CHAPTER 8

SWITCHES, SWITCHBOARDS, AND SWITCHING SYSTEMS

A basic understanding of switches and the functional use of switchboards and switching systems is a necessity for the Electronics Technician. In some instances, the switching systems used with electronic equipment are more difficult to understand than the operation of the equipment itself. In general, however, although switching systems are becoming more complex, the methods of operation are being simplified.

The Navy uses hundreds of different types of switches in (and associated with) electronic equipment. They are listed in the Federal Supply Catalog in group 59, class 30.

Switchboards make use of multisection switches that are not difficult in themselves to understand, but the entire switching function performed by switchboards, or by combinations of switchboards, may be somewhat involved. In this chapter a typical receiver switchboard and a typical transmitter switchboard are treated.

Simplified diagrams, showing how switchboards are connected to receivers, transmitters, radiophone units, and accessory equipment, are included. For completeness, block diagrams of the switching circuits between Radio Central, Radio II, and Radio III in one type of installation, are also included.

Another portion of the chapter includes a brief treatment of antenna switching systems.

Finally, the more complex radar data switching system is described with the aid of block diagrams and simplified switching circuits.

Bear in mind that in many of the switching systems described there are a large number of possible circuit arrangements. In this chapter a great deal of simplification is employed; and, in general, only the less complex arrangements are included. Enough basic information is included however, to give the prospective ET 3 the necessary background for further study in the subject.

TYPES OF SWITCHES

Some of the more common types of switches used with electronic equipment are illustrated and described briefly in this portion of the chapter. There are many variations of each type of switch; however, only a few representative examples are included here.

TOGGLE SWITCHES

Representative examples of toggle switches are shown in figure 8-1. In part A is shown a single-pole, single-throw (SPST) toggle switch, rated at 20 v and 20 amperes, and having 2 solder terminals. The schematic diagram is shown beneath the switch. This switch is used to open or close an electric circuit.

Part B shows a single-pole, double-throw (SPDT) switch, rated at 250 v and 1 ampere, and having 4 screw terminals. One of the uses of this switch is to turn a circuit on at one place and to turn it off at another place. It is sometimes called a 3-way switch.

A double-pole, single-throw (DPST) switch is shown in part C. It has 4 solder terminals and is rated at 250 v and 1 ampere.

A double-pole, double-throw (DPDT) switch is shown in part D. It has 6 solder terminals and is rated at 125 v and 3 amperes.

The following types of switches are also used: 3-pole, single-throw (3PST); 3-pole, double-throw (3PDT); 4-pole, single-throw (4PST); and 4-pole, double-throw (4PDT). The voltage ratings range from 20 v to 600 v, and the amperage ratings range from 1 ampere to 30 amperes.

PUSH SWITCHES

The contact arrangement of push switches is shown in figure 8-2A, and an example of

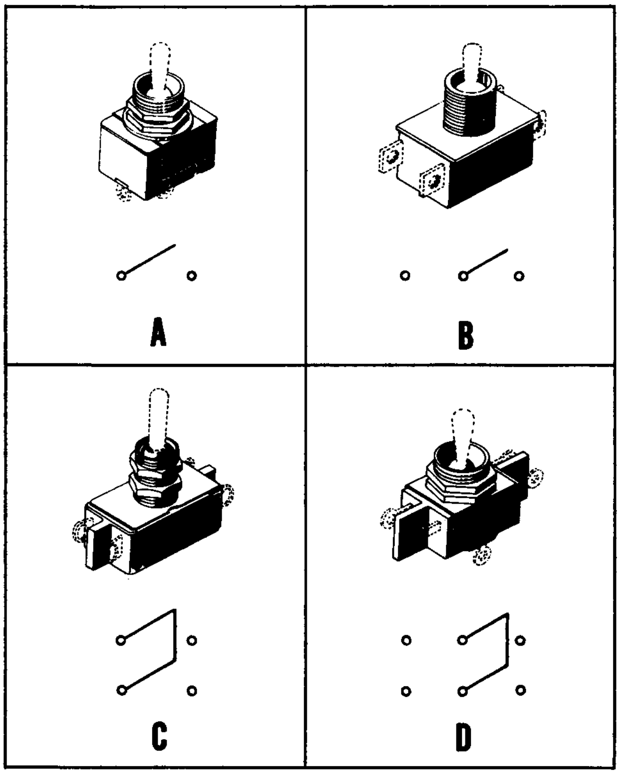

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Figure 8-1.—Toggle switches.

a typical contact arrangement is shown in part B. The type and quantity of each basic form used to make up the contact assembly are determined from part A. Part B illustrates how the illustrations in part A may be used in a practical switch assembly. Thus, in part B the switch contains a total of three separate basic forms: two forms A, and one form C. The contact arrangement for this switch is therefore 2A1C. Obviously, there are many possible contact arrangements. For example, 1A, 1A1A, 1A1B, 2A, 2A1B, 1B, etc., are common.

A push switch employing a 2A contact arrangement is shown in figure 8-2, C. It is rated at 250 v and 3 amperes.

WAFER LEVER SWITCHES

A wafer lever switch is shown in figure 8-3. It is a double-pole, triple-throw (DP3T) type of switch rated at 110 v and 0.150 ampere. It locks in position and is nonshorting; that is, one circuit is opened before the next circuit is closed. In switches of this type the action may be locking or momentary, and the contacts may be shorting (for example, one circuit remains closed until an instant after the next circuit is closed; then it is opened) or nonshorting. Other contact arrangements are DPDT, 4PDT, and 6P3T.

LEVER PILEUP SWITCHES

One type of 2-position lever pileup switch is shown in figure 8-4,A. There are 9 solder terminals, and the switch is rated at 48 v and 1 ampere. In the schematic diagrams the downstroke of the switch is designated by 2, the upstroke by 1, and OFF position by zero. The No. 2 position is momentary.

A 3-position, 21-terminal switch is shown in part B, and a 2-position, 9-terminal switch is shown in part C.

Nearly a hundred types of lever pileup switches are available for various uses. They may have up to 75 terminals, and the associated switch contacts may be arranged in various ways.

In addition to lever pileup switches, rotary pileup switches (activated by a rotary motion) and the jacktype pileup switches (activated by the thrust of the plug) are used in automatic telephone systems.

KNIFE SWITCHES

Knife switches are essentially power switches; they will handle up to 500 amperes and up to 15,000 v. Figure 8-5, A, shows a double-pole, single-throw (DPST) knife switch rated at 125 v and 30 amperes.

Part B shows a 4-pole, double-throw (4PDT) knife switch rated at 125 v and 100 amperes.

THERMOSTATIC SWITCHES

Thermostatic switches are designed to either open or close when the temperature reaches a certain value. A large number of different types of thermostatic switches are used by the Navy to control the temperatures in compartments and rooms, to regulate dampers, to maintain constant crystal temperatures in some radio transmitters; they are also used in many other heating and cooling applications. Switches of a given type may have different contact arrangements, be operated at different temperature ranges, or have different voltage or current ratings.

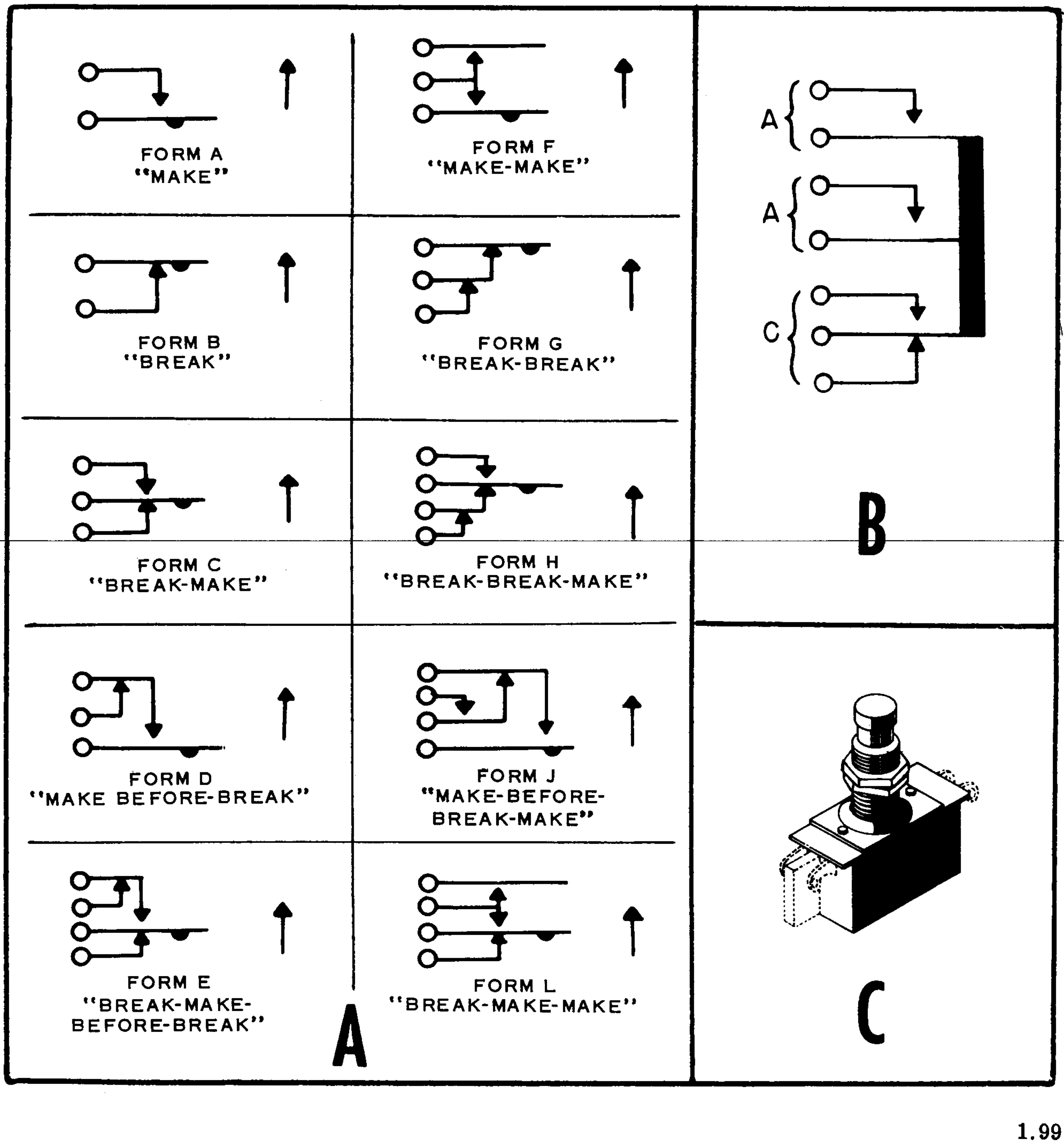

Figure 8-2.—Push switches.

A large number of thermostatic switches employ a bimetallic strip as the active element. The basic operating principle is illustrated in figure 8-6,A. One side of the bimetallic strip is brass and the other side is iron (other metals may also be used) welded to the brass. When the strip is heated, the brass expands more than the iron and the strip bends downward to open the switch contacts. Thus, power is removed from the load when a certain temperature is reached. The switch action may be reversed so that power is applied to the

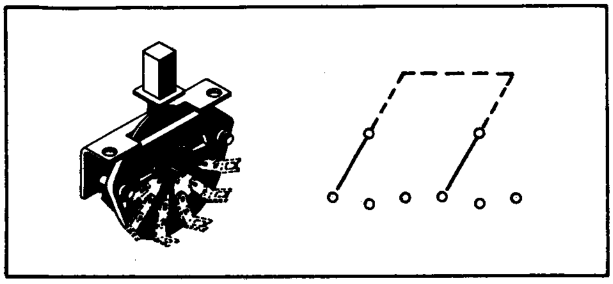

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Figure 8-3.—Wafer lever switches.

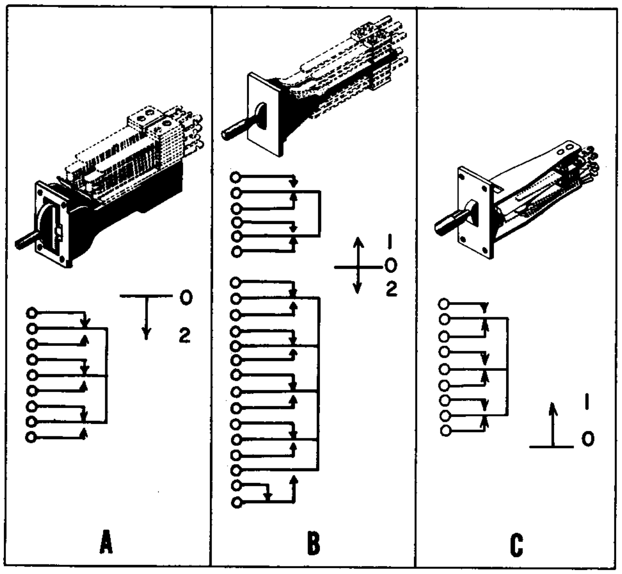

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Figure 8-4.—Lever pileup switches.

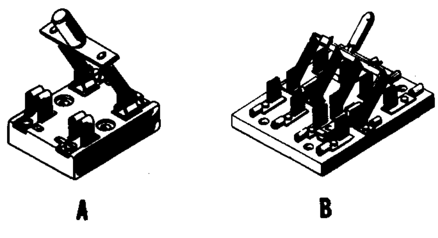

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Figure 8-5.—Knife switches.

load when a certain temperature is exceeded. Although not shown in the figure, various refinements such as adjustments and snap action may be incorporated in the switch.

In mercury thermostatic switches the mercury itself completes the circuit as it expands upward between two metallic contacts. The basic operating principle is illustrated in figure 8-6,B. When the temperature decreases, the mercury contracts and opens the circuit.

The principle of operation of gas thermostatic switches is illustrated in figure 8-6,C. When the gas is heated, it expands the bellows and closes the switch; when it is cooled, it contracts the bellows and opens the switch.

In each of the illustrations, only the basic principle of operation is shown. Certain refinements are generally added.

Figure 8-6,D, shows the thermostatic switch used in the crystal oven of one type of radio transmitter. The contact arrangement is for a single-pole, single-throw operation, and the switch is rated at 115 v and 0.75 ampere. The operating temperature is 170.6° F to 179.6° F, the temperature differential being 9°.

ROTARY PILEUP SWITCHES

Rotary pileup switches are so constructed that they open and/or close one or more electrical circuits; the contacts are arranged in a leaf, or pileup, fashion and they are actuated by a rotary motion.

One type of rotary pileup switch is illustrated in figure 8-7. As may be seen in the figure, there are six terminals. When the armature is moved upward by the rotary motion of the switch knob, two circuits are opened and two other circuits are closed.

This type of switch has numerous applications in low-voltage signal circuits.

ROTARY SELECTOR SWITCHES

Rotary selector switches, or nonpileup rotary switches, have many applications in electronic equipments. They may be made up of any number of sections, decks, or wafers depending upon the switching functions required. There are hundreds of possible contact arrangements. In many applications the switches are mechanically ganged to operate simultaneously from a single control (fig 8-8).

