, L101B, and L101C, are shunted by resistors R103, R102, and R101, respectively, and are connected in series with a resistor R104 and a potentiometer R105 across the unfiltered 600-volt output. Bias current in the reactor is set by R105 and is used thereafter as a regulation reference. A total of six reactors are used in this manner to compensate for current demand. Choke L102 and capacitor C102 form the ripple filter. A coolant is circulated around the rectifier assembly (placed in a well within the supply) to prevent overheating.

This power supply has a maximum output of 0.96 ampere, required when both the azimuth and range indicator and the topographical comparator are used. If just the former is used, a minimum of 0.27 ampere is required. All unrequired portions of the input excitation are absorbed by the reactors, as governed by output current demand. Input voltage variations cause output voltage variations in direct relationship to the transformation ratio.

The 570-volt taps are used in the system, giving the power supply an output range of 570 to 700 volts, and averaging 635-vdc output after regulation and filtering. The adjustment of these taps and potentiometer R105 must be made only at the depot.

Exercises (600):

1. **Give the voltage drop through the buck-boost transformer in the +150/+300-vdc power supply.**

2. **Loss of the −300 volts results in the loss of several other RDPS voltages. Identify them.**

3. **Name the components which cause the secondary loss of voltages described in exercise 2.**

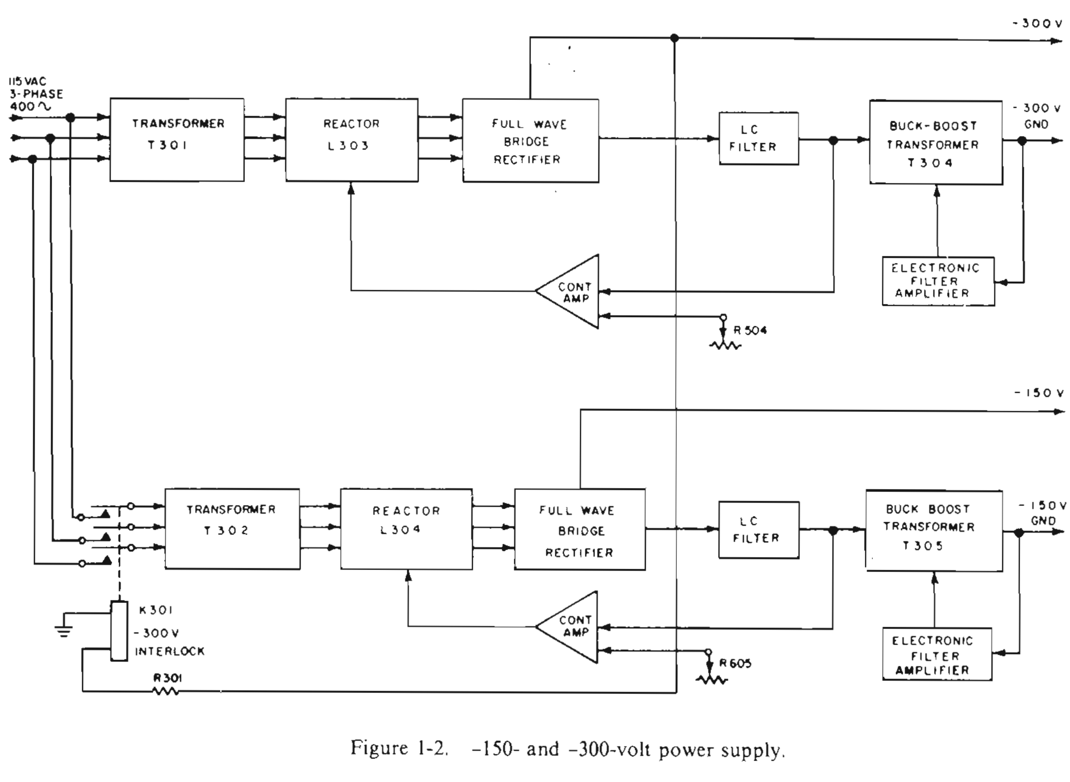

Figure 1-2. −150- and −300-volt power supply.

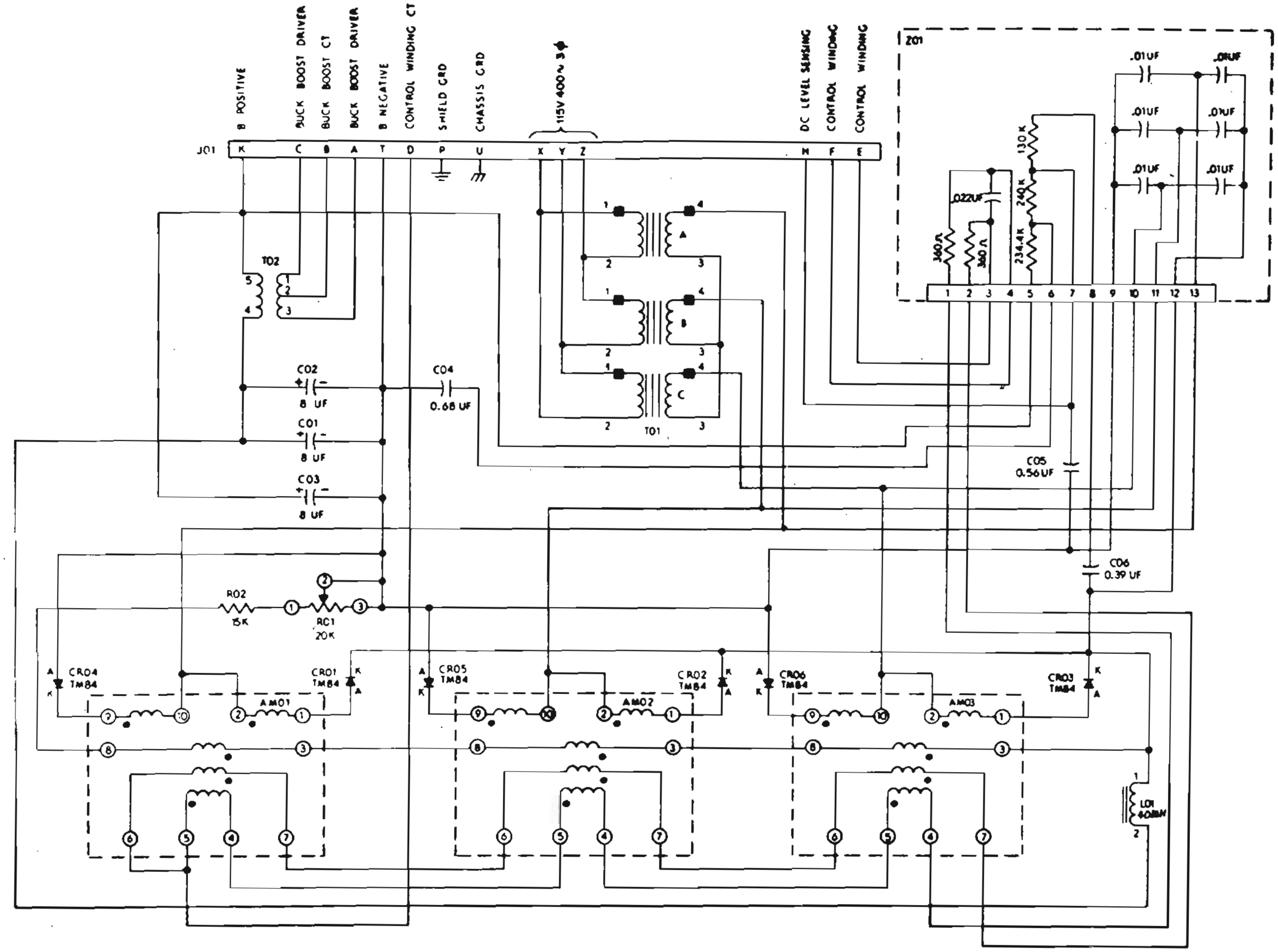

Figure 1-3. 150-volt power supply.

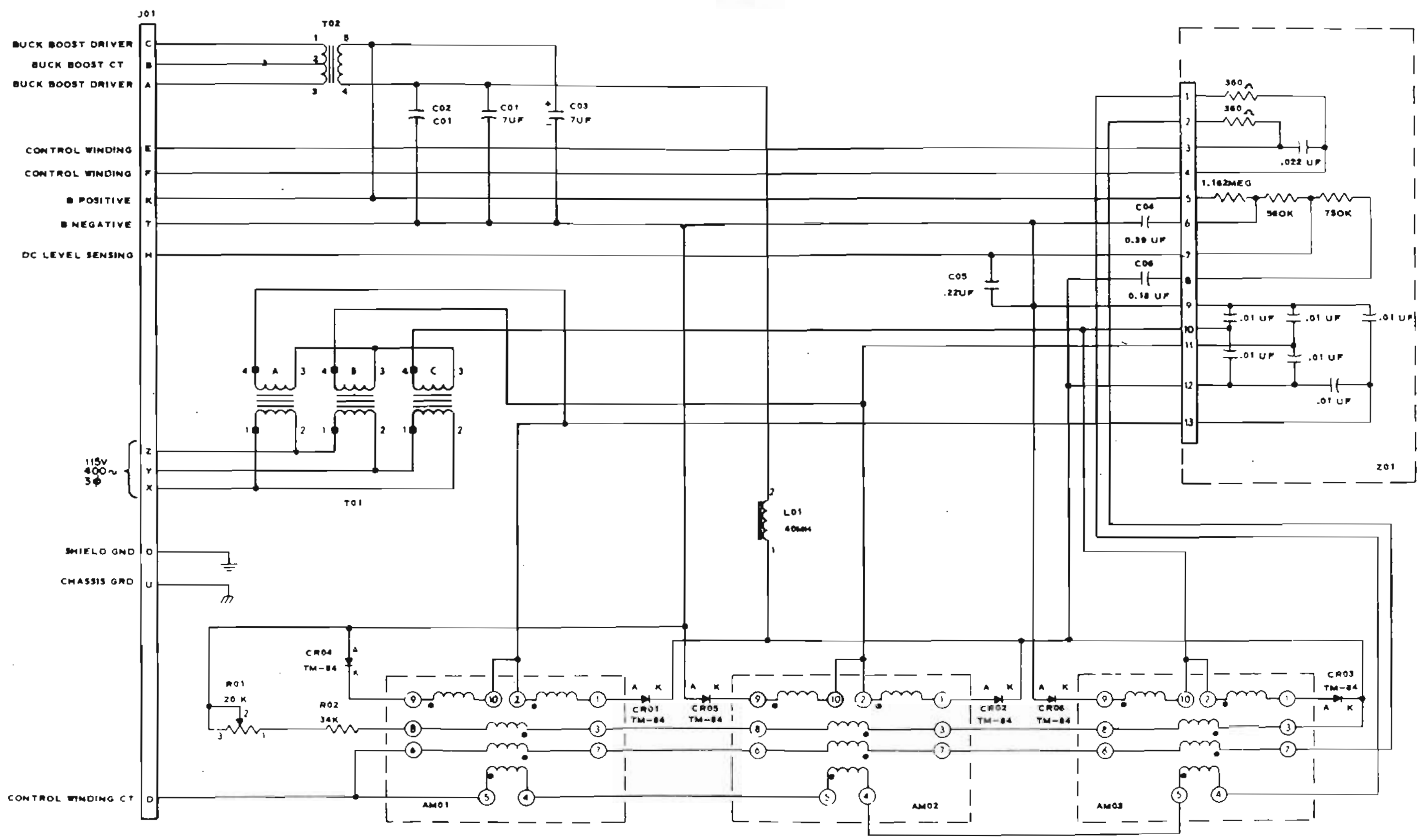

Figure 1-4. 300-volt power supply.

4. Specify the use of the 600-volt power supply output.

5. Cite the type of transformer connection used in the power input circuit of the 600-volt RDPS power supply.

6. In the following exercises match the power supplies listed in column B to the factual statements in column A. More than one column B answer may fit a column A statement.

	Column A	Column B
____ a.	Utilizes a liquid-cooled rectifier well.	1. +150/+300 volt.
____ b.	Component parts use a 300 series reference designator.	2. −150/−300 volt.
____ c.	Internal potentiometer R605 adjusts one of the outputs.	3. 600 volt.
____ d.	Supplies plate power to the current deflection amplifier.	
____ e.	The regulator reference is established by adjusting the bias current to the reactor.	

601. Examine the air-cooled power supplies of the ASB-9A system by identifying components and selected characteristics and giving chosen uses of these components.

Air-Cooled Power Supplies. As in the computer group, the air-cooled power supplies used in the ASB-9A system are cooled by natural connection. Two identical 150-volt power supplies are used to develop the +150 volts and the −150 volts required by the radar and RDPS. The same operational features hold true for the positive and negative 300 volts. The reversal of the power supply output is accomplished by simply reversing the output connections within the power supply itself.

150-volt power supply. A schematic diagram of the 150-volt power supply is provided in figure 1-3. As shown, the 3-phase, 400-Hz, 115-volt input power is applied to transformer T01, which provides three outputs of 135 volts RMS through the reactance windings of magnetic amplifiers (AM01, AM02, and AM03) to six silicon diodes. These six silicon diodes (CR01 through CR06) form a full-wave 3-phase bridge rectifier the 150-volt output of which is applied across filter capacitors C01, C02, and C03. To aid the filter capacitors in reducing the output ripple, buck-boost transformer T02 is used with an external filter amplifier. This filter amplifier is discussed separately later in this ofjective, since it is a separate unit.

Because the rectifier diodes are silicon junction diodes, they have sharp turn-on and turn-off characteristics which can introduce high-frequency ripple components unless suppressed. Suppression of these ripple components is accomplished by using six 0.01μf capacitors, all located in Z01, as shown in figure 1-3. These six capacitors are connected across six series combinations of a diode rectifier and a reactance winding of a magnetic amplifier.

The three magnetic amplifiers have their control windings (windings between terminals 4 and 5) connected in series and driven by an external regulator amplifier. As with the filter amplifier, this regulator amplifier is discussed separately later in this objective, since it is a separate unit. The regulator amplifier senses the 150-volt output level and controls the reactance of the six magnetic amplifier reactance windings. This controls the level of ac applied to the rectifier diodes and, thus, the 150-volt output.

Adjustment of the 150-volt output is accomplished with resistor R01 during depot level maintenance. Resistor R01 controls the magnetic amplifier bias current through the bias windings between terminals 3 and 8 of the magnetic amplifier. As with the control winding current, the bias winding current controls the reactance of the reactance windings and, thus, the power supply output.

300-volt power supply. An examination of the 300-volt power supply schematic in figure 1-4 will reveal very few differences from the 150-volt power supply just discussed. Checking the connections of T01 in figure 1-4 you can see a delta-to-wye connection instead of the delta-to-delta connection seen in figure 1-3. This delta-to-wye transformer connection provides a 245-volt RMS output for the 300-volt power supply instead of the 135-volt RMS output obtained by the delta-to-delta type of connection in figure 1-3. This higher RMS voltage is required to produce the 300-volt dc output. The only other difference between the 150-volt and 300-volt power supplies lies in the filter capacitor values. These values are smaller in the 300-volt power supply due to the lighter load current drawn from the power supply. The external filter and regulator amplifiers used with the 300-volt units are identical with those used with the 150-volt units.

Power supply regulator amplifier. As illustrated in figure 1-5, the dc level of the output of the RDPS (either 150 volts or 300 volts) magnetic unit power supply is sensed by an associated power supply regulator amplifier. This voltage level is converted to two push-pull dc levels and amplified by phase splitter and voltage amplifier V403402. The two outputs of this stage are individually amplified by voltage amplifiers V403403A and V403403B. The outputs are then amplified further by power amplifiers V403404 and V403405, which supply current to the series-connected control windings of magnetic amplifiers AM403401 through AM403403 (in the power supply). (For simplification, in this illustration, the three magnetic amplifiers are represented collectively as one.) These control winding voltages will then either add to or subtract from the voltage being supplied by the transformer and rectifier. Any change in the dc

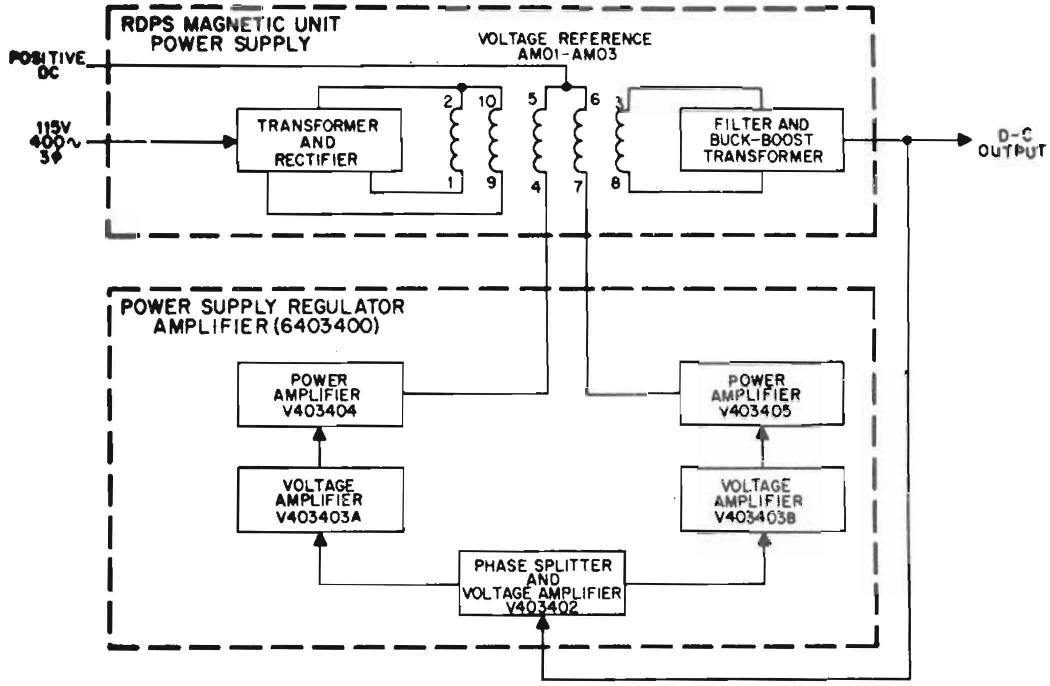

Figure 1-5. Power supply regulator amplifier.

level of the output is thus compensated for by this regulating action. The resultant output of the magnetic amplifiers is filtered by the filter and buck-boost transformer and then becomes the final output of the power supply.

Power supply filter amplifier. The filter amplifier (fig. 1-6) receives an input consisting of any ripple that is present in the dc output of the power supply. The ripple signal is converted into two push-pull signals (180° out of phase with each other) by phase splitter/voltage amplifier V403501. This stage also amplifies both signals. Finally the two ripple signals are amplified by power amplifiers [V403504A and V403504B], and applied to a buck-boost transformer

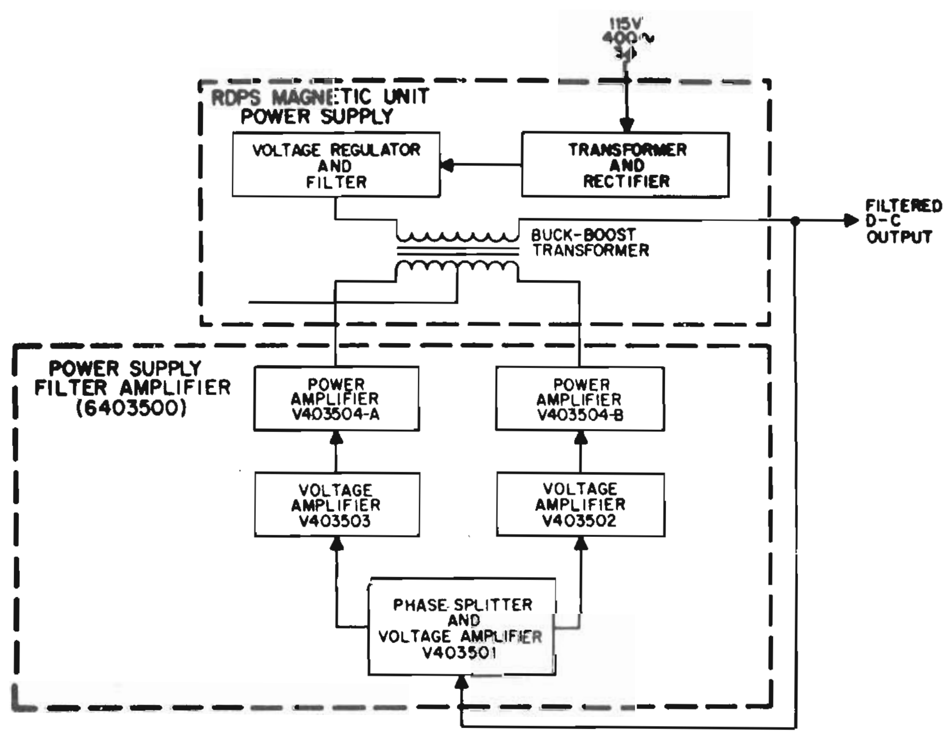

Figure 1-6. Power supply filter amplifier.

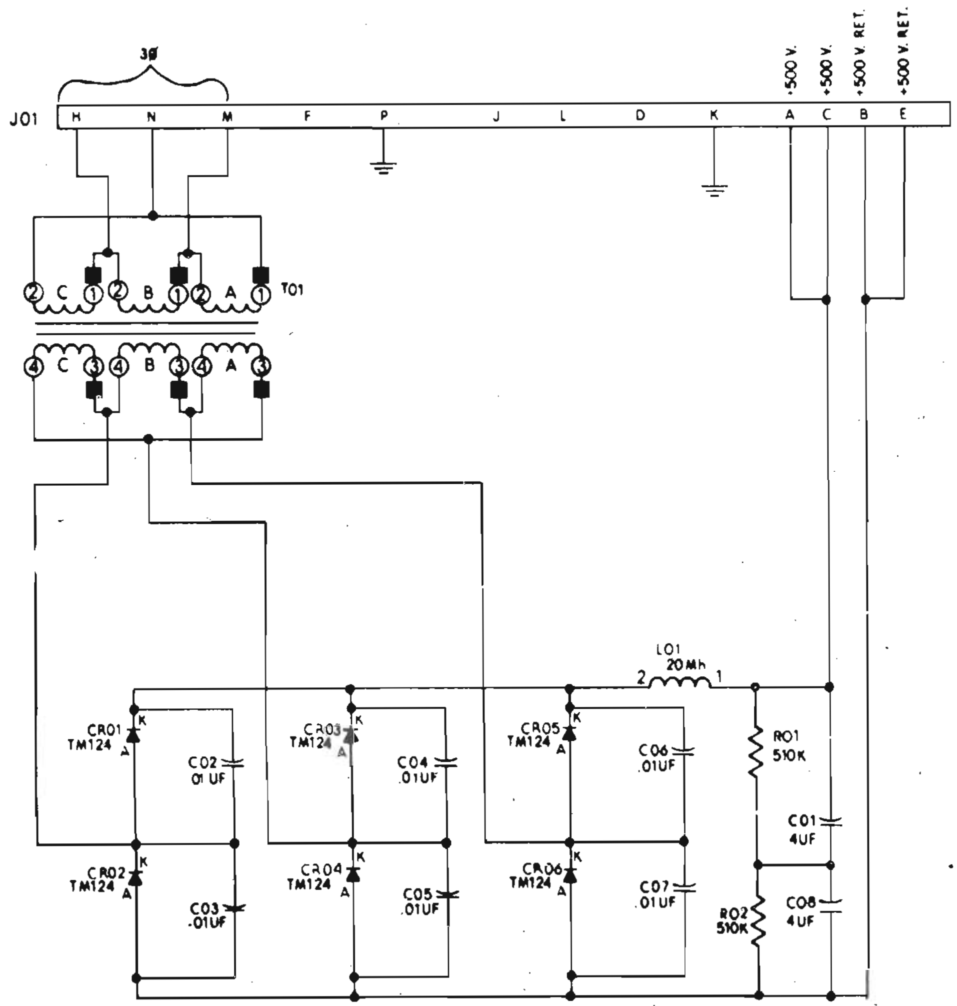

Figure 1-7. 500-volt power supply.

in the power supply. This transformer develops a secondary voltage, which is 180° out of phase with the original ripple in the dc output, thus eliminating the ripple. Four filter amplifiers are used with the system, one with each 150-volt and one with each 300-volt power supply.

500-volt power supply. The ASB-9A 500-volt power supply, shown in figure 1-7, replaces the ASB-16 600-volt power supply. As you can see in figure 1-7, this supply consists of an input power transformer, six silicon diodes connected as a 3-phase full-wave bridge rectifier, and an LC, choke-input filter. You should also note that six shunt capacitors are connected across the six silicon diodes to compensate for the rapid turn-on and turn-off characteristics. The input is 115-volt, 3-phase, 400-Hz power, and the output is 500 ± 100 vdc.

Exercises (601):

1. The bridge rectifier in the 150-volt power supply consists of six diodes. Identify the kind of diodes used here.

2. The diodes mentioned in exercise 1 have an undesirable characteristic. Give it.

3. Tell why the characteristic referred to in exercise 2 is undesirable.

4. Cite those components in the 150-volt power supply which compensate for the characteristic mentioned in exercise 2.

5. The 300-volt power supply uses a delta-to-wye connection on the input transformer. Specify the advantage this type of connection has over the delta-to-delta connection used in the 150-volt supply.

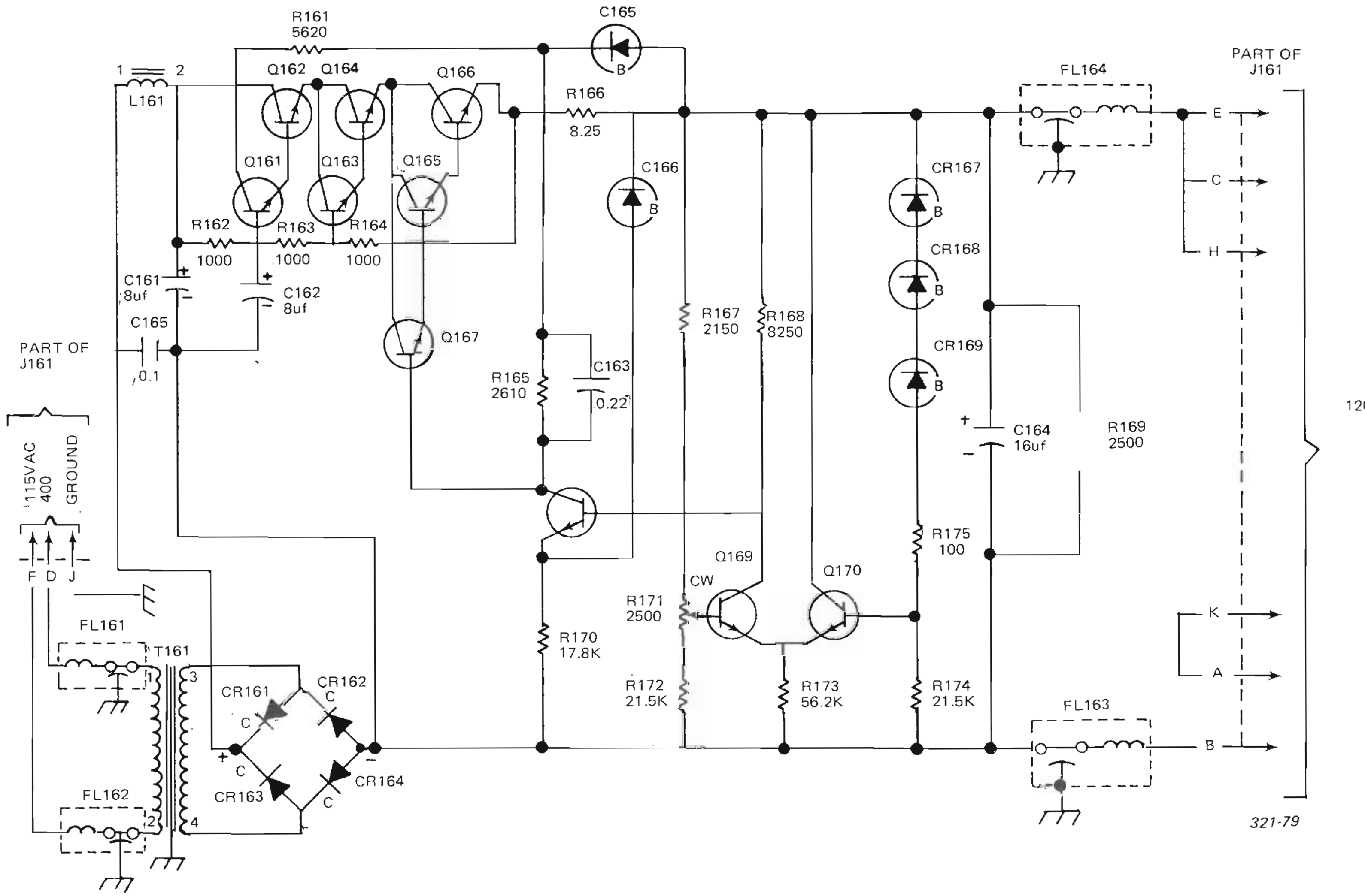

Figure 1-8. Radar 120-volt power supply.

