COMMON SYSTEMS
"N" "O" & "ON" CARRIER TELEPHONE
N1, O1, ON1 & ON2 CHANNEL CKT

CHANGES

B. CHANGES IN APPARATUS

B.1 Removed

In Fig. 8 and 9

1 - Resistor (R126)
KS-13490, List 1
5100 ohms

D. DESCRIPTION OF CIRCUIT CHANGES

D.1 Option "T" was rated "Mfr Disc."

D.2 Note 113 was expanded to cover D.1.

D.3 For diode (CR106), code F-54837 was shown in Fig. 8 and 9 and lined out to permit its temporary use.

D.4 In Section II, 3.142, the phrase "...and shunt resistor (R126)..." was deleted.

All other headings, no change.

BELL TELEPHONE LABORATORIES, INCORPORATED

DEPT 2168-RLH-RHK

COMMON SYSTEMS
"N" "O" & "ON" CARRIER TELEPHONE
N1, O1, ON1 & ON2 CHANNEL CKT

CHANGES

D. DESCRIPTION OF CIRCUIT CHANGES

D.1 Under 3. Connecting Circuits, the following changes were made:

(a) 3.11 to 3.14, 3.21, and 3.22 were deleted.

(b) 3.16 and 3.17 were added as follows:

(1) 3.16 Application Schematic For Shop-wired Terminal Bay - SD-97031-01

(2) 3.17 Application Schematic For Combined Carrier Terminal And E-Type Signaling Bays - SD-97034-01

D.2 The lead between (V102) and (T102) was identified as lead "A", and the VF output pair between terminals JA and PA were identified as leads "B".

D.3 Note 114 was added to cover D.1.

All other headings, no change.

BELL TELEPHONE LABORATORIES, INCORPORATED

DEPT 2168-JJL-RHK

COMMON SYSTEMS
"N", "O", & "ON" CARRIER TELEPHONE
N1, O1, ON1, & ON2 CHANNEL CKT

SECTION I - GENERAL DESCRIPTION

1. PURPOSE OF CIRCUIT

1.1 This circuit provides a means of modulating a voice-frequency channel to a position in the carrier-frequency range for transmission over a high-frequency medium, and, inversely in the receiving direction, it reconverts the carrier-frequency signal down to the voice-frequency range.

1.2 Before modulation of the voice signal, the volume range is compressed. After demodulation in the receiving direction, the compressed volume range is expanded to restore it to the original range. The voice signal is then amplified.

1.3 Automatic gain control of the received signal is provided on N1 carrier.

1.4 No regulation is provided in the O or ON channel unit. Regulation for the O and ON carrier terminal is provided by the twin-channel unit and the receiving group unit.

1.5 Means are provided to terminate the circuit on a 2-wire basis, when required. (See Section III, 2.109.)

1.6 Signaling is obtained through interruption by dc signal control of a 3700-cycle tone which is added to the voice channel before modulation, and which is normally on when the channel is idle. The on or off condition of the 3700-cycle tone is retranslated into dc indications at the receiving terminal.

SECTION II - DETAILED DESCRIPTION

1. GENERAL

1.1 N1 Carrier

1.11 The channel unit is made up of three subassemblies which are assembled together and interconnected by means of plugs and jacks mounted on the subassemblies. One subassembly consists of either a compressor with built-in, optionally wired, 4-wire terminating circuits, or a compressor without a 4-wire terminating circuit. This subassembly (Fig. 1 or 7) plugs in the second one (Fig. 2) which in turn plugs in the third (Fig. 3, 6, 8, or 9), on which is mounted the plug providing the external connections of the channel unit when inserted in the socket on the terminal mounting bracket. Fig. 3, 6, and 9 have been rated "Mfr Disc." Fig. 8 is now rated "Standard". The expandor and the transmitting and receiving signaling equipment are mounted on the second subassembly, while the third subassembly consists of the channel modulator and the carrier oscillator, the receiving band filter, the gain regulator, and demodulator. (See Section III, 2.109.)

1.2 O1, ON1, and ON2 Carrier

1.21 The first two subassemblies of the O or ON channel unit are functionally the same as those described in 1.11. However, they are not interchangeable with those of type N. The third O or ON carrier subassembly consists of the channel modulator, transmitting band filter, receiving band filter, demodulator, and demodulator-amplifier.

2. COMPRESSOR (FIG. 1 OR 7)

2.1 General

2.11 The purpose of the compressor is to compress speech signals having a wide range of volumes into a range of volumes approximately one half as great by amplifying weak signals considerably and attenuating strong signals slightly.