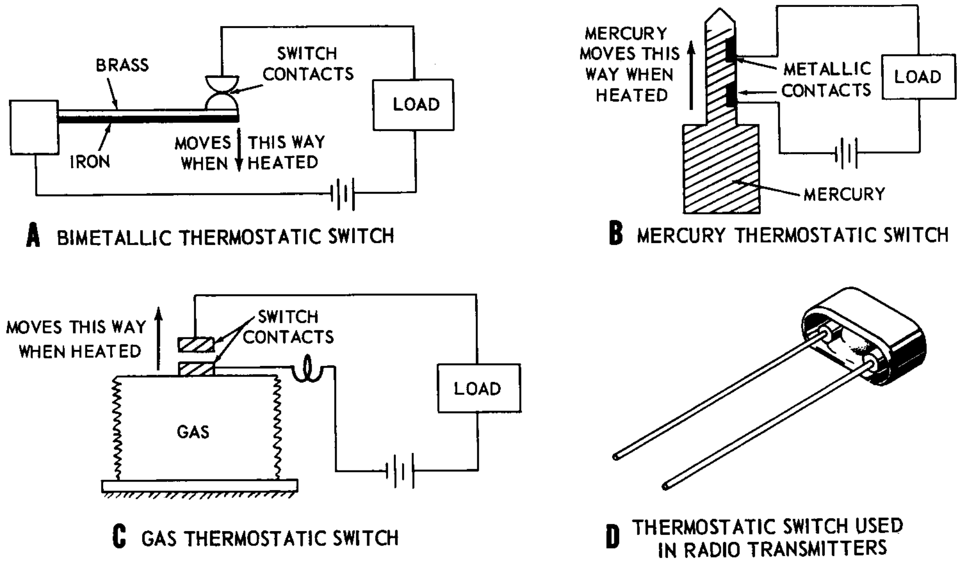

Figure 8-6.—Thermostatic switches.

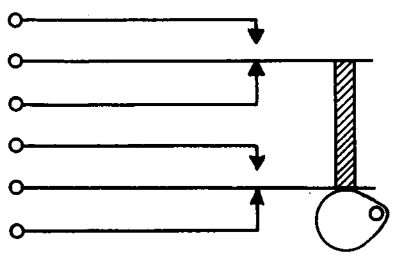

Figure 8-7.—Rotary pileup switches.

One deck of a rotary selector switch is shown in figure 8-9. The code letters are also included at the leads extending from the various terminals. Short clips are indicated by the letter, X. Dummy lugs are indicated by the letter, D. Nonshorting rotary teeth (or blades) are indicated by crossed lines. The word, nonshorting, means that the width of the rotor tooth is less than the distance between adjacent contact clips. This means that as the rotor is turned, one circuit will be opened before the next one is closed. The shorting type is shown without the crossed lines. In this case the rotary tooth is wider than the distance between adjacent clips, and therefore as the rotor is turned, one circuit is closed before the preceding one is opened. Clips that are insulated from their associated lugs are indicated by the letter, S; long clips thus insulated are indicated by the letters, YS. When a clip is thus insulated, the lug may be connected to a clip on the reverse side. A through electrical connection is indicated when the rotor (or a portion of it) is shown in black. This means that the section of the rotor so marked in the figure is connected through to a bottom rotor, not shown.

TELEPHONE TYPE JACKS

The contact assemblies on telephone type jacks are divided into two categories: (1) the plug contact assembly and (2) the pileup contact assembly. The plug contact assembly includes the contact springs (and all others making electrical connection with them) that make direct contact with the plug when it is inserted. Both categories are illustrated in figure 8-10A.

Figure 8-10C, illustrates the common varieties of plug contact assemblies used on jacks and indicates the code designation for each.

The proper contact arrangement for jacks is determined with the aid of figure 8-10B. The plug contact assembly (J7) is distinguished from the pileup contact assembly (B), and the code designation for the plug contact assembly is determined from figure 8-10C. The type and

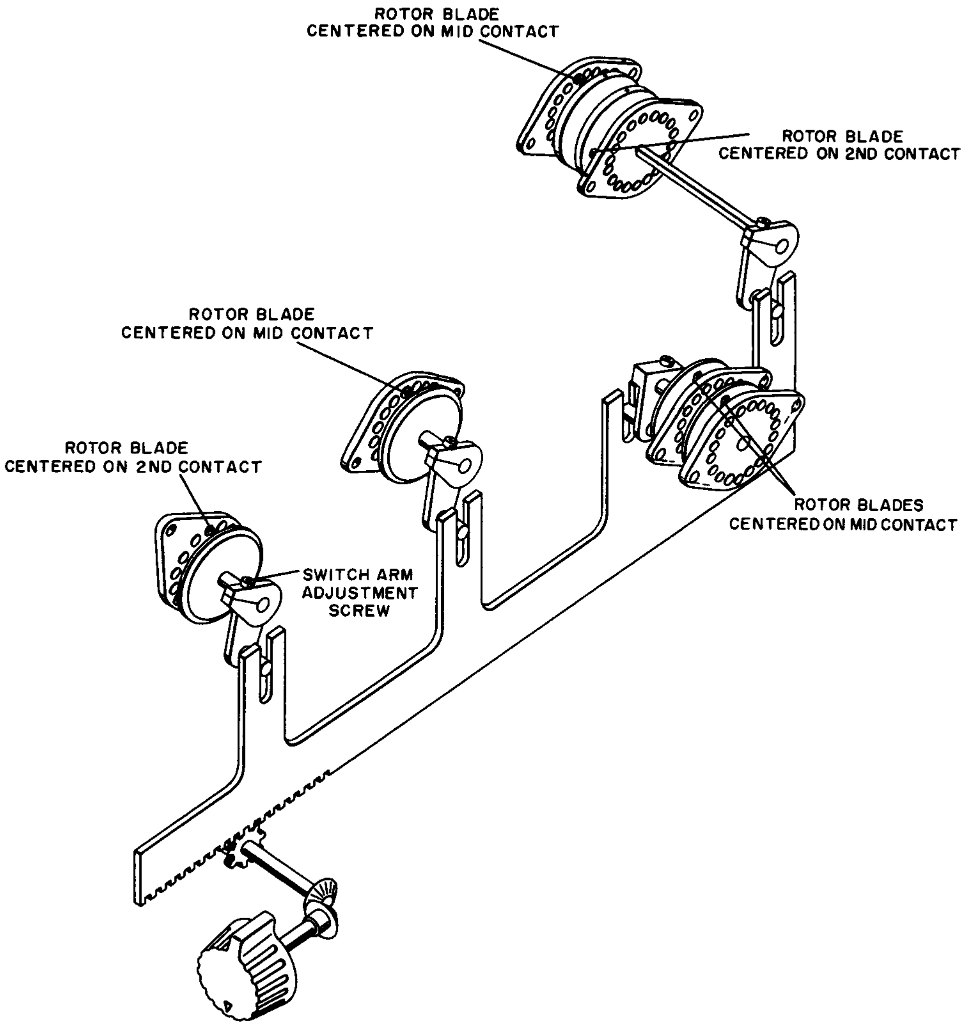

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Figure 8-8.—Rotary selector switches operated by gear and sliding bar.

quantity of each basic form used to make up the pileup contact assembly are determined. In the case of part B of the figure the proper contact arrangement designation for the jack is "J7-1B."

Jacks are used in plug panels, teletype panels, phone units, and in many other applications.

RADIO RECEIVER BAND-SWITCHING CIRCUITS

Band-switching circuits in radio receivers commonly employ rotary selector switches. In order to trace the various circuits through these switches, it is necessary to pay careful attention to the schematic diagrams. The band-switching circuit of a receiver that is relatively easy to follow is included in figure 8-11.

The 4-position switch, S101B, in the input grid circuit of the oscillator tube, V105, selects 1 of 4 crystals. An additional set of contacts on S101B provides for grounding the three crystals that are not in use at any given time. The operating crystal is connected directly to the grid of V105. In the switch position, 1, shown in the figure, crystal X106 is connected

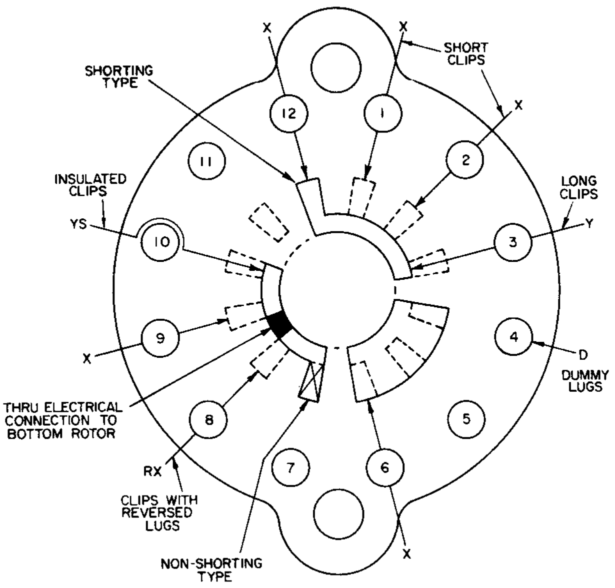

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Figure 8-9.—Deck of rotary selector switch, showing contact arrangement and code letters.

between the grid of V105 and ground; the other three crystals are shorted to ground. In position 2, X107 is connected to the grid, and crystals X106, X108, and X109 are grounded.

The 4-position switch, S101A, mounted on the same shaft as crystal-selector switch S101B, connects filament potential to the proper channel-indicating lamp through S102. In the position shown in the figure, S101A provides circuit continuity for lamp (1); the other three lamps are open at the switch contacts.

Rheostat R117 enables the operator to control the brilliancy of the channel-indicator lamp and the dial lamps E109, E110, and E111.

The band-switching circuits of the AN/SRR-11 (fig. 8-12) are somewhat more involved, however, careful circuit tracing will enable one to follow the signal path.

Band switching for radio receiving set AN/SRR-11 is accomplished through the use of four 2-section, and two single-section rotary selector switches. The 5-position band selector on the front panel of the receiver is geared to a sliding bar similar to figure 8-8, and operates the selector switches to connect the appropriate components for the frequency band selected.

These selector switches connect the appropriate input and output transformers for the selected band, and connect the ganged sections of tuning capacitor C251 across the selected transformers to maintain tuning within the band. They also serve to short out transformers used for bands lower than the selected band, thereby preventing any absorption of the signal on the band in use.

Antenna matching links 0101 and 0102 (fig. 8-12) are provided to match antenna transformers T101 through T105 to either a high or low impedance input. With the links in the low impedance position the antenna is connected across the primary of the selected transformer with capacitor C106 connected between the center tap and the low side of the secondary. With the links in the high impedance position (as shown in fig. 8-12), the antenna is connected between the tap and the low side of the selected transformer secondary.

Antenna compensation switch S102 and capacitor C103, operated by the antenna compensation control on the front panel of the receiver, compensate for variations in antenna capacitance.

The wafers of all selector switches (fig. 8-12) are shown in band 1 position. The signal from the antenna is through C102, matching link 0101, C107 to S101A, and out of S101A via contact 3, through R101 to pin D of T101 in the first r-f amplifier section. The output signal voltage developed by the autotransformer action of T101 is fed back into S101A through contact 15 and out to the grid of the first r-f amplifier V101. S101A also connects the antenna section of tuning capacitor C251D across the secondary of T101. S101B is used to short out transformers associated with lower frequency bands than the selected band, and therefore is not used in band position 1.

The output of V101 (terminal H on J103) is fed to S126A in the second r-f amplifier section, out of S126A via contact 9 to pin B on the primary of r-f coupling transformer T126. The output from pin D on T126 is fed into S126A via contact 3, and out to the grid of the second r-f amplifier V126. C251C is connected across the secondary of T126 by contact 15 of S126A. S126B serves to short out transformers associated with bands below the selected band, and to connect capacitor C139 across the primary of T127, T128, or T129 when operating on bands 2, 3, or 4. S126B, therefore, is not used in band position 1.

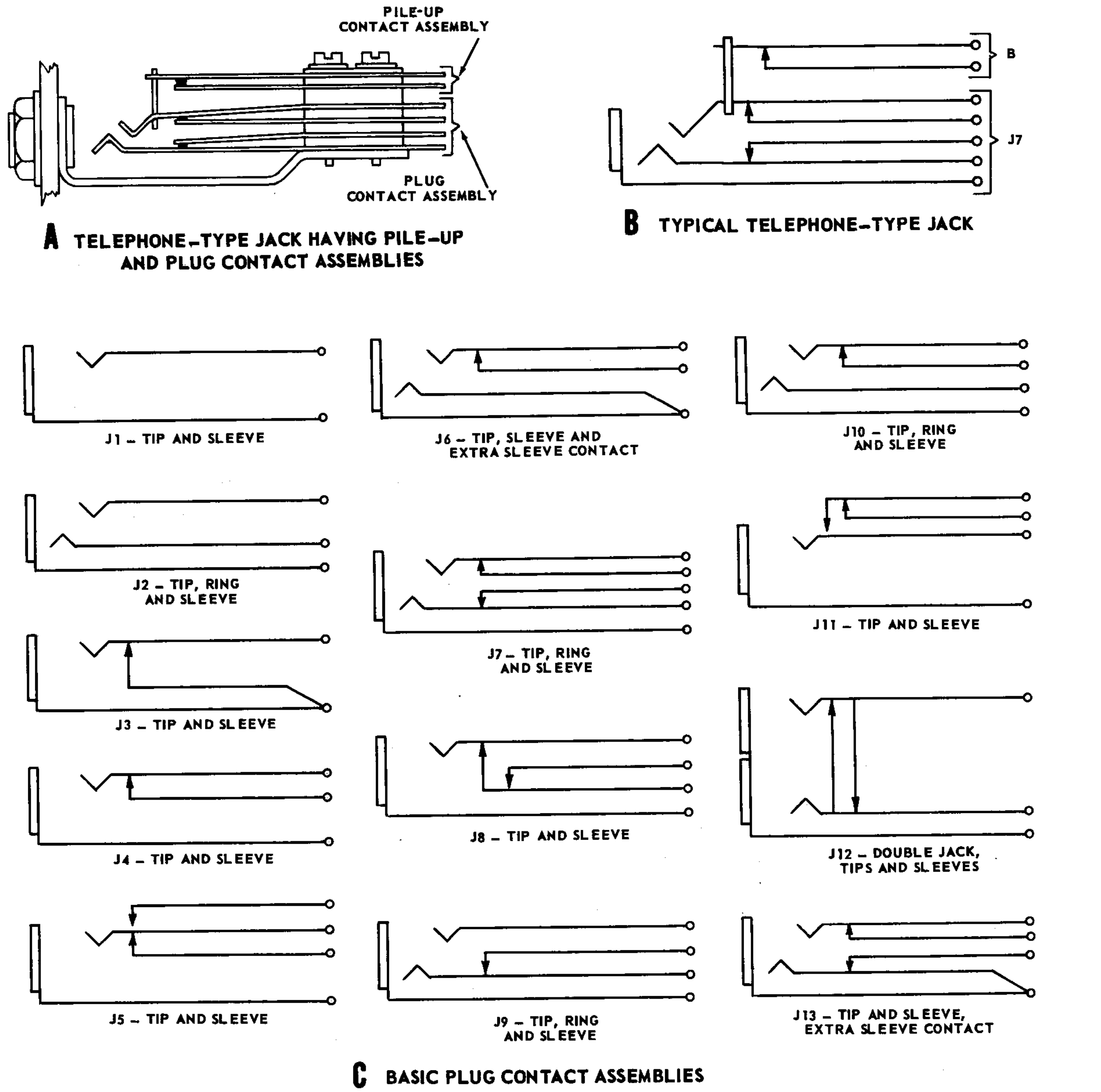

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Figure 8-10.—Telephone-type jacks.

The output of the second r-f amplifier V126 at terminal H on J128 is coupled to the grid of mixer V151 through transformer T151. Transformer T151 is connected in the circuit by S151A in the same manner as described for T126 and S126A. S151B also is not used for band position 1.

