TL MICROWAVE RADIO
DESCRIPTION
DIVERSITY SWITCH

CONTENTS PAGE

1. GENERAL

1.01 The diversity switch unit DIV SW shown in Photograph A automatically or manually establishes the through baseband transmission path from the better of two receivers in a diversity pair. Once established, the connection is maintained until equipment in the working path fails or transmission begins to degrade because of loss of receive signal level as may occur during selective fading conditions. The diversity channels are paired with adequate frequency separation to assure that simultaneous selective fading of both rarely occurs. Simultaneous equipment failures will also be an uncommon occurrence.

1.02 One DIV SW unit is required for each pair of receivers in a diversity system. One receiver of a pair is referred to as the regular receiver and the other the diversity receiver.

1.03 The baseband connection is made through a pair of make-before-break wire-spring relay transfer contacts that provide a noninterrupted or hitless switch. This relay is controlled by a relay logic circuit which is supplied receiver status information through two receiver pilot monitors and a fade comparator circuit. The pilot monitors are selective amplifier detectors which monitor 2600-cycle pilot tones at the output of each receiver baseband amplifier. The pilot is the 2600-cycle alarm system continuity tone applied to the radio at near-end terminals by the order-wire and alarm control station. This tone is looped back at the far-end radio terminal and reapplied to the diversity transmitters working toward the near-end terminal. Presence of the tone at a receiver output indicates that the 2600-cycle circuit from this receiver back to the near-end terminal is good. Absence of tone indicates a break in transmission. The comparator circuit measures receiver IF input levels by monitoring the receiver automatic gain control (AGC) voltages. This circuit compares the two voltages from the diversity pair of receivers and selects the receiver with the stronger input, within certain limits, to supply the baseband signal.

2. EQUIPMENT FEATURES

2.01 The DIV SW unit mounts between the transmitter-receiver panel and the power supply in the space normally occupied by an order-wire and alarm panel. In a diversity system, only one alarm panel is required for each diversity pair. This is mounted in the regular bay leaving space available in the diversity bay for the switch panel.

2.02 The unit shown in Photograph A measures 19 inches wide, 5-1/4 inches high, and 11-3/4 inches deep. For maintenance purposes, a front panel switch is provided that disables automatic receiver selection and permits either receiver to be selected manually. An indicating lamp lights when in the manual mode of operation. Telephone jacks are also provided to permit order-wire access from this bay. The logic circuit comprises three wire-spring relays, one operated by the comparator and the other two by the pilot monitors. The pilot monitor relays are contained in a common relay unit. This relay contains two independent cores and associated relay contacts.

Both ends of the baseband switch relay are brought out to a pair of jacks, K4 and GRD, located on the front of the hinged panel. This provides a positive method of determining which channel is active, the absence of any voltage being an indication that the regular channel is active.

2.03 The pilot monitors and comparator circuit are each contained in enclosed box subassemblies which mount within the DIV SW unit. Electrical connections to these circuits are made via terminal strips which mount on one end of the boxes. Located on this same end are necessary controls and measuring jacks which are available upon removal of a dust cover fastened to the front of the DIV SW unit. The pilot monitor controls are as follows: (1) AMPL BIAS, (2) SW BIAS, and (3) AMPL GAIN. The AMPL BIAS and SW BIAS controls adjust dc biasing voltages and are needed to compensate for different transistor parameters where replacement may be necessary. The AMPL GAIN control sets the amplifier gain. In addition, a pair of jacks, PIL TON LEV, are provided for monitoring the amplifier output. The comparator controls are as follows: (1) BAL, (2) COMPR GAIN, and (3) OUT. The BAL control is used for balancing the differential amplifier. The COMPR GAIN sets the differential amplifier gain. The OUT control sets the differential amplifier bias point which may be monitored by means of the COMPR BIAS test jacks.

2.04 In one corner of the DIV SW unit, a terminal block is located through which electrical connections are made to other assemblies within the bay. The dc operating voltages are obtained from the bay power supply.