6. Match the power supply circuit purposes (column B) with their related components (column A) by putting each numbered purpose beside its corresponding lettered component. Each item in column B may be used once or not at all.

Column A		*Column B*
	Components	*Purposes*
_____ a.	V403402.	1. Magnetic amplifier.
_____ b.	V403405.	2. Phase splitter and voltage amplifier.
_____ c.	AM403403.	3. Power amplifier.
_____ d.	V403504A.	4. Rectifier.
		5. Saturable reactor.

602. Clarify adjustment of the ASB-9A RDPS power supplies by listing the test equipment required and stating the voltage levels and tolerances required by tech data and any precautionary measures related to the task.

ASB-9A Power Supply Adjustment. You will be called upon frequently to check or adjust the ASB-9A power supplies. Many of the daily maintenance procedures on the RDPS and radar require you to check these voltages. Although not previously mentioned in the circuit description, each of the ASB-9A power supply regulator amplifiers is adjustable. There is *no* procedure listed in TO 1B-52G-2-26, *Organizational Maintenance Instructions—Bombing-Navagational System AN/ASB-9 and AN/ASB-16, B52G and B52H*, for this adjustment. However, the procedure normally used is to set up the test equipment for the system voltages check covered in section IV of TO 1B-52G-2-26, then to adjust the appropriate regulators to the required level. This procedure requires a 30-pin test point adapter and a TS340/U voltmeter or its equivalent. After connecting the test equipment as required in the technical manual adjust the power supplies to the following levels:

+300 ± 3.0 vdc
+150 ± 1.5 vdc
–300 ± 3.0 vdc
–150 ± 1.5 vdc

± 1%

Always be extremely cautious when measuring these voltages. Under certain conditions, the levels are sufficient to present a serious shock hazard. You should monitor each voltage for several moments after making an adjustment. This will allow you to see whether or not any drifting of the circuit is apparent. If you find that the circuit is drifting and does not maintain the correct level, the regulator amplifier for the affected circuit may be faulty.

Exercises (602):

1. List the test equipment used for the ASB-9A RDPS power supply adjustment.

2. List the voltage and tolerance for each RDPS power supply.

3. State the precautionary measures necessary when adjusting the RDPS voltages and briefly explain why each is necessary.

603. Probe the operation and use of the 120 volt radar power supply by supplying selected current, voltage, and circuit characteristics and listing significant transistors affected by certain load changes in this system.

Radar 120-Volt Power Supply. The radar 120-volt power supply provides plate voltages for the radar receiver-transmitter, radar electronic control amplifier, and sensitivity time control in the ASB-9A/16 systems. The radar 120-volt power supply (see fig. 1-8) receives a single-phase, 115-vac, 400-cycle input to the primary of T161. Transformer T161 steps up this input voltage to approximately 190 vac, which is applied to the full-wave bridge rectifier consisting of diodes CR161 through CR164. The rectified output is filtered by L161 and C161 and applied to the series regulator transistors. Capacitor C165 provides a bypass for switching transients generated by the bridge rectifier.

Transistors Q161 through Q167 are connected as current limiters and will limit the maximum output current from the power supply to less than 1 ampere. This is true even with a short circuit at the output terminals. Now let us examine in more detail how this current limiting takes place with a short between pin E of J161 and ground as in figure 1-8.

A short between pin E of J161 and ground places the anode of CR165 at ground potential (zero volts). Zener diode CR165 regulates the voltage at its cathode to 8.2-volts, which is felt at the base of Q167 through resistor R165. Transistors Q167, Q165, and Q166 are silicon transistors and will have approximately 0.6 volt between the emitter and base of each transistor. These voltage drops are in series, and a total of 1.8 volts is dropped between the base of Q167 and the emitter of Q166. Since these compound-connected transistors function as emitter followers, the voltage at the emitter of Q166 will therefore be approximately 6.4 (8.2 – 1.8) volts with the 120-volt output shorted. From this, the maximum current flow can be computed by Ohm's law ($I = E/R$). Performing this computation ($I = 6.4/8.25$) yields a maximum current flow of 0.777 ampere (or 777 milliamperes).

Compound-connected transistors Q167, Q165, and Q166 also function as voltage regulator transistors when no overload to the power supply exists during normal operation. Reference voltages for regulation of the 120-volt output are provided by four Zener

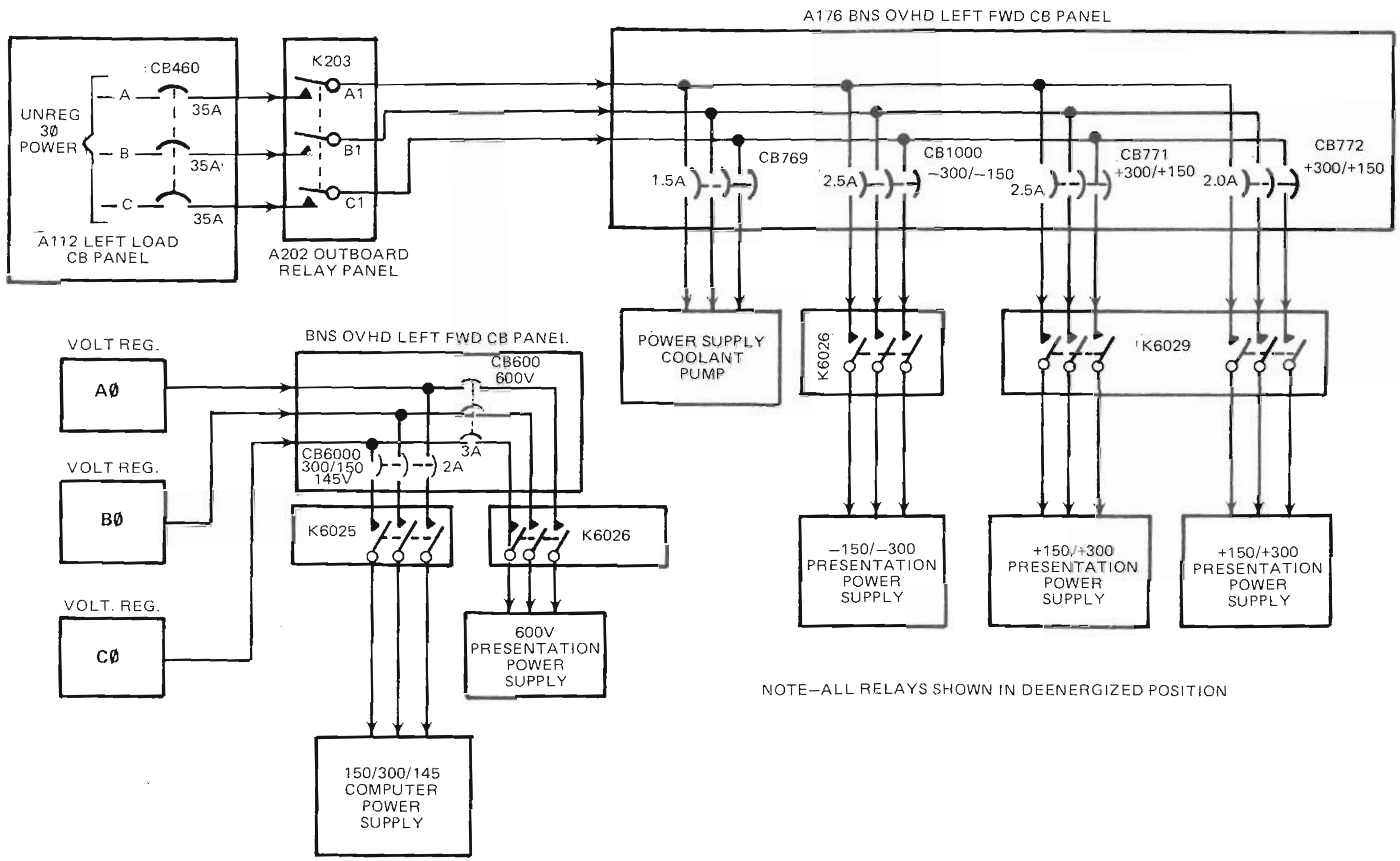

Figure 1-9. ASB-16 dc power supply input power distribution.

diodes (CR166 through CR169). A differential amplifier, consisting of Q169 and Q170, compares the reference voltage developed by Zener diodes CR167 through CR169 with the output of potentiometer R171 to provide one input to regulator control transistor Q168. The other input to Q168 is provided by reference Zener diode CR166.

Transistor Q168 has its emitter maintained at 114.9 volts by Zener diode CR166 with a power supply output of 120 volts. The collector supply for Q168 is regulated to 128.2 volts by Zener diode CR165 and series dropping resistor R161. Zener diodes CR167 through CR169 establish a potential of 104.7 volts at the base of Q170. By emitter follower action, the voltage at the emitters of Q170 and Q169 is 104.1 volts. Remember that a silicon transistor has approximately 0.6 volt between its emitter and base when forward-biased. Potentiometer R171 is adjusted to a point that provides 104.7 volts at the base of Q170. Conduction of Q170 places its collector at a potential of 115.6 volts, which forward-biases Q168, and the collector potential of Q168 is at a level of about 124 volts. This 124-volt potential is applied to the base of Q167 and causes Q167, Q165, and Q166 to conduct, providing 122.2 volts at the emitter of Q166. Approximately 2.2 volts is dropped by resistor R166, which leaves 120 volts at the output terminals of the power supply. This establishes the initial operating conditions of the regulator circuits. Now let us see how these circuits maintain the 120-volt output constant under changing load conditions.

Consider that the 120-volt load decreased (less current drain), causing the output to increase 1 volt. This 1-volt increase would be felt at the base of Q170 and raise its emitter potential 1 volt. The direct coupling between Q170 and Q169 raises the emitter of Q169 1 volt, which decreases the collector current of Q169. The resulting rise in the collector potential of Q169 is direct-coupled to the base of Q168. Transistor Q168 conducts heavier and drops the voltage applied to the base of Q167. With a lower voltage at the base of Q167, transistors Q167, Q165, and Q166 conduct less and drop the output voltage back to 120 volts. Had we considered an increased load, all changes would have been reversed, with regulator transistors conducting more to bring the output back to 120 volts.

Since the 120-volt radar power supply is hermetically sealed, no internal maintenance can be performed at base level. The principles of operation are applicable to any transistor power supply, and for this reason this discussion will help you to better understand new systems as they are developed and delivered to the field.

Exercises (603):

1. State the maximum current flow through Q166.

2. Specify the maximum output current of the 120-volt power supply.

3. Give the voltage applied to the full-wave bridge rectifier, CR161 through CR164.

4. Indicate the type of circuit function performed by Q169 and Q170.

5. List the transistors, by number, that would be affected by an output load change on the 120-volt power supply.

6. State the use of the output of the 120-volt radar power supply.

7. You find pin H of J161 shorted to ground. Cite the potential felt on the anode of CR165 in such circumstances.

1-2. Power Supply Inputs and Outputs

In order to troubleshoot and trace the RDPS power supply circuits, more information is needed. Where do the inputs come from and where do the outputs go? This portion of the text answers those questions.

604. Clarify the input power circuits for the RDPS power supplies by citing chosen operational features of these circuits.

General. The power supply input power circuits are quite different for the ASB-16 and ASB-9A systems. In order to effectively isolate malfunctions within these areas, you should be familiar with the circuit characteristics.

ASB-16 power supply inputs. The input power to the ASB-16 power supplies comes from two sources. Look at figure 1-9, upper left corner and locate the left load CB panel A112. From earlier discussions you may recall that on the aircraft this is located on the left side of the upper deck, behind the pilot. The three-phase power circuit breakers, shown on that panel in figure 1-9, control most of the unregulated ac electrical power to the BNS. After passing through CB460, the power is further controlled by contacts of K203, BNS aircraft power relay No. 2. When aircraft power is applied to the BNS, the external power switch is off, and the BNS main external power relay (not shown) is energized, K203's contacts close. Power is then applied to A176, the BNS overhead left forward circuit breaker panel. Here the three-phase voltages are distributed to the various power supply circuits which use the unregulated lines. CB769 protects the circuit that feeds the power supply coolant pump. CB1000 is in the circuit feeding K6026, the dc power supply relay,

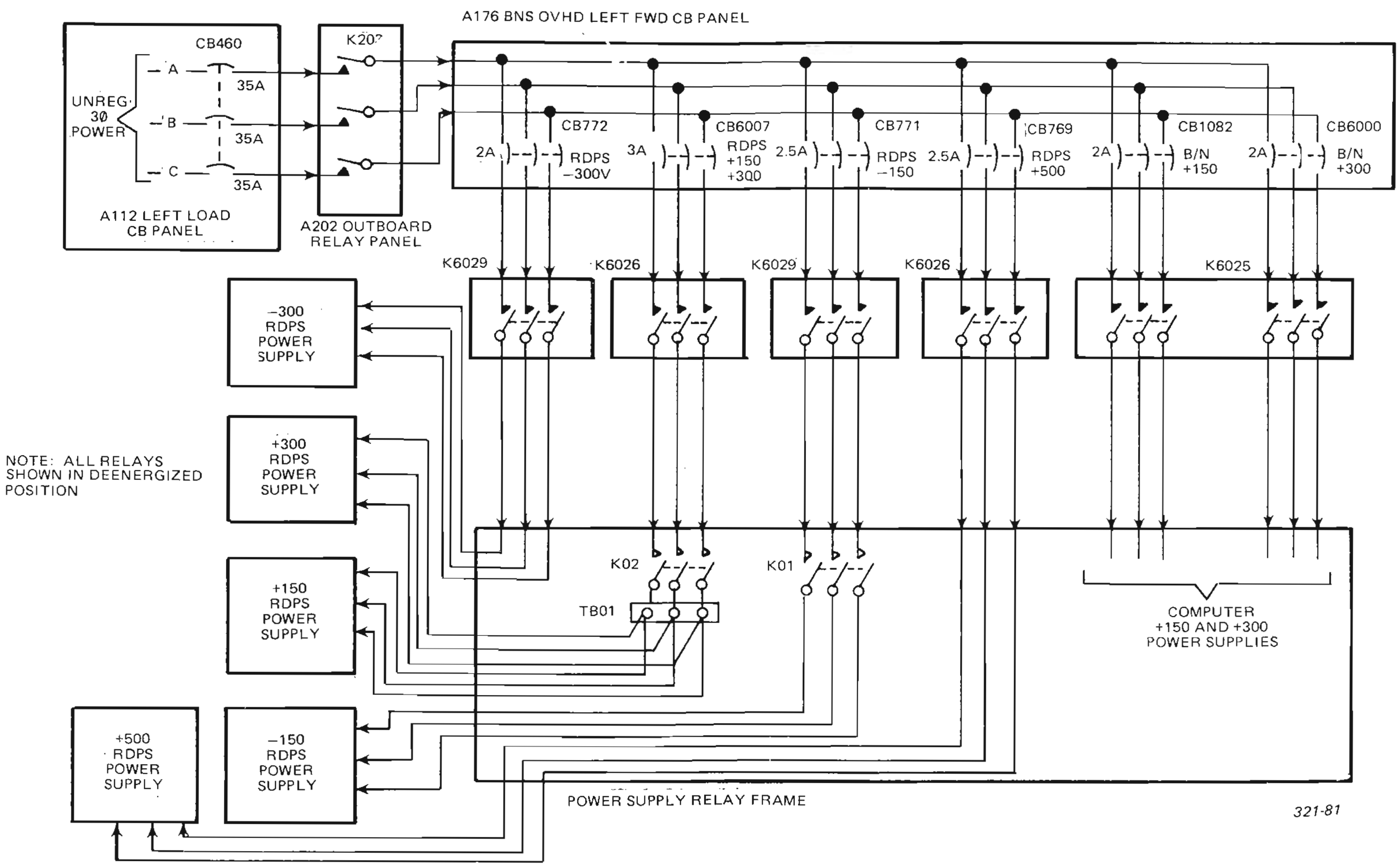

Figure 1-10. ASB-9A dc power supply input power distribution.

and the presentation 150/300-volt power supply. CB771 and CB772 feed contacts of K6029, the 300/150-volt dc power supply relay. From the relay both 150/300-volt presentation power supplies are fed. The ASB-16 computer power supply and 600-volt presentation power supply use regulated ac power inputs. The three-phase power from the voltage regulators is fed to the overhead left forward circuit breaker panel. CB6000 protects the computer power supply lines and CB6007 the 600-volt power supply lines. K6025 is energized 45 seconds after the computer power switch is turned on. K6026 is energized 45 seconds after the radar power switch is turned on. These power supplies use the regulated 117.5 vac, since the circuits they feed are more critical to power fluctuations.

Although these circuits appear rather simple they can be the source of much wasted time and effort. When malfunctions occur in this loop they often appear as a problem in the dc output circuits. This can be very misleading to you as you troubleshoot.

ASB-9A power supply inputs. The initial unregulated three-phase power circuit is the same as that for the ASB-16. The first differences occur at the overhead left forward circuit breaker panel. Look at figure 1-10 and notice that all of the power supplies shown use the unregulated power. This is possible because of the improved nature of the newer power supplies. From left to right the circuit breakers control and protect the following circuits. CB772 is in the circuit to K6029, the power supply relay frame, and the 300-volt RDPS power supply. CB6007 protects the circuits consisting of K6026, K02 in the power supply relay frame, and both the 300- and 150-volt RDPS power supplies. K02 in the power supply relay frame is energized by the operation of the 150-volt power supply. Known as the "sequence No. 2 relay," it prevents the positive power supplies from operating before the negative supply. Failure of this relay to operate in this fashion could result in exceptionally high voltages of the wrong polarity to be felt in the RDPS circuitry. CB771 controls and protects the circuit through K6029, K01 in the power supply relay frame, and the 150-volt power supply. K01 is termed the "sequence No. 1 relay" and is energized by the operation of the 300-volt power supply. Its purpose is similar to that of K02. CB1082 feeds contacts of K6026, the power supply relay frame, and the 150- and 300-volt computer power supplies respectively.

This concludes our discussion of the input circuitry to the RDPS power supplies. Reviewing figures 1-9 and 1-10, you should be aware of the protection and control provided in these circuits.

Exercises (604):

1. Name the ASB-16 presentation power supplies powered by the unregulated line voltages.

2. Cite the conditions which enable K203 to energize.

3. Concerning the ASB-16 system, tell how long after the radar power switch has been turned on before K6026 energize.

4. Specify which ASB-16 power supplies require a regulated ac power input.

5. Give the sequence in which the ASB-9A, -150-, +150-, -300-, and +300-volt power supplies energize.

6. Indicate what controls the sequence listed in exercise 5.

7. Relate the purpose(s) the circuit breakers in the power supply input loops serve(s).

605. Examining the RDPS dc power distribution circuits, specify the purpose of chosen components or units in those circuits.

RDPS DC Power Distribution. Although the power supplies themselves are different, the RDPS dc power distribution set up is basically the same for both the ASB-9A and the ASB-16 systems. To detail the entire dc distribution circuits would take an extremely lengthy dissertation—one which would most likely "bore you stiff." There are, however, certain points in the circuits with which you must be familiar. Therefore, only these key points are discussed in the following text.

In both systems the azimuth relay frame (184 frame) serves as the primary distribution point for the 150-, 150-, 300-, and 300-volt power from the RDPS supplies. In the 184 frame, there are two diodes connected into the dc power circuits. These diodes, CR01 and CR02, serve as protective circuitsd for the 150- and 300-volt power supplies. They also provide some protection for the display video amplifiers in the event of a partial power loss. CR01 is connected between the 150-volt line and 28 vdc. CR02 is connected between the 300-volt line and 28 vdc. The diodes protect the filter capacitors in the power supplies and amplifiers at initial system turn-on or in the event the positive supply is off while the negative supply is in operation. This second situation may occur as a malfunction or if the positive power supply circuit breaker is "popped" during maintenance. Either of these conditions could cause approximately 240 volts to be applied across the filter capacitors in the power supplier or across capacitor C02 in the video amplifiers. A reverse voltage of more than 1 volt can damage these capacitors. A large negative voltage, such as the 240 volts, will cause a complete breakdown with a resulting short circuit. The diode connections form a high resistance to current flow from the 28-vdc line to the 150- or 300-volt lines. The result is a 28-volt clamp on each line that prevents the positive connections on the filter capacitors from being at less than ground potential.

Separate outputs of the 500- or 600-volt power supplies are fed to each of the current deflection amplifiers. From there this power is applied to the deflection coils of both the topographical comparator and the azimuth and range indicator.

Another point you may want to remember about the RDPS dc power distribution relates to troubleshooting techniques. The dc distribution is such that many problems, such as "popping" circuit breakers, can be isolated simply by disconnecting cables feeding the various loops. You must always use caution, however, when applying this technique. Do not disconnect the system cables with power applied. Check the power interlock circuit to make sure that you do not break an interlock when doing this. This method is not foolproof, but it can frequently help you narrow a malfunction to a particular unit or relay frame.

Exercises (605):

1. State the RDPS power supply the filter capacitors of which are protected by CR01 in the azimuth relay frame.

2. Indicate the result if a large negative voltage were fed back across the power supply filter capacitors.

3. Tell where—in addition to the current deflection amplifiers—the outputs of the 500- or 600-volt power supply are used.

4. Cite the components which prevent the positive connection on the power supply filter capacitors from being at less than ground potential.

5. You wish to disconnect the power distribution cables during troubleshooting. Specify the additional circuit diagrams which should be consulted at this time.

CHAPTER 2

RDPS Signal Generation and Control

THE RADAR and RDPS functions must have a specific time relationship. Although normally considered as part of the RDPS, several of the circuits to be discussed in this chapter are critical to the radar portion of the BNS. For maintenance purposes you divide the radar and RDPS. However, you should always keep in mind that the circuits, in reality, combine to form a complete radar system.

2-1. Marker and Trigger Generation Circuits

The marker and trigger generation circuits provide the various timing signals needed to synchronize the operation of the transmitter, receiver, and display circuits. In addition these circuits provide the signals to establish the ranging between the radar and RDPS. This last function basically is the generation of the fixed and variable range marks.

In order to achieve a full understanding of this circuit, you should have a more detailed understanding of certain key units and components. This portion of the text will first describe the operation of each of these units. Next it will discuss the entire circuit.

606. Clarify operation of the timing pulse generator by determining how certain specified outputs of it are developed.

Timing Pulse Generator. The timing pulse generator functions both as a master oscillator for the system and as a frequency divider. It may actually be divided into two parts, performing these two functions—the master timing oscillator circuit and the marker generation circuit.

Master timing oscillator. The master timing oscillator produces a highly stable frequency of 161.73 kHz. Basically, it is a crystal-controlled Pierce oscillator circuit with certain improvements. The improvements consist of the addition of two capacitors which make the feedback amplitude and the oscillator frequency independent of the oscillator tube's interelectrode capacitance. Another improvement, in the oscillator tube plate tank circuit, enables the unit to be factory adjusted to precisely 161.73 kHz. Thus, maximum efficiency is gained from the oscillator.

A cathode follower circuit functions as a buffer amplifier to isolate the oscillator from its load. This prevents any variations in load from affecting the frequency or amplitude of the 161.73 kHz signal. As you know, a cathode follower is also an impedance-matching device. This provides for the maximum power transfer of the signal.

This signal is applied to the frequency divider circuits of the timing pulse generator itself and is also an output of the unit. The 161.73 kHz output is applied to the radar range signal data converter. Its use will be discussed in the overall marker and trigger loop discussion later in this chapter.

Marker generation. The marker generation portion of the timing pulse generator has the 161.73 kHz as its input. This input is applied to a trigger amplifier tube which conducts only on the positive peaks of the input sine wave. The result is a negative-going output pulse which is applied to a series of blocking oscillators.

The first blocking oscillator operates at a 1:1 ratio. Therefore, it produces a negative 1/2-mile marker pulse. This is both a unit output and is also applied to the next internal blocking oscillator circuit. This second oscillator circuit has a ratio of 4 to 1, producing one negative-going pulse for every four input pulses. Since the input pulses are at 1/2-mile increments, the output occurs as 2-mile pulses. Again, this is both a unit output and is also applied to the next stage.

The next two 5:1 blocking oscillators successively divide the pulse repetition rates by 5, resulting in the production of 10-mile and 50-mile marker pulses.

The 1/2, 2, 10, and 50-mile marks are applied to the marker mixing pulse generator. The 50-mile marks occurring at 1617 pulses per second (PPS) are also sent to the pulse repetition frequency generator and to the terrain avoidance video processing circuits.

Exercises (606):

1. Give the output frequency of the master timing oscillator.

2. State the type of circuit which develops the master frequency.

3. Specify how the range mark pulses are developed.

4. Tell how the trigger amplifier acts upon its input signal.

5. Provide the ratio of the third blocking oscillator stage.

6. Cite the pulse repetition rate of the output of the fourth blocking oscillator stage.

7. With 2-mile marker pulses being applied to a 5:1 blocking oscillator, supply the resulting output.

607. Examine the operation of the pulse repetition frequency generator by specifying certain TA and non-TA PRF selections and operational determinants, controls, and limits affecting this generator.

Pulse Repetition Frequency Generator. The pulse repetition frequency (PRF) generator produces outputs of system and radar triggers. The PRF, which depends upon the selected range and mode of operation, may be 1617, 808, or 323 pulses per second (PPS). The inputs to the PRF generator are 50-mile marks from the timing pulse generator, a PRF selection control voltage, and a radar trigger delay control voltage (zero calibrate). When the system is in the terrain avoidance (TA) mode, a fixed 808 PRF selection control voltage is applied. In a non-TA mode, the PRF selection control voltage comes from the range target scale selector and is variable with range. NOTE: It is important at this point to remember that some schematics refer to the 50-mile range marks from the timing pulse generator simply as "1617 PPS."

Figure 2-1 is a block diagram of the PRF generator. Notice that it shows the circuits divided into two parts—the system trigger generation circuit and the radar trigger generation circuit. The PRF selection voltage signal and the 1617-PPS signal are inputs to coupling diode CR02. These signals determine the division rate of phantastron tube V02. A division rate of 1:1, 2:1, or 5:1 results in a system trigger PRF of 1617 PPS, 808 PPS, or 323 PPS. The screen output from the phantastron tube is sent to trigger amplifier tube V03A to be differentiated, amplified, and inverted. The resulting negative pulse is transformer-coupled to blocking oscillator V03B to generate the system trigger. The system trigger is sent to the range timing gate generator, range crosshair gate-pulse generator sweep trigger pulse generator, and the TA video processing circuits.

The system trigger is also applied to inverter tube V04A. There the trigger is inverted and amplified before it is applied to pulse-shaping amplifier V04B. The pulse-shaping amplifier produces a positive-going waveform with an exponential rise. The exponential rise is longer in time than the longest delay used by the radar modulator. A negative delay control voltage is applied to delay control diode V05. This clamps the pulse-shaping amplifier output, which is applied to blocking oscillator V06. Blocking oscillator tube V06B is biased below cutoff by the clamped pulse-shaping amplifier output until the exponential rise exceeds the value of cutoff bias. When the exponential rise exceeds the cutoff bias for V06, blocking oscillator tube V06 generates the radar trigger. As you can see in figure 2-1, the radar trigger is delayed from the system trigger by a small amount (0.4 to 1.4 microseconds). The

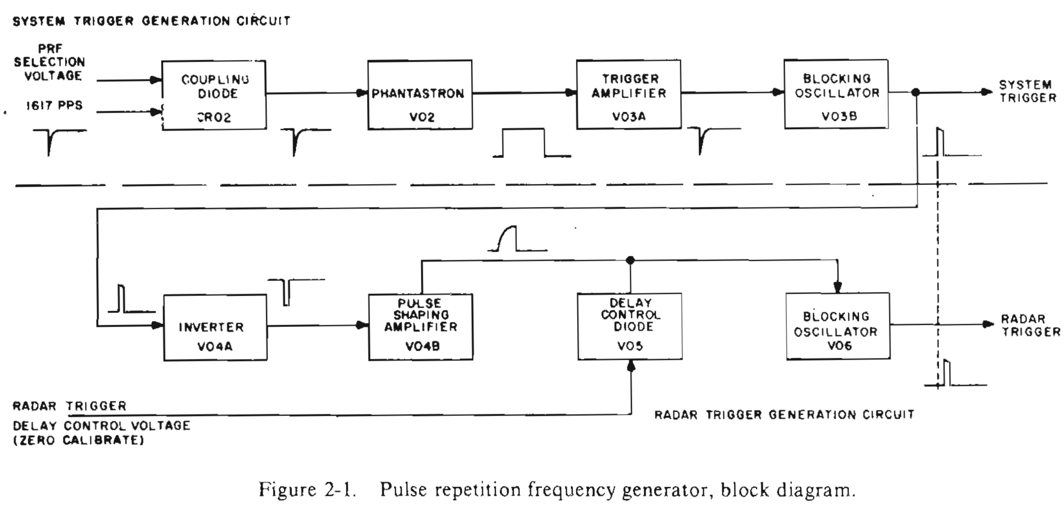

Figure 2-1. Pulse repetition frequency generator, block diagram.

amount of delay is controlled by the radar trigger delay control voltage, which you adjust during a zero calibration.