Oscillator assembly Z201 in the oscillator section generates 60 kc above the signal frequency on frequency bands 1 and 4, and 200 kc above the signal frequency on the remaining bands. Oscillator signals for band 1 operation are from pin D on L201, into S201A via contact 9, out of S201A through R201, to the grid of V201. Oscillator feedback is from pin E on L201 into S201A via contact 3, and out of S201A through R202 to the cathode of V201. S201A also connects tuning gang capacitor

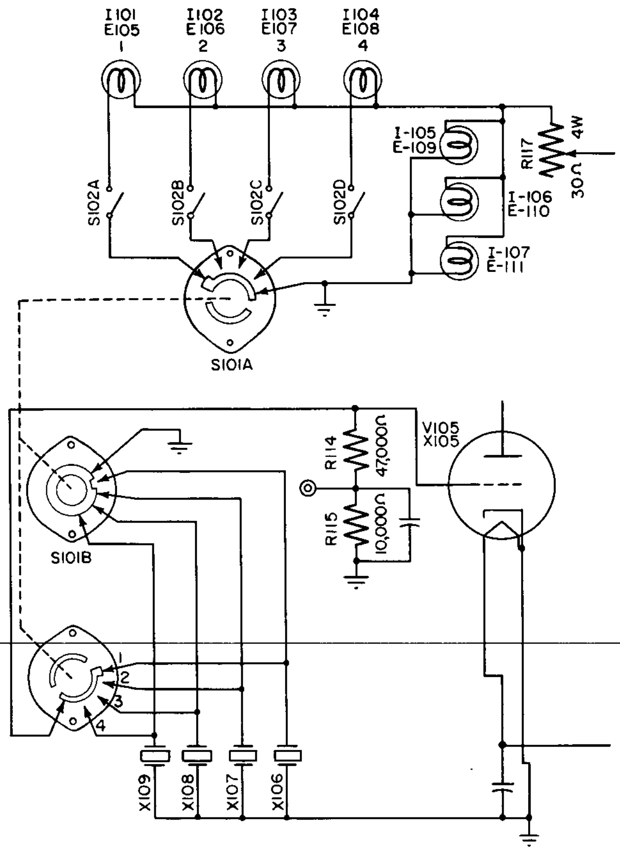

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Figure 8-11.—Band-switching circuit of a receiver.

C251A in the oscillator tuned circuit. Contact 9 on S201B grounds pin D of coil L202 to prevent absorption of band 1 signals. The oscillator output is through C226, terminal E on J203, terminal B on J153, to the suppressor grid of mixer V151.

The output of mixer V151 during bands 1 and 4 operation is applied to the first i-f amplifier. The first i-f amplifier is bypassed on bands 2, 3, and 5.

Switches S701 and S702 in the first i-f section are two-pole, six-position, single-section, rotary selector switches. They serve to bypass the first i-f assembly in bands 2, 3, and 5. They also connect bandpass filter Z702 in the input circuit, and the B+ supply for operation of the first i-f assembly in bands 1 and 4.

In band position 1, the 60-kc output of mixer V151 at terminal H on J153 is fed to S701 and out on contact 16 to bandpass filter Z702. The output of Z702 is fed to the suppressor grid of V701. The 200-kc output of V701 is fed into S702 via contact 16 and out to the primary of T703. The secondary of T703 is the output to the second i-f assembly.

The circuits for band position 2 may be traced by rotating the arrows in all wafer switches one position in the direction shown. To trace the circuits for the remaining bands, rotate the switches the number of positions corresponding to the band to be traced.

RADIO RECEIVER AND TRANSMITTER REMOTE-CONTROL TRANSFER SWITCHBOARDS

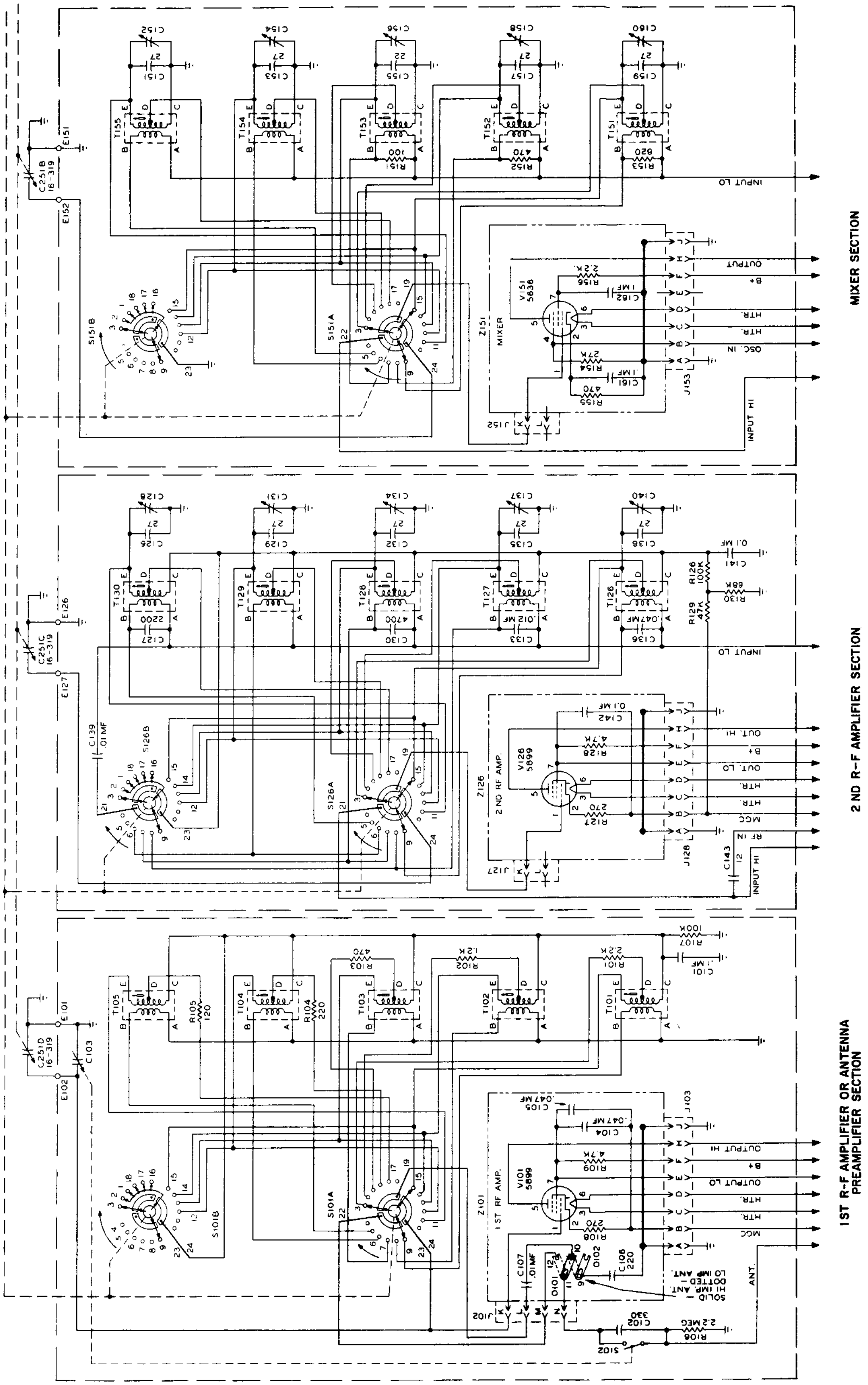
Radio remote-control transfer plug panels have become too cumbersome to be used in shipboard radio installations on modern Navy ships. Therefore, control panels utilizing switches instead of plugs and patchboards are being installed in new construction and in conversion jobs. Two unit-constructed panels (one for receivers and one for transmitters) now provide all of the facilities that were available in three types of plug panels (the receiver transfer panel, the transmitter transfer panel, and the radiophone transfer panel), and in addition afford greater flexibility in the remote-control system. These units are Receiver Transfer Switchboard, Type SB-82/SRR, and Transmitter Transfer Switchboard, Type SB-863/SRT.

RECEIVER TRANSFER SWITCHBOARD

An external view of the Receiver Transfer Switchboard, Type SB-82/SRR, is shown in figure 8-13. A simplified schematic diagram of a portion of the internal switching arrangement is shown in figure 8-14.

The receiver switchboard has 5 vertical rows of 10 double-pole, single-throw (ON-OFF) switches that are continuously rotatable in either direction.

One side of each switch within a vertical row is wired in parallel with the same sides of the other nine switches within that row. Similarly, the other side of each switch is wired in parallel horizontally with the corresponding sides of each of the other four switches in a horizontal row. This method of connecting the switches gives rise to the term CROSS-MAT


MIXER SECTION
2 ND R-F AMPLIFIER SECTION
1ST R-F AMPLIFIER OR ANTENNA PREAMPLIFIER SECTION

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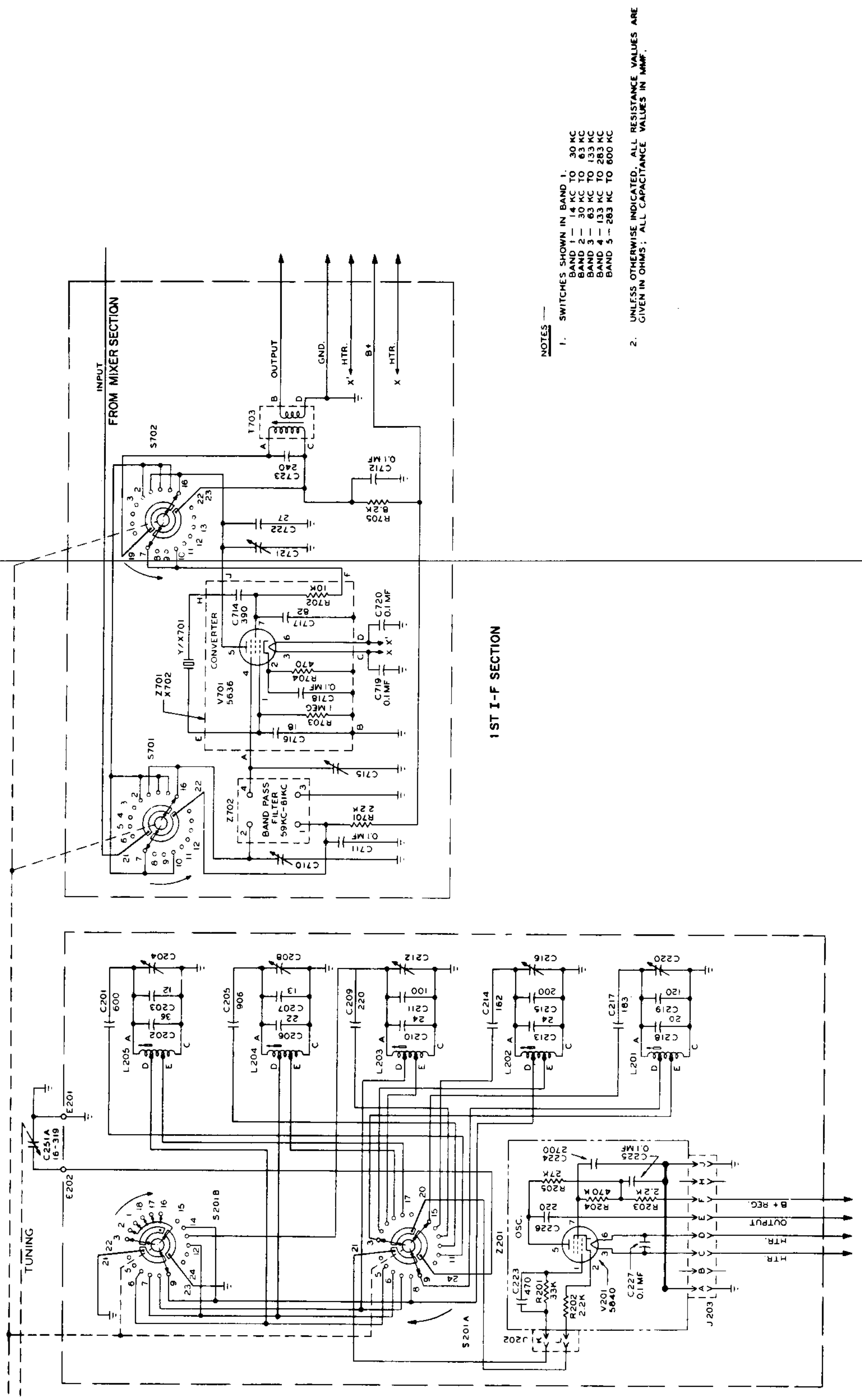

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Figure 8-12. —Band-switching circuits—Radio Receiving Set AN/SRR-11—Continued.

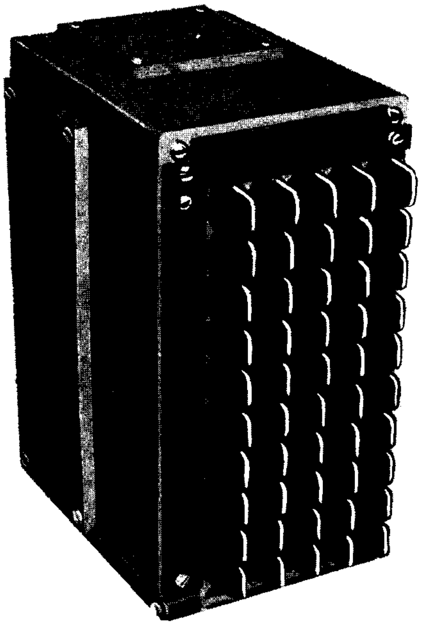

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Figure 8-13.—External view of the Receiver Transfer Switchboard type SB-82/SRR.

PARALLELING, and permits a high degree of flexibility.

The audio output from the receiving equipments, connected to the five vertical rows of switches, may be fed to any or all of the remote stations by closing the proper switch or switches. For example, the audio output from the L-F receiver may be fed to remote radiophone station No. 1 by closing switch 16; it may be fed to all of the remote stations by closing all of the switches in the left-hand vertical column.

Shielded leads are used for the audio circuits.

The knob of each switch is marked with a heavy white line to provide visual indication of the communication setup. In general, there are more remote stations than there are receivers, and therefore the switchboards are normally mounted in a vertical position (as in fig. 8-13). This arrangement permits the outputs from 5 receivers to be fed to the 5 vertical rows and up to 10 remote stations to be fed from the 10 horizontal rows of switches. Switchboards are furnished with the knobs in the OFF position when the white line is vertical.

If it becomes necessary to employ a system where there are 10 receivers and 5 remote stations, the switchboard may be mounted in a horizontal position and each switch knob rotated 90° with respect to the shaft. All shafts have two flat sides for setscrews so that this change can be made if desired. The purpose of rotating the switch knobs with respect to the shaft is to standardize the setup so that the switches will be in the OFF position when the white line is vertical. To further standardize all installations, receivers are always connected to the vertical rows of switches, and remote stations are always connected to the horizontal rows of switches after the orientation (vertical or horizontal) of the switchboard has been determined.

It should be noted that only the receiver audio output circuit is connected to the switchboard. This is true also of the receiver transfer plug panel used in earlier installations. Transmitter transfer switchboards, however, handle several other types of circuits in addition to audio circuits.

TRANSMITTER TRANSFER SWITCHBOARD

Transmitter Transfer Switchboard type SB-863/SRT has replaced type SB-83/SRT. The SB-863/SRT (fig. 8-15) has ten 20-position rotary selector switches, in two vertical columns. Each rotary switch corresponds to a remote control station, and each switch position (1 through 19) corresponds to a controlled transmitter. Thus switching control is provided for up to 10 remote control stations, and 19 transmitters. When more than 10 remote stations, or 19 transmitters, are to be connected, additional transfer switchboards may be installed. Position 20 of each rotary switch is provided for connections to an additional transfer switchboard to control extra transmiters. The switches consist of 12 wafers which serve to connect the start-stop indicator, keying, 12-v d-c microphone, carrier control, and carrier indicator circuits for the various transmitters.