3. CIRCUIT DESCRIPTION

A. General

3.01 A block diagram of the DIV SW unit is shown in Fig. 1. The unit comprises the fade comparator, two pilot tone monitors, and a logic circuit which controls the state of relay K4. The baseband signals from two diversity receivers pass through two pair of K4 transfer contacts. The relay provides a through connection for one signal and terminates the other signal in a 75-ohm resistor. The pilot monitors, which consist of a 2600-cycle tuned amplifier and a Schmitt trigger, are bridged across the receiver output lines. When 2600-cycle signaling tone is present in the basebands, the trigger circuits keep two relays energized in the logic circuit. The state of these relays, K1 and K2, indicates whether pilot tones and, therefore, the entire baseband signals are present at the receiver outputs. A third relay in the logic circuit, K3, is controlled by the comparator circuit. The comparator is fed by two AGC voltages which it amplifies in a differential amplifier. The amplifier is essentially insensitive to the absolute value of the two AGC input voltages and responsive only to their dif-

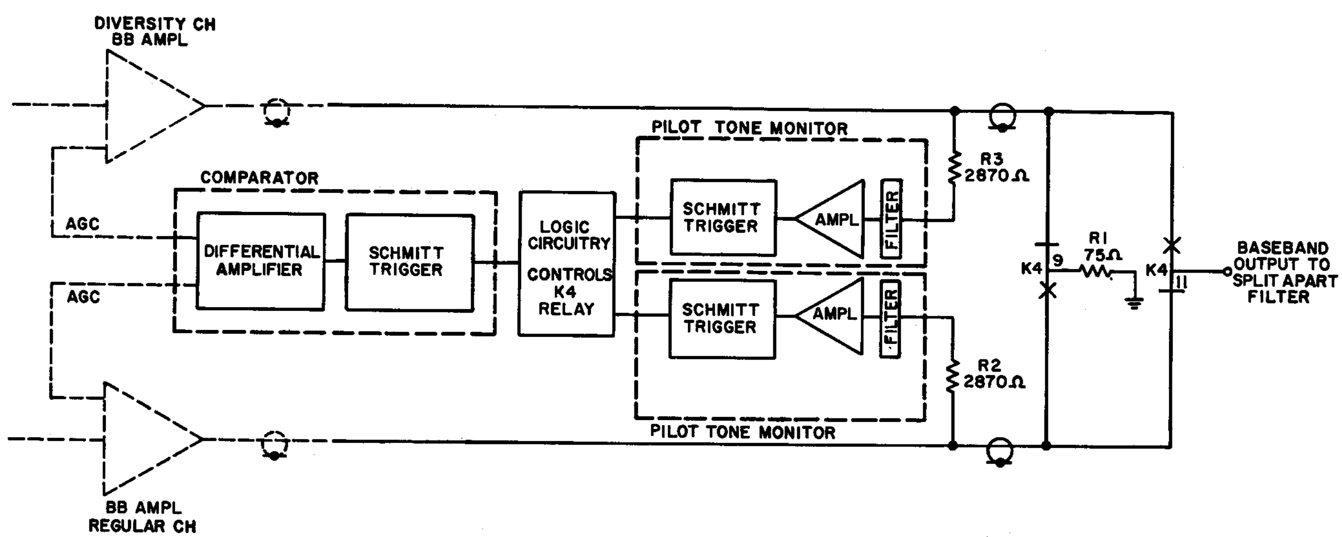


Fig. 1 — TL Radio Diversity Switch Block Diagram

ference. A Schmitt trigger, which controls K3, is driven by this amplifier. The state of K3 indicates, within certain limits, which receiver has a stronger IF input signal.

B. Pilot Monitor Circuit

3.02 The pilot monitor circuit is shown in Fig. 3A. The 2600-cycle pilot tone at the output of the receiving baseband amplifier is applied to the base of the first-stage transistor Q6 through a 2600-cycle bandpass filter, input resistors R2 or R3 (shown in Fig. 1), R38, and coupling capacitor C1. The split input resistance minimizes bridging loss at the baseband amplifier output and also isolates the coaxial line capacity from the pilot monitor amplifier.

3.03 The first-stage bias is determined by resistors R22, R24, and R25. Resistor R25 is variable to provide a means of compensation for the effects of different transistor parameters in cases where replacement may be necessary.

3.04 Resistor R23 develops the output voltage applied to the second-stage transistor base. Resistor R35, bypassed by capacitor C10, provides emitter bias and some degree of stabilization of Q6 emitter current.

3.05 The Zener diode CR6 provides a nominal 8.2-volt bias on the emitter of Q7 while its low ac impedance minimizes emitter degeneration.

3.06 The voltage divider network, comprised of resistor R30, Zener diode CR7, and resistor R31, determines the bias voltage at the base of the third-stage transistor Q8. At the same time, diode CR7 provides a low ac impedance coupling path from the collector of Q7 to the base of Q8.

3.07 A capacitor across the output transformer T1 shapes the gain and phase characteristic of the amplifier to ensure an adequate margin of stability.