Exercises (607):

1. Cite the PRF of the radar trigger in TA mode.

2. Certain PRF's may be selected in a non-TA mode. Name them.

3. Tell what determines the division rate of phantastron tube V02.

4. State what controls the delay of the radar trigger.

5. Give the limits of adjustment on the radar trigger delay.

608. Clarify the operation of the sweep trigger pulse generator by citing selected sequential actions, applications, outputs, and circuit factors producing identifiable amplications in generator components.

Sweep Trigger Pulse Generator. The sweep trigger pulse generator is used to develop the delayed sweep trigger. A simplified diagram of the delay circuit is shown in figure 2-2. A detailed discussion of all the circuits will not be included here, however. Instead, the signal data flow is presented. You should follow the circuitry in figure 2-2 as you read the following explanation.

The sweep trigger pulse generator receives three inputs: (1) a delay enable +150 volts through the contacts of delay marker relay K01 DM; (2) system trigger pulses from the PRF generator; and (3) sweep delay control voltage from the presentation adjustment control. The delay enable +150 volts is applied through the energized contacts of K01 DM to the phantastron screen-grid circuit. This application enables the operation of the sweep trigger pulse generator. The positive sweep trigger pulses (waveform A in fig. 2-2) are applied to trigger amplifier tube V01A to be amplified and inverted. The inverted waveform B is coupled through coupling diode CR01 to the plate of phantastron tube V03. These trigger pulses at the plate of V03 initiate the plate waveform rundown of waveform C. The sweep delay control voltage is coupled through coupling diode CR01 to the plate of V03 and establishes the initial plate potential of V03. Phantastron tube V03 functions in the following manner: decreasing the initial plate potential decreases the rundown time and, hence, the delay time.

The output of V03, taken from the cathode, is a negative-going trapezoidal pulse. This negative pulse (waveform D) is applied to cathode follower V04A, producing the output waveform E shown in figure 2-2. Waveform E is differentiated by capacitor C10 and resistor R20. The differentiated output (waveform F) is applied to the control grid of trigger amplifier tube V01B. Since tube V01B is biased at cutoff, the negative-going spike of waveform F drives the control grid of V01B more negative, and no output is obtained. But the positive-going spike of waveform F drives trigger amplifier tube V01B into conduction. This results in the amplified and inverted output—waveform G in figure 2-2. The negative-going output pulse of V01B is sent to blocking oscillator V04 as a trigger. This causes V04B to generate the delay sweep trigger pulse, waveform H.

The delayed sweep trigger pulse is sent to relay K05 SD. Relay K05 SD sends the delayed sweep trigger to the marker mixing pulse amplifier, when K05 SD is deenergized. This results in the delayed sweep trigger being presented as a delay marker on the radar presentation. Also, with K05 SD deenergized, the system trigger is sent to the sweep generation circuits to start the radar sweep.

Keep in mind that relay K05 SD is energized when the sweep delay switch is placed in the ON position. Consequently, the delayed sweep trigger is sent through the energized contacts of K05 SD to the sweep generation circuits to determine the start of the sweep. With the sweep delay switch in the ON position, the sweep starts at the range determined by the sweep delay marker observed on the radar indicator prior to placing the sweep delay switch to the ON position. This permits you to determine very accurately the start of the delayed sweep on the radar indicator.

Exercises (608):

1. Specify when the sweep trigger pulse generator is used.

2. Tell when relay K05 SD is energized.

3. Pinpoint where, within the sweep trigger pulse generator, the sweep delay control voltage is applied.

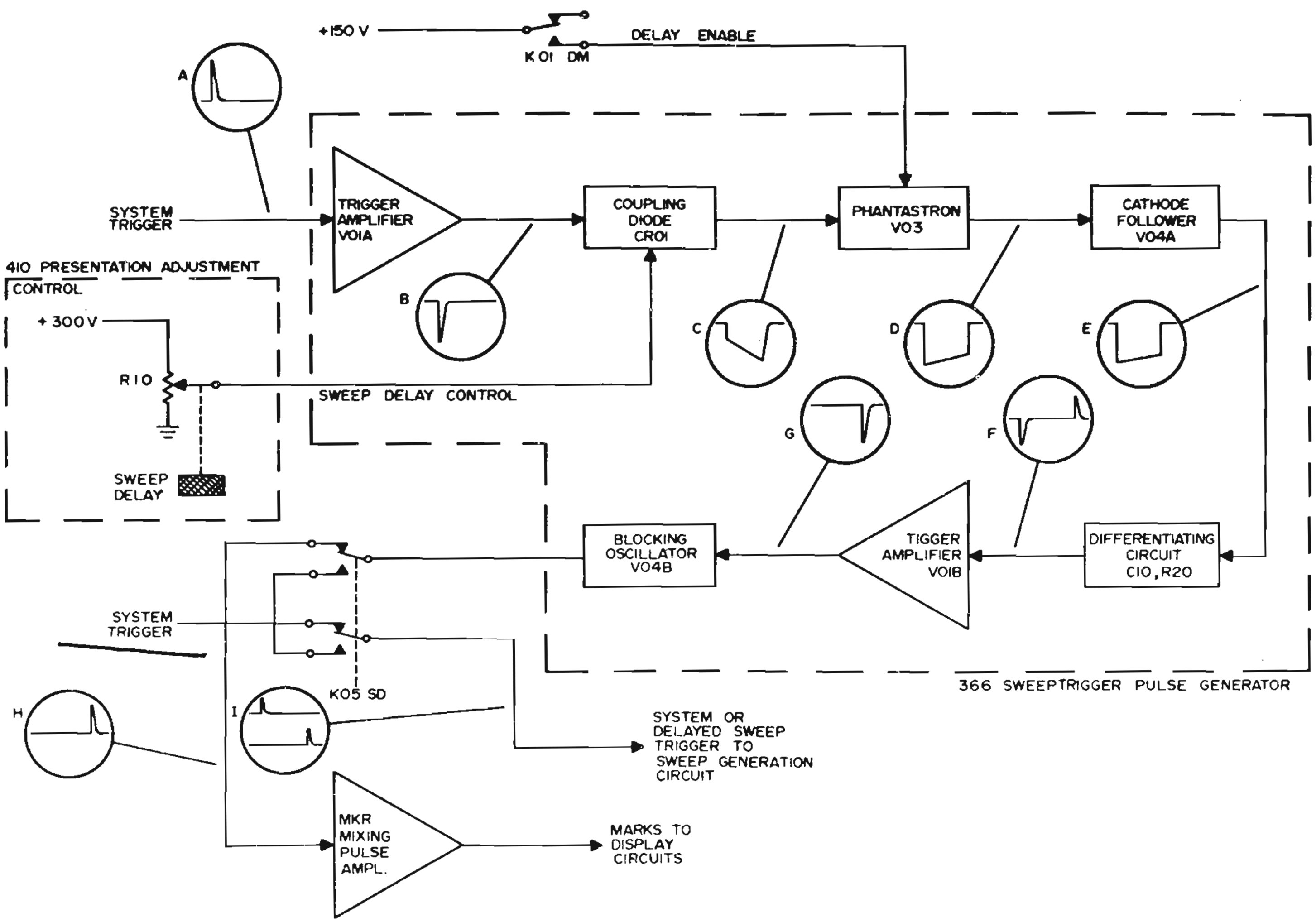

Figure 2-2. Delayed sweep trigger generation circuit.

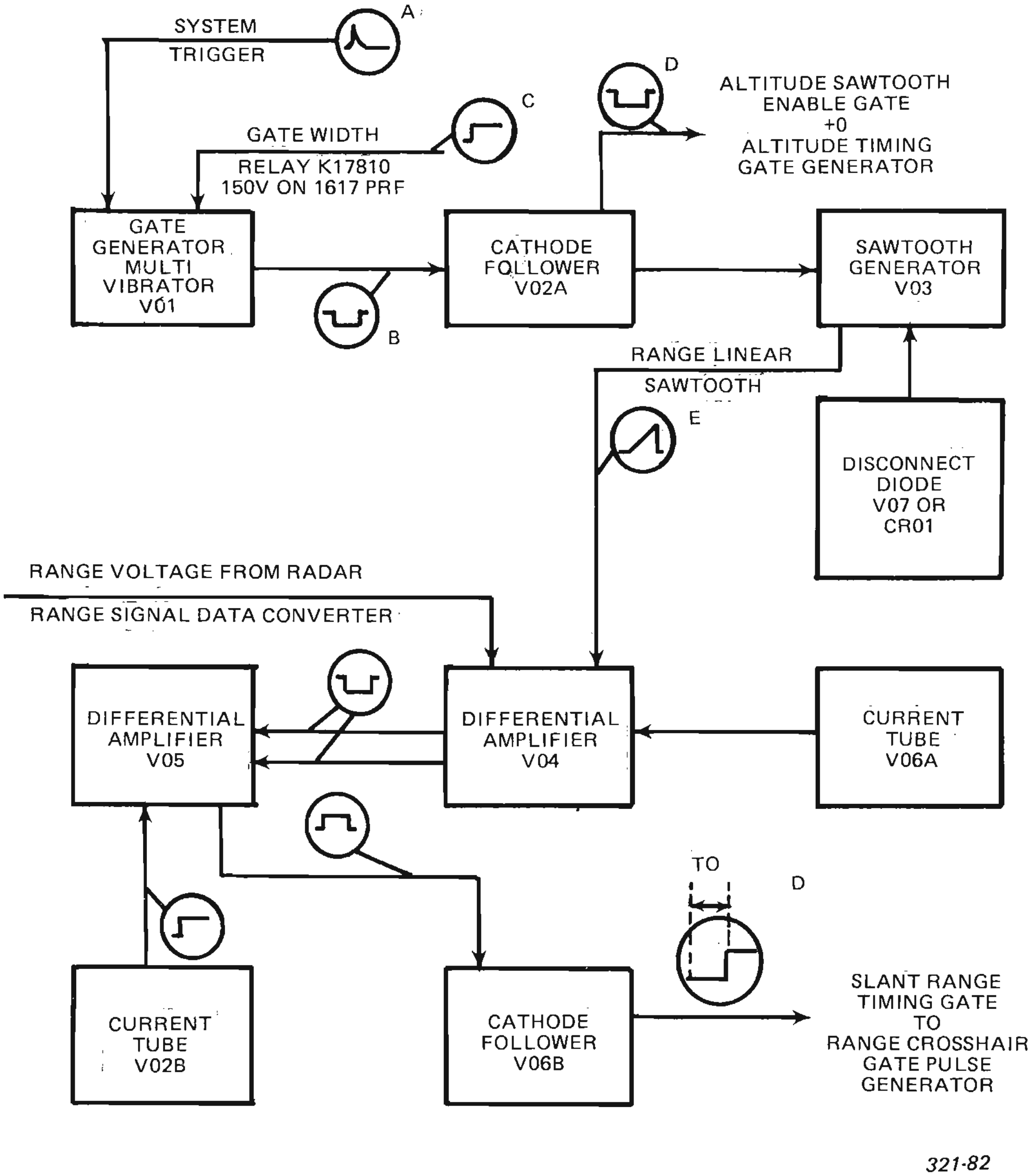

Figure 2-3. Range timing gate generator, block diagram.

4. Clarify the cathode output of phantastron tube V03.

5. Identify the portion of the output waveform from differentiating circuit C10 and R20 which causes trigger amplifier V01B to conduct.

609. Review the range timing gate generator by providing the inputs and outputs and giving the causes, waveform type, and polarity as well as the appearance of selected portions of this generator.

Range Timing Gate Generator. The range timing gate generator is one of the two components primarily involved in the generation of the range crosshair. It receives the following as input signals: (1) the system trigger from the PRF generator; (2) +150 volts from relay K17810, at a point in the circuit dependent upon 1617 PRF operation; and (3) a coarse range voltage from the radar range signal data converter in the bombing computer.

You should follow the block diagram shown in figure 2-3 during the circuit description. A better understanding of this unit can aid you in the performance of the range track-range zero adjustment on the system. The potentiometers you will adjust, during that procedure, are located on this unit.

The system trigger (waveform A in fig. 2-3) input to gate generator V01 causes the generation of a negative rectangular waveform. The gate generator is actually a monostable multivibrator triggered by the system trigger input. The duration or width of the negative rectangular gate (waveform B in fig. 2-3) is dependent upon the condition of gate width relay K17810. When K17810 is deenergized, the output gate from V01 is approximately 730 microseconds in duration. When K17810 energizes (1617 PRF selected), 150 vdc (C on fig. 2-3) is applied to the multivibrator, causing the gate width to be reduced to 330 microseconds. The output from V01 is applied through cathode follower V02A to sawtooth generator V03. V02A provides isolation for V01. The output of V02A is also applied to the altitude timing gate generator as the altitude sawtooth enable gate (D, fig. 2-3).

Sawtooth generator V03 generates a linear, high-amplitude sawtooth waveform (E, fig. 2-3). This is accomplished by RC feedback networks sometimes referred to as "bootstrap" circuits. This means that the sweep capacitor charge voltage is reapplied to its charging resistance. This causes the waveform linearity. The positive excursion of the sawtooth is limited by disconnect diode V07 or CR01 (depending upon the unit modification level).

The linear range sawtooth (E, fig. 2-3) is applied to differential amplifier V04. Another input to V04 is the coarse slant range voltage from the radar range signal data converter. Both the inputs have the same scale factor and are compared in V04 to form two square waveforms. At the point where the instantaneous value of the sawtooth equals the range voltage, the two outputs invert and current transfer takes place. The cathode current of V04 is maintained by constant current tube V06A.

The outputs of V04 are applied directly to the differential amplifier V05. Tube V05 accentuates the waveform sharpening and inversion that took place in V04. The constant current source for V05 is tube V02B.

The output of V05 is applied through cathode follower V06B to the range crosshair gate pulse generator as the slant range timing gate. The gate is the result of comparing the range voltage with a linear sawtooth voltage to produce a positive square waveform. The leading edge of this gate is delayed from system trigger by an amount of time proportional to slant range (D, fig. 2-3). The trailing edge is caused by the linear sawtooth returning to its reference level.

There is another separate circuit contained within the range timing gate generator. The range track and range zero adjustment potentiometer (R29 and R31 on fig. 2-4) provide for proper radar ranging and range crosshair tracking throughout the computer ranges. The range zero potentiometer R31 adjusts the negative potential applied to the range zero end of the range potentiometer in the signal data converter. The range track potentiometer adjusts the positive potential applied to the opposite end of the range potentiometer. Its effect is to vary the slope (or scale factor) of the range voltage output. This allows one range crosshair to be tracked from 50 down to 0 nautical miles of slant range. Looking at the circuit shown in figure 2-4, you should see that these adjustments will definitely interact. Since this is the case, you may find it necessary to perform several readjustments of each potentiometer to establish the true slope from the proper starting point. The output from R02 in the signal data converter is the range voltage applied to V04 in the range timing gate generator.

Exercises (609):

1. List the signal inputs to the range timing gate generator.

2. List the outputs of the range timing gate generator.

3. Describe briefly the slant range timing gate.

4. Relate what causes the termination of the slant range timing gate.

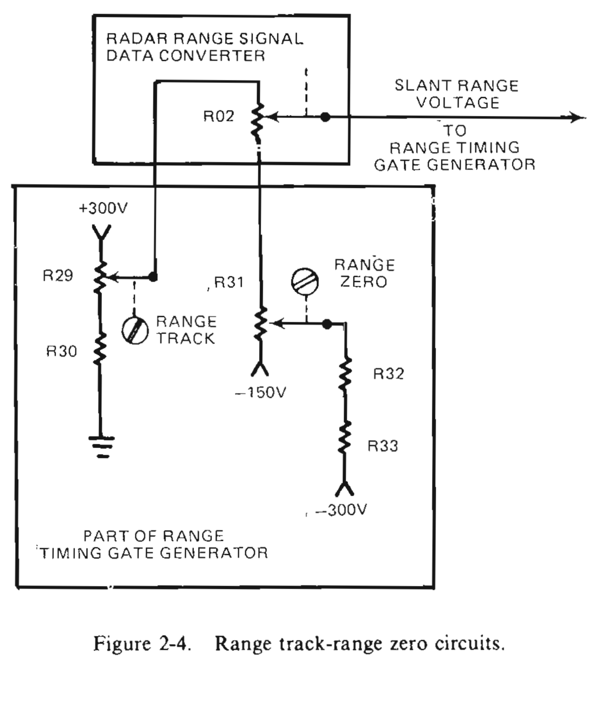

Figure 2-4. Range track-range zero circuits.

5. Name the type of waveform of which the altitude sawtooth enable gate is an example.

6. Identify the polarity of the range zero voltage output.

610. Clarify the range crosshair gate pulse generator by completing certain significant statements about its components and operation.

Range Crosshair Gate Pulse Generator. The range crosshair gate pulse generator (fig. 2-5) develops a range crosshair pulse for display on the RDPS indicators. This pulse will be time coincident with fine slant range D. A slant range gate is also developed and

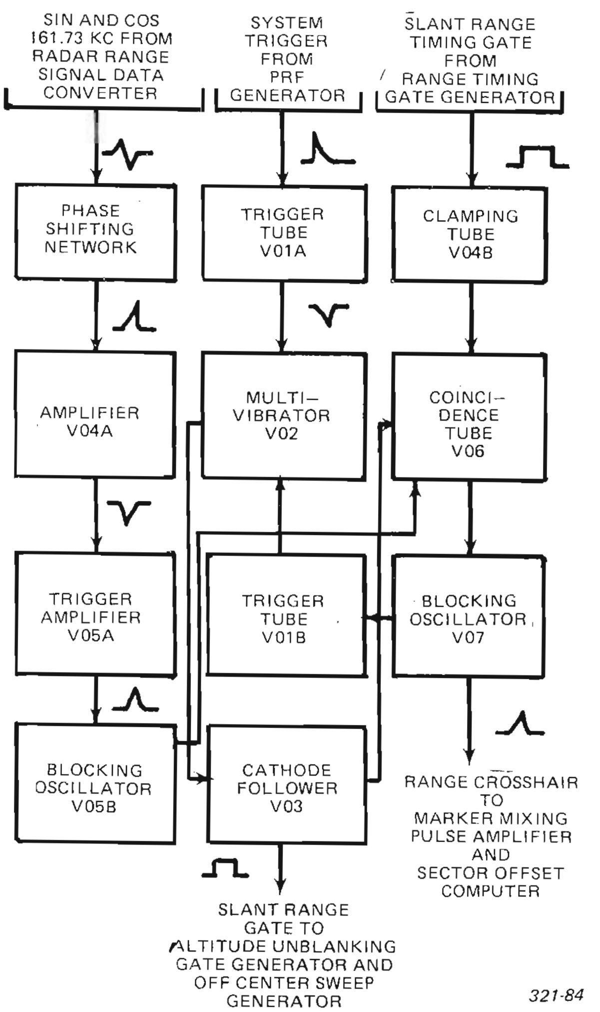

Figure 2-5. Range crosshair gate pulse generator, block diagram.

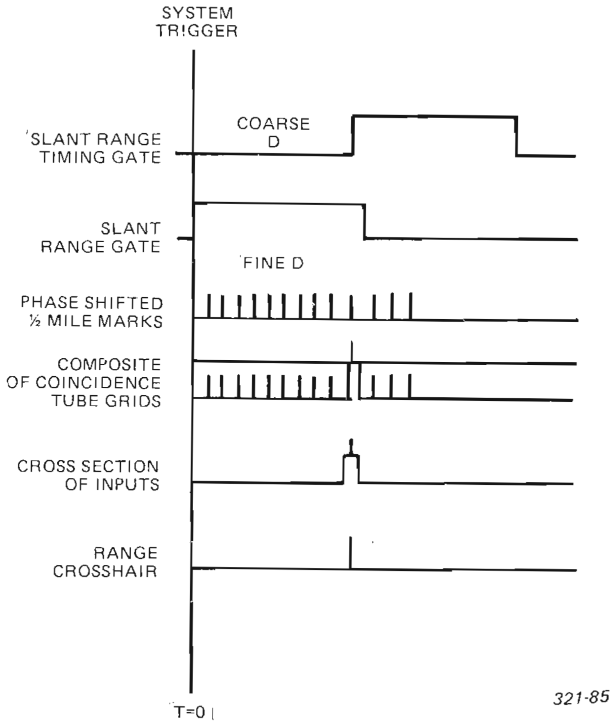

Figure 2-6. Range crosshair-coincidence inputs.

is applied to the altitude unblanking gate generator and the off-center sweep generator for consideration in altitude compensation. The unit develops these signals from three inputs. The first input is system trigger, the second is the 161.73-kHz sin and cos signals from the radar range signal data converter, and the third is the slant range timing gate from the range timing gate generator.

System trigger. The system trigger input from the PRF generator is applied to trigger tube V01A. The trigger tube output triggers bistable multivibrator V02. The positive-going output of V02 is applied to cathode follower V03. The cathode follower output is sent to coincidence tube V06, the altitude unblanking gate generator, and to the off-center sweep generator as the slant range gate. Bistable multivibrator V02 supplies this positive gate until triggered into its static state by V01B.

Sine and cosine, 161.73 kHz. The sine and cosine 161.73-kHz signals are applied to a phase-shifting network composed of a capacitance and a resistance. The capacitive reactance at 161.73 kHz equals the resistance and thus the network output leads the input by 45°. Since the 161.73-kHz master frequency generates both the system trigger and 1/2-mile marker, this phase shift of the input produces 1/2-mile markers variable in time with respect to system trigger. Tube V04A amplifies the phase-shifting network output before it is applied to trigger amplifier V05B, a blocking oscillator. The output of V05B, a positive pulse which is phase-shifted 1/2-mile marks, is then applied to coincidence tube V06.

Slant range timing gate. The slant range timing gate (fig. 2-5) is a negative square wave at system trigger time. It remains negative for a period of time equivalent to coarse slant range D. The negative waveform, in conjunction with clamping tube V04B, holds coincidence tube V06 cut off. The positive-going edge of the slant range timing gate enables V06. Then the 1/2-mile marker immediately following the slant range timing gate drives V06 into conduction. The output of V06 now fires blocking oscillator V07. The positive pulse output of V07 is applied to the marker mixing pulse amplifier, the sector offset computer, and to trigger tube V01B. As an externally applied output, the signal represents the range crosshair pulse equal in time to fine slant range.

The output of V07 applied to V01B passes through a 1-microsecond delay line (not shown in fig. 2-5) to fire the trigger tube. V01B, as previously mentioned, then resets multivibrator V02 to its original state. This action terminates the positive slant range gate 1 microsecond after range crosshair time and also inhibits the coincidence amplifier. The inhibition prevents any other 1/2-mile mark from generating a range crosshair pulse.

In case you feel somewhat befuddled by the explanation just given, you may find figure 2-6 enlightening. Figure 2-6 shows the time relationship of the various signals discussed in the preceding paragraphs.

Exercises (610):

Complete the following statements by supplying the missing word or words in each.

1. The range crosshair pulse is time coincident with ________ ________ ________.
2. The positive gate output of VO2 is called the ____ ________ ________ ________.
3. The phase-shifting network shifts the 161.73 kHz approximately ____________.
4. The slant range timing gate is ____________ at system trigger time.
5. The externally applied output of VO7 represents the ________ ________ ________ and is equal in time to ________ ________ ________.
6. The positive slant range gate is ____________ 1 microsecond after ________ ________ ________.
7. The signal inputs to the range crosshair gate pulse generator are: (a) ________ ________; (b) ________ ________ and ________; and (c) ________ ________ ________ ________.

611. Examine the operation and circuits of the marker mixing pulse amplifier by completing selected statements labeling components and circuits to briefly describe the functioning of this amplifier.

Marker Mixing Pulse Amplifier. The marker mixing pulse amplifier controls and switches the markers that are applied to the video amplifiers. This amplifier receives the range and indirect bomb damage assessment (IBDA) azimuth crosshairs, delayed marker, 1/2-, 2-, 10-, and 50-mile markers, and switching voltages.

Operation. The operation of the marker mixing pulse amplifier is controlled by external relay switching. A block diagram of the circuitry is shown in figure 2-7. The negative-going 2-, 10-, and 50-mile markers are applied to the cathodes of coupling diodes V03A, V01B, and V02A respectively. The external switching relays control the plate potential of these diodes. When a diode conducts, the output pulse is transformer-coupled to either clipping diode V04A or V04B. The clipping diode outputs trigger pulse amplifier V05-V06A, and the output is applied to the marker control potentiometers for the RDPS indicators. It should be apparent to you that it is possible to have both 10- and 50-mile markers "mixed" within this unit for display purposes.

The azimuth crosshair gate from the azimuth crosshair gate generator is applied to pulse amplifier V06B (lower left corner of fig. 2-7). The negative crosshair waveform is expanded at the input section of V06B. The output is applied to coupling diode V01A along with the 1/2-mile markers. This mixing action, when enabled by the external switching circuits, allows the display of 1/2-mile "feathers" on the azimuth crosshair during the IBDA function.

The delay marker, from the sweep trigger pulse generator, is applied to coupling diode V02B. The range crosshair gate pulse generator is applied to V03B. As shown in figure 2-7, these coupling diodes are connected electrically. When enabled by the external switches and controls, the associated pulses are generated, clipped by V04B, and applied to the pulse amplifier for output. This output is the negative delay marker pulse used during the sweep delay mode of the RDPS.

Exercises (611):

Complete the following statements by supplying the missing word or words in each.

1. The marker mixing pulse amplifier receives inputs from the ________ ________ ________, ________ ________ ________ ________, ________ ________ ________ ________ ________, and the ________ ________ ________ ________.
2. The "feathers" on the azimuth mark, used in the IBDA mode, are developed by combining the ________ ________ ________ and the ________ ________ ________ ________.
3. The delay marker from the sweep trigger pulse generator and the ________ ________ ________ are combined during the ________ ________ ________.

4. The plate potenials of coupling diodes V03A, V01B, and V02A are controlled by ______________________.

5. When a coupling diode conducts, its output is ______________ coupled to one of the ______________________.

612. Analyze the marker and trigger generator circuits by citing specified purposes, relays, and operational actions and functions of these circuits.

Overall Circuit Operation. You have now completed your study of the main units contained in the marker and trigger generation circuits. This portion of the text simply ties these units together in order to insure your understanding. You should follow the signal flow displayed on figure 2-8 as you read the following circuit descriptions.

Trigger generation. The portion of the circuit pertaining to trigger generation starts with the timing pulse generator 361. This unit functions as the master oscillator for the system and as a frequency divider. The 161.73-kHz master frequency is divided to produce a 1617-PPS signal, which is fed to the PRF generator 362 to produce the radar trigger and the system trigger.