Any of the remote stations may be connected to control any of the transmitters in the system. For example, to connect remote station No. 1 (fig. 8-16) to control the TED transmitter,

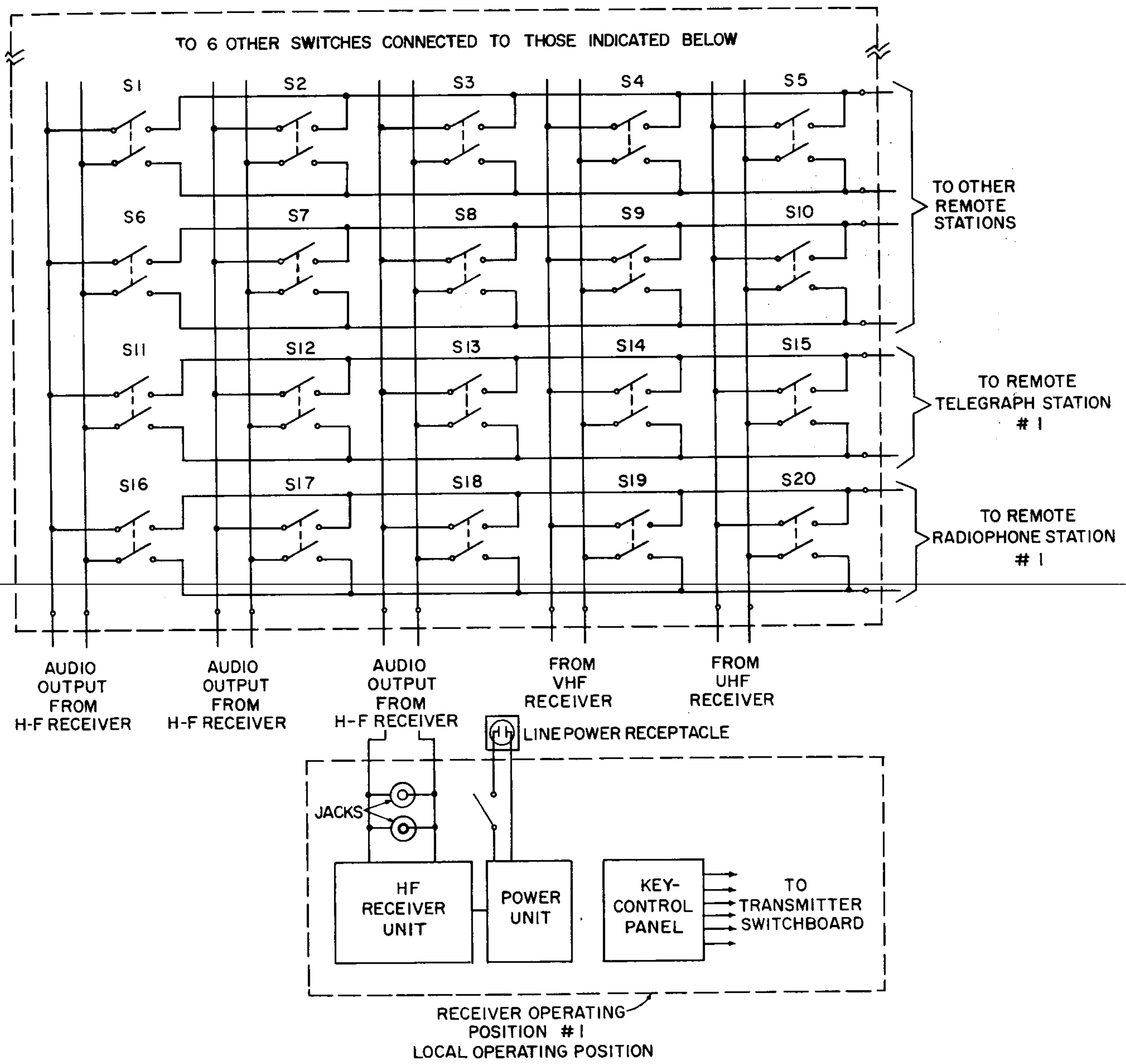

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Figure 8-14.—Simplified schematic diagram of the receiver transfer switchboard type SB-82/SRR.

rotary switch No. 1 (S1) is placed in position 1. To control the AN/GRC-27 from remote station No. 1, switch S1 is placed in position 2. Switch 2(S2) is used for remote station No. 2 in the same manner.

The remote stations assigned to each rotary switch, and the transmitters assigned to positions 1 through 19, are engraved on the engraving plates when the switchboard is installed (fig. 8-15). If an extra switchboard is installed, switch position No. 1 on the second switchboard is assigned to transmitter No. 20, position No. 2 to transmitter No. 21, etc. Thus, if remote station No. 2 is to have control of transmitter No. 22, switch No. 2 on the first switchboard is placed in position 20, and switch No. 2 on the additional switchboard is placed in position 3.

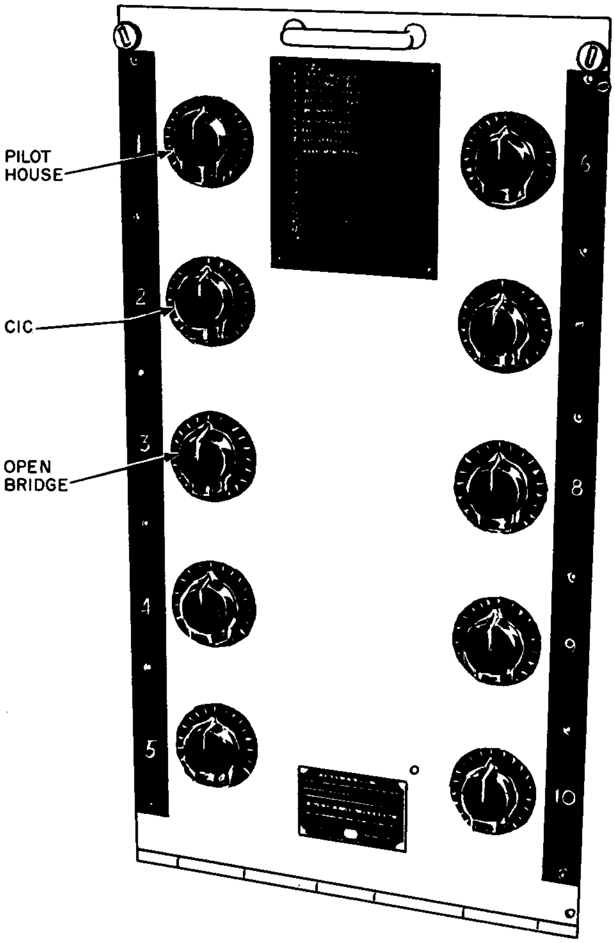

Figure 8-15.—Transmitter transfer switchboard—SB-863/SRT.

INTERCONNECTIONS BETWEEN TRANSFER SWITCHBOARDS

Figure 8-17 illustrates possible interconnections between the various switchboards located in Radio Central, Radio II, and Radio III.

Increased flexibility may be obtained by the use of a large number of switchboards in Radio Central and a smaller number of switchboards in Radio II and Radio III. Most of the space on two bulkheads may be taken up by the switchboards in Radio Central.

SWITCH CONNECTIONS BETWEEN RADIOPHONE UNIT AND TRANSMITTER

Generally, a radio transmitter connects through the transmitter transfer switchboard to a radiophone unit. However, in figure 8-18 the transmitter transfer switchboard has been omitted; and only a simplified diagram of the transmitter (Navy Model TED-8), showing the control circuits, is included.

The line power switch, S1, is a 2-pole, single-throw switch in the 60-cycle, single-phase, power-line circuit and must be closed before the equipment can be started with the start-stop switch at the transmitter or RPU. In an emergency, power can be quickly removed from the entire equipment by throwing the line power switch to the EMERGENCY OFF position.

The local start-stop switch, S2, in the transmitter is a momentary contact (nonlocking) switch used to start or stop the equipment after S1 has been closed. Momentary closure of S2 on the START side energizes the equipment start-stop relay, K1, which locks itself in the closed position through contacts K1A, the thermal cutout relay contacts, and resistor R. Relay K1 remains energized until its coil is shorted when S2 is moved to the STOP position.

The local remote switch, S3, affords local or remote control of the operation of the transmitter. When S3 is set to LOCAL, S3(a) connects the parallel combination of the local handset, the microphone jack, and the local carrier-control switch in series with the input windings of the input transformer, T1 (winding 1-2 in series with winding 3-4), thus providing local control of the carrier. Indicating and control functions are disconnected from all remote units by operation of S3(a), S3(b), S3(c), and S3(d).

When S3 is turned to the REMOTE position, the following sequence of events takes place:

1. Switch S3(a) connects the T2 secondary and the microphone or key jack in the RPU as a parallel combination across the transmitter T1 primary (1-2 winding in series with the 3-4 winding) and disables the local carrier-control circuits. The circuits through the handset microphone in the RPU are from the -12-v supply (terminal 7), the T2 primary, terminals C and D of the handset extension jacks by way of the push-to-talk switch (not shown in the RPU), and ground return at terminal 8. The circuits through the handset receiver in the RPU are

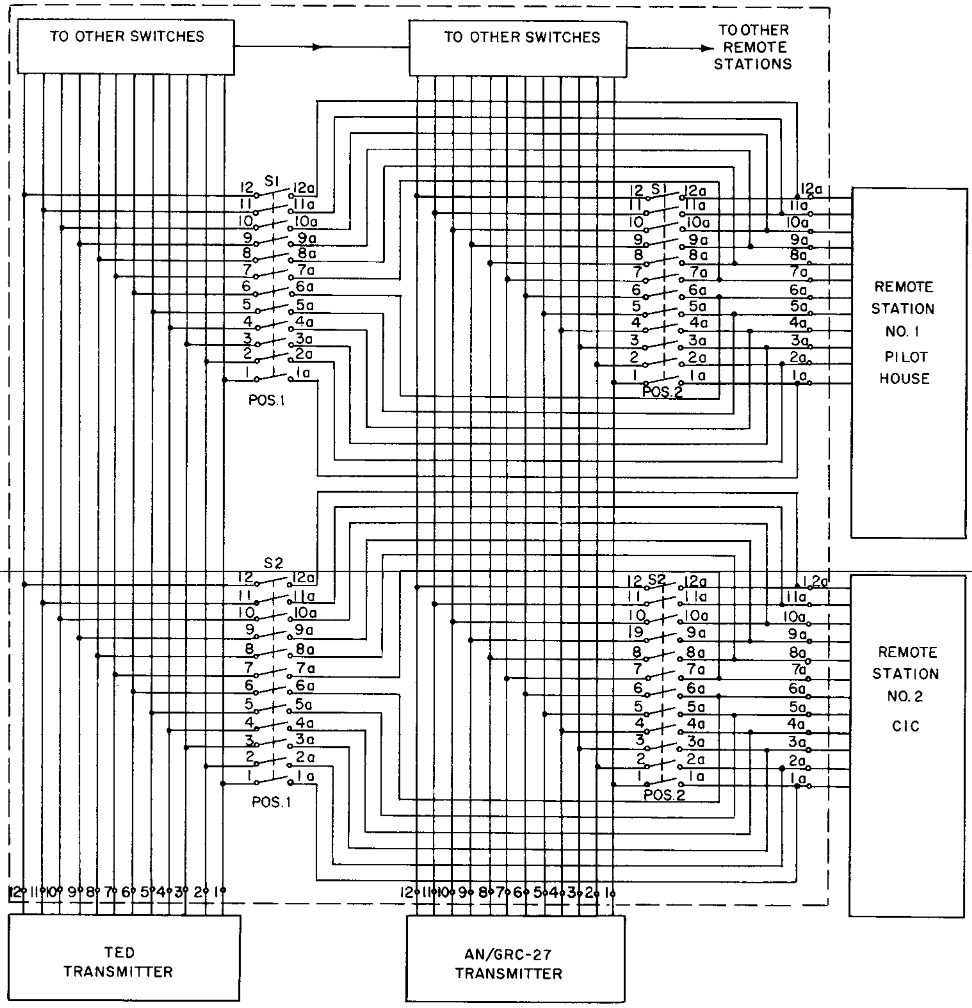

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Figure 8-16.—Simplified schematic diagram of transmitter transfer switchboard SB-863/SRT, showing first two positions of rotary switches 1 and 2.

from terminals A and B of the handset extension jacks, the earphone-level potentiometer, and terminals 13-14 to the associated receiver via the receiver transfer switchboard (not shown).

2. Switch S3(b) connects the common lead to the start-stop circuit to the stop switch in the RPU.

3. Switch S3(c) connects one side of the 115-v a-c line to the RPU power indicator by way of terminal 4. The other side of the 115-v line is always connected directly to the other side of the power indicator.

4. By means of S3(d), -12 v is applied to the RPU for microphone current.

The audio monitoring circuit involves the circuits connected to terminals 5, 6, 10, 13, and 14 on the terminal board. The audio monitoring circuit enables the operator to listen to the

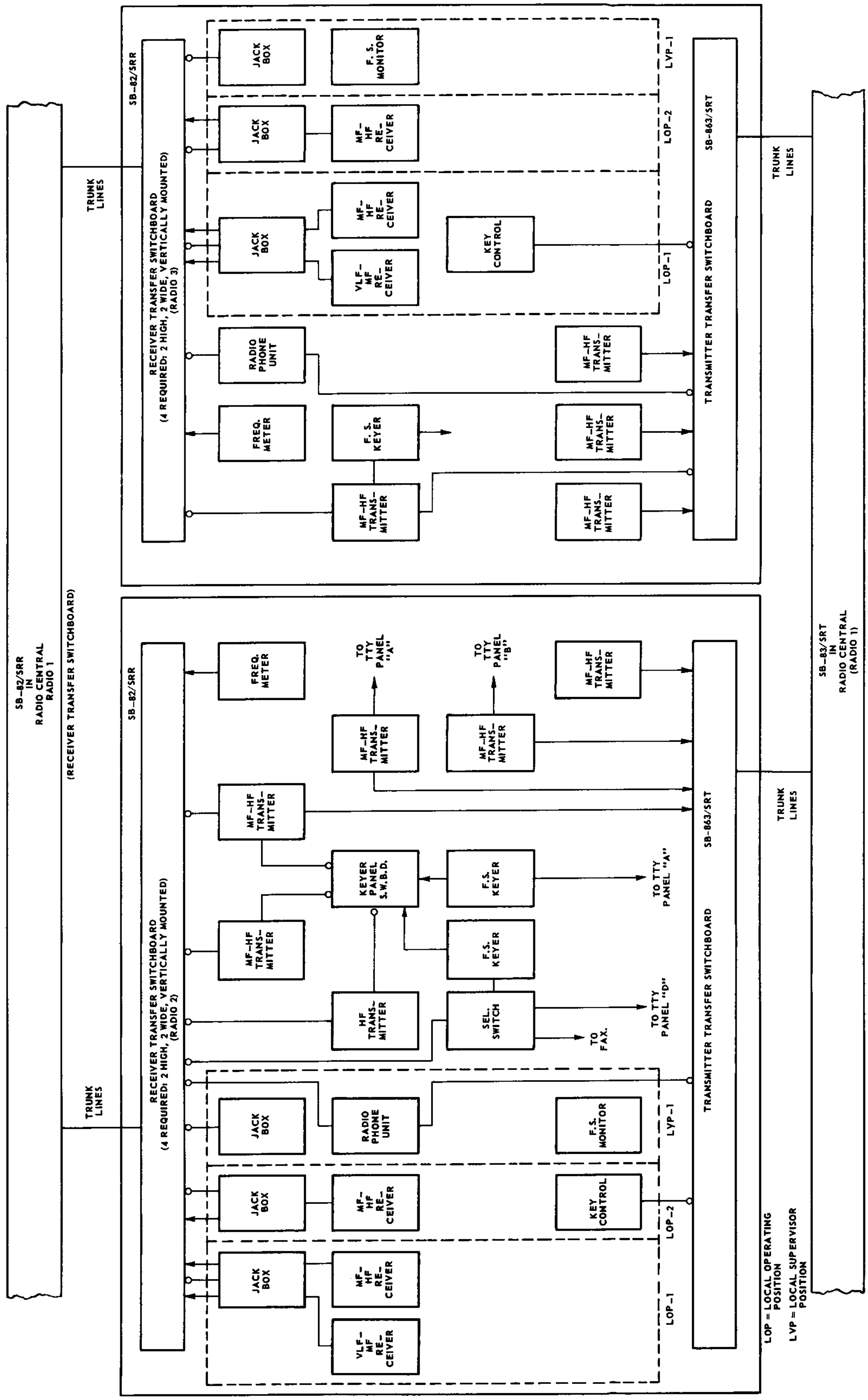

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Figure 8-17.—Interconnections between transfer switchboards.