3.08 The primary dc resistance of transformer T1 plus resistor R33, bypassed by capacitor C5, provides the proper collector bias for transistor Q8.

3.09 Resistors R26 and R32 and bridging capacitors C2 and C3 make up the basic shunt negative feedback loop for gain stabilization. The 2600-cps series resonant network Z1 and resistor R28 shunt the feedback path in such a manner as to decrease the amount of feedback at 2600 cps and produce a sharply selective gain peak at this frequency.

3.10 Bridged across resistor R32 is a gain control network made up of R44, R27 which is variable, and the dc blocking capacitor C9. This blocking capacitor keeps direct current off the gain control and ensures a constant amount of dc feedback for operating point stabilization.

3.11 The pilot tone amplifier output is coupled to a bridge rectifier through the impedance matching transforme T1. The signal is rectified, filtered, and then applied to the Schmitt trigger input. Diodes CR8 to CR11 make up the diode bridge, while resistor R34 and capacitor C6 act as a filter. Resistor R36 is the rectifier load.

3.12 The bias level at the Schmitt trigger input, which is the base of transistor Q9, is determined by the voltage divider network comprised of resistors R37, R42, and R43. Resistor R37 is a variable control providing a means of compensation for different transistor parameters.

3.13 The load resistor R41 sets the collector bias for transistor Q9 and, in series with resistor R40, determines the voltage at the base of transistor Q10. Emitter resistor R39 is common to both Q9 and Q10. The value of this resistor controls the amount of common coupling and determines the difference between the two voltage levels at which the circuit changes state.

C. Schmitt Trigger Circuit

3.14 Switching is accomplished by a change of voltage level at the base of transistor Q9, which in turn is a function of the signal level at the pilot monitor input. For example, an increase of signal level causes the base of transistor Q9 to become more negative than the emitter, constituting a reverse bias and allowing Q9 to be cut off. With the collector of Q9 now at ground potential, the base of Q10 becomes more positive with respect to its emitter, allowing Q10 to conduct. The resulting current flow through the relay coil operates the pilot relay.

3.15 A drop in signal level allows Q9 to conduct, driving Q10 to cut off so that current ceases to flow through the relay coil, thereby releasing the relay.

3.16 Diode CR13, Zener diode CR14, and capacitor C7 protect the transistors against the large voltage transients developed by the relay winding during switching.

3.17 Capacitor C14 reduces the high-frequency loop gain of the trigger circuit and eliminates any tendency for the pilot relay chatter.

D. Comparator Circuit

3.18 The comparator circuit is shown in Fig. 3B. Transistors Q1 to Q3 and associated circuitry comprise a difference amplifier which controls the operation of the Schmitt trigger circuit made up of transistors Q4 and Q5 plus associated components. Basically, transistors Q1 and Q2 comprise the difference amplifier while the high ac impedance provided by the collector of Q3 results in a high degree of degeneration. This makes the amplifier essentially insensitive to the absolute value of the two AGC input voltages and responsive only to their difference.

3.19 Resistors R4, R5, R48, and R49 serve to isolate the input of the difference amplifier from the external circuitry.

3.20 Base bias for Q1 is obtained from the voltage divider network formed by resistors R17, R7, and R8. Base bias for transistor Q2 is obtained from the voltage divider formed by resistors R17, R6, and R9. The BAL potentiometer R17, which is common to the voltage divider networks of both transistors Q1 and Q2, is used to balance out the differences in collector currents of the two transistors.

3.21 Resistors R10 and R11 are the collector load resistors for Q1 and Q2, respectively.

3.22 The COMPR GAIN potentiometer R12 is the gain control for the difference amplifier, and acts as a variable load for transverse voltages without affecting the no-signal bias conditions.

3.23 Transistor Q3 functions as a current source for transistors Q1 and Q2, maintaining the sum of their emitter currents essentially constant. Diode CR15 and resistor R15, varistor RV2 and resistor R16 form the base bias voltage divider.

3.24 Diode CR15 is a Zener diode which is used to regulate the base bias of transistor Q3. Varistor RV2 is used for temperature compensation to maintain the base bias of transistor Q3 at a constant level over a temperature range of −40° to +140 F. Resistor R14 and OUT potentiometer R13 are used to control the collector current of Q3 and, hence, the sum of the emitter currents of Q1 and Q2. Control of these emitter currents also provides a control of the voltage at test jack J5. The OUT potentiometer is used to set the voltage at the COMPR BIAS test jack J5 to the desired operating level.