2.12 Two compressor circuits are provided, one (Fig. 1) having a built-in but optionally wired 4-wire terminating circuit, and another (Fig. 7) in which no 4-wire terminating circuit is provided. Both include an adjustable pad, repeating coil, variolosser, voice-frequency amplifier (including output low-pass filter), and control rectifier. The variolosser is a diode network which acts as an attenuator in the voice transmission circuit, the loss of which is adjusted automatically at a syllabic rate by the output voltage of the compressor so that high output signals cause high loss, tending to reduce the output, and low output signals cause low loss, tending to increase the output. (See Section III, 2.109.)

2.2 Input Circuit

2.21 4-wire Operation

2.211 In Fig. 1, the circuit is strapped ("X" wiring) so that the input voice-frequency signals are impressed directly across the primary of repeating coil (T1) and transmitted to the variolosser. The output of the expandor from the secondary of transformer (T42) in Fig. 2 goes through a

600-ohm adjustable pad consisting of resistors (R2) and (R3) and (REC) potentiometer (R4). (See Section III, 2.109.)

2.22 2-wire Operation

2.221 In Fig. 1, the circuit is strapped ("Y" wiring) so that a resistor hybrid, consisting of resistors (R1), (R5), and (R6) with blocking capacitors (C1) and (C2), is inserted between the outgoing and incoming sides of the 4-wire carrier circuit and the 2-wire connection to the switchboard. The adjustable pad mentioned above is inserted in the incoming branch. (See Section III, 2.109.)

2.222 In Fig. 7, no 4-wire terminating circuit is ever provided, and operation is as described in 2.21. (See Section III, 2.109.)

2.223 For all the above conditions, (C1) and (C2) test jacks (J3) and (J4) provide means for measuring the input to the compressor, and (E1) and (E2) jacks (J1) and (J2) the output of the expandor.

2.3 Variolosser Network

2.31 Voice signals applied through the above input circuit to the primary of repeating coil (T1) pass from the secondary through the variolosser network to the input of the voice amplifier. The variolosser is a balanced attenuator consisting of resistors (R11) to (R14) as series elements and the four diodes of diode assembly (CR1) as shunt elements. The resistance of these diodes, and hence the loss of the attenuator, varies under control of current inserted longitudinally between terminals 1 and 5 and 4 and 8 by the control rectifier circuit, which is energized by a portion of the output power of the voice amplifier. The variolosser has a fixed loss of about 2 db for small input signals. For inputs greater than -51 dbm at the transmitting toll switchboard, the output of the voice amplifier, and hence the direct current fed to the variolosser, varies in such a way that, for a 2-db increase in input power, the variolosser attenuation increases 1 db. This means the db change at the input of the voice amplifier at transformer (T2) is only one half the db change at the input of the variolosser.

2.4 Amplifier and Low-pass Filter

2.41 The voice-frequency amplifier is a 2-stage negative-feedback amplifier having an adjustable gain. Signals from the secondary of input transformer (T2) are fed directly to the control grid of tube (V1) and through resistor (R16) to the cathode. Resistor (R16) also furnishes the cathode bias and is part of the feedback circuit which couples back a portion of the output voltage. Capacitor (C7) and resistor (R7) are used to provide singing margin at low frequency around the loop. The signals are amplified by tube (V1), which is resistance-coupled to tube (V2) by means of (R20), (C5), and (R23). Resistor (R22) and capacitor (C6), shunted across the grid of (V2), shape the feedback characteristic to improve the high-frequency singing margin. (R8) serves to limit grid current in tube (V2) on initial peaks of strong input signals. The plate of tube (V2) delivers the amplified signals to the primary of output transformer (T3). A portion of the amplifier output voltage determined by the voltage divider, (COMP) potentiometer (R27) and resistor (R28), is fed back through (R21) and (R16) to the input of tube (V1) to stabilize the amplifier performance against variations in supply voltages and tubes. The potentiometer allows the gain of the amplifier to be adjusted. Signals from the 300-ohm winding of transformer (T3) are also fed to a low-pass filter (FL1), which reduces the possibility of voice interference with signaling. Capacitor (C8) is bridged across the input side of filter (FL1) to shape the feedback characteristic to improve high-frequency singing margin. Plate power for tube (V1) is supplied through resistor (R20), and the screen power is supplied through resistor (R19), with capacitor (C4) serving to bypass the screen alternating currents. Battery is also supplied to the cathode of tube (V1) through resistor (R17) to raise the cathode bias on the tube. The plate supply for tube (V2) is through the primary winding of output transformer (T3). The screen supply is fed directly from the +130 volt battery supply. Resistor (R24) provides the cathode bias for tube (V2) and, being unbypassed, provides local feedback.

2.42 The filaments of tubes (V1) and (V2) are fed in series from the 40-volt supply through connections in the expandor and signaling subassembly.