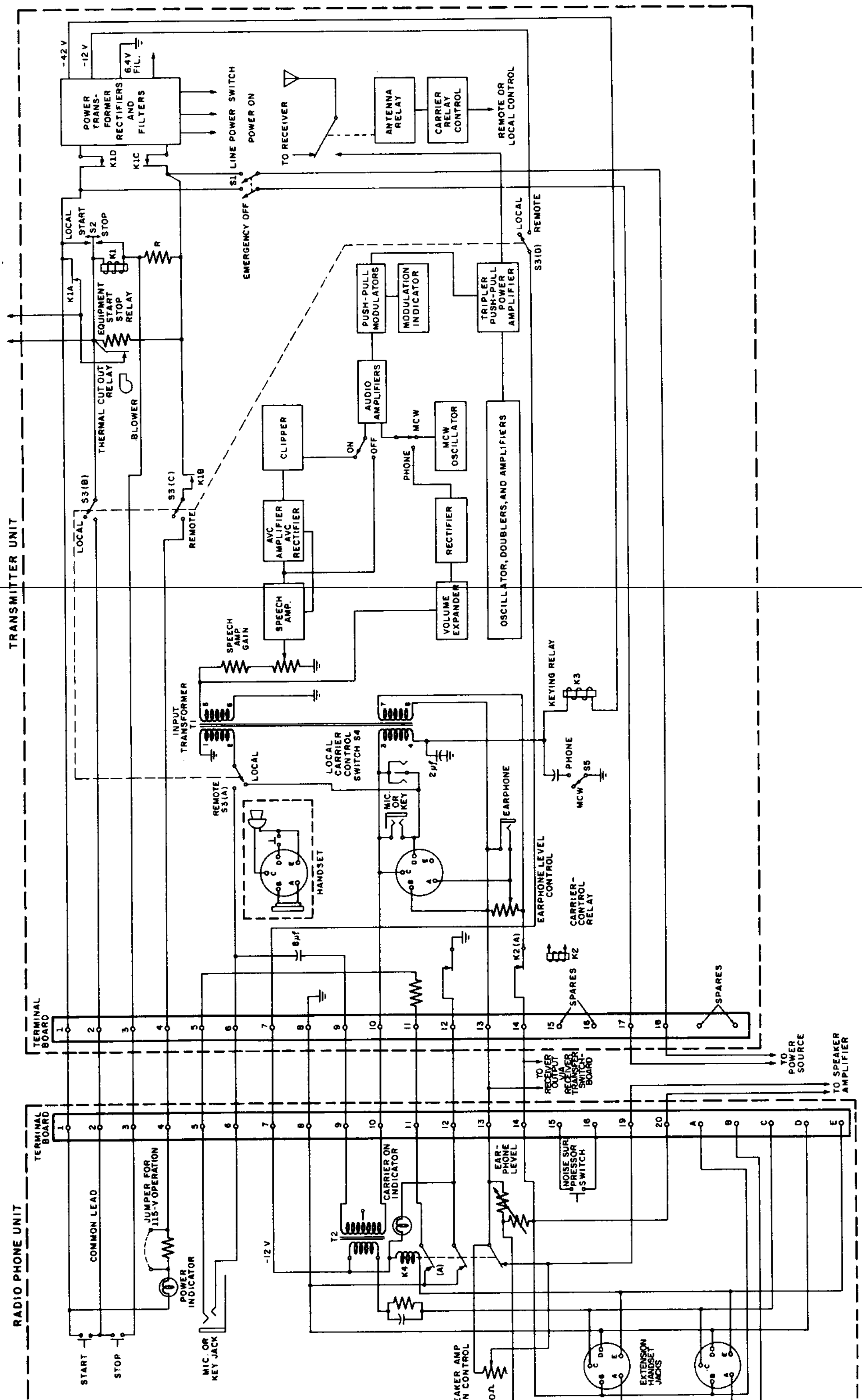

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Figure 8-18. —Switch connections between radiophone and transmitter.

output of the receiver when the transmitter is off and to listen to speech "sidetone" when the transmitter is being used. Circuits are provided so that this may be done either locally or at a remote location. The audio signal from the receiver is brought into terminals 13 and 14.

When the transmitter carrier is off, relay contacts K2(a) are closed (K2 is deenergized), and the audio signal from the receiver is fed via K2(a) to the earphone-level volume control at the transmitter and to the 7-8 winding of T1. The receiver may be monitored locally by plugging the earphones into the earphone jack at the transmitter, because this jack is connected across a part of the earphone-level volume control.

When the transmitter carrier is on, relay K2 is energized and contacts K2(a) are open. This condition disconnects the receiver audio signal circuit from the earphone-level control at the transmitter, the associated earphone jack, the receiver handset plug terminals A and B, and the 7-8 winding of T1. The transmitter sidetone signal is picked up by the secondary, 7-8, winding of T1 and impressed across the earphone-level control for local monitoring. The remote monitoring signal is picked up from the control lines on which the signal is normally present during voice operation.

When S5 is in the PHONE position and the local microphone handset press-to-talk switch is operated, keying relay K3 is energized. This action indirectly energizes carrier control relay K2, which disconnects the receiver from T1, as previously described. Thus, the receiver is disconnected when the transmitter carrier is on. The same action takes place in remote operation, except that relay K4 in the RPU energizes K3 by applying ground to terminal 3 of the 3-4 winding of T1 via terminals 8 and 11 and contacts K4(a).

RECEIVING-ANTENNA DISTRIBUTION SYSTEMS

Shipboard Antenna Details, NavShips 900121 (revised), contains information concerning antenna distribution systems. Antenna transfer panels and filter assemblies have replaced older systems on board ship. Filter type multicouplers were discussed in chapter 5 of this course.

SYSTEM EMPLOYING TRANSFER PANELS

A receiving-antenna distribution system, using antenna transfer panels, is shown in figure 8-19. The transfer panels are interconnected so that a receiver in any radio space may be connected to any receiving antenna, regardless of its topside location.

Two different views of the antenna transfer panel, type 23406, are shown in figure 8-20 (A and B) a simplified schematic diagram is shown in figure 8-20,C. These transfer panels provide the means by which as many as four radio receivers may be operated simultaneously from one antenna. At the transfer panel, each antenna is connected to a vertical row of four jacks. One jack is connected directly to the antenna; the other jacks are connected in parallel through 600-ohm decoupling resistors. The receivers connected to the three decoupled jacks operate at reduced efficiency.

There are nine interspace lines (one for each vertical row of four jacks) that connect to the various antennas (fig. 8-20,C). These lines connect to the vertical rows composed of four jacks (fig. 8-20,A). The escutcheon plate at the top of each line of four jacks is marked to indicate the remote termination of that line.

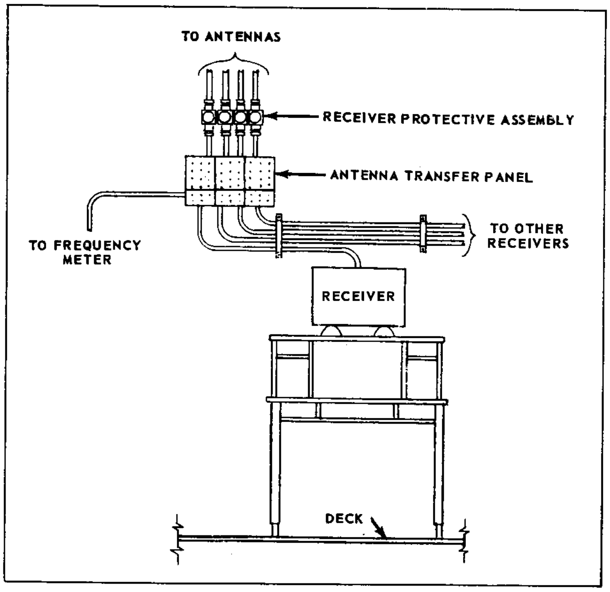

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Figure 8-19.—Receiving-antenna distribution system, using antenna transfer panels.

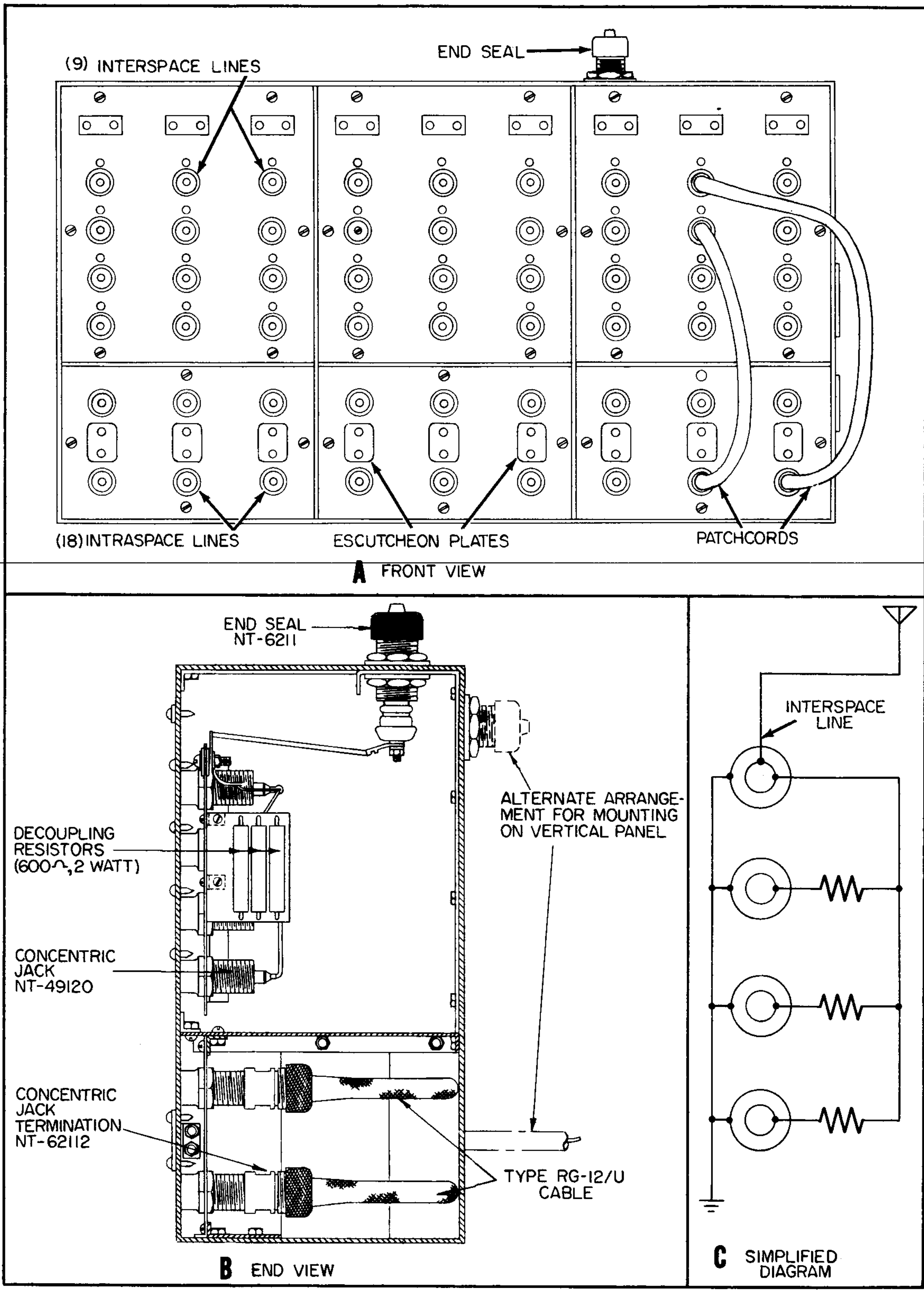

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Figure 8-20.—Antenna transfer panel, type 23406.

The 18 intraspace lines (lower 2 rows of jacks) connect to terminal boxes located at the various receiver, frequency meter, or other equipment positions. White escutcheon plates are mounted between each pair of jacks to enable the operator to mark the respective communications channel, frequencies, or schedules thereon. Patch cords are provided to complete the connections between the various jacks on the front of the panels.

SYSTEM EMPLOYING FILTER ASSEMBLY

A receiving-antenna distribution system, using a filter assembly, is shown in figure 8-21. This type of distribution system makes possible the multiple operation of a maximum of 28 radio receivers from a single antenna. It is generally preferable however, to limit the total number of receivers to 7.

This filter assembly or "multicoupler" provides 7 r-f channels in the frequency range from 14 kc to 32 mc. Any or all of these channels may be used independently of, or simultaneously with, any of the other channels. Connections to the receivers are made by means of coaxial patch cords and a patch panel.

An external view of the filter assembly is shown in figure 8-21,A. Separation of the frequency range into channels is accomplished by combinations of filter subassemblies, which plug into the main chassis. Each filter subassembly consists of complementary high-pass and low-pass filter sections, the common crossover frequency (F_c) of which marks the division between channels.

The filters not only guard against interference at frequencies falling outside the channel being used, but also prevent receivers connected to alternate rows of jacks from interacting with each other when their tuning and trimming adjustments are made.

A set of nine filter subassemblies is available, any six of which may be used at one time. The filter subassemblies are sealed units consisting of inductors and capacitors and are terminated in 4-terminal plugs, which are designed to engage octal receptacles on the main chassis. The subassemblies have numbers stamped on them that indicate their crossover frequencies. These numbers can be viewed through windows in the front panel. The six subassemblies that are used are assembled in the order of decreasing frequencies from left to right, as viewed from the front of the panel.

The filter panel (fig. 8-21,B) contains 1 antenna input jack, 28 output jacks, 21 decoupling resistors, and 6 octal sockets. The antenna input jack and the 28 output jacks are all Navy type-49120 r-f connectors. [In the AN/SRA-12 Receiving Filter Assembly, these connectors have been changed to receptacle connectors UG-1111/U (and plug connectors UG-968/U) which are improved quick-disconnect type r-f connectors.] The filter subassemblies plug into octal sockets in the rear of the main chassis (not shown).

To keep the losses to a minimum, the input and output of the filter assembly should be terminated in 180 ohms, however, only a slight reflection loss (of the order of 1.0 db) results when the input is terminated in 70 ohms.

Because Navy communications receivers generally operate throughout frequency bands that exceed the widths of the channels normally provided by the filter subassemblies, a given receiver must be connected to the particular row of output jacks that provides the signals of the desired frequency. For example, if a receiver is tuned from some frequency in the 7- to 14-mc band to some frequency in the 14- to 32-mc band, the patch cord would have to be moved from the output of the 14- to 7-mc subassembly unit to the output of the 32- to 14-mc subassembly unit.

When necessary, the bands of frequencies available in a given row of output jacks may be changed either by using different combinations of filter subassemblies or by removing various subassemblies and inserting "shorting plugs." provided with the equipment. These shorting plugs provide continuity between successive subassemblies, as required when testing or when a subassembly is removed for any reason, without the necessity for changing the position of the remaining subassemblies.