3.25 The Schmitt trigger input transistor Q4 has its base bias developed by the network comprised of resistor R18 and Zener diode CR1. Resistors R21 and R54 are the emitter resistance common to both Q4 and Q5. Resistor R19 is the collector load for Q4 and with R20 determines the base bias voltage of transistor Q5. The collector load for Q5 is relay K3, shown in Fig. 4. Capacitor C11 and diodes CR16 and CR12 serve as a transient suppression network in the same manner as that on the pilot monitor relays.

3.26 Without temperature compensation, the gain-temperature characteristic of the difference amplifier would result in a decrease in the switching hysteresis with increasing temperature. To correct this, the switching hysteresis of the trigger circuit is given a positive temperature coefficient by means of resistor R54. This resistor has a high-positive temperature coefficient of approximately 6000 parts per million per degree centigrade.

3.27 The operation of this Schmitt trigger circuit is the same as that of the pilot tone monitors. A typical switching characteristic of the comparator is shown in Fig. 2.

E. Logic Circuit

3.28 The logic circuit is shown in Fig. 4. This circuit controls the operation of the baseband switch relay K4 when switch S1 is in the AUTO position. The level of the AGC voltage from each receiver IF amplifier and the presence or absence of a pilot tone at the output of each baseband amplifier will determine whether the output of the diversity channel or the regular channel is selected to be transmitted to the split-apart filter in the order-wire and alarm panel.

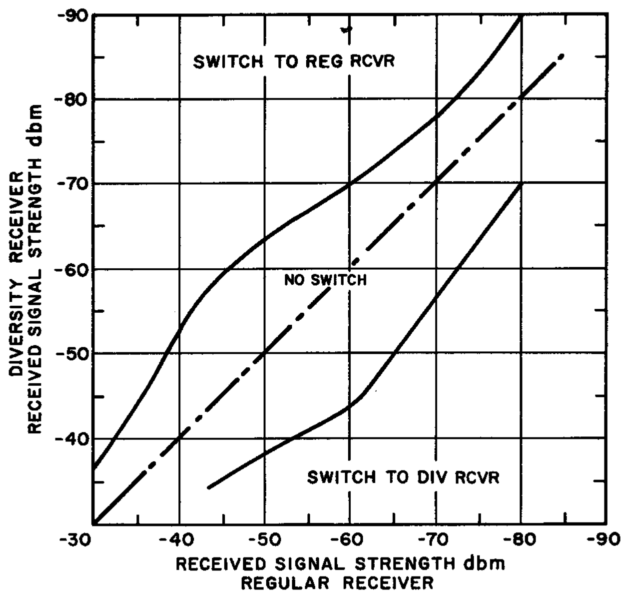


Fig. 2 — Typical Comparator Switching Characteristic

3.29 The baseband switch relay K4 momentarily parallels the outputs of both receivers during a switch by the use of a pair of make-before-break contacts in the signal path. This, combined with the fact that both signals are in phase to eliminate cancellations, results in a hitless switch during a fade which takes place on the order of 35 milliseconds. Any level changes resulting from the double termination or signal strength differences are insufficient to cause hits.

3.30 The operation of the logic circuit can be seen by referring to Table A. This table lists the six combinations of states that relays K1, K2, and K3 may assume. The resulting K4 state is then listed for each combination. The following explanation is the key to the symbols used.

0 = an unenergized or nonoperated relay.
1 = an energized or operated relay.

K1 or K2 = 0 = absence of pilot tone.
K1 or K2 = 1 = presence of pilot tone.

K3 = 0 = fade on diversity channel.
K3 = 1 = fade on regular channel.

K4 = 0 = regular channel active.
K4 = 1 = diversity channel active.

K1 = diversity pilot monitor relay.
K2 = regular pilot monitor relay.
K3 = comparator fade relay.
K4 = signal switching relay.

TABLE A

DESCRIPTION OF SITUATION				RELAY CONDITIONS			
CONDITION OF DIVERSITY PILOT TONE	CONDITION OF REGULAR PILOT TONE	CHANNEL EXPERIENCING A FADE	ACTIVE CHANNEL	K1	K2	K3	K4
Present	Present	Regular Diversity None or Both	Diversity Regular See Note	1 1	1 1	1 0	1 0
Absent	Absent	Regular Diversity None or Both	Diversity Regular See Note	0 0	0 0	1 0	1 0
Present	Absent	Any Condition	Diversity	1	0	1	1
Absent	Present	Any Condition	Regular	0	1	0	0

Note: If there is no fading condition, K3 will maintain its previous condition and either the regular or diversity channel will be active. If both channels are undergoing fades, K3 will operate or not, so as to select the better of the two channels in accordance with Fig. 2.