The radar trigger can be 1617, 808, or 323 pulses per second depending upon the range required and the mode of operation. The pulse repetition frequency is selected by range target scale selector 191. The characteristics for range and mode of operation are listed in section II of TO 1B-52G-2-26. The radar trigger is used to establish and regulate the timing of

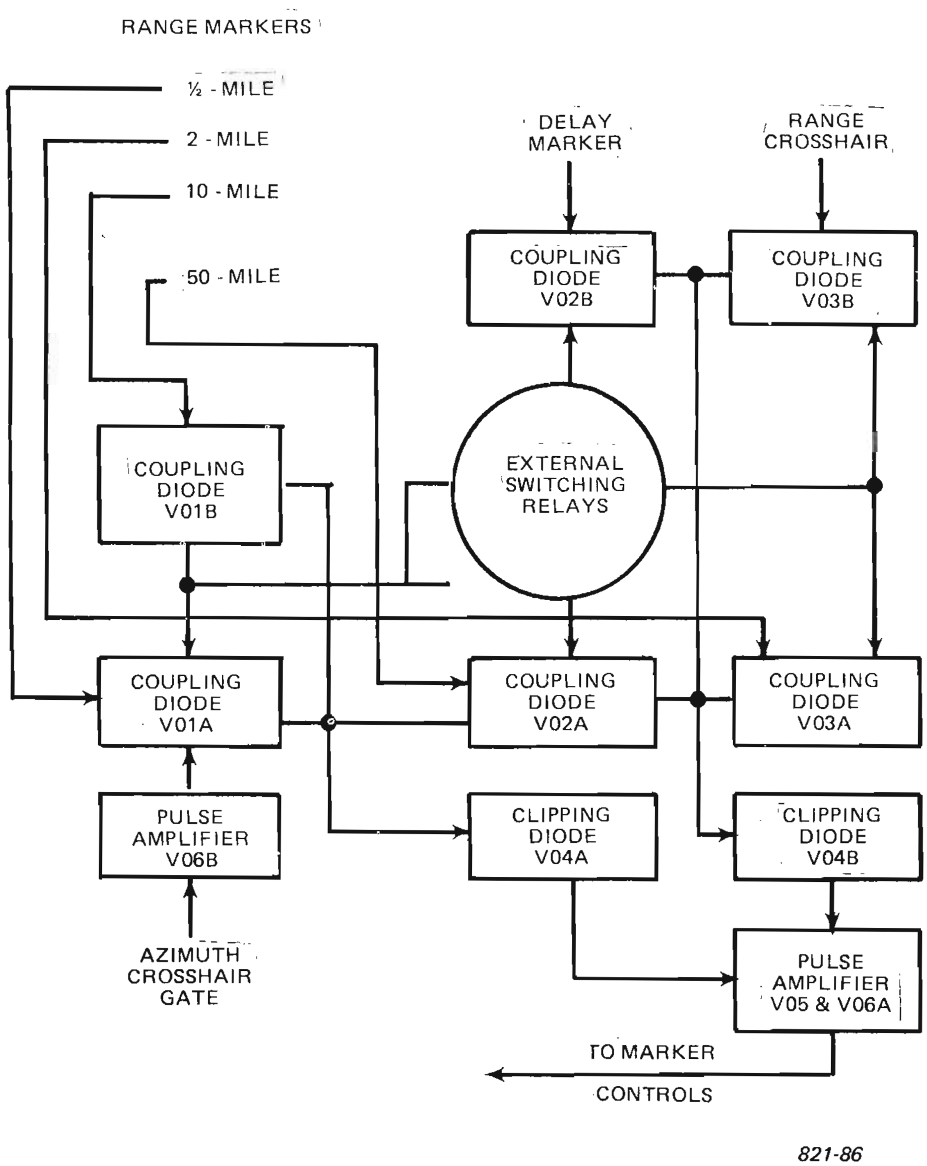

Figure 2-7. Marker mixing pulse amplifier, block diagram.

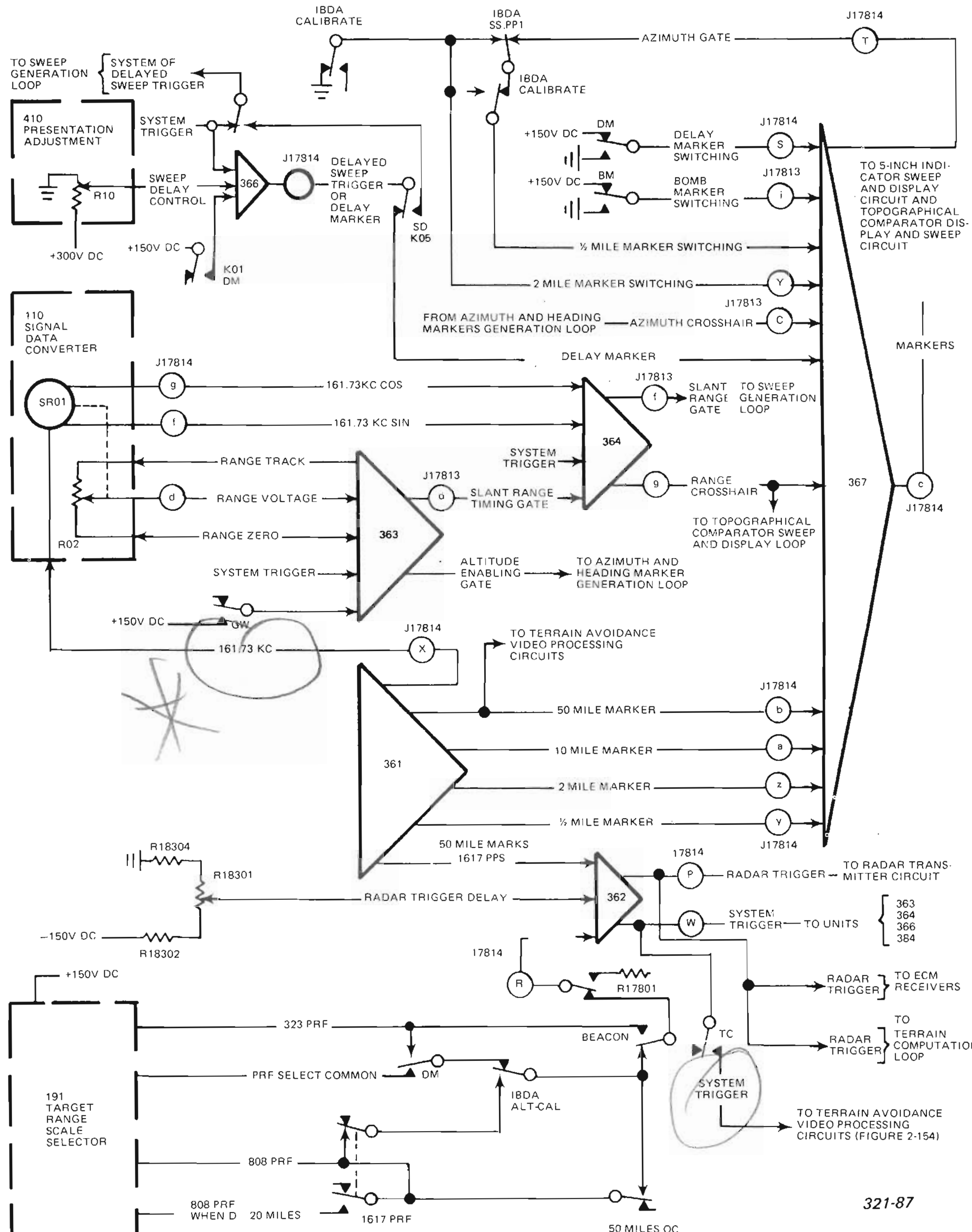

Figure 2-8. Marker and trigger generation circuit.

the radar transmitter pulses and the terrain computation loop. It is also applied to the blanking amplifier of the electronic countermeasure system for blanking purposes.

The radar trigger is delayed so that the transmitted radar pulses correspond to the zero range crosshair. This is accomplished during zero calibrate by adjusting the zero calibrate potentiometer. The radar trigger may be delayed approximately 0.4 to 1.4 microseconds during this procedure.

The system trigger is fed to the range timing gate generator 363, the range crosshair gate pulse generator 364, the sweep trigger pulse generator 366, and the sweep gate generator 384. During normal sweep operation the system trigger is applied directly to the sweep gate generator.

If you take the sweep delay control out of detent, without energizing the sweep delay switch, delay marker relay K01 is energized. The system trigger, applied to the sweep trigger pulse generator 366, is delayed in an amount determined by the control position. A delay marker is fed from the 366 unit through the deenergized sweep delay relay (K05) contacts to the marker mixing pulse amplifier. This manually variable delay marker is applied to the display circuits. It is used to initially set the range for the sweep delay function.

Now the sweep delay toggle switch is activated. This energizes sweep delay relay K05, causing system trigger to be replaced with a delayed sweep trigger. At that time the sweep center is representative of the distance selected with the delay marker.

You should keep in mind that the system and radar triggers are essential to the RDPS and radar timing. Just as your car will not run properly if the timing is improper, the system will not work properly if its timing is faulty.

Range mark generation. The range marks are developed in the timing pulse generator 361. The master frequency of 161.73 kHz is applied to a series of frequency dividers and the 1/2-, 2-, 10-, and 50-mile markers are developed. The markers are applied to the marker mixing pulse amplifier 367. From there the so-called "navigation range marks" are sent to the indicator circuits. The variable range mark used during bombing is a little more complicated in its development. The 161.73-kHz master frequency is applied to the signal data converter 110, where it is modulated in a resolver by slant range. The shaft of the resolver turns one complete revolution for each 1/2-mile of slant range. The results of this action are the 161.73 kHz sin Ψ and 161.73 kHz cos V signals. These signals represent fine slant range and are fed to the range crosshair gate pulse generator 364. In the 364 unit they are combined with the slant range timing gate and the slant range gate to produce a range crosshair. The range crosshair is applied to both the marker mixing pulse amplifier 367 and to the sweep and display loop. The slant range gate, also produced in the 364 unit, is sent to the sweep generation loop, which will be discussed later in this chapter.

Range zero and range track voltages from the range timing gate generator 363 are applied to the signal data converter. You will frequently find it necessary to adjust these voltages to keep the range crosshair tracking linearly from 0 to 50 miles. These voltages are applied to a variable resistor. The wiper arm of the resistor is positioned by slant range. The resulting range voltage output is returned to the 363 unit to determine the start time of the slant range timing gate.

The range timing gate generator 363 also produces an altitude enable gate signal. This signal is sent to the azimuth and heading marker generation loop, where it is used in the development of the altitude timing gate.

If you have studied and followed the data flow shown in figure 2-8, you have probably noticed the azimuth gate output of the marker mixing pulse amplifier 367. This unit received an azimuth crosshair signal from the azimuth and heading marker loop during IBDA operation. The switching voltages and the azimuth gate signal allow the superimposing of the 1/2-mile marks or feathers on the azimuth crosshair during IBDA operation.

Exercises (612):

1. Give the primary purpose served by the system and radar triggers.

2. Tell what determines the PRF of the radar trigger.

3. Identify whatever controls the delay of the radar trigger.

4. The sweep delay control knob has been taken out of detent. Specify the actions which occur at this time as a result.

5. Name the relay energized by activation of the sweep delay toggle switch.

6. Locate where the navigation range marks are developed.

7. Give how many revolutions of the fine slant range resolver, in the signal data converter 110, represent 1/2 mile of slant range.

8. Provide the source of the slant range gate.

9. Give the purpose of the range track and range zero voltages.

10. Tell what is established by the range voltage input to the range timing gate generator.

11. Supply the use of the altitude enable gate signal.

12. Relate when the sweep trigger pulse generator is used.

13. Locate where the pulse characteristics of the radar trigger may be found.

14. Identify the signal retulating the timing of the radar transmitter pulse.

15. Specify which marker and trigger loop unit superimposes the 1/2-mile markers on the azimuth gate during IBDA operation.

2-2. Azimuth and Heading Marker Circuits

Another RDPS circuit you must be very familiar with is the azimuth and heading marker generation circuit. As the discussion of this circuit progresses, you will find it to be tied heavily into the radar, computer, and other RDPS loops.

The azimuth and heading marker circuits develop the sector scan reversing pulses, azimuth marker, heading, marker, altitude gate, 2045 cos (a - θg), 2045 sin (a - θg) 2045 cos ($a + h$), and the 2045 sin ($a + h$).

613. Examine the azimuth and heading marker generation circuit signals by determining selected origins, purposes, processes, and developments of and among these signals.

Data Flow. In this portion of the text you will begin to see the operation of some of the RDPS controls. In addition to learning the data flow of the azimuth and heading marker circuit you should learn which units are affected by these controls. In the RDPS circuits previously discussed, many of the individual units were discussed separately. This was necessary to insure your understanding of the critical timing nature of those circuits. Only the overall circuit data flow will be discussed for the azimuth and heading marker generation circuit.

A 2045-Hz reference signal (see fig. 2-9) is sent to resolver synchro B458 on the radar antenna, where it is resolved into two signals (2045 cos a and 2045 sin a). These two signals are sent to two 372 amplifiers and then to two resolver synchros SR03 (in the azimuth and elevation computer) and SR05 (in the heading data computer), where the signals are resolved about θg and h. Resolver synchro SR03 develops 2045 cos (a - θg) and 2045 sin (a - θg) signals, while resolver synchro SR05 develops 2045 cos (a + h) and 2045 sin (a + h) signals. The two (a - θg) signals are used by the sector control circuits, the azimuth crosshair generation circuits, and the sweep generation circuits. The two (a + h) signals are used by the sweep generation circuits and the azimuth crosshair generation circuits.

Relay K01 TC selects a sector width control voltage from either the range selector control or the terrain relay frame. The selected sector width control voltage is sent to the sector scan pulse generator 375. Sine and cosine (a - θg or a - d) signals are also selected by K01 TC and supplied to the sector scan pulse generator. The sector scan pulse generator develops a control current output to energize sector scan reverse relay K01 at each edge of the antenna sector scan. To obtain sector scan operation, you may energize the sector scan enable relay by placing the sector scan switch (a part of sector width control but not shown on fig. 2-9) to the ON position. Keep in mind, however, that the sector scan enable relay is automatically energized during the TA and off-center modes by way of TA and off-center relays. When the sector scan enable relay is energized, +150 vdc is applied to sector scan reverse relay K01. Each time K01 is energized, a ground pulse is supplied through its energized contacts to the direction and cycle relays. These relays reverse the direction of antenna rotation each time a ground pulse is received.

Refer again to figure 2-9 and examine the development of the azimuth crosshair. During search operation, the 2045 sin (a - θg) signal is sent to the azimuth crosshair gate generator 375 along with a 2045-Hz reference signal. These two signals are used to develop the 30-volt sin (a - θg) signal output, which is sent through the deenergized contacts of K01 back to the azimuth crosshair gate generator as an input. An ambiguity signal, 30-volt cos (a - θg), from the ground track repeater loop, is sent to the 376 unit to eliminate the generation of an ambiguous azimuth marker 180° from the line of sight. The 376 unit produces an azimuth mark when a - θg equals 0°, and this is fed to the marker and trigger generation circuits and to the marker mixing gate amplifier.

During off-center operation and during altitude calibrate operation, the 30-volt sin ($a - \theta g$) signal is replaced by either the 100-volt sin ($a - \theta g$) or the 100-volt sin ($a + h$) signal, depending upon the orientation of the radarscope presentation. The off-center relay, K02, OC, replaces the 2045 sin ($a - \theta g$) signal with a ground signal and energizes the altitude calibrate relay, K01 TB. Energizing relay K01 replaces the 30-volt sin ($a - \theta g$) signal with the 100-volt sin ($a - \theta g$) signal. In search operation, placing the altitude calibrate switch to the ON position causes K01 to be energized (without energizing K02 OC) and replaces the 30-volt sin ($a - \theta g$) signal with the 100-volt sin ($a + h$) signal. Details of this particular switching are shown on the sweep generation circuits and are discussed in a later objective.

As indicated in figure 2-9, the altitude timing gate generator 365 and the altitude unblanking gate generator 383 receive inputs of Ha, H_T, or X_H, altitude enable gate, sweep gate, slant range gate, vertical sweep, and -150-volt enable voltage. From these input signals, altitude gate and unblanking gate signals are generated. The altitude gate signal is sent to the sweep generation circuits, while the unblanking

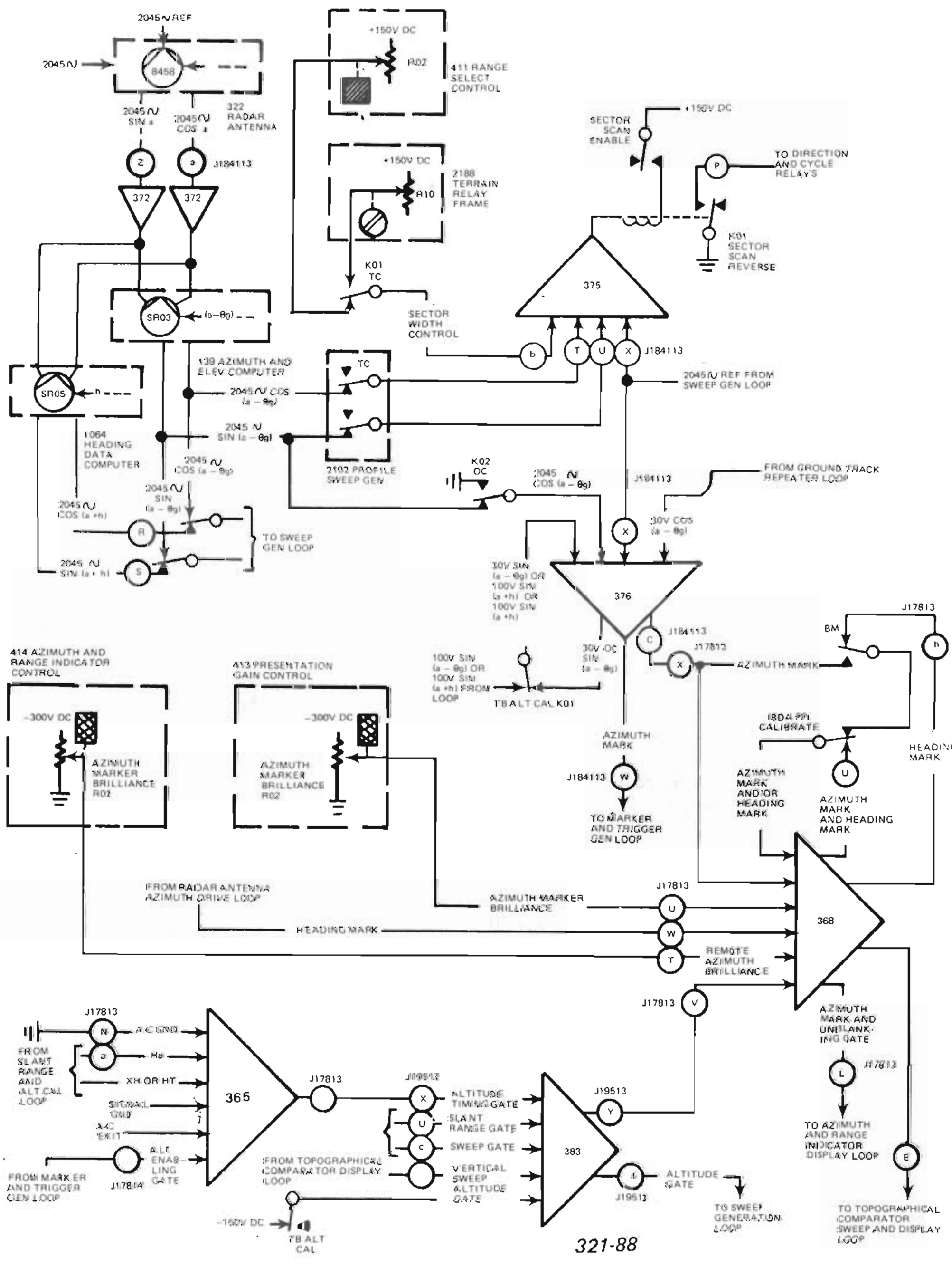

Figure 2-9. Azimuth and heading marker generation circuit.

gate signal is sent to the marker mixing gate amplifier 368.

The marker mixing gate amplifier receives the azimuth mark, heading mark, unblanking gate, and marker brilliance control signals as inputs. This amplifier produces gated azimuth, heading, and mixed azimuth and heading mark outputs. The particular mark to be presented is selected by the relay control circuits of the marker mixing gate amplifier.

Exercises (613):

1. Locate the origin of the 2045 cos α and 2045 sin α signals.

2. Find and name the relay selecting the sector width control voltage input to the sector scan pulse generator.

3. Relate the purpose of the 30-volt cos ($\alpha - \theta g$) signal.

4. Determine when the azimuth crosshair gate generator produces an azimuth mark.

5. During search mode operation, pinpoint the inputs to the azimuth crosshair gate generator.

6. Tell where the 30-volt sin ($\alpha - \theta g$) signal is produced and where it is applied.

7. Name the signals used to develop the altitude timing gate.

8. Cite the outputs of the altitude unblanking gate generator.

9. Specify the type of signal applied to the direction and cycle relays through sector scan reverse relay contacts.

2-3 Sweep Generation

Although the circuits previously discussed are very important, they would be of little value to you unless the sweep circuits are operational. There must be some method of sweeping the intelligence across the indicator. In this portion of the text you will study the signal flow for the sweep circuits. This includes how the voltages are generated and, in some cases, how they are controlled.

An understanding of the operation of these circuits can aid you in troubleshooting the system. In many cases the sweeps can be used to isolate system malfunctions. Learn these circuits well—it will pay you dividends later.

614. Clarify the nature of the sweep generation circuit by identifying its modes of operation and selected characteristics.

Sweep Modes. The BNS RDPS uses two basic sweep modes. These are off-center, OC, and plan position indicator, PPI. The two modes are discussed separately here so that you can fully appreciate their likenesses and differences.

PPI mode. You may find that the PPI mode is referred to in several different ways. Normally, PPI refers to a search type presentation utilizing a full 360° indicator scan. This mode is used primarily as a navigational aid, since the operator may view a large area surrounding the aircraft. The radar returns produce a radar ground map of the area scanned. The BNS has an added feature in this mode which allows you to look more closely at any segment of the 360°. You have already studied that circuit. Manual sector control is allowed through the use of the sector width control. Targets further out in range may be viewed through use of the sweep delay circuit. In flight an operator can also determine his position by monitoring beacon station radar returns.

It takes time for a radar transmitted pulse to go out, bounce off a target, and return to the aircraft. During PPI operation this time delay would cause a blank area, called an "altitude hole," to appear on the radar indicator. In the discussion of the azimuth and heading marker loop, you may recall that an altitude gate signal was developed. In the PPI mode the sweep circuits will use that altitude gate to prevent the altitude hole from appearing on the indicators.

To further enhance your understanding of what the PPI mode is, several of the available presentastions are illustrated in figure 2-10. These are certainly not all of the available displays, but they are examples of some typical ones. Figure 2-10,A, shows a full 360° scan with navigation range marks selected. Note that the azimuth crosshair does not appear, since it is a bomb mark. Figure 2-10,B, shows a full PPI display with bomb marks selected. The azimuth crosshair and the variable range mark (D) are shown. Figure 2-10,C,

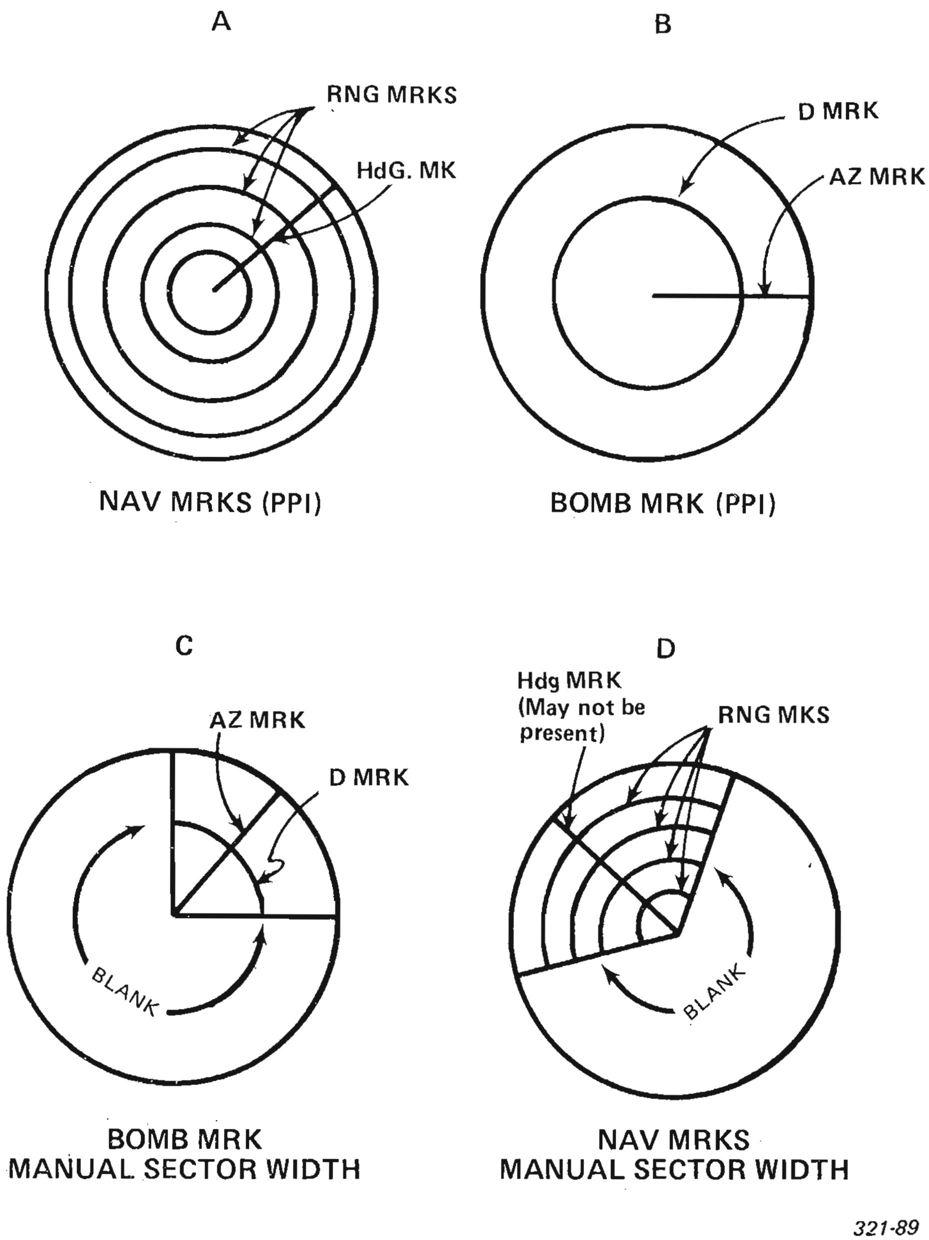

Figure 2-10. Examples of PPI displays.

shows a PPI display with bomb marks but also shows that manual sector width has been selected. Figure 2-10,D, again shows manual sector width, but the navigation marks have been retained. The heading mark may not be shown, since sector position is controlled manually.

Off-center mode. The off-center display mode is used when tracking of a target or aimpoint is desired. In order to enter this mode the computer must be either in track or in bomb mode. The display vertex is displaced from the center of the indicator screen and looks like a large letter V. Navigation marks are not available in the off-center mode; only bomb marks can be displayed. You may select either a north-stabilized or line-of-sight-oriented display.

Figure 2-11 illustrates several off-center displays. Section A shows a basic off-center display with line-of-sight orientation. Section B shows a north-stabilized off-center presentation. Section C is an example of the off-center display during a bomb run when TG reaches 16 seconds. The IBDA 1/2-mile markers appear on the azimuth mark. Figure 2-11,D, shows the crosshairs behind the aircraft, tracking away from the target.

Exercise (614):

1. Match the description listed in column B to the display given in column A. Each item in column B may be used once or not at all.