The red-painted jacks at the bottom of each row are directly connected to the subassemblies and should be used whenever maximum signal strength is desired. The other 3 jacks in each row are decoupled by 300-ohm resistors and are best suited for use with relatively strong signals (fig. 8-21C). In the ideal arrangement, only one receiver is connected to each vertical row of jacks, and that receiver is connected to the bottom jack in each row. This means that seven receivers are fed from each antenna. At frequencies somewhat removed from the crossover points, the performance of each of these seven receivers should be comparable with that

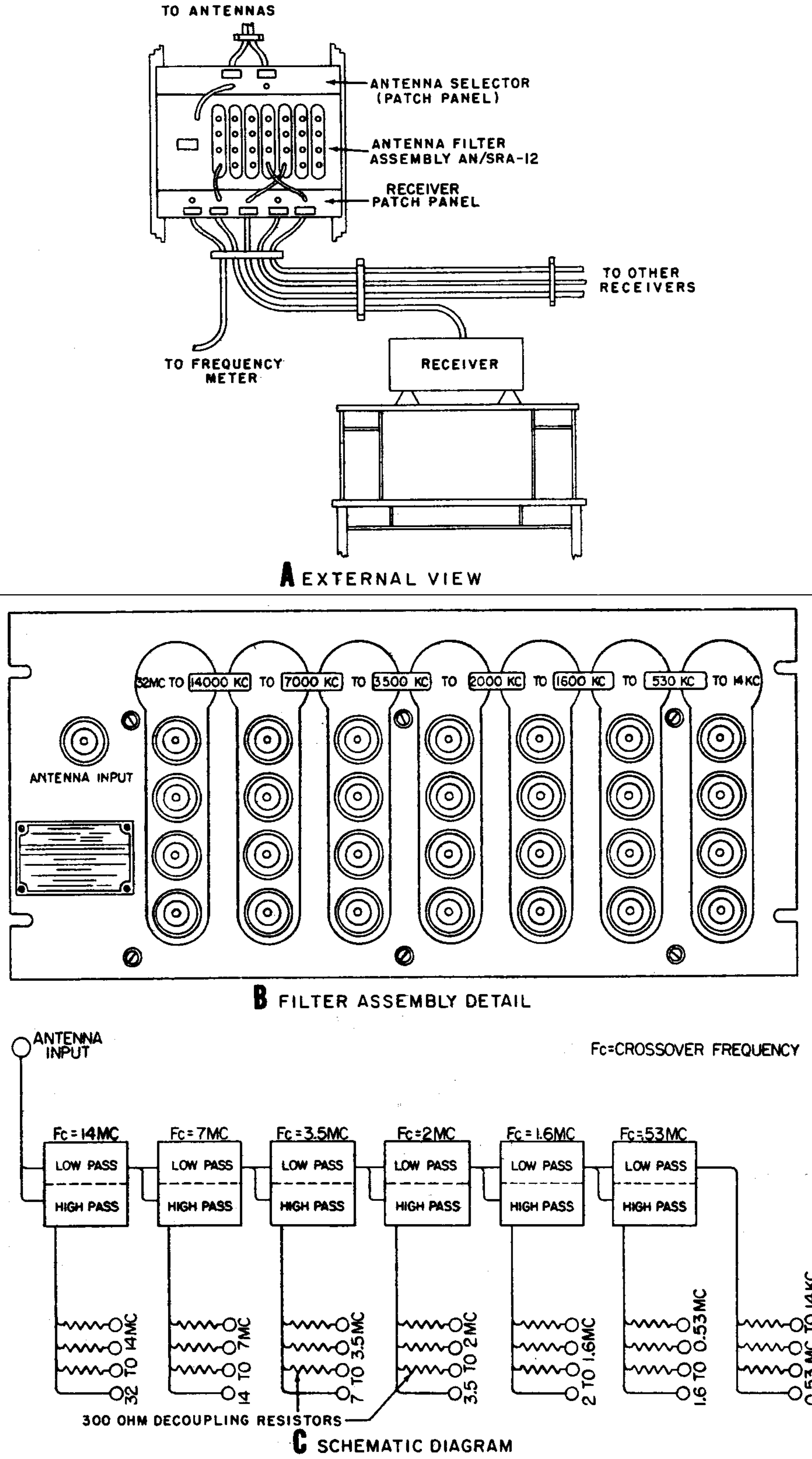

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Figure 8-21.—Receiving-antenna distribution system, using antenna filter assembly.

obtained if a given one of the receivers were connected directly to an antenna. Likewise, the performance of 21 receivers connected to the "decoupled jacks" should be comparable with the performance of 3 receivers decoupled in like manner, using conventional patch panels with a given antenna.

DISTRIBUTION OF RADAR INFORMATION

The distribution of radar information is somewhat involved, and complex switching equipment is needed. There are various types of switching gear and various combinations of radar equipments and radar repeaters.

For the purpose of this chapter, a brief discussion of Data Switching Group OA-496/SSA is included. Included with this switching group is Video Amplifier Assembly AM-518/SSA, Rotary Switch SA-243/SSA, and Rotary Switch SA-247/SSA (Fig. 8-22). For remote servo operation, Rotary Switch SA-243/U (not shown) is also needed at other repeaters.

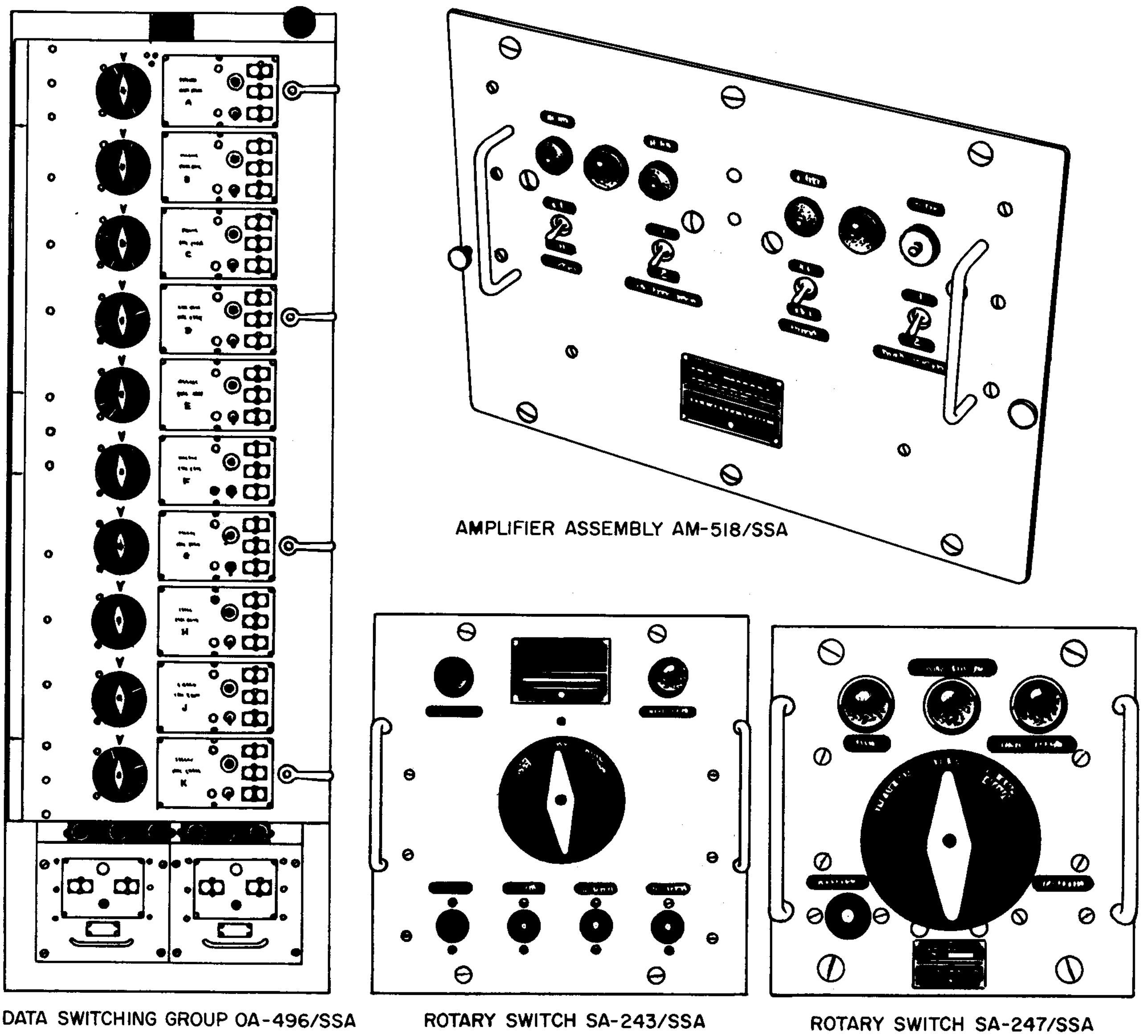

Figure 8-22.—Data switching group OA-496/SSA, Amplifier Assembly AM-518/SSA, and Rotary switches SA-243/SSA and SA-247/SSA-front panels.

As indicated in the block diagram (fig. 8-23), the purpose of the equipment is to distribute radar information to remote indicators throughout the ship. The number of data switching groups actually required in any particular installation depends on the number of signal sources and the number of repeaters to be served. Only a relatively simple system is shown in this figure.

Each of the 10 radar selector switch units in the data switching group provides for the selection (remote or local) of any one of seven radar-data inputs (only 2 are shown in the figure), as selected by the operator at any

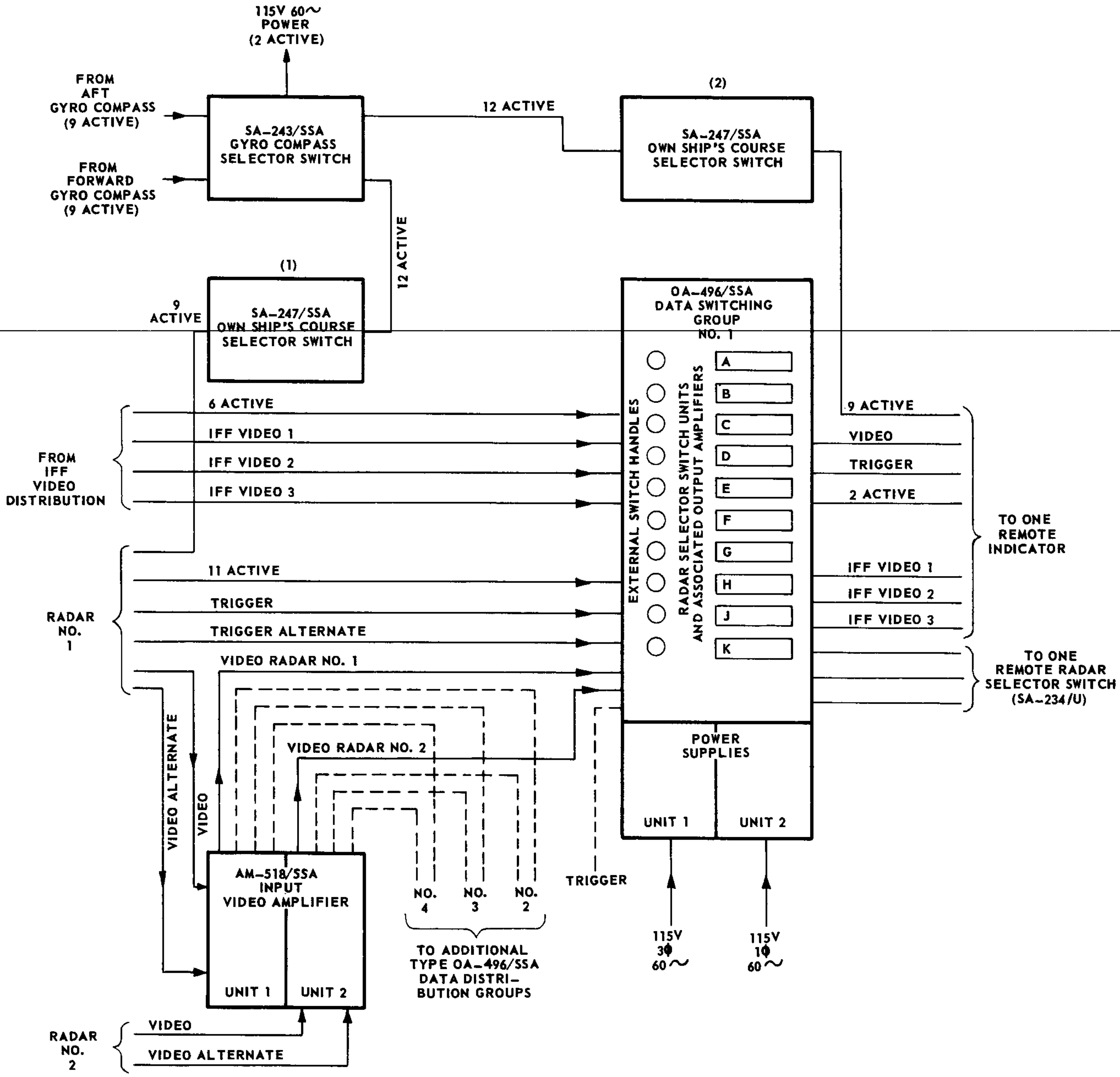

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Figure 8-23.—Block diagram of data switching group OA-496/SSA, and associated units.

one of ten remote radar repeaters. The assembly data switching group consists of 10 radar selector switches (A through K), 10 video and trigger cathode follower subassemblies, and 2 power supplies.

Each selector switch has 25 data sections (decks), the 8 positions (7 active positions; the eighth is OFF) of which are selected automatically by a commutator-type switch used in connection with the remote-control servosystem. The switch may be manually operated locally by means of the external switch handle or remotely by means of the remote selector switches. Each switch section has seven input circuit contacts and one output contact from the common arm.

A 3-section video and trigger switch is installed on the back end of the 25-section switch.

Video signals from the radar receivers are fed through Video Amplifier Assembly AM-518/SSA to the data switching group. This amplifier is capable of providing an essentially flat frequency response for any input signal over a range from 100 cycles through 10 mc. The assembly consists of two amplifiers, each providing for one regular and one alternate input, and four outputs so that the input signal may be delivered to four data switching groups, (one is shown in figure 8-23).

Trigger voltages and IFF video signals are fed directly to the data switching group where they are distributed to the desired remote location.

SWITCHING-CONTROL SERVOSYSTEM

A simplified schematic diagram of the switching-control servosystem is shown in figure 8-24. The system consists of a 3-phase motor, which drives the 8-position, rotary type switch through a gear train; and a split phase motor, which controls the operation and direction of rotation of the 3-phase motor by means of switch S502.

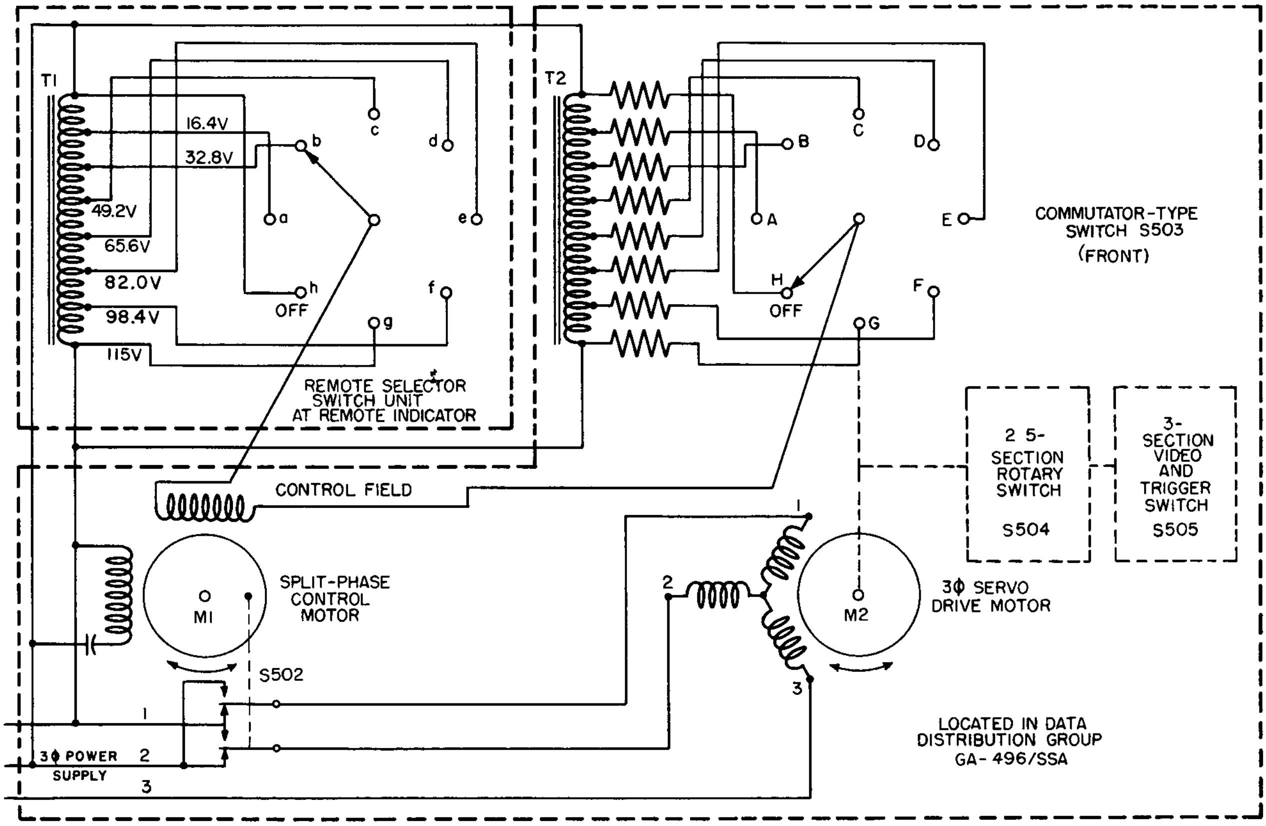

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Figure 8-24.—Switching-control servo system.