3.31 The two combinations, 1001 and 0110, which are missing from Table A cannot exist because of the fade simulating network. This is because a pilot failure on one channel automatically results in a simulated fade on that same channel. The network, made up of contacts 8 and 10 of relay K2, contact 2 on relay K1, and resistor R50, automatically simulates a fade on one channel when the pilot tone on that channel fails by applying a ground to the appropriate comparator input.

3.32 As the table indicates, if pilot tone is present or absent ***simultaneously*** on both channels, the fading condition will control the selection of the active channel. However, when pilot tone is present on only ***one*** of the channels, fading is disregarded and the channel with pilot tone is selected.

3.33 It will be observed that a simultaneous failure of both pilot tones does not cause a switch, but leaves relay K4 under control of the comparator. This feature eliminates unnecessary switches when the pilot tone is removed from the system which occurs for short periods during alarm signaling. When switch relay K4 is de-energized, the regular channel supplies the signal output; when K4 is energized, the signal is supplied by the diversity channel.

3.34 Switch S1 provides a means of manually switching to the regular or diversity channel. When the switch is on other than the AUTO position, the logic circuitry is bypassed and relay K4 is no longer under its control. With S1 in the REG CH position, the MAN lamp DS1 is on and the relay is de-energized. With S1 in the DIV CH position, the lamp is again on and K4 is now energized. With S1 in the AUTO position, the lamp is no longer on and control of the operation of relay K4 is returned to the logic circuit.

3.35 Resistor R46 limits the flow of current through the winding of relay K4. Resistor R45 and diode CR5 serve as a contact protection network for the contacts of relays K1 to K3. This network helps suppress any voltage transients caused by the operation and release of relay K4.

3.36 The break-make contacts at position 3 on switch relay K4 supply the T1 carrier equipment with −20 volts from the active transmitter-receiver cabinet. This allows power to be shut down at the inactive transmitter-receiver cabinet for maintenance purposes without interrupting carrier transmission. Resistors R52 and R53 plus diodes CR17 and CR18 isolate the −20 volt supplies on the regular and diversity channels in the event that one of them fails. The isolation is only required during the bunching interval of relay K4 following a failure of one power supply.

3.37 Terminals 9 and 10 on terminal block TS2 are tied to two sets of transfer BM contacts, one on relay K1 and one on relay K2. This is a simple logic circuit which causes an open circuit between terminals 9 and 10 on TS2 should one or the other pilot tones fail. In cases where both pilot tones are absent, a closed circuit is provided between these two terminals in the same manner as when both pilot tones are present. The alarm circuitry connected to these two terminals will notify the alarm control center ***if and only if*** one or the other of the pilot monitors indicates a failure.

3.38 The network, made up of contacts 8 and 10 of relay K2, contact 2 of relay K1, and resistor R50, automatically simulates a fade on one channel when the pilot tone on that channel fails. The fade is simulated by applying a ground to the appropriate input of the comparator.

3.39 Without this network, periodic pulsing of the 2600-cps tone might, in some cases, cause relay K4 to follow the pulses and result in a series of rapid switches.

3.40 Splitting the input resistance of the comparators isolates this network from the AGC circuits to prevent shorting them during bunching of relay K4 contacts.

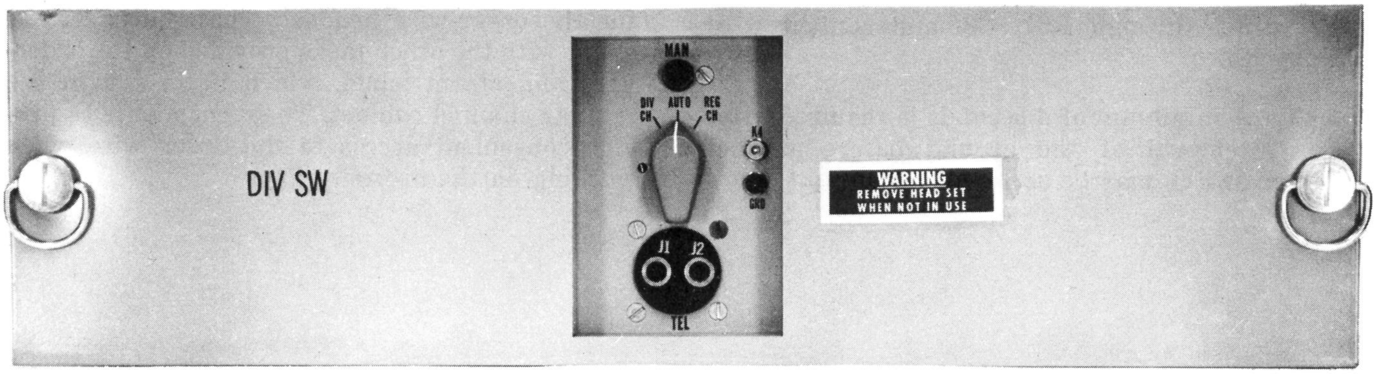
3.41 Whenever the need arises, a means has been provided for externally forcing a switch by applying a ground pulse at terminal 21 of TS2. The minimum length of the ground pulse should be 1 millisecond, and there is no limitation on the maximum length.