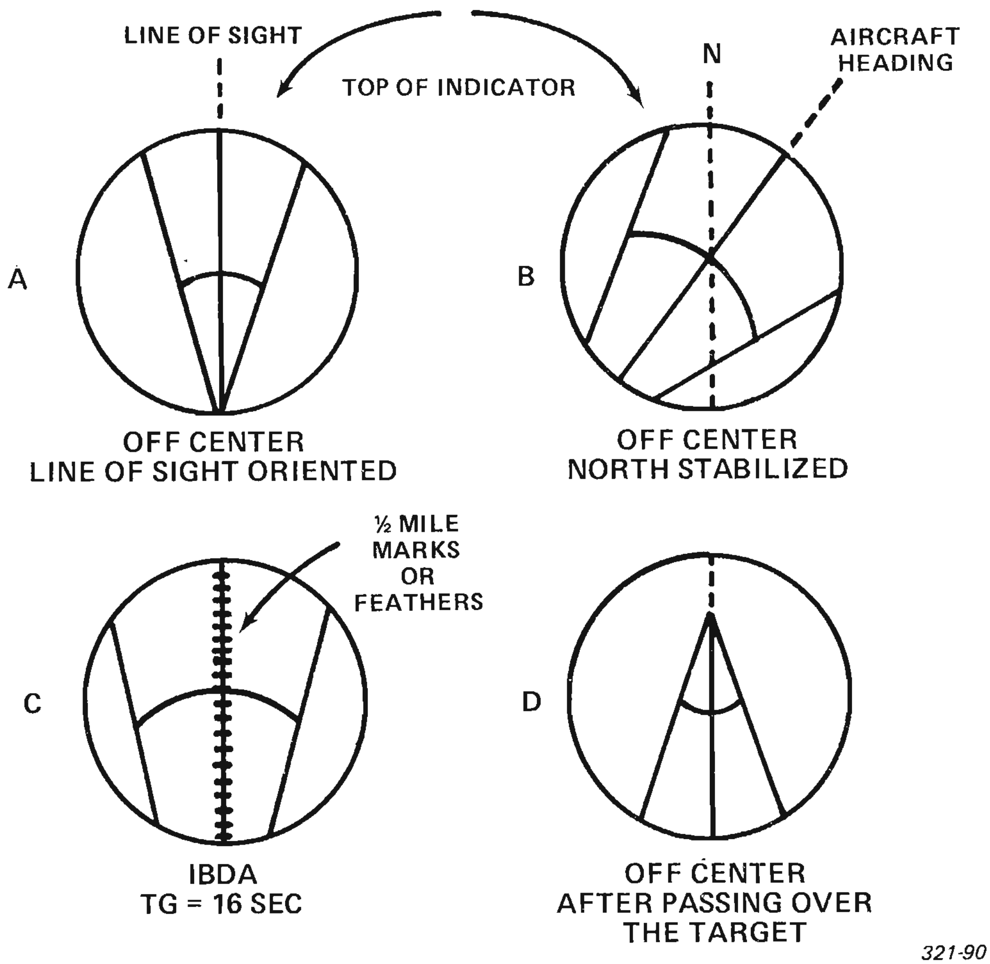

Figure 2-11. Examples of off-center displays.

Column A	*Column B*
_____ a. PPI/NAV.	1. Sector scan, 10-mile markers to 50-mile range.
_____ b. PPI/bomb.	2. Full scan, azimuth and variable range marker present.
_____ c. Off-center.	3. Sector scan, vertex displaced, azimuth and variable range marker present.
_____ d. PPI/manual. sector width.	4. Full scan, heading marker, and fixed range markers.
_____ e. IBDA.	5. Sector scan, vertex displaced, azimuth marker with ½-mile marks superimposed.
	6. Sector scan, vertex displaced, fixed range marks.

615. Examine the signal flow of the sweep generation circuits by identifying specific units and signals and providing reasons for selected sweep and voltage actions in these circuits.

Sweep Generation Circuit Signal Flow. The sweep generation circuits, shown in figure 2-12, develop the vertical and horizontal sweeps. They also develop the 2045-Hz voltage used in the terrain avoidance sweep generation circuits, the azimuth and heading marker generation circuits, and the range crosshair generation circuits. The altitude gate and the 2045-Hz rotation voltages—2045 sin $(a + h)$, 2045 cos $(a + h)$, 2045 sin $(a - \theta g)$, and 2045 cos $(a - \theta g)$ (from the azimuth and heading marker generation circuits), the system trigger or the delayed sweep trigger (from the trigger generation circuits), and the slant range gate (from the range crosshair generation circuits) are used in the sweep development.

PPI generation. In PPI mode, relay K02 is deenergized as shown. Therefore, 2045-Hz sine and cosine $(a + h)$ rotational voltages are supplied as inputs to the two azimuth signal data converters. Another input to the azimuth signal data converters is the 2045-Hz reference voltage from the 1600-Hz oscillator amplifier. You may recall from your 3-level school training that the output of the 1600-Hz oscillator amplifier is 2045 Hz. The azimuth signal data converters phase-detect the 2045-Hz rotational voltage inputs and produce 100-volt sin and cos $(a + h)$ rotational outputs. Two electronic integrators are used in conjunction with the two azimuth signal data

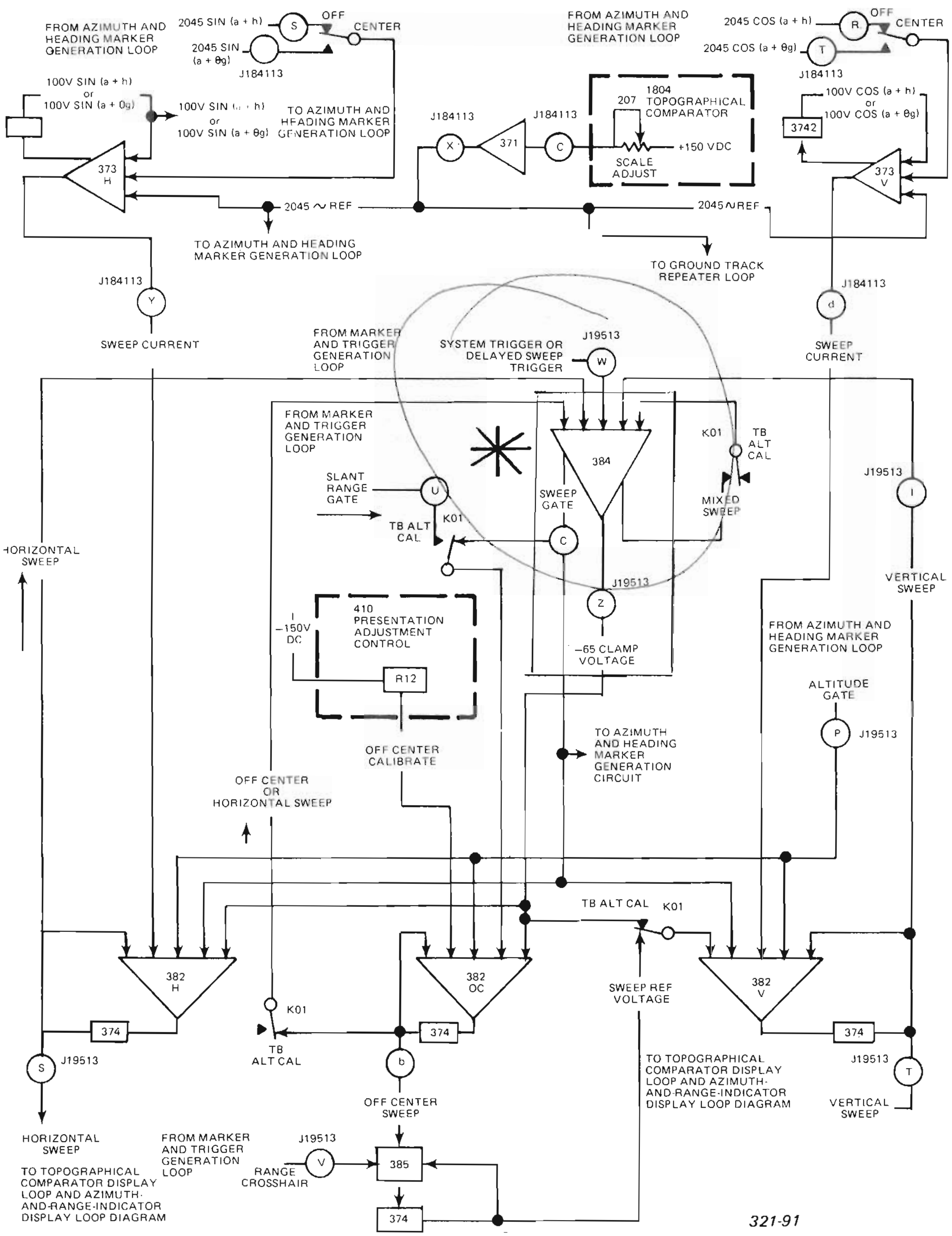

Figure 2-12. Sweep generation circuits.

converters to provide smooth, phase-detected outputs. The 100-volt sine and cosine rotational outputs are then sent to the range target scale selector, where they are converted to sweep currents for the horizontal and vertical sweep generators.

The sweep gate generator receives either the system or the delayed sweep trigger, which is used to start the sweep gate. The off-center sweep is supplied to the sweep gate generator to terminate the sweep gate when in the PPI mode. In the off-center mode, the vertical and horizontal sweep inputs are used to terminate the sweep gate. In addition to supplying the sweep gate as an output, the sweep gate generator develops the -65-volt clamp voltage and the mixed-sweeps signal.

The sweep gate signal is supplied to the vertical and horizontal sweep generators during both PPI and off-center modes. In the PPI mode, the sweep gate is also supplied through relay K01 to the off-center sweep generator. In the off-center mode, relay K01 is energized, and the slant range gate replaces the sweep gate input to the off-center sweep generator. The -65-volt clamp voltage from the sweep gate generator is sent to the horizontal and off-center sweep generators. This voltage is also sent to the vertical sweep generator when relay K01 is deenergized. Another input to the three sweep generators is the altitude gate.

The -65-volt clamp voltage (in PPI mode) establishes the starting point for the vertical sweep as the center of the CRT. The altitude gate charges hyperbolic network capacitors during altitude time and delays the start of the vertical sweep. At the end of altitude time, the altitude gate and the sweep gate permit the sweep current (from the range target scale selector) to charge a sweep-forming capacitor in the sweep generator. Also, at this time, the charge on the hyperbolic network capacitors is transferred to the sweep-forming capacitor. The sweep current can be either positive (for an upward deflection of the CRT electron beam) or negative (for a downward deflection of the CRT electron beam). This sweep current determines the charge (positive or negative) placed on the sweep-forming capacitor. The rising (or falling) waveform, developed by the charging sweep-forming capacitor, is inverted by the electronic integrator and becomes the vertical sweep. The vertical sweep is, therefore, either a negative sweep waveform for deflecting the CRT beam toward the top of the CRT screen or a positive sweep waveform for deflecting the CRT beam toward the bottom of the CRT screen. The vertical sweep is fed back to the vertical sweep generator as degenerative feedback to linearize the vertical sweep waveform.

Off-center generation. During off-center mode, the -65-volt clamp voltage is replaced by the sweep reference voltage from the electronic integrator associated with the sector offset computer. The sweep reference voltage is supplied through the energized contacts of relay K01 (see fig. 2-12).

The off-center sweep generator generates the off-center sweep, which is always a positive sweep waveform. This off-center sweep is used to terminate the vertical and horizontal sweeps during PPI mode of operation. Also the off-center sweep is used by the sector offset computer to develop the sweep reference voltage. The sector offset computer develops a sweep reference voltage of the correct magnitude to keep the range crosshair centered on the CRT screen during off-center mode of operation.

Exercises (615):

1. Identify the units which convert the 2045 sine and cosine signals to the 100-volt sine and cosine signals.

2. Cite the signal which establishes the starting point for the vertical sweep as the center of the CRT in PPI mode.

3. Tell what terminates the vertical and horizontal sweeps in PPI mode.

4. Indicate what terminates the sweep gate in off-center mode.

5. State why the vertical sweep is used as feedback to the vertical sweep generator.

6. Specify the signal which replaces the sweep gate input to the off-center sweep generator in the off-center mode.

7. Give the purpose of the sweep reference voltage applied to the vertical sweep generator in the off-center mode.

616. Examine sweep voltage conditions by, given specific system or sweep voltage conditions, determining the display characteristics present on the system indicators.

Sweep Voltages. You have now studied the development of the sweep signals. Now you should be ready to learn the voltage conditions which exist for each of the display modes.

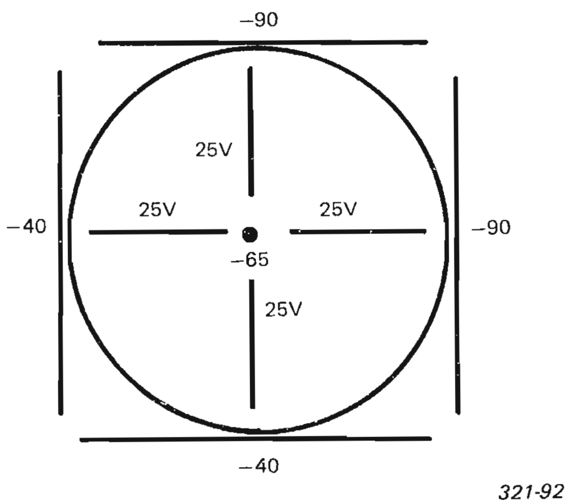

Figure 2-13. Required deflection voltages.

PPI sweep voltages. As you know, in PPI operation two sweeps are necessary, one for the horizontal sweep coils and one for the vertical sweep coils. Figure 2-13 shows the required deflection voltages for PPI operation. Notice that though the polarity of the signal may vary in its relation to the sweep center, a change of 25 volts is necessary in all cases.

Now look at figure 2-14. Four selected sweep positions are shown by means of dotted lines in part A of this illustration. The specific sweep voltage relationship for each of these sweep positions is shown in parts B, C, and D of the illustration. Note that in actuality none of the vertical or horizontal sweeps quite reach the -40-volt or -90-volt lines. Also, note that the off-center sweeps always reach to the -40-volt line. When the off-center sweep reaches -40 volts, the sweep gate is terminated if you are in the PPI mode.

Off-center sweep voltages. There are major differences between the off-center and PPI sweep voltages. To understand these differences you must understand certain conditions which exist in the off-center mode. These are as follows:

- The aircraft position is represented by the vertex of the sector.
- The range crosshair or variable range mark (VRM) will always be in the center of the CRT.
- The -65 volts is still used to represent the center of the CRT horizontally.

The primary problem is to obtain the information needed to determine the sweep reference. The radius of the scope still requires a 25-volt sweep. For any target scale selected, a voltage-to-nautical-mile ratio can be set. In figure 2-15 the target scale selected is 30 miles and the slant range is 30 miles. Therefore 15 nautical miles is equal to 25 volts. The ratio of miles to voltage is determined by both the target scale setting and the slant range. In the example shown, the vertex must be displaced about two tube radii, or 50 volts. Slant range is 30 miles and due to the target scale setting, one radium is equal to 15 nautical miles. The vertex is displaced to the aircraft position 30 miles or 50 volts from the range mark. The range mark is at the -65-volt reference. As the aircraft moves closer to the target, the vertex moves in with it and the VRM remains fixed in the CRT center. A new slant range value is constantly being computed, and a new vertex is determined and positioned.

To help you understand these voltage computations, here is another example: If the slant range is at 50 nautical miles and the target scale selector is set to 20 miles, the ratio is 10 nautical miles and equals 25 volts. At 25 volts per radii, the vertical sweep reference voltage is 125 volts positive from the -65-volt CRT center, or +60 volts.

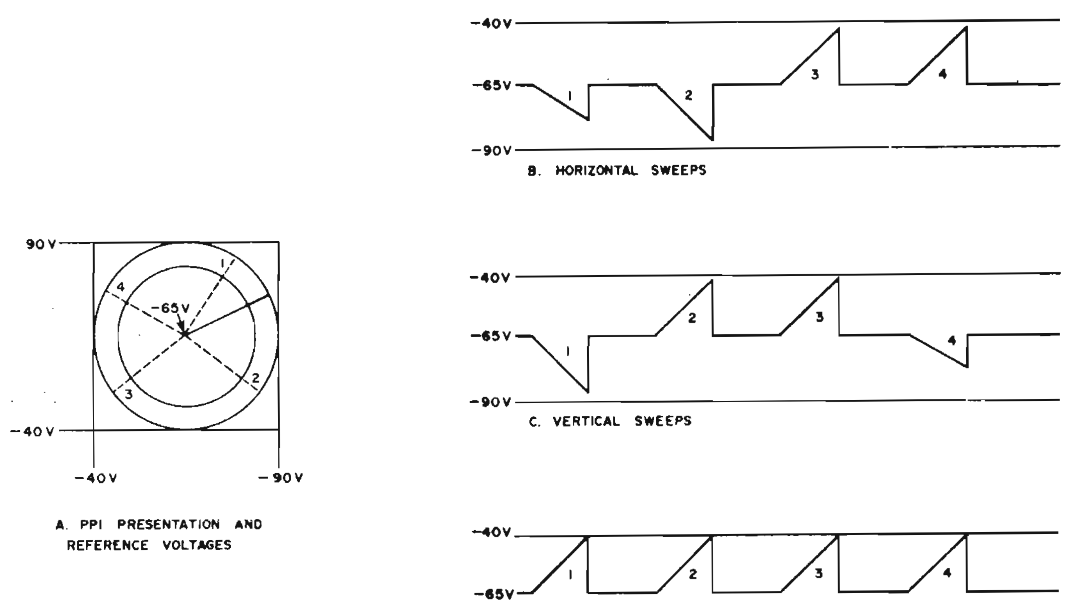

Figure 2-14. PPI mode display relationships.

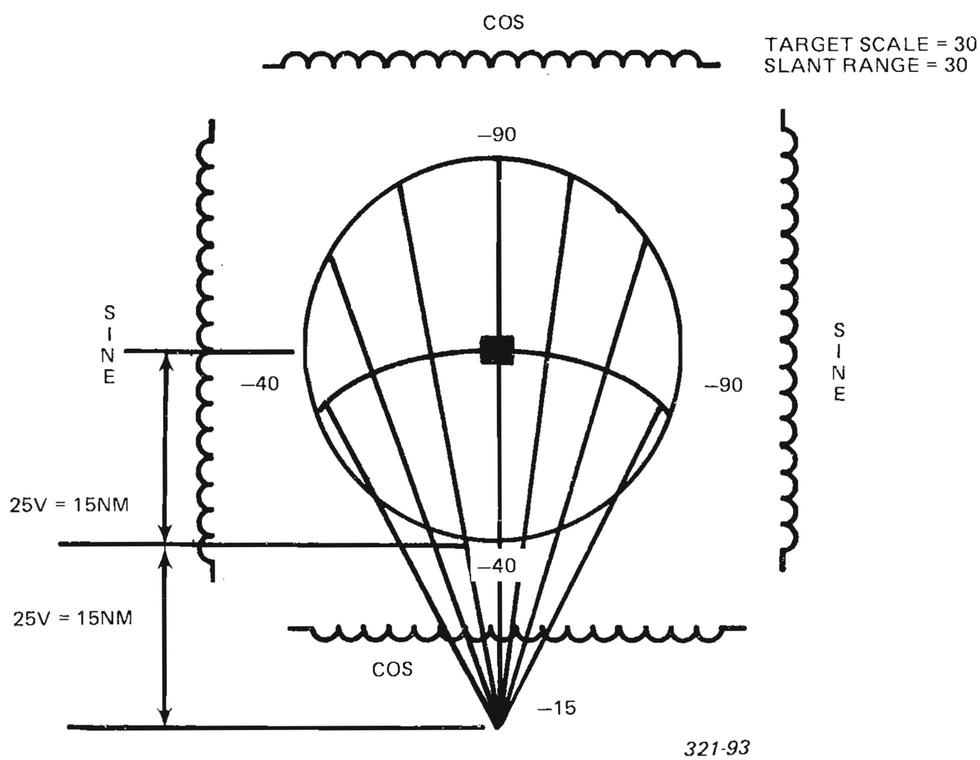

Figure 2-15. Off-center sweep voltages.

Exercises (616):

1. The slant range dial is at 15 nautical miles and the target scale is set to 30 nautical miles. Tell where the sweep vertex will appear on the indicator.

2. During PPI operation a change of 25 volts from the -65-volt reference takes place. State how much sweep deflection should occur on the indicator.

3. You have selected a PPI mode, the horizontal and vertical sweeps are near the -40-volt level. Indicate approximately where, in degrees, the leading edge of the sweep should appear on the indicator.

4. In a PPI mode, the horizontal sweep near the -90-volt level and the vertical sweep is near the -40-volt level. Specify approximately where, in degrees, the leading edge of the sweep should appear on the indicator.

5. In off-center operation, the target scale is set to 30 nautical miles and the slant range is at 30 nautical miles. The sweep vertex is now at the -15-volt level. Indicate whether the vertex will appear on the indicator.

6. Show the logic you used to arrive at your answer in exercise 5.

2-4. RDPS Controls

Your studies so far in this chapter have been devoted to the various modes, circuits, and presentations of the RDPS. Before you study the display circuits themselves, more time must be devoted to the controls that affect the RDPS. Some of the controls have been mentioned briefly as the circuits were explained. This portion of the text will summarize the controls you will use in the selection of the various RDPS conditions that have been discussed. These are the range target scale selector, range selector, target scale selector, presentation gain, and the presentation adjust controls.

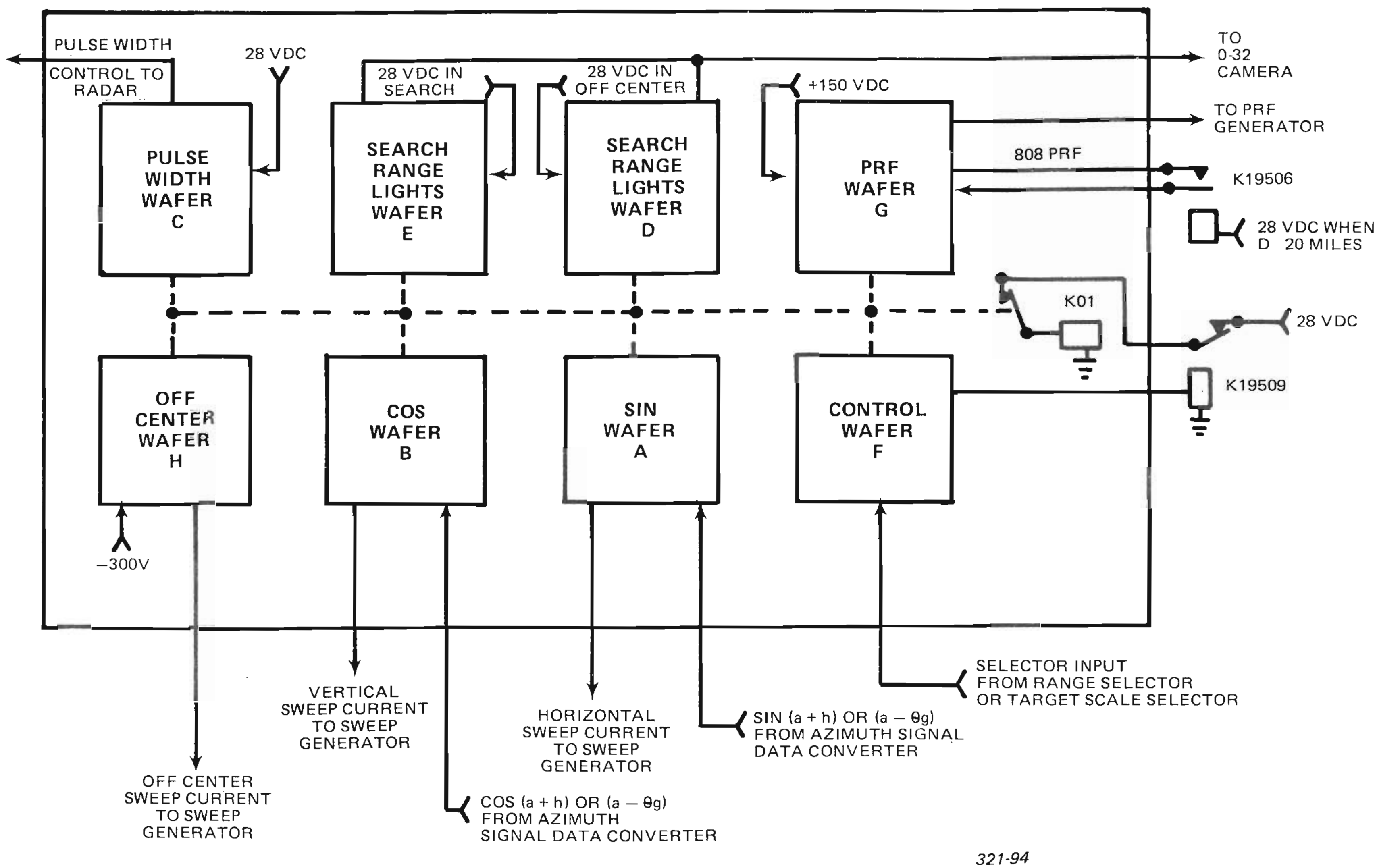

Figure 2-16. Range target scale selector, block diagram.

617. Examine the various control units of the RDPS by identifying selected functional uses, positions, locations, and operational features of these units.

Purpose. In order to operate the RDPS you should have an understanding of the purpose or functional use of each of the controls. This is the reason for this part of the text.

Range target scale selector. The range target scale selector is not an RDPS control in the normal sense. It does control several RDPS functions, but it is itself controlled by the range selector or target scale selector. The unit contains a stepping relay to control the vertical, horizontal, and off-center sweep voltages, range marker lights, and the pulse width control voltage. It also controls the PRF to the radar set.

As shown in figure 2-16, this unit contains eight wafer switches that are positioned by a common stepping relay. Each wafer has 20 positions, but each position is not always used.

Operation. Wafer F, the control wafer, receives 28 vdc from either the range selector or target scale selector, depending upon the operating mode. The wiper arm of the switch connects the 28 vdc to the coil of selector stop relay K19509. The normally closed contact of K19509 now receives 28 vdc. This in turn causes K19101, the stepping relay, to be energized through its own normally closed contact. When K01 energizes, a pawl and ratchet mechanism advances the wafer assembly one position in the clockwise direction. Energizing K01 also breaks the energizing path through the normally closed contact. However, if the new position on wafer F is not carrying voltage, K19509 remains deenergized. Its closed contacts reapply energizing voltage to K01, again shifting its wiper arms. The process continues until wafer F's wiper arm reaches a live contact.

Wafers A, B, and H control the amount of resistance placed in series with the inputs to each of their respective sweep generators. Wafer C selects the pulse width of the radar modulator. Wafers D and E supply the initial selection of 28 vdc for the camera coding circuits of the bombing computer. Wafer G determines the control voltage for the phantastron circuit of the PRF generator. Relay K19506 energizes when slant range is greater than 20 miles and overrides the 1617 PRF output from this wafer with an 808 PRF. This is used to obtain optimum returns when operating in short ranges, and still maintain a sufficient recovery period on the medium ranges. In off-center with 50-mile target scale selected, K19506 is bypassed.

Range selector control. The range selector control provides the manual selection of PPI display range, sector scan width, and the type of markers used on the indicators.

During PPI, the range knob controls the stepping switch in the range target scale selector. It may be set to 12 positions from 5 to 200 miles range. The sector width knob is a combination switch and variable potentiometer. It can be used to vary the sector width in both PPI and off-center. The markers switch selects either bomb or navigation markers for display on the indicators.

Target scale selector. The target scale selector control provides two switching functions for the system. The target scale knob selects ranges of from 10- to 50-mile increments in off-center modes. The other switch, radar-beacon, selects either radar or beacon, or a combination of both.

Presentation gain control. The presentation gain control primarily affects the topographical comparator display. Most of the controls are self-explanatory. These are the intensity control, marker brilliance control, ring lite control, and the video intensity control. The receiver gain control varies the gain of the IF amplifier in the receiver-transmitter unit of the radar.

Presentation adjust control. The presentation adjust control provides the horizontal and vertical centering adjustments for the topographical comparator, a focus control, the off-center calibrate control, the sweep delay control, and the IBDA control switches.

Exercises (617):

1. Tell when the range target scale selector is controlled by the target scale selector control.

2. Identify the wafer switch in the range target scale selector which controls the modulator pulse width.

3. Determine when K19506 energizes.

4. State how the range target scale selector changes the various RDPS and radar functions simultaneously when a range change is made by the system operator.

5. Indicate when the range selector control may be used to change the display range.

6. Specify the number of range positions found on the range selector control.

7. Tell what control is located on the target scale selector control in addition to the target scale knob.

8. Give the maximum target scale which may be selected.

9. State how many presentation gain control knobs affect the radar. Name it/them.

10. Cite the unit on which the sector width knob is located.

11. Locate the intensity control for the topographical comparator.

12. Cite the controls which would be adjusted to center the topographical comparator presentation and the location of these controls.

13. Indicate the unit containing the selector switch for the types of markers to be displayed.

14. Locate the off-center calibrate control.

15. Identify the RDPS control you would adjust to increase the marker intensity on the topographical comparator.

Display Circuits

BEFORE YOU or the operator can use the radar information it must be displayed. Since the radar target echoes are returning at an extremely high velocity (161,730 nautical miles per second), you can see that the returns must be presented so that you and the navigator have time to interpret them and make decisions. The presentation time is controlled by using a cathode-ray tube (CRT) with a long persistency. In effect, the CRT stores the target returns until the next target sampling period.