Two multitapped, single-phase autotransformers, one in the data switch selector servo unit and one in the remote selector switch unit, provide the required control power to the split-phase motor. These transformers are energized from 1 phase of the 3-phase supply. At the remote selector switch unit, the operator turns the switch to the position that will bring in the desired radar information. The transformer in the switch unit develops an opposing voltage to that developed by the transformer in the servo unit. The voltage contributed by the transformer in the servo unit is zero when S503 is in the H, or OFF position. The potential difference (the potential not balanced out by the action of the two transformers) is applied to the control winding of the split-phase motor and causes it to develop a torque in one direction or the other, depending on the condition of unbalance. A vane on the shaft of the control motor actuates the sensitive switches, S502 (upward or downward against spring action), depending upon the direction in which the torque is developed. The switches apply 3-phase power to the 3 windings of the 3-phase drive motor. The drive motor, M2, drives S503 to zero the voltage on the control field of M1, thereby removing the torque developed by M1 and opening S502 to stop the drive motor.

The drive motor is reversed by reversing the torque on M1 to operate S502 in the opposite direction. This action interchanges two line leads to M2 to reverse its direction of rotation. The reversal of torque on M1 is brought about by the reversal of the control field of M1 with respect to the constant field of M1. The relative phase of the control field depends upon the relative magnitudes of the voltages at T1 and T2 that are applied to the control field.

The 3-phase drive motor drives the commutator switch, S503; the 25-section rotary switch, S504; and the 3-section video and trigger switch, S505. As the commutator switch arm contacts the tap that corresponds to the one selected at the remote selector switch unit, the unbalanced potential is reduced to zero. The control field of the control motor is then deenergized, switch S502 returns to the neutral position, the drive motor is deenergized, and the switch arm of S503 remains in the desired position. The 25-section rotary switch and the 3-section video and trigger switch, on the same shaft with S503, remain in the desired position also.

Rotation of the commutator switch in the opposite direction is accomplished in the same manner, except that the polarity of the unbalanced difference voltage applied to the control field of the control motor is opposite, and the direction of rotation of both motors is opposite.

As an example of automatic operation, assume that the operator at the remote selector switch unit (located at a repeater) desires to receive radar information that will be available if he moves his switch to position b. Assume also that his switch and the one in the data switching group are in the OFF position.

The operator turns his switch to position b, and a potential of 32.8 v developed by T1 is applied to the control field. The opposing voltage in T2 is zero. The control motor turns (for example, clockwise) because of the phase relationship of the control and the constant fields. The motion of the control motor moves S502 downward (for example) and applies phase 1 to terminal 1 and phase 2 to terminal 2 of the 3-phase drive motor. The drive motor rotates switch S503 through position A. The 16.4 v developed by T2 at position A opposes the 32.8 v developed by T1, but a net potential difference of 16.4 v is still applied to the control field of M1. Motor M1 continues to rotate clockwise and M2 moves the contact of S503 to position B. In this position, the voltages developed by T1 and T2 are equal and opposite and no voltage is applied to the control field of M1. Motor M1 stops, S502 springs open, power is removed from M2, and the contact of S503 remains in position B.

The example just given applies to all cases where the remote controller calls for higher position in the alphabet than the initial position of the setting at the data switching group.

For the opposite case, where the remote controller calls for a dial setting lower in the alphabet than the one at the data switching group, a similar analysis will show that the unbalanced control field voltage will produce a current opposite in direction to that of the example given. This results from the fact that the higher voltage now comes from the taps on T2. Accordingly, S502 will be moved upward by the movement of M1 in a counterclockwise direction because of the reversal in phase of the control field with respect to the constant field. Phase 2 will be applied to terminal 1 of the drive motor M1 and phase 1 of the line to terminal 2 of M2, and the contact arm of S503 will be rotated in a direction opposite to that given in the previous example. Again, when the two voltages (from T1 and T2) are equal, the switch positions are matched and both motors stop.

GYROCOMPASS SELECTOR SWITCH

The Gyrocompass Selector Switch, SA-243/SSA (fig. 8-25) is used to select either the forward or aft gyrocompass synchro output (both 1X and 36X speed) and to provide a 78-v synchro electrical zero reference voltage. The switch consists of a 20-pole, 3-position type switch controlled by a relay. Electrical zero reference voltage is provided by autotransformer T701 when the switch is turned to either the forward or aft gyro position. In case of a power failure of the selected gyro source, relay K701 (A and B) is deenergized, providing a signal from the alternate source. Indicator lights inform the operator which gyro output is appearing on the switch position selected.

OWN SHIP'S COURSE SELECTOR SWITCH

This switch (fig. 8-26) is capable of selecting either a gyro output signal (from the fore or aft gyro, as selected by the gyrocompass selector switch) or the electrical zero reference voltage from the rotary gyrocompass selector switch.

A relay in the unit automatically selects the electrical zero supply voltage and applies it to the synchro in the repeater on failure of the gyro output from the gyrocompass selector switch. A flashing light on the front of the own ship's course selector switch indicates gyro failure.

RADAR SELECTOR SWITCHES

The ten 25-section switches (one of which is shown as S504 in fig. 8-27) in the data switching group, transfer the incoming information (except video and trigger) from any one of the seven radars and the information from the IFF video distribution system to any or all of the 10 remote indicators. A wiring diagram of a typical radar selector switch is shown in figure 8-27. Each switch includes two units, S504 and S505. Unit S504 has 25 data sections and 8 positions referred to previously in the introduction to the distribution of radar information.

Unit S505 has three sections and eight positions and is mounted on the same shaft as S504. Both S504 and S505 turn as a single unit and may be operated by an external handle or automatically by a servo unit, as previously described. The video and trigger signals are fed into S505 from the input terminal group, indicated as a block in figure 8-27.

TRIGGER AND VIDEO SWITCHING.—Trigger and video signals from the various radars (up to seven) connected to the switching group are fed to the input terminal group. From the input terminal group, trigger voltages are fed to seven sections of deck section 1 of S505. Video signals from the seven radars are likewise fed to seven sections of deck section 3. Deck section 2 serves as ground.

Although only one switch (made up of S504 and S505) is shown in figure 8-27, it should be recalled that 10 of these switches are wired into the system.

For example, assume that after being amplified in video amplifier AM-518/SSA, the video signal from radar 1 is fed through the input terminal group to switch terminal 1-80 of S505 (fig. 8-27). The same signal is also fed to terminals 1-80 of S505 in the nine remaining switches. The outputs (from terminal 180) of the 10 switches are fed independently through the output amplifier associated with each switch to the repeater associated with each amplifier. Any or all of the repeaters may be switched to radar 1. The radars connected to the other terminals of the radar selector switch may likewise be selected at the repeater.

Trigger switching follows the same general pattern as video switching, except that the trigger voltage is not amplified before it is fed to the input of the data switching group.

The detailed connections of one switch unit are shown in figure 8-28.

SWITCHING OF IFF AND OTHER DATA.—Whereas S505 handles video and trigger switching, S504 handles such additional data as antenna bearing, relative bearing IFF video signals, IFF control functions, etc.

The various circuits feeding into and out of a typical switch (S504) are illustrated in figure 8-29. The type of data passing through the various terminals are written on the terminals to simplify signal tracing. The parallel nature

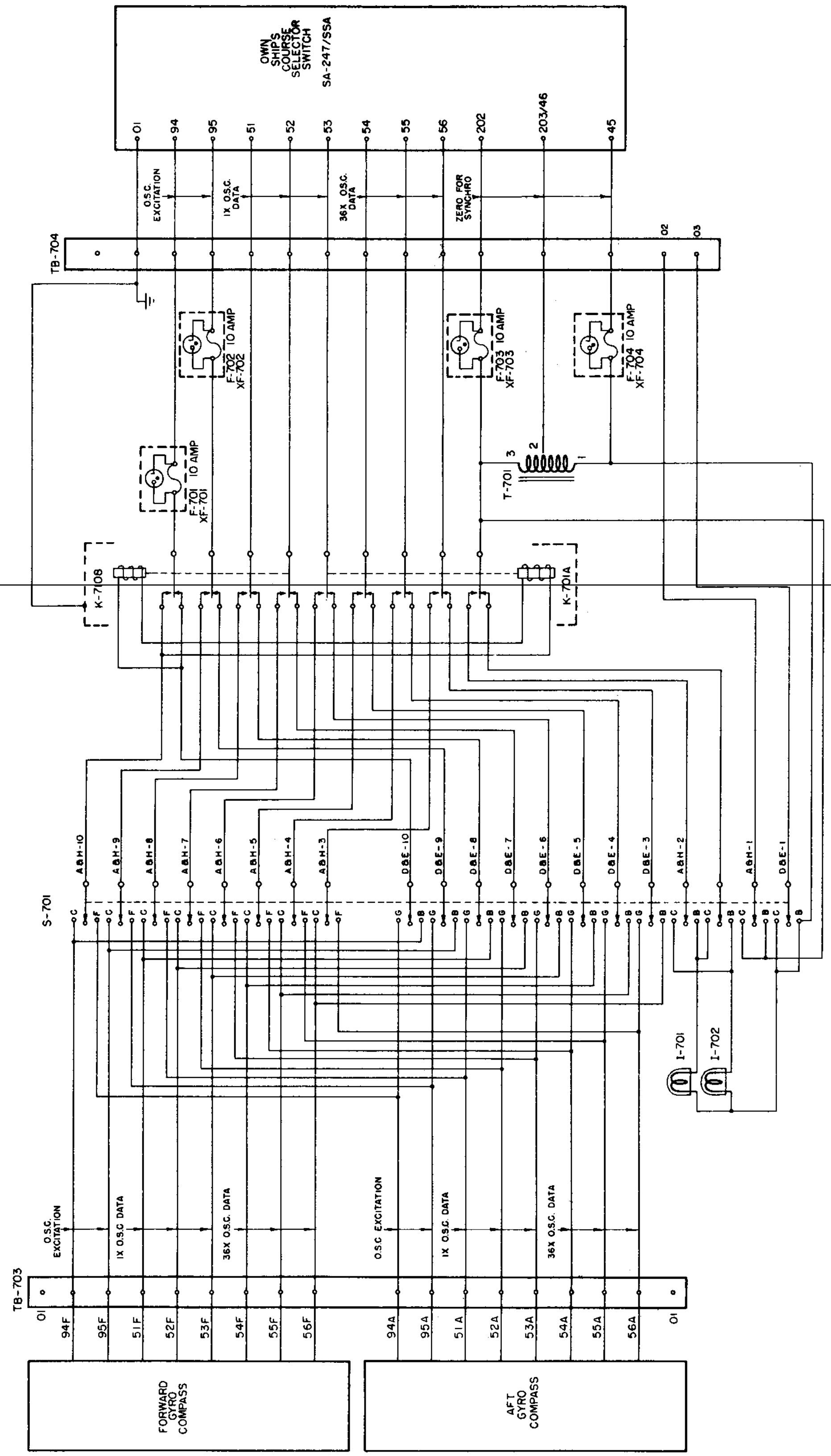

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Figure 8-25.—Gyrocompass selector switch.

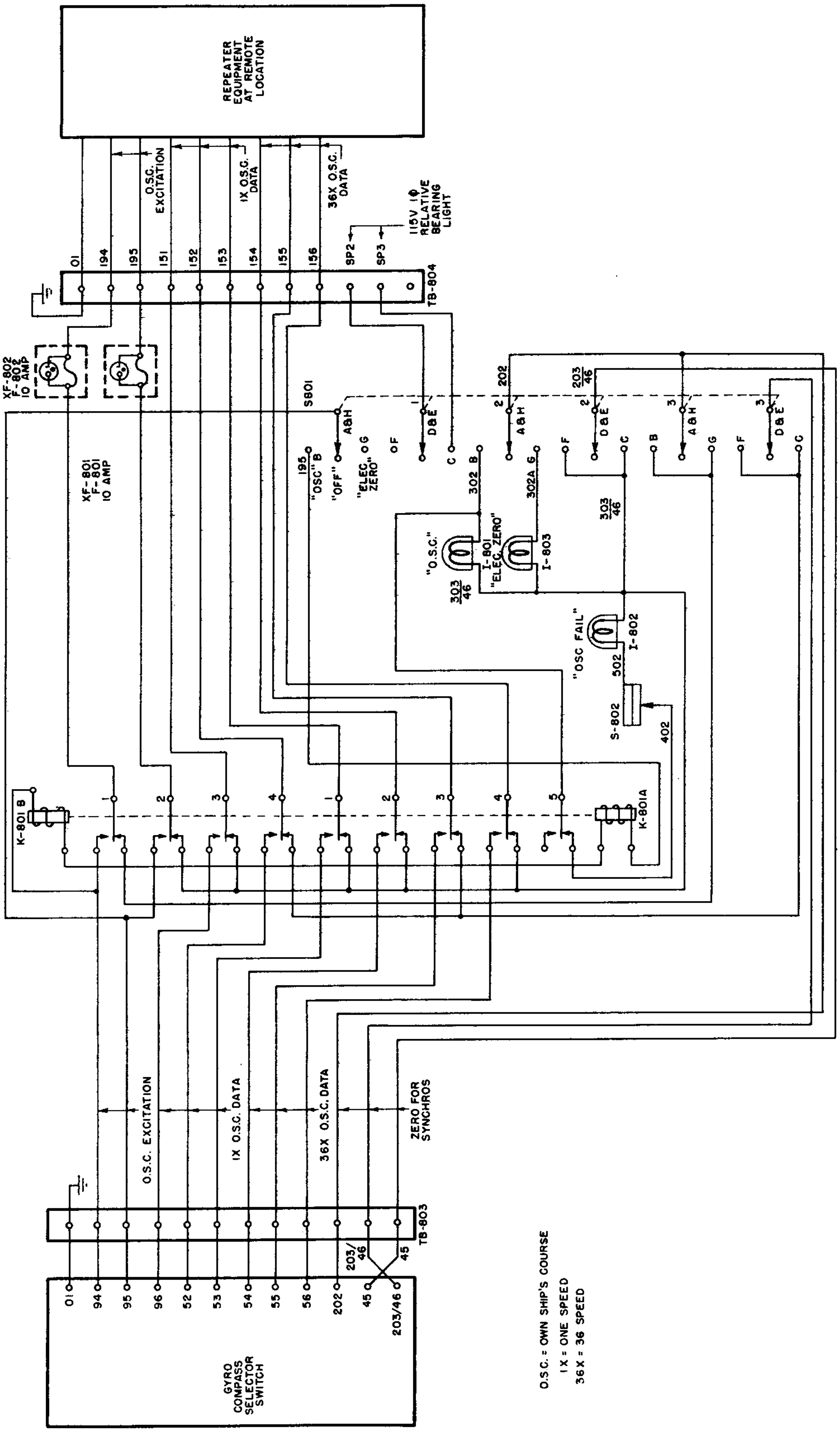

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Figure 8-26.—Own ship's course selector switch.