3.42 The ground is applied to the active channel through R51, C8, and contact 6 of relay K4.

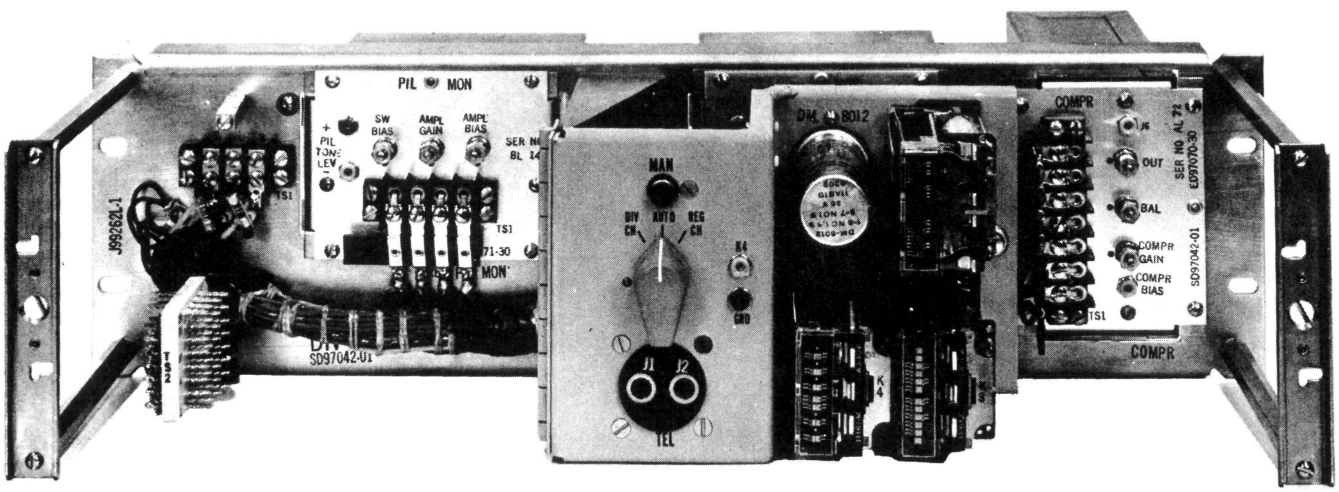
3.43 A minimum of 4 seconds is required after removal of the ground before another forced switch may be accomplished.

F. Order Wire Access Circuit

3.44 Telephone jacks J1 and J2 are provided on the front panel of the diversity switch for the order-wire headset. These jacks are in shunt with the other jacks provided on the order-wire and alarm panel, which is located in the regular channel cabinet. Their purpose is to provide convenient access to the order wire when working on the diversity bay.



Front View (Cover On)



Front View (Cover Off)