By using a planned position indicator (PPI) type of presentation, you can monitor both target range and target azimuth on a single indicator. The PPI type of presentation results in a ground map type of presentation. With a PPI type of presentation, the aircraft is effectively at the center of the cathode-ray tube, and you can measure all ranges from this center. Furthermore, the top of the CRT is the reference point for target azimuth angles.

In this chapter you will study both the topographical comparator (10" indicator) and the azimuth and range indicator (5" indicator) display circuits. Also discussed will be the RDPS special display modes, camera tie-in, alignments, and troubleshooting. Electro-optical viewing system displays will not be covered in this portion of the text. These displays will be explained more appropriately in Volumn 5 of this course.

3-1. Indicator Display Circuits

The display circuits receive the vertical and horizontal sweeps from the sweep generation circuits and convert them into a varying magnetic field. This varying magnetic field deflects the CRT electron beam across the face of the CRT. The video portion of the display circuits receives marks from the marker mixing pulse amplifier, azimuth marker and unblanking gate from the marker mixing gate-pulse amplifier, and video from the radar receiver circuits. These signals are used to intensity modulate the CRT electron beam. Accelerating power for the electron beam is obtained from the comparator high voltage power supply.

Another important, but simple, part of the display circuits is the display orientation loop. This loop enables you, or the navigator, to select either a north-oriented or a line-of-sight (LOS) oriented display. Having two types of displays provides the simplest type of display for both navigation (north oriented) and bombing (LOS oriented.)

618. Clarify the nature of the topographical comparator sweep circuits by completing statements identifying selected operations, input and outputs, purposes, and other features of these circuits.

Topographical Comparator Sweep Circuits. Refer to figure 3-1, and let us first consider the signal data flow of the vertical and the horizontal sweep circuits.

The vertical deflection voltage amplifier receives four signals as inputs: (1) vertical sweep, (2) vertical centering voltage, (3) feedback 1, and (4) feedback 2. From these signals, the vertical deflection voltage amplifier develops two sweep output signals, which are sent to the vertical deflection current amplifier. The vertical deflection current amplifier develops two feedback sweep signals and two sweep current output signals. The two feedback signals are sent to the deflection voltage amplifier, while the two sweep current signals are sent to the vertical sweep coils of the topographical comparator.

The vertical sweep coils have +600 volts dc applied to one side of each coil. The other side of each of the sweep coils is connected to one of the vertical sweep outputs from the deflection current amplifier. The +600 volts dc is the plate voltage for the two power output tubes in the deflection current amplifier, and the sweep coils are the plate loads for these same two power output tubes. The two feedback signals to the deflection voltage amplifier are degenerative signals used to generate linear sweep currents from linear sweep voltage waveforms. Should either feedback signal be missing, bunching of target returns and range marks would occur in either the upper or the lower half of the PPI presentation. The fault could be in the deflection voltage amplifier, in the deflection current amplifier, or in the interconnecting wiring.

The horizontal sweep circuits operate in the same manner as the vertical sweep circuits. To make the preceding text read as a discussion on the horizontal circuits, it is only necessary to replace the word "vertical" with the word "horizontal" and words "upper" and "lower" with "right" and "left" respectively.

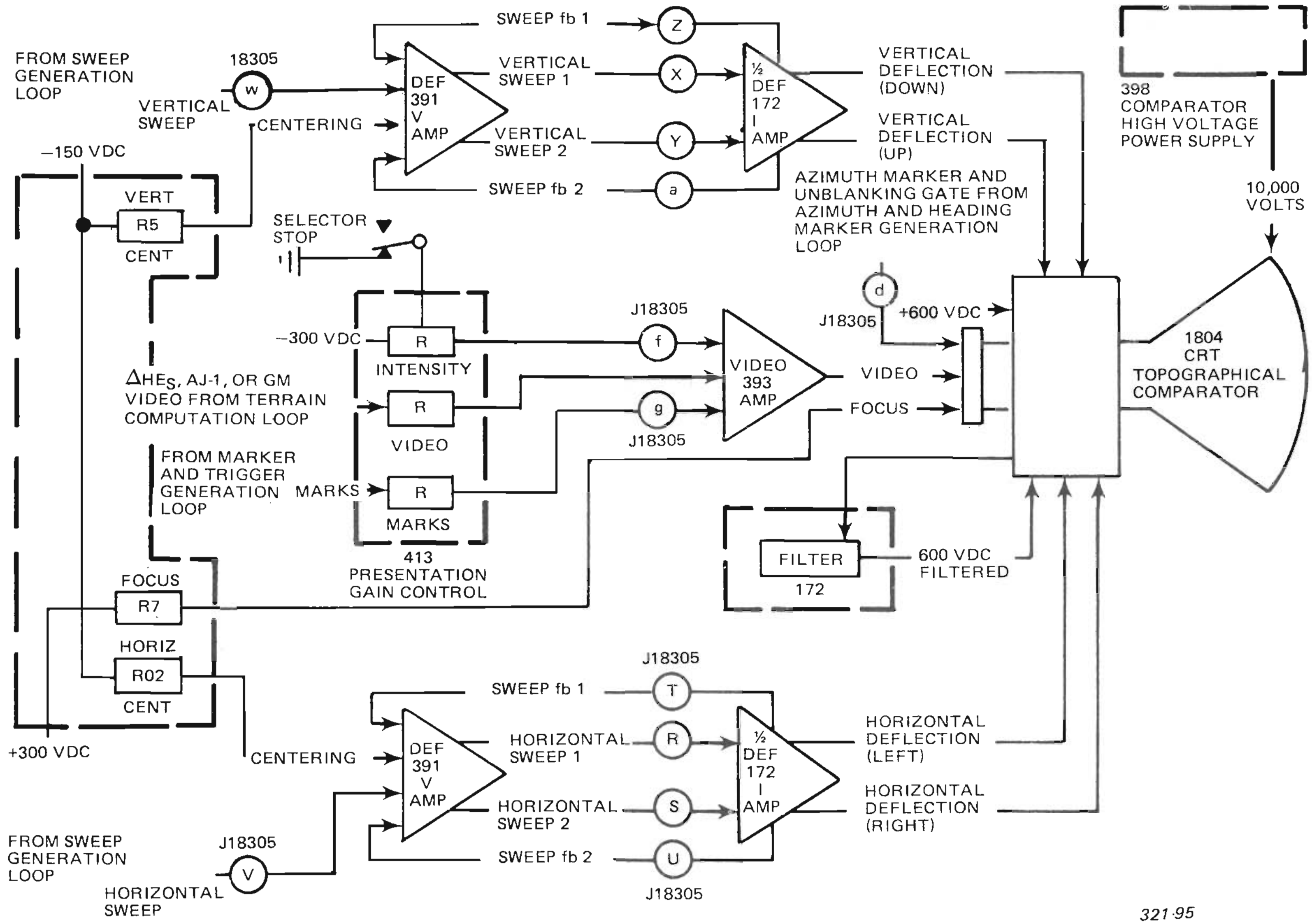

Figure 3-1. Topographical comparator display circuits.

Exercises (618):

Complete the following statements by inserting the correct word or phrase in each.

1. In addition to the sweep and feedback signals each voltage deflection amplifier has a ________ ________ applied.
2. The outputs of the voltage deflection amplifiers are fed to the ________ ________ ________.
3. Each half of the current deflection amplifier has ________ outputs.
4. One input to the horizontal sweep coil of the topographical comparator is 600 vdc and the other is the ________ ________ signal.
5. The purpose of the degenerative feedback between the current and voltage deflection amplifiers is to insure ________ ________ ________.
6. Bunching or compression of the target returns on one side of the indicator is usually caused by the loss of a ________ signal.
7. The plate voltage for the power output tubes of the current deflection amplifier is ________.

619. Examine the topographical comparator video circuits by identifying selected signals, controls, and components comprising these circuits.

Video Circuits. The video amplifier circuits, shown in figure 3-2, combine target video, range markers, and an intensity control voltage. This combined signal is applied to the control grid of the indicator CRT to intensity modulate the CRT electron beam. Tube V01 in figure 3-2 inverts the video signal and applies the inverted video to tube V02. Tubes V02 and V03B receive the negative range markers and the negative video; the tubes amplify, invert, and mix these two signals and apply the mixed signal to cathode follower V03A. The output from V03A is further amplified by tubes V04, V05, and V06 and applied to a clamper circuit. This clamper circuit consists of capacitor C13, resistor R26, and diodes CR04 and CR05. The clamp (intensity control) voltage establishes the reference level for the mixed video output. You vary the magnitude of this mixed video with the intensity control on the presentation gain control.

Diodes CR01, CR02, and CR03 are clamp diodes used to clamp the video and mixed video signals to the reference shown in figure 3-2. Clamping the video and mixed video signals insures that the signals always start at a predetermined level and prevents the video intensity from changing due to amplifier drift and charge buildup on coupling capacitors.

Refer back to figure 3-1. Note that the azimuth marker and unblanking gate is applied directly to the CRT. Although not specified on the figure the heading marker is also applied there. They are all applied directly from the marker mixing gate amplifier to the CRT cathode.

Exercises (619):

1. Specify the three signals which combine to form the mixed video signal from the video amplifier.

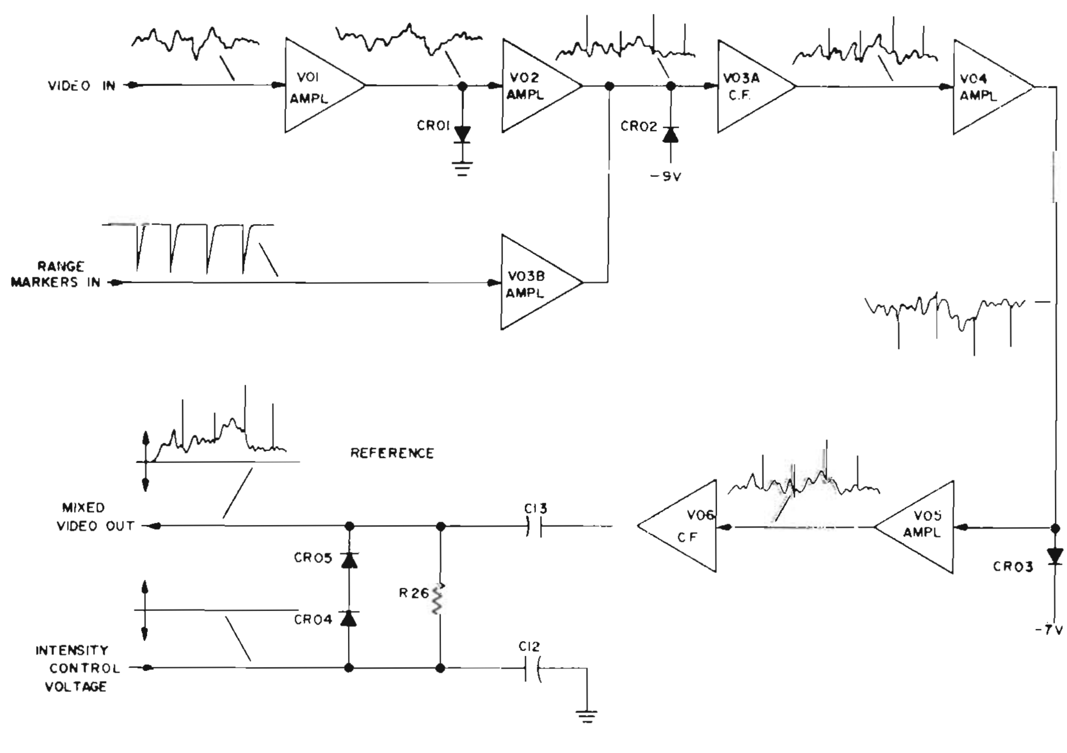

Figure 3-2. Video processing.

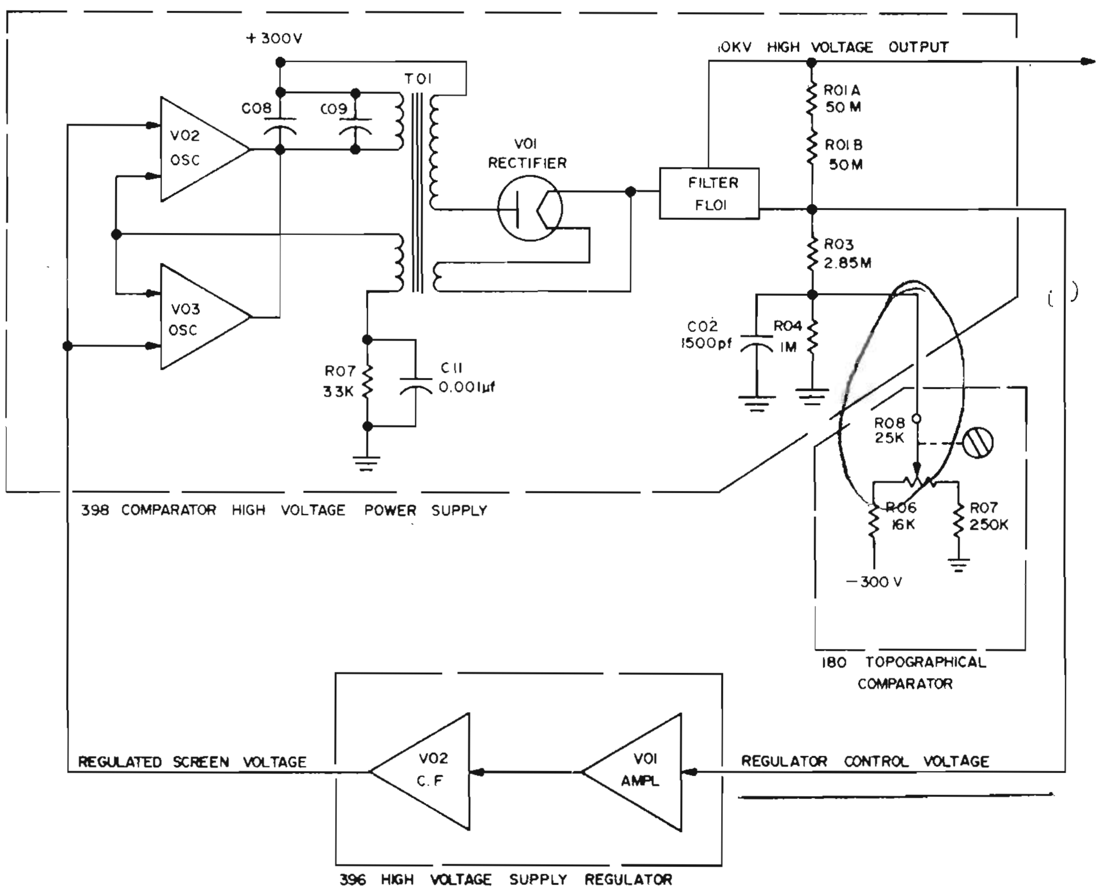

Figure 3-3. Comparator high-voltage power supply circuits.

2. Name the control which establishes the reference level for the mixed video output of the video amplifier.

3. Cite the components within the video amplifier which prevent video intensity drift.

4. Identify the part of the CRT to which the azimuth or heading markers are applied.

620. Analyze the operation of the comparator high-voltage power supply circuit by stating this circuit's purpose, supplying the reason for using a particular oscillar, and citing key effects of specified operational adjustments therein.

Comparator High-Voltage Power Supply. All of the display circuits discussed previously are useless without a high-voltage power source for the CRT. Without this high-voltage power to accelerate the electron beam, no video or marker information can be displayed. Figure 3-3 illustrates the high-voltage supply circuitry used to develop this accelerating potential. Since variations in this high voltage affect the focus of the CRT, a regulator circuit is incorporated to maintain the high voltage at a constant level.

Tubes V02 and V03, capacitors C08 and C09, and transformer T01 form an oscillator circuit which oscillates at 200 kHz. You may ask, "Why not use the aircraft 400-Hz voltage rather than incorporate a special oscillator circuit?" The reason for including this special oscillator circuit is to reduce component size. A transformer that will step a 400-Hz voltage up to 10 kv is large and weighs several pounds; whereas a transformer that will step a 200-kHz voltage up to 10 kv is small and weighs only a few ounces. Also, the filter capacitors need not be as large at a 200-kHz ripple frequency as at a 400-Hz frequency. Since weight is a primary consideration in the design of avionics equipment, you can see then why the additional oscillator is included in this circuit.

The 200-kHz output is stepped up to 10 kv by transformer T01 and applied to rectifier V01. The stepped up 200-kHz signal is rectified by the tube V01, and the pulsating dc output is filtered by FL01. The 10-kv filtered output is sent to the topographical comparator and applied to the CRT. The 10-kv filtered output is also applied to a voltage divider circuit consisting of resistors R01A, R01B, R03, and R04. Also applied to this voltage divider circuit is a negative reference potential from potentiometer R08. The output (taken from the voltage divider circuit at the junction of Ro1B and R03) is applied to the high-voltage supply regulator.

This regulator control voltage is amplified and inverted by V01 in the 396 unit and then applied to cathode follower V02. The output from V02 in the 396 unit is supplied to the 200-kHz oscillator tubes as a regulated screen voltage. By controlling the screen voltage to the oscillator, the 200-kHz output amplitude is controlled. Let us take a typical example to see how the 10-kv regulation is accomplished.

If the 10 kv increases due to a lighter current load, the voltage divider regulator control voltage increases. When this change is amplified and inverted by V01 in the 398 unit, a lower voltage is applied to cathode follower V02 in the 398 unit. Tube V02 therefore has a lower output voltage to the 200-kHz oscillator screen grids. With a lower screen-grid voltage, the 200-kHz oscillator has a lower output, and the high voltage is reduced to 10 kv, restoring the balanced output from the voltage divider. If the 10 kv decreases due to a heavier current load, the regulator input decreases and causes the regulator output to increase. This increased voltage, applied to the oscillator screen grids, increases the 200-kHz output and, therefore, brings the 10 kv back to its original value.

You position potentiometer R08 to adjust the 10 kv applied to the topographical comparator. The presentation size is affected by the level of the 10-kv CRT voltage and, for this reason, you adjust the 10-kv to obtain a specific presentation size. This establishes an accurate topographical comparator scale (nautical miles per inch). Detailed procedures for adjusting the high voltage are contained in the adjustment section of your -26 technical order.

Exercises (620):

1. Supply the purpose of the comparator high-voltage power supply.

2. Tell why a 200-kHz oscillator is used in the high-voltage power supply.

3. Indicate the effect increasing the 200-kHz signal amplitude has on the 10-kv output.

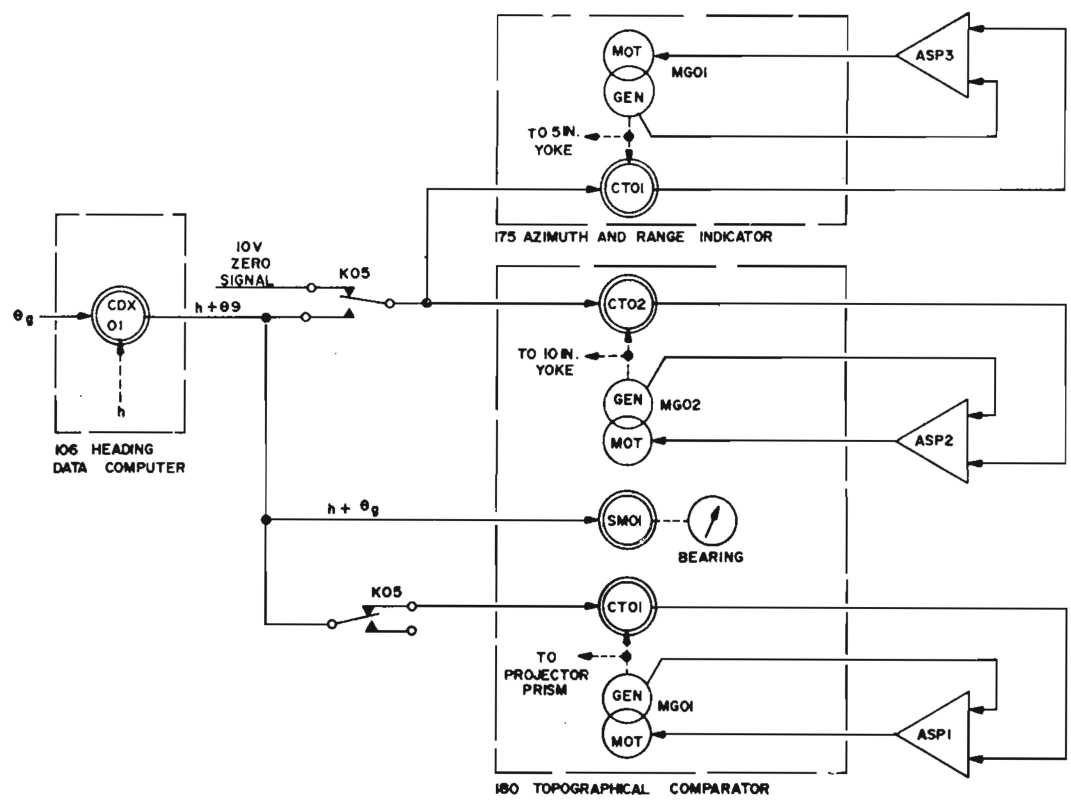

Figure 3-4. Display orientation loop.

4. Specify the effect adjusting the 10-kv output has on the comparator presentation.

621. Clarify the nature of the display orientation circuits by completing statements identifying specified operational features of these circuits.

Display Orientation. You will recall that the display is either north- or line-of-sight orientated. The display orientation loop, shown in figure 3-4, positions the 10-inch yoke, bearing pointer, and projector prism in the topographical comparator. The 5-inch yoke of the azimuth and range indicator is also positioned by this loop.

Ground azimuth angle θg is added to true heading h in the heading data computer and sent to orient relay K05 and synchro motor SM01. Synchro motor SM01 positions a bearing pointer on a reticle. The camera photographs this pointer of each exposure to provide a record of true bearing of line of sight. Single $h + \theta g$ passes through the deenergized contacts of K05 to CT01 in the topographical comparator. Control transformer CT01, motor generator MG01, and servoamplifier ASP1 form a control transformer servoloop to position the projector prism. The projector prism maintains the orientation of the map projection when the system is in LOS mode. In the north-oriented mode, relay K05 is energized, and the map projection is not stabilized. Orientation of the map projection can be accomplished manually in the north-oriented mode.

In the LOS-oriented mode, a 10-volt zeroing signal is supplied, through the deenergized contacts of relay K05, to control transformer CT02 in the topographical comparator and to control transformer CT01 in the azimuth and range indicator. Control transformer CT02, motor generator MG02, and servoamplifier ASP2 form a control transformer servoloop to position the 10-inch yoke. Control transformer CT01, motor generator MG01, and servoamplifier ASP3 form a control transformer servoloops drive the 5- and 10-inch yokes to zero, while display orientation is maintained by the sweep generation circuits.

In the north-oriented mode, orient relay K05 is energized, and signal $h + \theta g$ is supplied through its energized contacts to the 5- and the 10-inch yoke control transformer servoloops. The 5- and 10-inch yokes are now positioned to an angle of $h + \theta g$, and the presentations on the 5- and 10-inch indicators are north oriented. We have discussed some of the display circuits for the topographical comparator and the azimuth and range indicator display circuits. Let us complete our discussion of the display circuits with a comparison between the azimuth and range (5-inch) indicator display circuits and circuits discussed previously.

Exercises (621):

1. The indicator displays may be either ________ ________ ________ or ________ oriented.

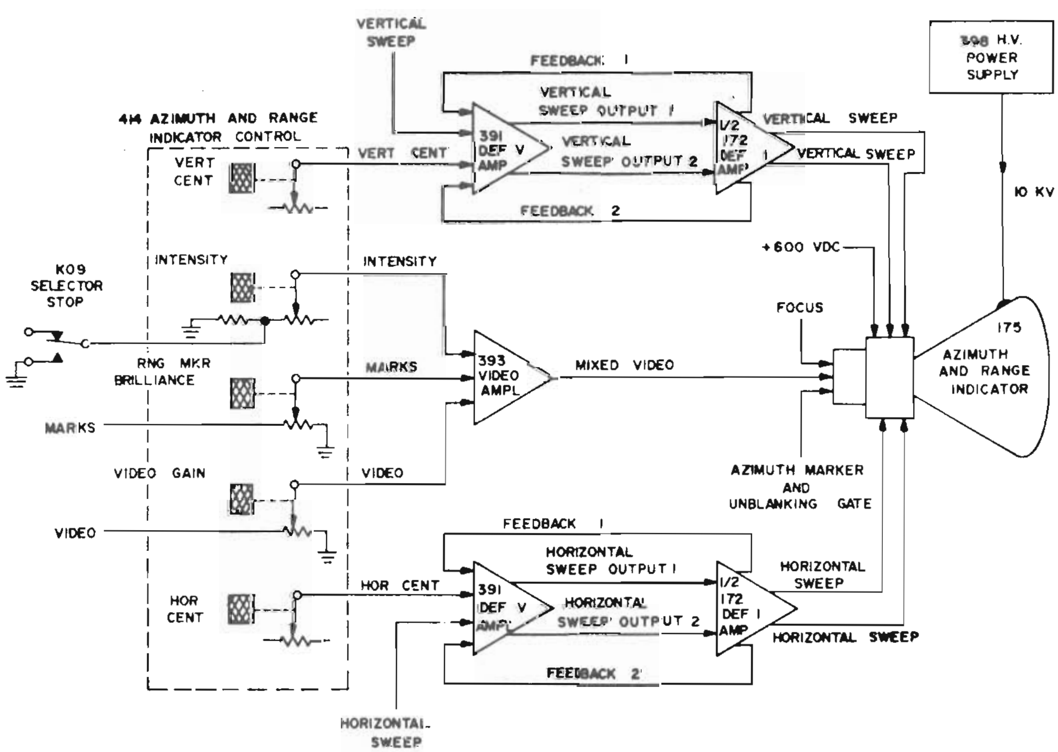

Figure 3-5. Five-inch indicator display circuits.

2. Relay K05 is ______________ during the north-oriented mode.
3. In the north-oriented mode the signal __________ controls the yoke position.
4. When K05 is deenergized, a __________ __________ signal is applied to CT02 in the topographical comparator.
5. One of the ASP amplifiers on the topographical comparator drives the ______________ and the other ______________ ______________.

622. Distinguish between the topographical comparator and the azimuth and range indicators as to the location of control panels and other more outstanding differences between them.

Azimuth and Range Indicator Circuits. Usually the azimuth and range indicator is simply referred to as the "5-inch indicator." Its display circuits are shown in figure 3-5.

With the exception of the indicator not having the map match or camera capability, and its controls, all components found here are the same ones as those existing in the topographical comparator display circuits. All circuits operate in an identical manner to that of the topographical comparator circuits and, for this reason, do not need to be discussed again. You should note here, however, that these are separate units from those used with the topographical comparator display circuits. This means that a total of four voltage deflection amplifiers are used—two with the topographical comparator and two with the azimuth and range indicator. This, you will find, simplifies your job when you troubleshoot the display circuits. Having more than one unit of a kind permits you to use a substitution type of trouble isolation procedure.

Exercises (622):

1. Give the location of the controls for the 5-inch indicator display.

2. The control panel distinguishes one indicator from another. Cite the other more prominent differences between the topographical comparator and the azimuth and range indicators.

3-2 Special Display Modes

The ASB-9A/16 BNS incorporates several special display modes to provide additional functions. These are: (1) station keeping, (2) indirect bomb damage assessment (IBDA), and (3) altitude calibration. We will discuss them in that order.

623. Clarify the station-keeping mode by identifying selected operational features and indicating when each is used.

Station-Keeping Mode. Station keeping is an independent mode utilizing a PPI display. This mode is useful when you fly in formation and for air refueling. The station-keeping mode is entered by placing the station-keeping switch on the topographical comparator to ON (see fig. 3-6). This action energizes K18403 by applying 28 vdc through the station-keeping switch and through the deenergized contacts of K17806 to the coil of K18403. The contacts of K18403 energize and, through the lower set of contacts, 28 vdc is applied to relays K17804 and 18404. Relay K18404 passes 28 vdc through its energized contacts and causes K19510 to be energized. Energized relay K19510 disables the altitude gate, and the altitude compensation of the PPI sweep is eliminated. Relay K18404 also supplies 28 vdc to the 5-mile position of the range selector switch, changing the PPI sweep presentatin to a 5-mile range. You should recall that energizing K17804 supplies both an azimuth marker and a heading marker to the display circuits, where they are both presented.