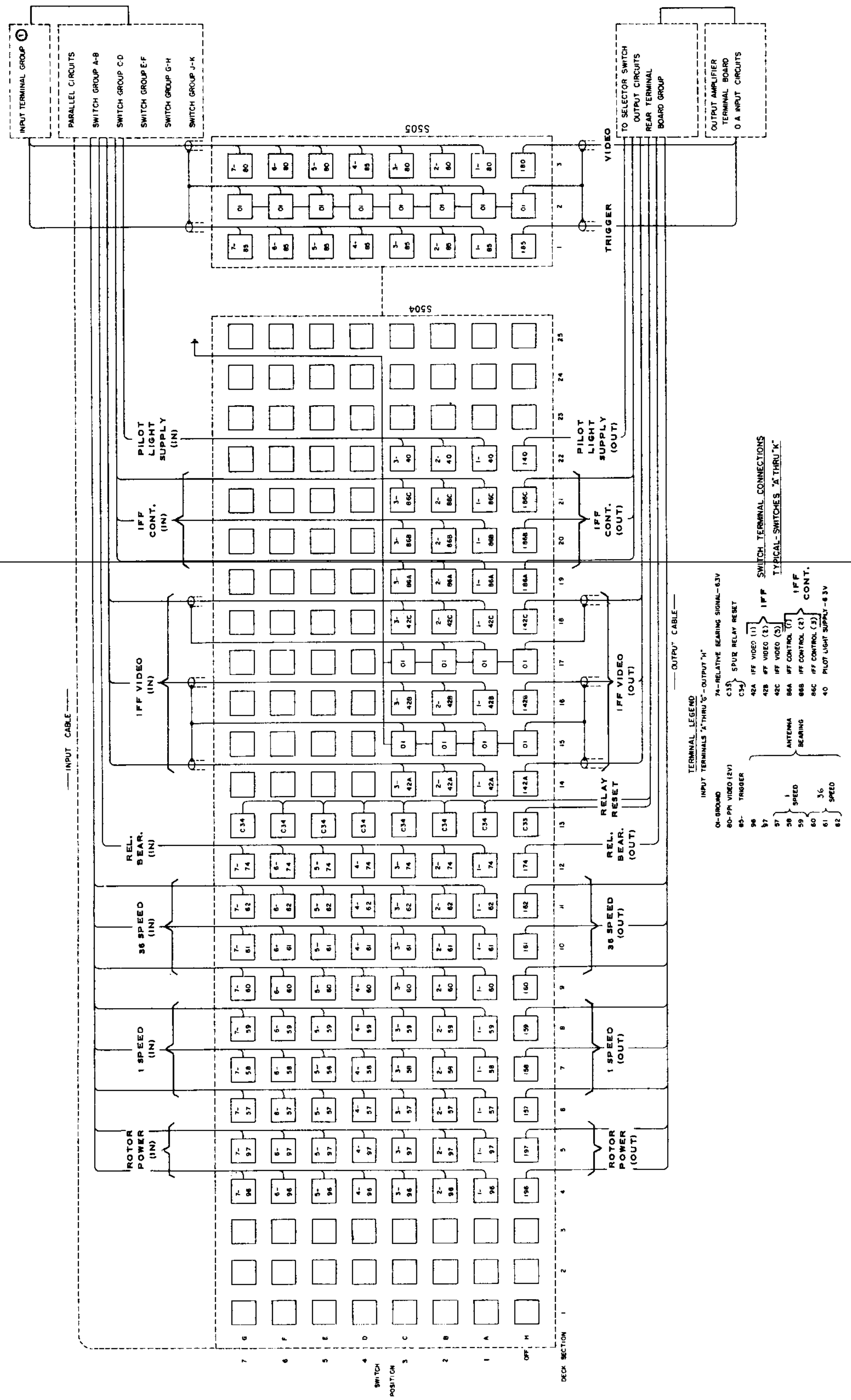

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Figure 8-27.—Radar selector switch in the data switching group.

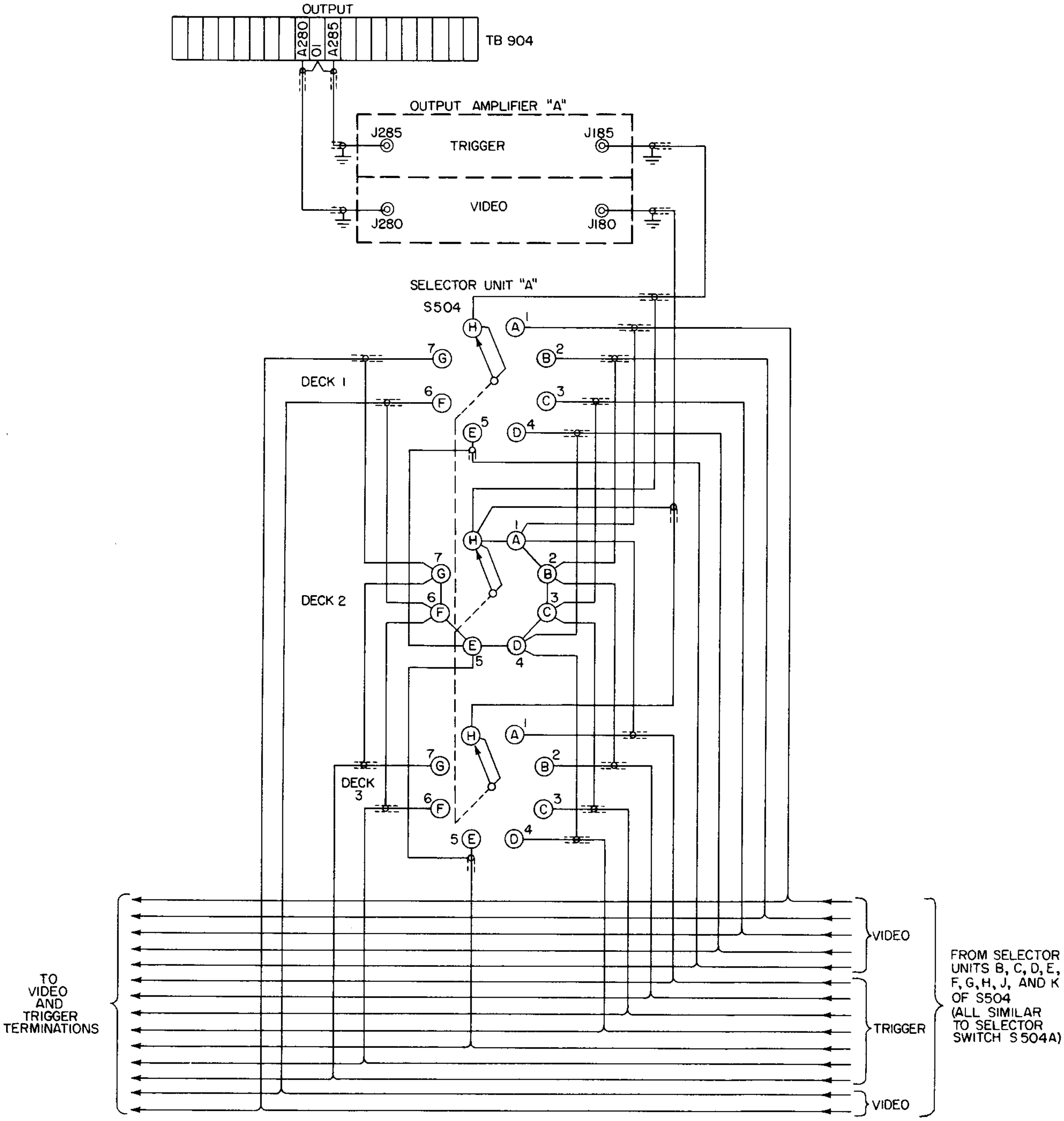

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Figure 8-28.—Wiring diagram of video and trigger switching circuits.

of the circuit connections should be kept in mind, and the same reasoning that was employed in video and trigger switching may be employed here.

The paralleling of switch contacts bearing the same information in the 10 switches is accomplished in the parallel circuits section of the switching group.

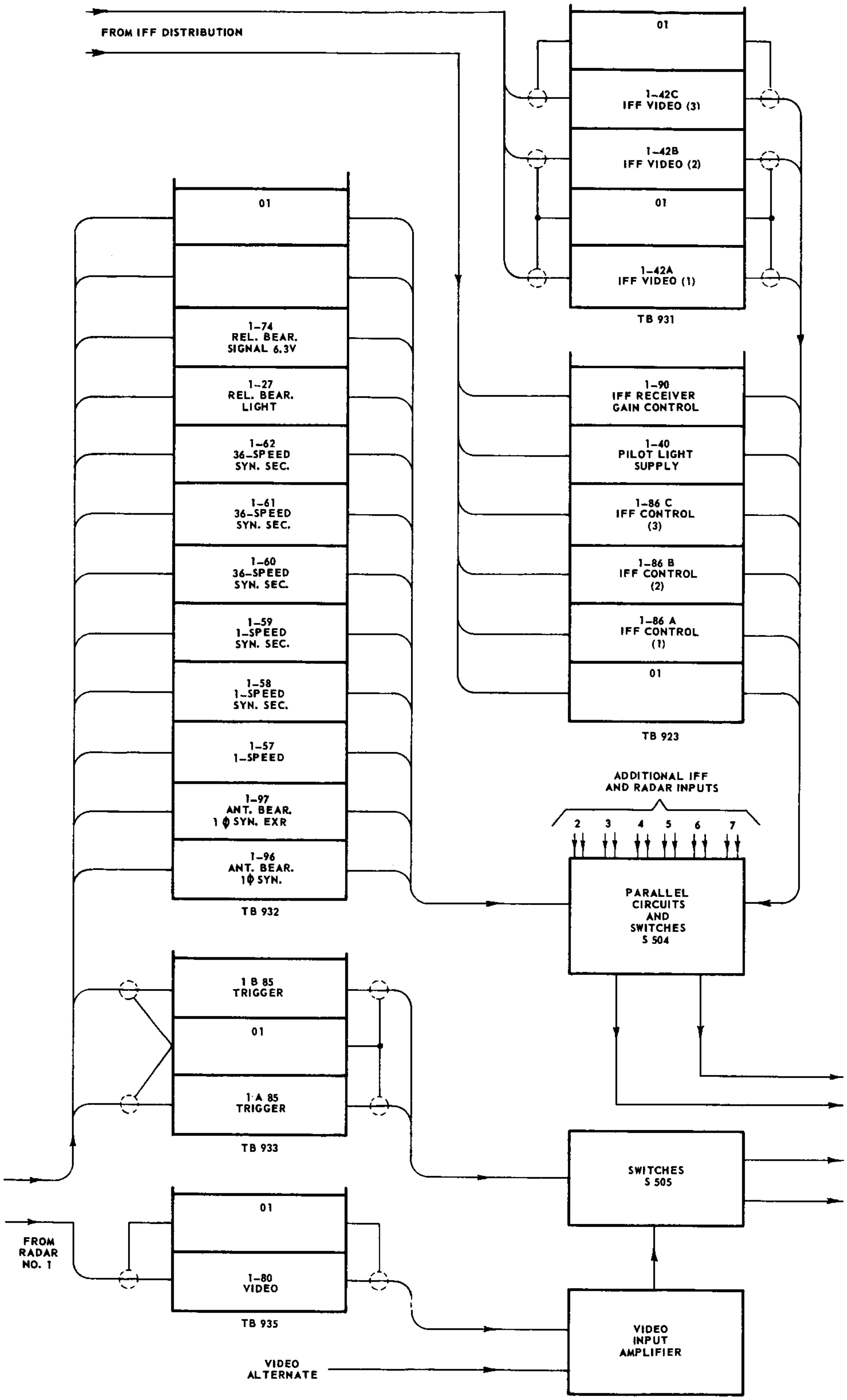

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Figure 8-29. –Diagram showing route of signals from radar to repeater through the radar switchboard–Continued.

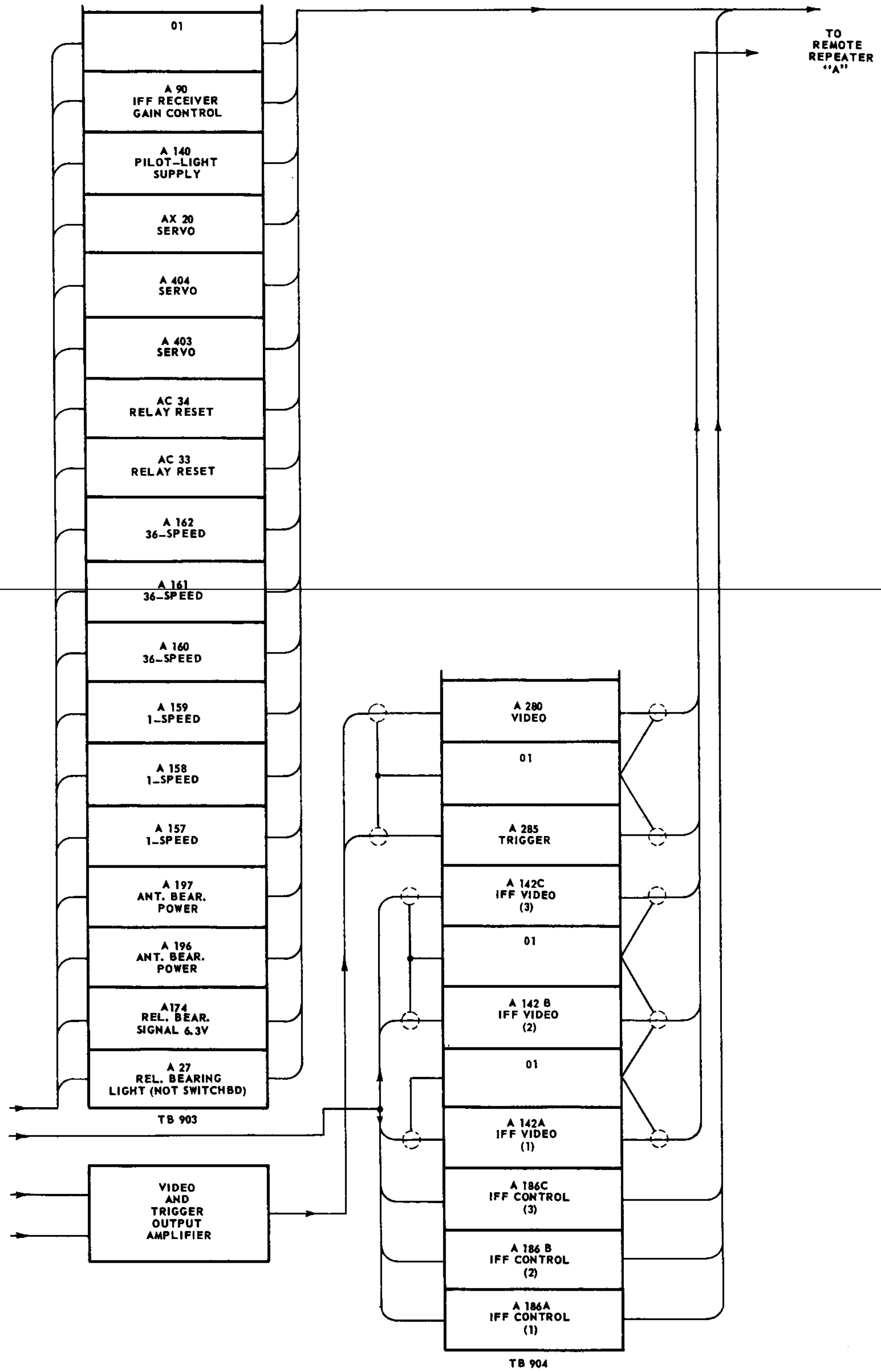

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Figure 8-29. –Diagram showing route of signals from radar to repeater through the radar switchboard–Continued.