Diversity Switch Unit

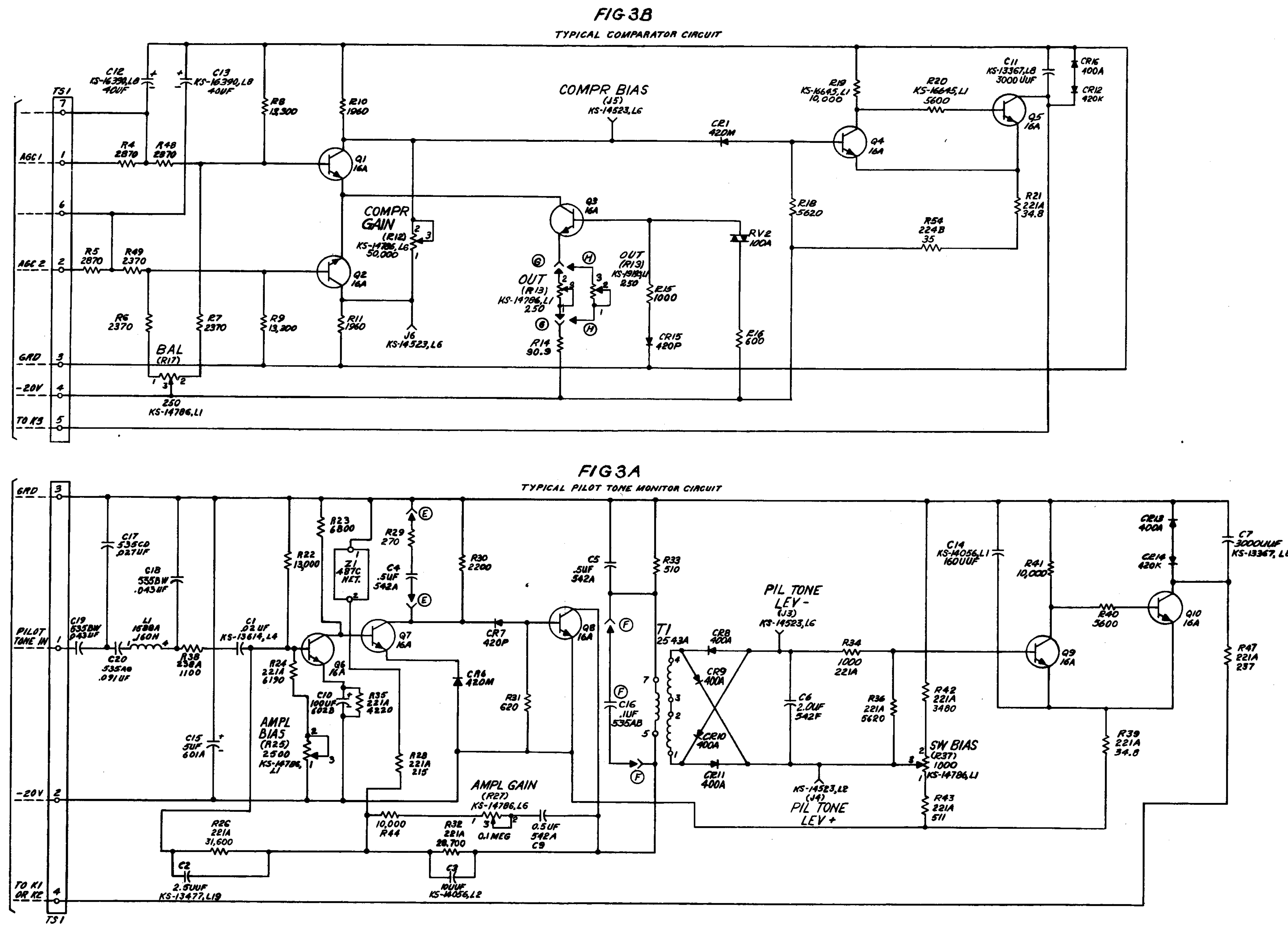
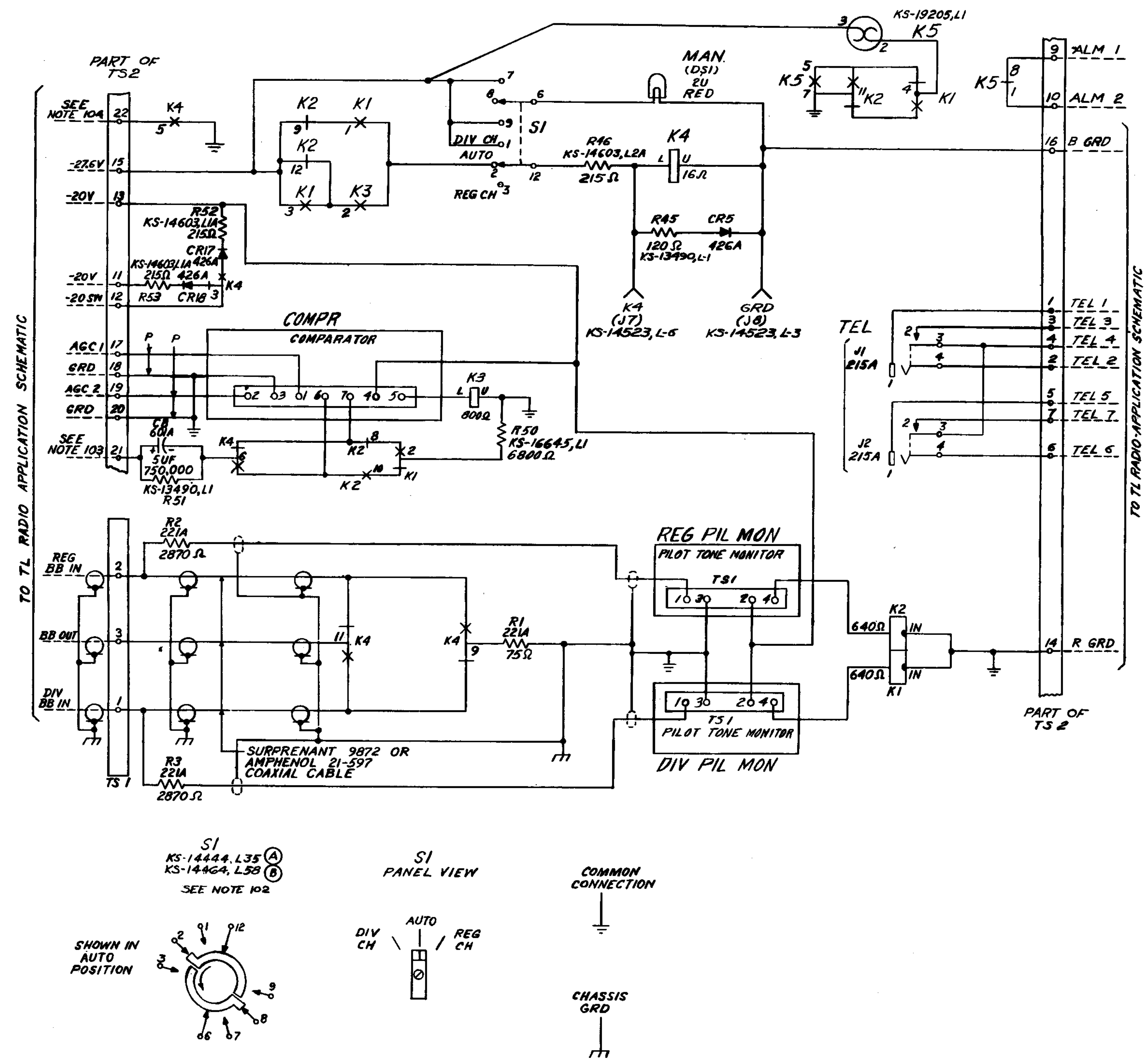