Another set of contacts of K18403 couples +150 vdc to the 2-mile switching input of the 367 marker mixing pulse amplifier. Also, +150 vdc is coupled through the center set of contacts of K18403 to the 1/2-mile switching input of the 367 unit. This results in the output of the 367 marker mixing pulse amplifier being switched to 1/2-mile and 2-mile markers, which are presented on the 5-mile display along with the heading and azimuth markers. The bright markers displayed are actually at 1¾-miles and 2¾-miles of slant range, as indicated in figure 3-7.

Figure 3-7 illustrates: (1) the usable field pattern, (2) the actual aircraft formation, and (3) the topographical comparator presentation. Note the TR hole in the center of the presentation. This hole has an approximate radius of 2000 feet and establishes the minimum station-keeping separation between aircraft. This maximum station-keeping separation is established by the 5-mile PPI sweep. From figure 3-7, you can see that each navigator has the necessary azimuth and range information for directing his aircraft commander when flying in formation. The formation can, therefore, be held within close limits by using the station mode.

Exercises (623):

1. Tell when the station-keeping mode is normally used.

2. Give the minimum station separation between aircraft.

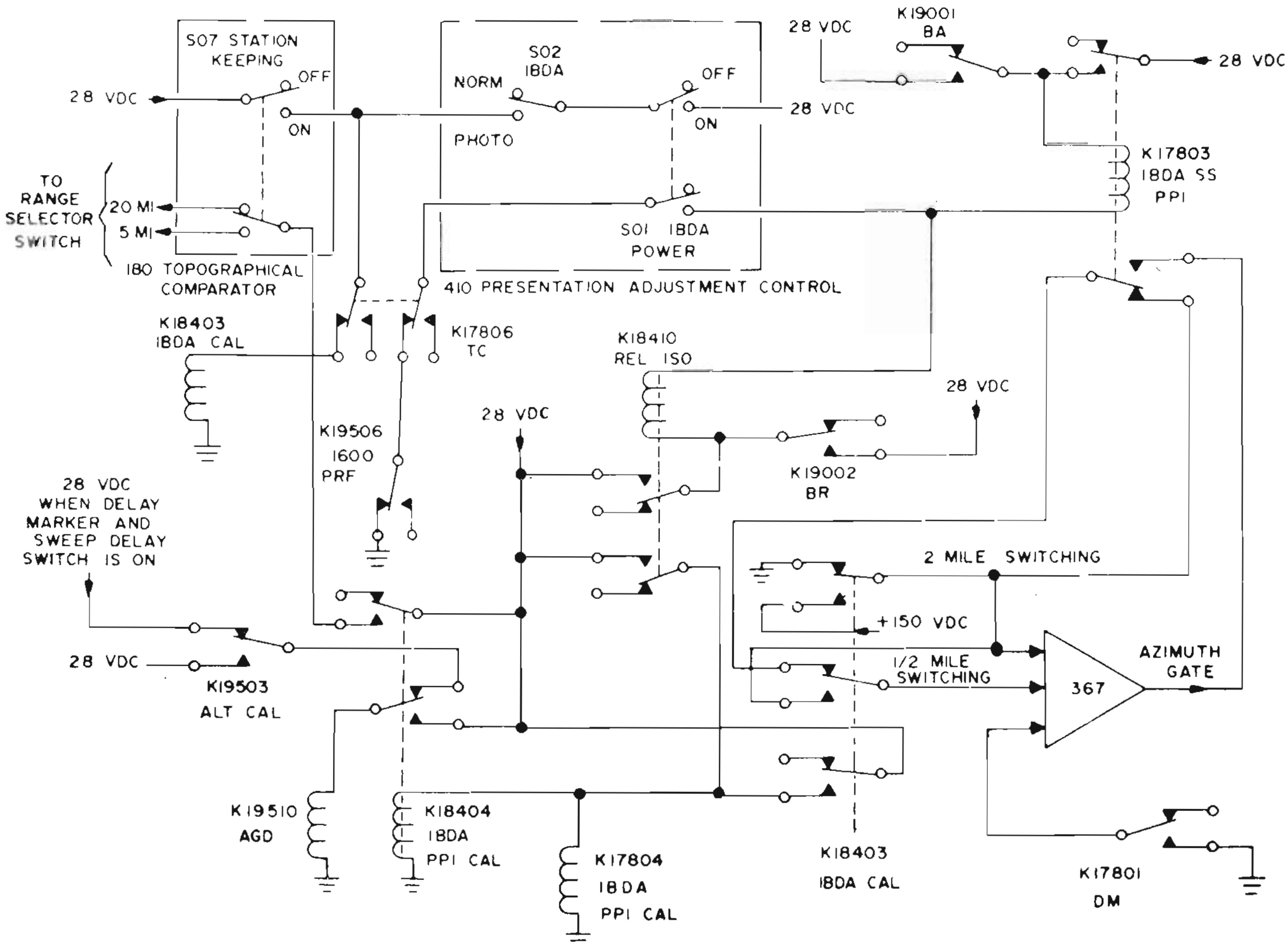

Figure 3-6. IBDA/station-keeping circuits.

3. Indicate the markers displayed on the CRT during the station-keeping mode operation.

4. State the maximum display range in the station-keeping mode.

5. Identify the relay which must be energized to allow display of both the azimuth and the heading markers.

624. Clarify the IBDA function by identifying its major phases and stating selected characteristics of these phases.

IBDA Mode. Direct your attention back to figure 3-6 while you study the IBDA mode of operation. Indirect bomb damage assessment consists of these three phases: (1) the calibrate phase, (2) the prebomb phase, and (3) the postbomb phase. A final operation is the release of the IBDA function. The same circuits are used for the IBDA mode as are used for the station-keeping mode.

IBDA calibrate phase. The IBDA calibrate phase consists of obtaining photographs of 1/2-mile and 2-mile slant range marks on a 20-mile slant range PPI display without target video. These photographs are used as overlay grids to assist in evaluation of the IBDA photographs. To prepare the display for taking calibration photographs, you place the IBDA power switch to the ON position and the camera power switch to the ON position. Either the radar set must be out of the radiate mode or the video gain control must be turned down to eliminate target video returns. Moving the IBDA photo switch to the PHOTO position (see fig. 3-6) initiates the IBDA calibrate display.

The IBDA CAL relay K18403 is energized by 28 vdc through the IBDA power and photo switches. Relay K18403 moves contacts to energize the IBDA PPI CAL relays K17804 and K18404. Relay K18404 moves contacts to energize altitude gate disable relay K19510 and sends 28 vdc through its energized contacts and through the OFF position on the station-keeping switch to the 20-mile position on the range selector switch. This disables the altitude gate and causes the target scale selector to step to the 20-mile scale; thus an uncompensated 20-mile PPI presentation is obtained on the topographical comparator. Relay K18403 also moves contacts which supply +150 vdc to the 367 marker mixing pulse amplifier; this causes 1/2-mile and 2-mile markers to be presented on the uncompensated 20-mile presentation. Relay K18404 contacts (not shown on fig. 3-6) also disable the sector scan relay and the off-center relay, this results in a PPI presentation regardless of the type of presentation selected previously.

IBDA prebomb phase. The prebomb phase begins in the bomb mode when Tg is reduced to 16 seconds. Switch S02 is in the NORM position, and switch S01 is in the ON position. When Tg is reduced to 16 seconds, relay K19001 energizes and 28 vdc is applied, through its energized contacts, to K17803. Relay K17803 energizes and supplies a holding 28 vdc through its own contacts to its coil. Relay K17803 also moves contacts which connect the azimuth gate from the 367 unit, through the deenergized contacts of K18403, to the 1/2-mile switching input of the 367 unit. You will recall, from our earlier discussion of the 367 marker mixing pulse generator unit, that this results in 1/2-mile feathers being presented on the azimuth crosshair. This prebomb phase lasts from Tg = 16 seconds until Tg = 0 seconds, the postbomb phase is initiated.

IBDA postbomb phase. At bomb release (Tg = 0 seconds), bomb release relay K19002 is energized, and 28 vdc is sent through its energized contacts to the coil of release isolation relay K18410. Relay K18410 energizes and becomes self-holding through its own

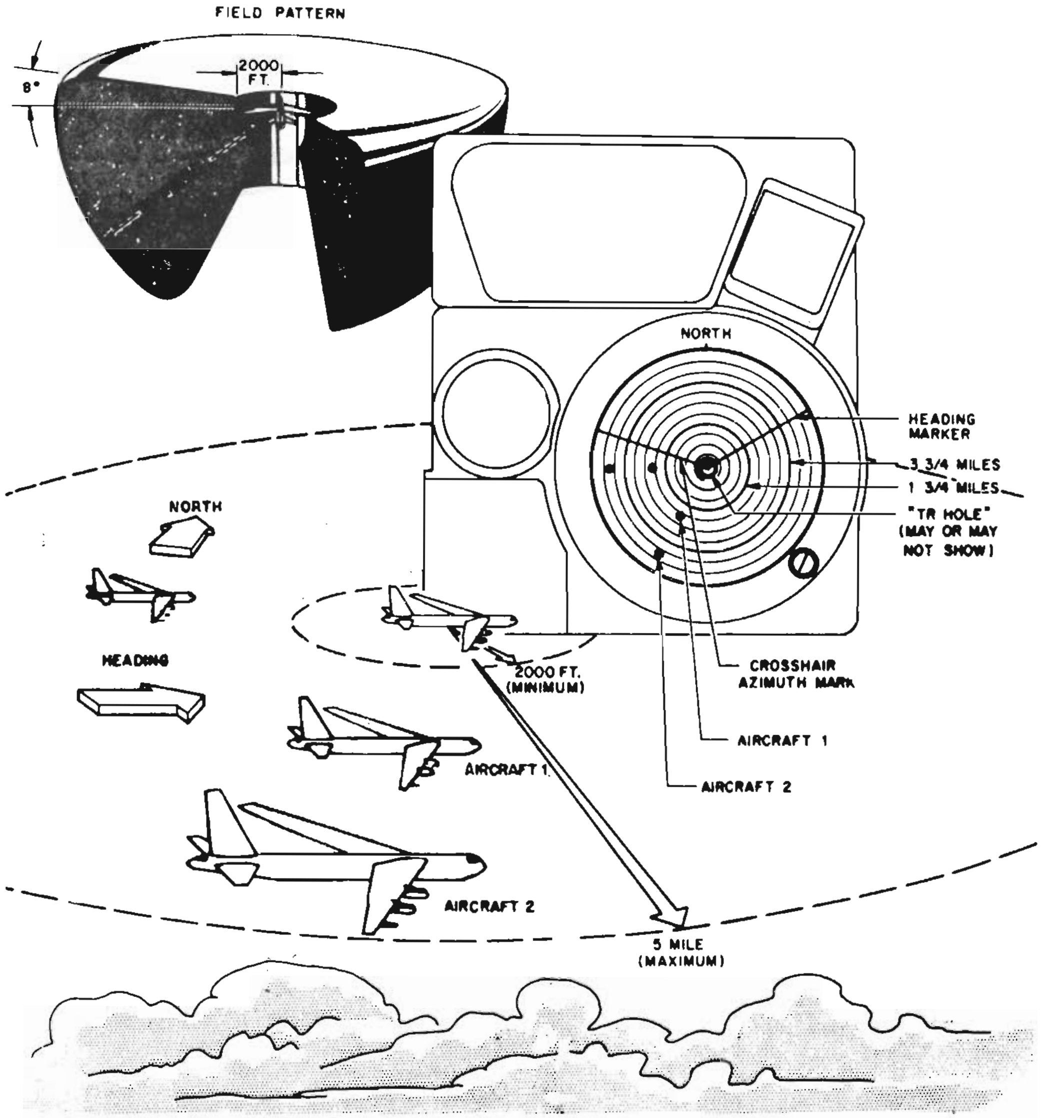

Figure 3-7. Station-keeping operations.

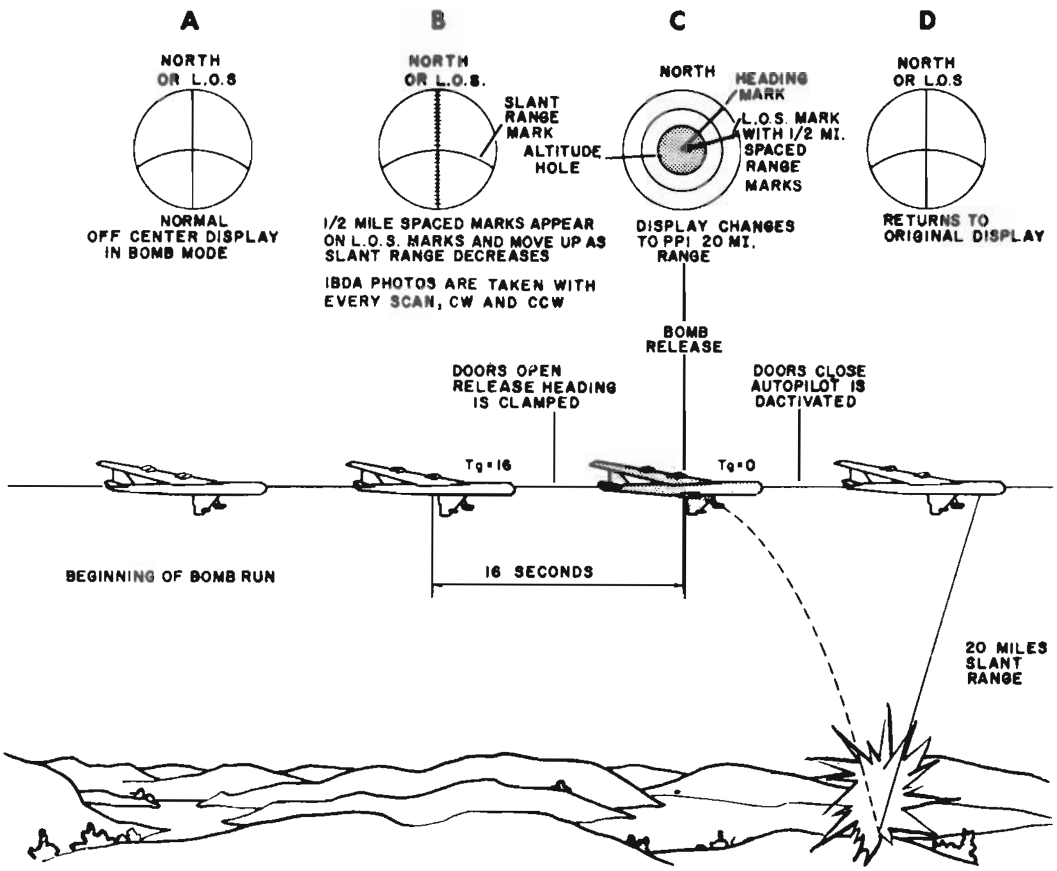

Figure 3-8. IBDA sequence.

contacts. Relay K18410 also passes 28 vdc through its energized contacts to relays K17804 and K18404. Relay K18404 energizes and sends 28 vdc through its energized cotacts to K19510, which becomes energized and disables the altitude gate. Through another set of energized K18404 contacts, 28 vdc is sent to stationkeeping switch S07. Through S07's contacts, in the OFF position, the 28 vdc is sent to the range selector switch, and a 20-mile display is selected. You will recall that when relay K18404 energizes, the sector scan relay and the off-center relay are disabled and an uncompensated, 20-mile PPI presentation results. Relay K17804 is energized and provides both an azimuth marker and a heading marker on the display. Also, since K17803 is still energized during the postbomb phase, 1/2-mile feathered markers are presented on the azimuth marker.

Figure 3-8 illustrates the normal bomb mode display, the prebomb display (from Tg = 16 seconds to Tg = 0 seconds), and the postbomb display (from Tg = 0 seconds to IBDA release). Release of the IBDA function is accomplished when slant range equals 20 miles. The 1600-PRF relay K19506 (fig. 3-6) energizes when slant range equals 20 miles and removes the ground from K18410 causing K18410 to deenergize. When K18410 deenergizes, power is removed from K17804 and K18404. Relay K18404 deenergizes and removes power from K19510 and from the 20-mile position of the range selector switch. When K18404 deenergizes, the sector scan and off-center relays energize and restore the presentation to the normal off-center presentation.

Exercises (624):

1. Match the IBDA phases listed in column B with the descriptions in colume A. Each column B selection may be used more than once.

	Column A	*Column B*
_____ a.	Tg = 10 seconds.	1. Calibrate.
_____ b.	IBDA Photo switch to PHOTO.	2. Prebomb.
_____ c.	K19510 energized.	3. Postbomb.
_____ d.	Lasts 16 seconds.	
_____ e.	K17803 energizes.	
_____ f.	20-mile PPI presentation with 1/2-mile markers.	

2. State the display characteristics present during the IBDA prebomb function.

3. Provide the display characteristics on the indicator when the IBDA postbomb function is initiated.

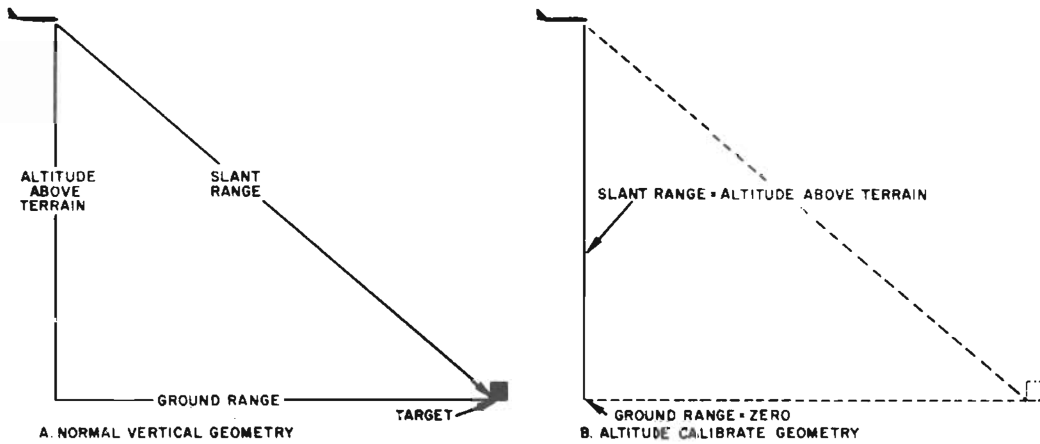

Figure 3-9. Changes in vertical sighting geometry during altitude calibrate.

4. At the completion of the IBDA postbomb function, a particular type of display should be present on the topographical comparator. Name it.

625. Examine the display and vertical geometry for the altitude calibrate mode by specifying the display type occuring, the geometric distance cut to zero, and the control used to change a selected stored value in this mode.

Altitude Calibration. The RDPS automatically switches to an off-center uncompensated display during altitude calibration. Ground range is removed from the slant range loop, as illustrated in figure 3-9. If the system altitude is incorrect, a presentation, as shown in figure 3-10A, is obtained. You would then use the data setting control to calibrate aircraft altitude Ha and to make it equal to the radar measured altitude plus the terrain elevation. This is indicated by the equation

$$Ha = H + Ht \text{ or } Ha - Ht = H$$

After altitude is calibrated, the presentation is like the one shown in figure 3-10B. You may recall that the mechanics of the altitude calibrate loop have been discussed in an earlier volume.

Exercises (625):

1. Identify the type of display which occurs in the altitude calibrate mode.

2. Specify the geometric distance reduced to zero during altitude calibrate.

3. Indicate the control used to change the stored value of H during the altitude calibration.

3-3 Camera System Tie-In

The 0-32 camera system is tied in with the RDPS and computer circuits. The camera and its film magazine are mounted on the topographical comparator. Its purpose is to record pertinent events which occur during the aircraft mission. This is done by photographing the indicator display through a series of prisms and lenses. Information from the computers is also shown on the film by coded data lights. In this section you will study the camera tie-in circuits and the data lamp circuits.

626. Clarify the camera tie-in circuits by completing statements about selected operational features of these circuits.

0-32 Camera. The camera tie-in circuits are interconnected with the RDPS circuits and are arranged to permit either the radar or the IBDA circuits to control the film advance and shutter-

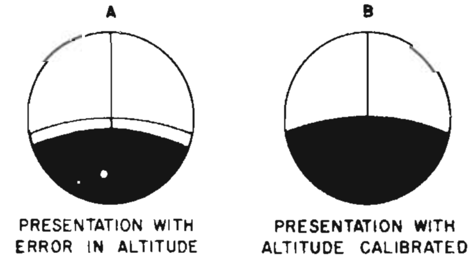

Figure 3-10. Altitute calibrate displays.

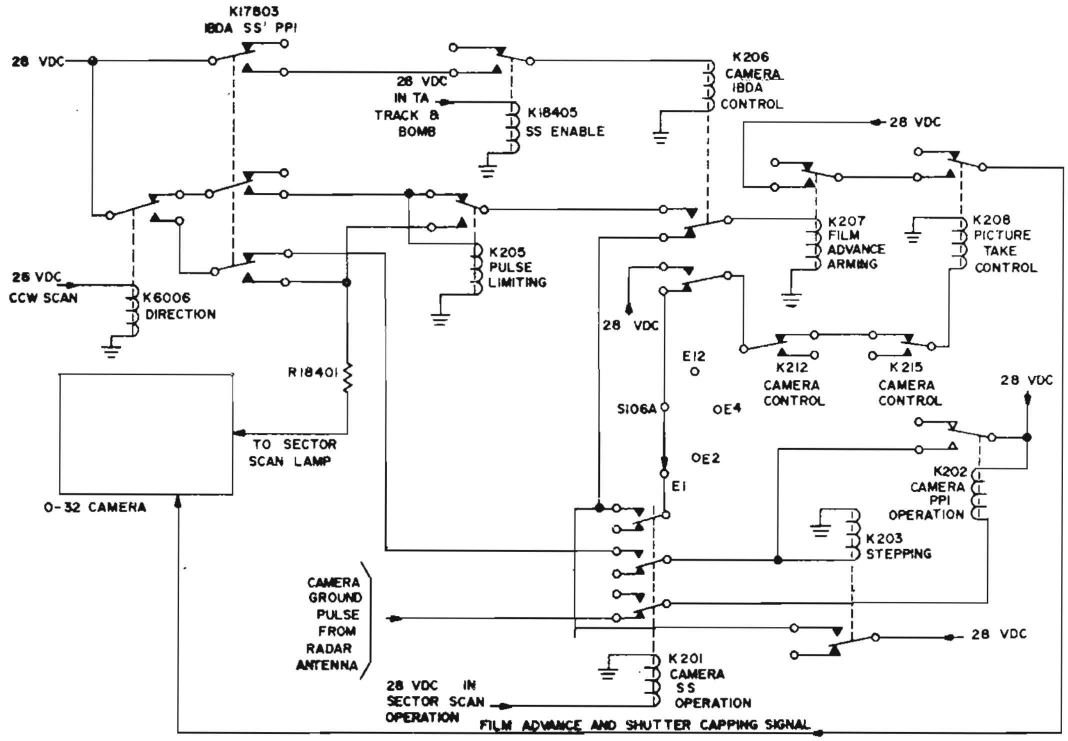

Figure 3-11. Camera tie-in circuits.

capping signal. In the PPI mode, selection of "picture take" intervals is accomplished by the camera interval control, with a grounding pulse from the radar antenna serving as the camera control signal. In the off-center mode, the CW direction pulse serves as the camera control signal. The operation is a little more complicated in IBDA, since the camera is controlled by the IBDA circuits to take pictures of every CW and every CCW scan.

Camera circuits. In sector scan operation, K201 and K18405 are energized and move their contacts opposite to the positions shown in figure 3-11. Relay K17803 becomes energized at Tg = 16 seconds (beginning of the prebomb IBDA phase) and moves its contacts opposite to that shown in figure 3-11. When K17803 energizes, 28 vdc is sent to K206; relay K206 also energizes and, in turn, energizes K208. Relay K6006 is deenergized (as shown) during CW scan and sends 28 vdc through the energized contacts of K17803, through deenergized contacts of K205, and through the energized contacts of K206 to the coil of K207. Relay K207 energizes and sends 28 vdc through its energized contacts and the energized contacts of K208 to the 0-32 camera. This 28-vdc signal caps the shutter and advances the film. After 50 milliseconds, relay K205 energizes and removes the 28 vdc from K207. Relay K207 deenergizes and removes the 28-vdc film advance and shutter-capping signal. This opens the shutter, and a picture is taken of the radar screen for all of the CW scan, except the first 50 milliseconds.

At the end of the CW scan, direction relay K6006 energizes, and 28 vdc is sent through its energized contacts, through the energized contacts of K17803, through the energized contacts of K205, and through energized contacts of K206 to the coil of K207. Relay K207 energizes and sends a 28-vdc signal through the energized contacts of K208 to the 0-32 camera. This 28 vdc caps the shutter and advances the film. When relay K6006 energizes, 28 vdc is removed from the coil of K205. Relay K205 remains energized for 50 milliseconds and passes the 28-vdc CCW pulse to the coil of K207. After 50 milliseconds, K205 deenergizes and, in turn, causes K207 to deenergize. This removes the film advance and shutter-capping signal, opening the shutter, and a picture is taken of the CCW scan. As before, the first 50 milliseconds of the CCW scan are not photographed while the shutter is capped and the film is being advanced.

From the time Tg = 0 16 seconds until Tg = 0 seconds, pictures are taken of every CW and CCW scan under the control of the IBDA circuits. Relay K205 limits the film advance and shutter-capping signal to 50 milliseconds at the beginning of each CW and CCW scan. This provides photographs of each CW and CCW scan for indirect bomb damage assessment.

Exercises (626):

Complete these statements by supplying the missing word or words in each.

1. In the PPI mode, the "picture take" interval is selected with the ______ ______ ______.
2. In the PPI mode, the camera control signal is a ______ ______ from the ______ ______.
3. During a bomb run with Tg = 16 seconds, pictures are taken of the CRT every ______ antenna scan.
4. Relay K17803 becomes energized at ______ seconds Tg.
5. Relay K6006 is ______ during the CCW antenna scan.

627. Analyze the camera data lamp circuits by supplying chosen operational features and the purpose of these circuits' information and determining the meaning of given data lamp indications.

Data Lamp Circuits. In addition to the radarscope presentation, camera data lamps are photographed. These lamps provide coded indications of specific system and operator operations. From the information provided by these lamps, a more complete analysis of the IBDA photographs can be made. Figure 3-12 shows the camera coding relay circuits. From this figure you can determine when each coding relay is energized. Let us follow the excitation to a few of these relay coils to see how this determination is made.

In the PPI mode, relay K19504 ia deenergized, and 28 vdc is applied to S19101E. With a 5-mile range selected, S19101E is stepped one position clockwise, and 28 vdc is supplied to RSA relay K59606, causing it

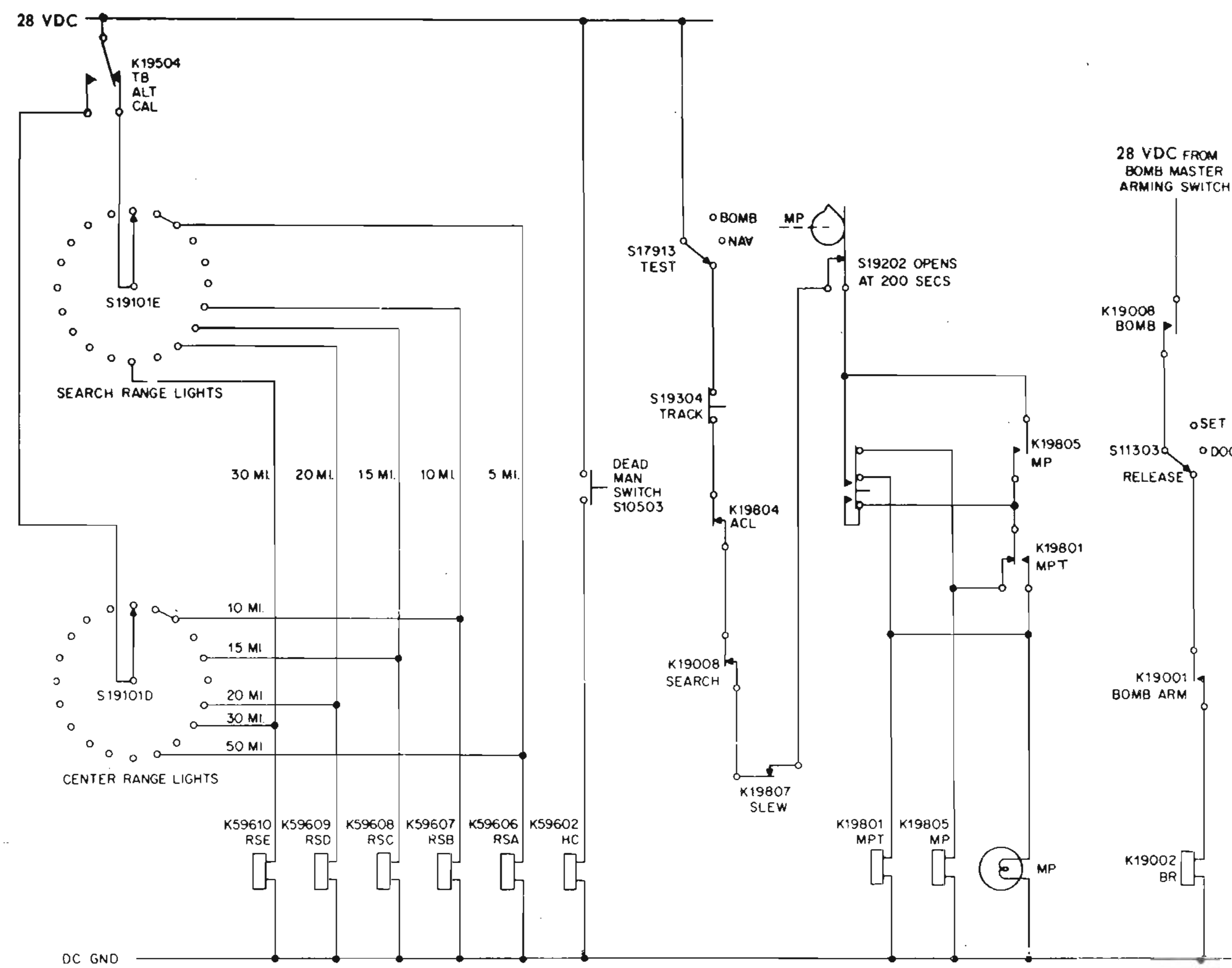

Figure 3-12. Camera coding relay circuits.