Fig. 3 – Typical Comparator and Pilot Tone Monitor Circuits

NOTES:

101. ALL RESISTORS VALUES IN OHMS UNLESS OTHERWISE SPECIFIED.
102. SWITCH (S1) IS SHOWN VIEWED FROM WIRING SIDE.
103. CONNECTION PROVIDED FOR FORCED SWITCH FEATURE IF AND WHEN REQUIRED.
104. CONNECTION PROVIDED FOR REMOTE INDICATION OF ACTIVE CHANNEL, IF AND WHEN REQUIRED.
105. COMPONENT CODES AND VALUES SHOWN MAY NOT AGREE WITH THE LATEST ISSUE OF SD-97042-01.



RELAYS - WIRE SPRING TYPE ONLY

DESIG	K1		K2		K3		K4		DESIG
CODE	AK34				AJ84		AJ106		CODE
OPTION									OPTION
	CONT ARR	LOC	CONT ARR	LOC	CONT ARR	LOC	CONT ARR	LOC	
12			B	C5					12
11			BM	D7			EMB	F4	11
10			M	E5	EBM				10
9			B	C5	M		EMB	F5	9
8			B	E5	EBM				8
7					M		BM		7
6					EBM		EBM	E4	6
5	B				M		BM	C4	5
4	BM	D8			EBM				4
3	M	C5			M		EMB	D4	3
2	BM	E5			M	C5			2
1	M	C5					EMB		1
CODE		E7		F7		D5		C6	CODE

LEGEND

DETACHED	ATTACHED	EXPLANATION
1 2	1 2	MAKE CONTACT, OPEN WHEN RELAY NOT OPERATED
1 2	2 1	BREAK, CONTACT, CLOSED WHEN RELAY NOT OPERATED
2 3 1 OR 2 3 1	2 3 1	TRANSFER CONTACTS MAY BE MB, EMB, OR EBM
A	A	RELAY CORE (OF A RELAY)
1 2	1 2	JACK SYMBOL 1-2 WILL BREAK WHEN PLUG IS INSERTED

Fig. 4 – Typical Diversity Switch Circuit