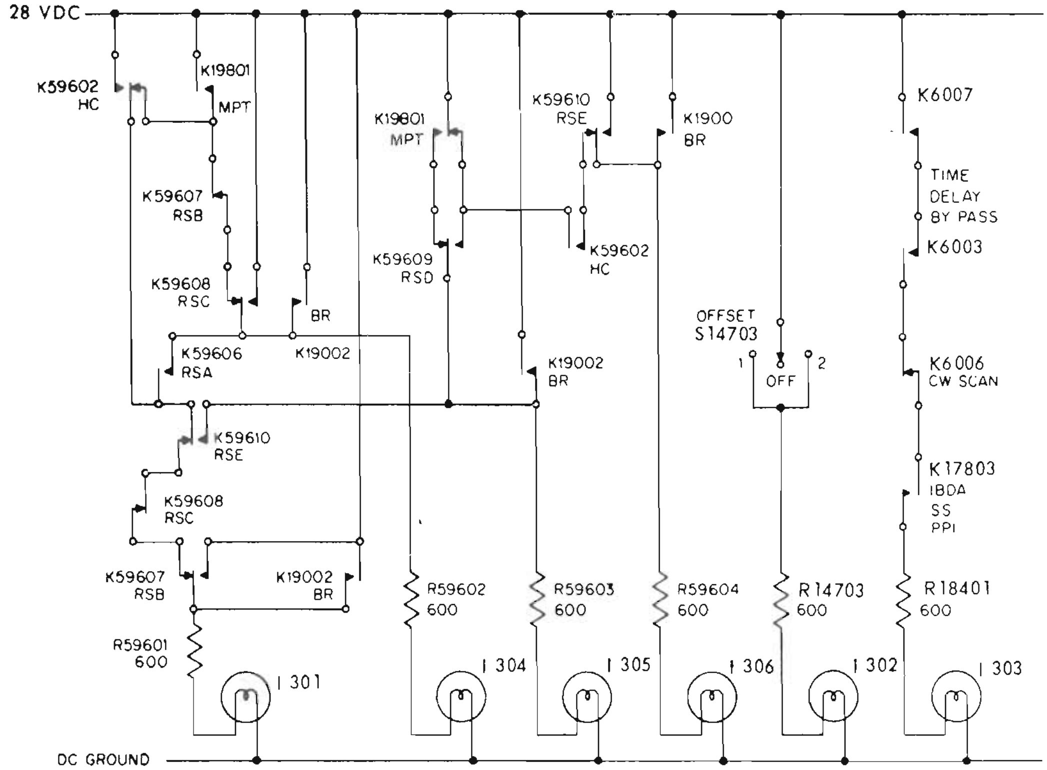

Figure 3-13. Camera coding light circuits.

to energize. However, if a 20-mile range is selected, S19101E is stepped eight positions clockwise, and 28 vdc is provided to energize RSD relay K59609. In the off-center mode, relay K19504 is energized, and 28 vdc is applied to S19101D and, depending upon the range selected, this switch provides 28 vdc to energize one of the RS relays (RSA, RSB, RSC, RSD, or RSE).

The hand control (HC) relay is energized whenever the deadman switch is depressed. The memory point (MP) and the memory point timer (MPT) relays are energized by first depressing the memory point button and then releasing it. Bomb release (BR) relay K19002 is energized at bomb release (tg = 0 seconds). When you look at the circuits controlled by the contacts of these relays, you can see how the camera data lamps are illuminated.

Refer to both figures 3-12 and 3-13 and let us determine the conditions that would illuminate the six camera data lamps.

NOTE: No two RS relays can be energized at the same time.

Starting with the ranges selected, a 10-mile off-center range energizes the RSB relay and illuminates I301. A 15-mile off-center range illuminates I304 through the energized contacts of the RSC relay. A 20-mile off-center range illuminates I305 through the energized contacts of the RSD relay. A 30-mile off-center range illuminates I306 through the energized contacts of the RSE relay. Energizing the RSA relay does not illuminate any lamps by itself, but it determines what lamps will be illuminated when the hand control or memory point relays are energized.

The hand control relay, when energized, will illuminate one of the following lamps, depending upon the range and memory point relays that are energized: I301, I304, I305, or I306. The same holds true for the memory point relay. That is, I301, I304, I305, or I306 will be illuminated in memory point, depending upon which range relay is energized. At bomb release, the BR relay will cause lamps I301, I304, I305, and I306 to illuminate. Lamp I302 is illuminated whenever offsets are inserted into the system. Lamp I303 is illuminated

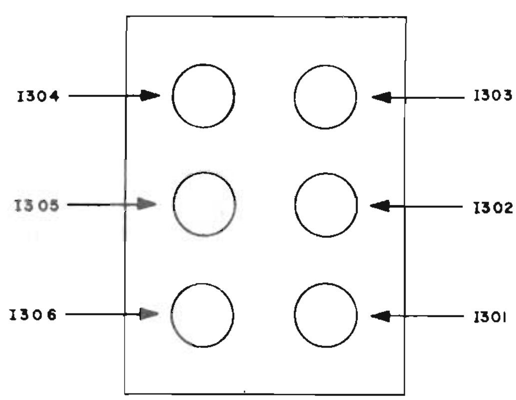

Figure 3-14. Camera data lamps.

on each CW scan of the radar antenna to identify the direction of antenna scan on the IBDA photographs.

The lamp positions on the camera data plaque are shown in figure 3-14. Table 1-1 tabulates the lamps illuminated for the various codes that indicate system and operator operations. Note that only the last digit of each lamp number is used in the table.

RANGE TARGET SCALE	*HAND CONTROL (DEADMAN SWITCH)*	*MEMORY POINT*	*LAMP(S) ILLUMINATED (SEE FIGURE 2-16)*
10	OFF	OFF	1
10	ON	OFF	1 6
	OFF OR ON	ON	1 5
	OFF	OFF	4
15	ON	OFF	4 6
	OFF OR ON	ON	4 5
	OFF	OFF	5
20	ON	OFF	1 5 6
	OFF OR ON	ON	4
	OFF	OFF	6
30	ON	OFF	5 6
	OFF OR ON	ON	4 5 6
	OFF	OFF	NONE
50	ON	OFF	1 4 6
	OFF OR ON	ON	1 4 5
* BOMB RELEASE			1 4 5 6

NOTE:
- In offsets, lamp 2 will be illuminated in addition to those lamps listed under above conditions.
- During clockwise sector scan, lamp 3 will be illuminated in addition to those lamps listed under above conditions.
- Lamp numbers refer to the last digit of the lamps indicated in figure 3-14.

321-107

TABLE 1-1

CAMERA DATA LAMP ILLUMINATION CODE

Exercises (627):

1. The camera data lamps provide coded information. State the purpose of this.

2. Specify how many RS relays can be energized at once.

3. Indicate the information displayed by the data lights.

4. Identify the information which could be derived if data lamps 1, 4, and 6 were illuminated.

5. Determine when data lamp number 2 illuminates.

6. Determine when data lamp number 3 illuminates.

3-4. Troubleshooting the RDPS

The RDPS can be one of your most valuable troubleshooting aids. This is true, however, only if you can interpret the information you see on the indicators. In most cases, the RDPS presentation cannot "pinpoint" the malfunction. It can, however, often show you the area of the problem. In other words, if you use it properly, the RDPS can show you the presence or absence of key signals and help isolate the problem to a particular system loop.

628. Given selected symptoms of RDPS malfunctions, analyze the problems, and decide which circuit would most likely cause the problem in each situation.

RDPS Malfunction Analysis. Frequently, the best way to learn RDPS troubleshooting is to actually do it. Of course this is not possible in this type of correspondence course. But it is possible to learn by this means some of the isolation techniques and some of the malfunction symptoms.

Figure 3-15 shows a group of RDPS malfunction presentations. Let us discuss each of these presentations and consider how you can use it to "localize" the malfunction.

The first presentation (part A of fig. 3-15) is a completely blank scope. With a completely blank scope, you may immediately think "we've got a bad CRT." But wait a minute; how about making a couple of simple checks before suspecting the CRT? Is the intensity control turned up? How about power? With the CRT blank, we cannot tell for sure that we have power to all parts of the RDPS. Check for "popped" circuit breakers and loose cable connections. Check to determine whether or not both the topographical comparator and the azimuth and range indicator CRT screens are blank. If only one of the two CRT screens is blank, then you have isolated the malfunction to one of the two display circuits. If both CRT screens are blank, then you can be fairly certain that the malfunction is in the RDPS circuits ahead of the two display circuits.

Having two display circuits, with some identical components, gives you an added advantage in isolating malfunctions. To isolate your blank CRT

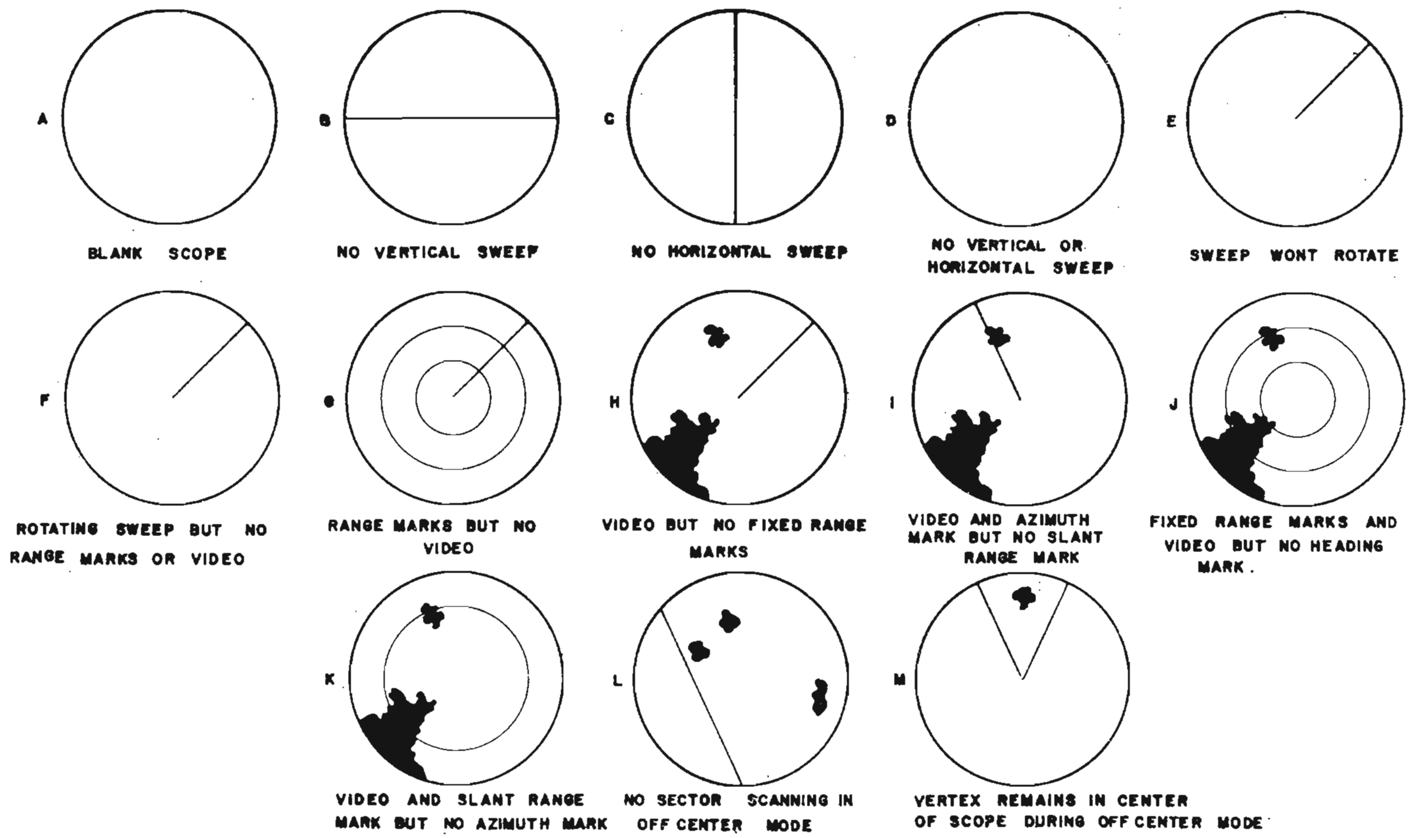

Figure 3-15. RDPS malfunction presentations.

malfunction, we can interchange high-voltage power supplies and regulators to determine whether or not the trouble lies in the high-voltage circuits. For other malfunctions, which can be isolated in figure 3-15, you will also be able to use this type of exchange procedure between the components of the operating circuits and those of the nonoperating circuits. After you have made all of the simple checks and component exchanges, you can then start on the more detailed checks.

The next malfunction, indicated by presentation B of figure 3-15, is a rather simple one but can lead to many wrong component replacements before you successfully eliminate the malfunction. In this presentation, we have lost our vertical sweep. This is obvious because, as the antenna rotates, the electron beam traces a horizontal line across the scope with no vertical deflection. Before you jump to the conclusion that our vertical sweep generator is bad, make a quick check. Check both indicators to see whether or not you have lost the vertical sweep to both indicators. If both presentations have no vertical sweep. then the malfunction is in the sweep generation circuits, but not necessarily the vertical sweep generator. Remember that the vertical sweep is controlled by different synchros in LOS- and north-oriented presentations. So switch from LOS to north orientation. If a vertical sweep is obtained in one orientation, but not in the other, then the malfunction lies in the circuits providing the 2045-Hz rotational inputs. Otherwise, the malfunction lies in the vertical signal data converter, the vertical sweep generator, or the vertical electronic integrator. Switch these components with the identical horizontal components to determine which one is defective.

Now, suppose that the topographical indicator has no vertical sweep but that the azimuth and range indicator does. This situation tells you that the sweep generation circuits are functioning correctly and that the vertical deflection voltage amplifier, the vertical deflection current amplifier, or the vertical sweep coils of the topographical comparator are defective. Again, by exchanging these components with those in the horizontal display circuits, you will isolate the malfunction to the specific component.

Presentation C of figure 3-15 has a vertical sweep but no horizontal sweep. The same line of reasoning holds true for this malfunction as applied for the previous one, where no vertical sweep existed. Another thing you should consider here is that, in order to have even one sweep, the system trigger circuits, the sweep trigger circuits, and the sweep gate circuits must be functioning properly. Therefore, we need not look into these areas for our malfunction.

Presentation D of figure 3-15 shows a condition where we have neither a vertical nor a horizontal deflection. Assume, however, that we have a bright spot in the center of the scope that becomes instantaneously brighter each time the reference mark is generated. The key to this situation is the bright spot in the center of the scope. As you will recall, the CRT can conduct only during the time that the unblanking gate is present. Therefore, if a bright spot appears at the center of the scope, the unblanking gate must be present. In order to have the unblanking gate, the system trigger must be present. Therefore, our trouble probably must exist in either the sweep generation circuits or the display circuits. If the bright dot does not appear in the center of the scope, our trouble may be due to the loss of the system trigger or of the sweep trigger. Switch to altitude calibrate to determine whether or not the system trigger is present.

A stationary sweep appears in presentation E of figure 3-15. This type of trouble is almost definitely due to the gearing that drives the antenna synchros. However, before you spend time replacing the antenna, be sure the antenna is rotating! You might also switch the system into the off-center mode and see whether or not the antenna will sector scan. In other words, do not forget the easy things. Make all easy and simple checks first.

Presentation F of figure 3-15 shows a normal sweep, but we have no video or range marks. Since we are missing both video and range marks, look for the trouble in an area that is common to both of these signals. Before changing the video amplifier or other common circuits, be sure to check for broken or disconnected cables.

In presentation G of figure 3-15, we have fixed range marks but no video. Since our video amplifier is passing the fixed range marks, the video amplifier is probably all right. You will more than likely find the trouble in the radar circuits. In presentation H, we have the opposite condition: video but no fixed range marks. With this type of malfunction, switch from nav marks to bomb marks. If the slant range mark appears, the marker mixing pulse generator is probably at fault. If the slant range mark does not appear, look for the trouble in that part of the circuit that is common to both the fixed range marks and slant range mark.

Presentation I of figure 3-15 shows a similar condition where the slant range mark is missing. A simple condition that will cause you not to have a slant range mark exists when the CRT sweep is shorter than the slant range set into the system. Move the range switch to a higher value and see whether or not the slant range mark appears. You can positively identify the slant range mark by moving the crosshair control. The slant range mark should be seen moving in or out along the CRT sweep. In this type of malfunction, as well as in others, look for such troubles as loose or broken cables. Remember that a range mark intensity control turned down all of the way can cause us to lose range marks just as easily as can a faulty range mark generator.

Presentation J of figure 3-15 shows a normal presentation, except that the heading mark is missing. In presentation K, the azimuth mark is missing. With either of these conditions, switch from nav to bomb marks and vice versa. If neither reference mark occurs, look for the trouble in the circuits that are common to both reference marks. If one reference mark appears but the other does not, disregard the common circuit and look for the trouble in the missing reference mark circuit. In the case of a missing azimuth mark, check and see whether or not the antenna will sector scan in the off-center mode. In our systems, the azimuth mark circuit and the sector scan circuit use signals that are common to both circuits.

In presentation L of figure 3-15, you have an off-center presentation that is normal, except that the antenna is rotating 360° rather than sector scanning about the line of sight. As mentioned earlier, some systems use some of the same signals to produce both the sector scan signals and the azimuth mark. Therefore, with this type of trouble, check to see whether or not you have an azimuth mark. The presence or absence of the azimuth mark should tell you where to start troubleshooting. Our systems have a manual sector scan control. Try it; if it works, the problem is more than likely in the automatic sector scanning circuits. If the manual sector scanning control will not work, the problem is in that part of the sector scan circuit that is common to both the automatic and manual sector scan control.

Presentation M of figure 3-15 shows an off-center presentation, with the vertex at the center of the slope. This is the proper place for it when slant range is at its minimum value; but as slant range is increased, the vertex should move out to the edge of the scope, and then it moves completely off the edge. This type of malfunction usually is due to troubles in the off-center deflection circuits. As an added check, however, switch the radar system into search operation and see whether or not you have a normal presentation.

This has been a brief look at just a few of the many malfunctions that may occur. Keep in mind that, in all of these examples, several general rules hold true: For one, when a malfunction is first detected, make as many simple tests as possible, using the existing presentation on the scope. Also, look for simple things first. Do not spend several hours on a complicated check, only to find a disconnected cable or an incorrectly adjusted presentation control.

Exercises (628):

1. The 5-inch indicator has no horizontal sweep but the 10-inch indicator does. Cite the area of the RDPS which you would suspect of malfunctioning.

2. There is no video present on the RDPS indicators, but the sweeps and markers all appear normal. Indicate the area of the system which should be suspected of malfunctioning.

3. The PPI full scan display is normal, but the off-center display vertex will not move from the CRT center. Name the first circuit you should check for malfunctions.

4. Specify the unit that would most likely cause loss of the fixed range marks without affecting the variable range marks.

5. Both indicators are completely blank, all the circuit breakers are set, and the control settings are good. There is no spot, no sweep on the indicators, regardless of the mode selected. State the circuit that should be checked first.

6. The 5-inch indicator is normal, but the 10-inch indicator has no video or range marks. Name the unit which would probably cause this malfunction.

7. Both indicators are blank except for a bright spot appearing in the center of the indicators. Cite the circuits which may be eliminated as causes of the malfunction.

8. The indicators are missing the vertical sweep when a north-oriented display is selected. State the circuits you should begin troubleshooting.

9. A distorted sweep appears on one indicator only. Identify the method of troubleshooting which is the quickest and easiest method of determining the cause of the problem.

3-5. RDPS Checks and Alignments

Frequently, your repair of RDPS malfunctions will require the performance of certain checks or adjustments. The checks discussed here include the RDPS fast checkout, RDPS display check, IBDA check, display stabilization check, and map-matching checking. The alignments include the zero calibration, range zero-range track, IBDA calibration, and the presentation alignment. No attempt will be made in this course to repeat the step-by-step procedures of these checks and adjustments. Instead, the purpose for their performance will be explained. You may wish to review the procedures in the appropriate system technical order, available in your shop, prior to reading this section.

629. Clarify the various RDPS checks and adjustments by giving the purpose of each and indicating when each should be preformed.

Operations and Alignments. You should, as a BNS mechanic, be able to state the purpose for the various checks and adjustments in the RDPS. There is a very good liklihood that as a 5 level you will be assigned the duty and responsibility of being an OJT trainer. You may also discover in promotion testing that a better understanding of these will improve your testing ability. Each of the listed checks and adjustments will be discussed separately for your ease of understanding.

RDPS fast checkout. The RDPS fast checkout is designed to give you a quick overview of the entire RDPS operation. It should not be considered a thorough check, however. During the performance of this fast checkout, you will briefly test each of the RDPS functions. If you encounter a problem in any of the areas, you should proceed to the complete checkout for that portion of the RDPS. You might perform this check when an aircraft returns from depot, or when it has not been operational for some period of time whatever the reason. Another time to make this check might be when you have performed maintenance on the system and are simply performing a fast system overview type of check on it. Still another use for it might be to determine, in your troubleshooting, which area of the RDPS is causing a specific malfunction and whether or not there are any related problems.

RDPS display check. The RDPS display check is a more complete operational test of specific display functions. This includes the sweep delay, station-keeping, sector width, and range selection circuits. If the RDPS fast check has indicated a malfunction in one of these circuits, you should perform this complete check to isolate the problem further. In many cases this test may be of sufficient depth to allow you to determine exactly which unit is causing a malfunction. Other times you may be able to isolate the problem to several possible units. In any case, you can frequently save much time and effort by using the checks available as a tool in troubleshooting. You should perform the complete checks prior to any "could not duplicate" sign off of a malfunction.

IBDA check. The IBDA check is an in-depth operation of the IBDA circuits as they may be used during an aircraft mission. Since this circuit is often only operationally checked during a flight, it does not appear to malfunction very often. For that very reason, many maintenance personnel are not sufficiently familiar with this capability. This causes simple malfunctions to turn into difficult problems entailing long hours of troubleshooting. To prevent this from happening to you, learn the check and study the circuits involved.

The IBDA check tests both the automatic and the manually operated features of that portion of the system. This is done by simulating bomb runs, with the switches set in the various possible positions. The display results during the check are listed in the technical manual.

Display stabilization check. The display stabilization check is very simple. Using the emergency control circuits, drive the topographical comparator yoke to insure that the amplifier and motor are working. This check also shows that the yoke is not binding.

Map-matching check. The map-matching check requires you to perform the map match film loading instructions. These loading instructions check all of the map match features, except the auto advance function. In most cases that feature is no longer used. When loading and operationally checking the map match, always use extreme caution. Why? Because you are exposed to bare wiring terminals inside the map-match compartment. You must treat the film carefully, since one torn film drive hole could prevent proper operation.

Zero calibration. At various points in the text, the zero calibration has been mentioned. Its purpose is to insure that the leading edge of the transmitted radar pulse is time coincident with the leading edge of the range crosshair pulse. You should check, but not necessarily adjust, this before performing the range zero and range track adjustment. This adjustment is also required by technical data before you perform the IBDA calibration.

Range zero and range track adjustment. The range zero and range track adjustment establishes the correct relationship between the range crosshair and the slant range timing gate throughout the bombing computer range. If this relationship is improperly adjusted, two variable range markers may appear on the indicator 1/2 mile apart. This would render the system incapable of delivering a weapon within the allowable limits. Another situation which could result is the appearance of a single variable range mark that is not at the correct time. The marker would be in error by 1/2-mile increments. This could result in rather large bombing errors.

IBDA calibration. The IBDA calibration is not performed too frequently. Unless you suspect the circuit of malfunctioning, this calibration is normally an initial calibration of the system. It was originally designed to compensate for the varying delays between the radar trigger and the fixed range marks in the different systems. The amount of compensation needed must be known in order to evaluate the IBDA photographs of a bomb run.

Presentation alignment procedure. Before performing the presentation alignment, you should operate the RDPS indicators at normal intensity for 30 minutes. If for some reason you are unable to take that much time, operate them at maximum intensity for a few minutes. By doing this you neutralize the static screen charge and should eliminate the indicator circular instability. The topographical comparator (10-inch) and the azimuth and range indicator (5-inch) adjustments are somewhat different. The 10-inch indicator, being primary, should be adjusted first.

The 10-inch indicator adjustment takes longer, since the procedure includes setting the scale adjust potentiometer. As you may recall, the scale adjust is used to set the 100-vdc level for the sine and cosine sweeps. After making the scale adjustment, center the presentation using the horizontal and vertical centering controls. You then adjust the circularity controls (left, right, up, down) to produce true circles. Now adjust the high-voltage potentiometer for the correct size sweep. All of these adjustments are made with the RDPS in a PPI display mode, with 50-mile range selected. Then place the system in off-center, set in certain prescribed ranges, and adjust the off-center CAL control. Set the control at the point where the range crosshair stays in the indicator center through the entire target scale range. The technical manual allows a crosshair movement of 1/2 inch, but you should try to get much less movement than this.

The 5-inch indicator adjustments do not include scale adjust or the off-center cal adjustment. The other adjustments are still performed in a manner similar to that for the 10-inch indicators.

These adjustments marry the indicators to the various sweep and sweep deflection units of the system. Since most of the units in the system are built within certain tolerance limits, only minor deviations should occur. But you should realize the importance of this adjustment. If, for example, the scale adjust setting is incorrect, the range marks may appear to "daisy chain" on the indicator. This would render them virtually useless. Another example would be if the high-voltage adjustment ia in error. You might find that with 50-mile range selected the 50-mile marker does not appear on the indicator.

The extra time and effort used in doing these adjustments properly is always worthwhile. This holds true for all the adjustments discussed in this section. Do it right the first time, and you will not have to do it over later.

Exercises (629):

1. Give the purpose of the RDPS fast check.

2. Tell when the RDPS display check would be used.

3. Cite the circuits tested during the IBDA check.

4. Indicate the topographical comparator circuits tested during the display stabilization check.

5. The map-matching check tests all but one feature of the map-match circuits. Name the feature *not* tested.

6. Give the purpose of the zero calibration.

7. Specify the purpose of the range zero and range track adjustment.

8. Indicate the purpose of the IBDA calibration.

9. Identify the procedure during which the off-center cal is performed.

10. Tell why the presentation alignment procedure is necessary.

11. Identify the adjustments, listed for the 10-inch indicator, not performed on the 5-inch indicator.

12. Point out the indicator characteristic adjusted by using the horizontal and vertical controls.

13. Cite the indicator characteristic adjusted with the high-voltage potentiometer.