2.5 Rectifier Control Circuit

2.51 This circuit changes syllabic pulses into spurts of direct current which control the insertion loss of the variolosser. One winding of output transformer (T3) receives part of the output of the amplifier and feeds a full-wave rectifier, consisting of diode units (CR2) to (CR5), through resistor pads (R29), (R25), and (R26). The rectified output, which produces a charge on capacitor (C3), also causes current to flow through (R15) and the diodes in (CR1), as well as resistors (R13) and (R14), to vary the shunt resistance of the (CR1) diodes. The output of the rectifiers (CR2) to (CR5) is shunted by capacitor (C3) and resistor (R18), which are used to integrate the rectified speech voltage amplitudes, and determines the timing characteristics required for proper operation of the variolosser network. Current then flows through resistor (R15) to terminals 1 and 5 of the diode unit (CR1), splitting between the two diodes connected together, flowing through

(R13) and (R14), and then through the diodes to terminals 4 and 8 to ground. As the output of the rectifier is increased due to an increase in output of the amplifier, the biasing current at terminals 1 and 5 and 4 and 8 of the diode unit (CR1) is increased. This bias, being positive at terminals 1 and 5 and negative at terminals 4 and 8, lowers the impedance of the diodes shunted across the sending path, and thereby lowers the input to the amplifier.

3. CARRIER SUBASSEMBLY

3.1 N1 Carrier (Fig. 3, 6, 8, or 9)

3.11 Modulator

3.111 The compressed voice signals coming out of low-pass filter (FL1) (Fig. 1 or 7) are connected through Fig. 2 to the modulator input pad, consisting of resistors (R101), (R102), and (R103), which provides a suitable input termination for the modulator. The 3700-cycle signaling tone from the keyer circuit in Fig. 2 is applied to the modulator circuit at the output of this pad. Modulation is produced in the (MOD) diode unit (CR101), the carrier from the oscillator output transformer (T101) being applied between terminals 1 and 5 and 4 and 8 of the diode. During one half-cycle of the carrier, the polarity is such as to allow the voice signals to flow through the diode, while in the other half-cycle, the signals are blocked. This periodic interruption at carrier frequency produces upper and lower sidebands around the carrier and the harmonics. Unwanted products are filtered out by a low-pass filter in the transmitting group unit which follows this circuit. Inductor (L101) and capacitor (C114) provide low-impedance paths for the voice and carrier signals, respectively. A positive bias is applied from the 130-volt supply through resistors (R122) and (R104) on Fig. 3 and 6, and from the reference diode (CR106) through resistor (R104) on Fig. 8 and 9, to the 3 and 4 element of the diode, then through the low winding of transformer (T101) to the 5 and 6 element of the diode and inductor (L101). This unbalances the diode bridge so that the carrier is transmitted with the sidebands. (M2) testing jack (J103) provides a means of measuring the total carrier and sideband output. The voice signals are attenuated by the shunt inductor (L101) and the series capacitor (C114). In Fig. 3 and 6, connecting (M1) test jack (J102) to ground removes the dc bias from the diode, greatly reducing the carrier transmitted so that the sideband output can be measured alone. In Fig. 8 and 9, this can be accomplished by connecting the test point (TP7) to ground. In Fig. 8 and 9, the (F) test jack (J102) provides a convenient means of measuring the compressor output. (See Section II, 1.11.)

3.112 In Fig. 3 and 9, resistor (R123) builds up the terminating impedance of the modulator. In Fig. 6 and 8, (MOD) potentiometer (R125) adjusts the level of the carrier frequency applied to the transmitting group unit. (See Section II, 1.11.)

3.12 Carrier Oscillator

3.121 The carrier oscillator is a crystal-oscillator, the feedback path of which is from screen to grid. The output is obtained from the plate circuit by electronic coupling. The screen of electron tube (V101) is coupled to the control grid by means of a network composed of capacitors (C106), (C102), and (C104); crystal (Y101); grid return resistor (R110); and screen resistor (R112). This network provides the proper amplitude and phase of the feedback voltage necessary for oscillation at a frequency determined by the crystal. Resistor (R109) provides cathode bias for the tube; and capacitor (C115), Fig. 3 and 9 only, or resistor (R113) prevents spurious oscillation at approximately 200 mc. The oscillator output from the plate of tube (V101) is connected to the output transformer (T101) through resistors (R106) and (R108). In Fig. 3 and 9 only, the (OSC) potentiometer (R107), together with the above-named resistors, provides an adjustable pad, controlling by means of the (OSC) potentiometer (R107) the level of the carrier supplied to the modulator from the low winding of the transformer. Capacitor (C103) is provided to improve the balance to ground of the carrier input circuit. (See Section II, 1.11.)

3.122 Voltage is applied to the plate through resistor (R105), which with capacitor (C105) provides filtering. The same functions for the screen supply are obtained with resistor (R111) and capacitor (C107). Resistor (R112) reduces the voltage reaching the screen, thus limiting the amplitude of oscillation. The filament of tube (V101), in series with that of (V45), is supplied from a -40 volt source. The -40 volt supply is obtained from the office -48 volt battery through a resistor associated with the carrier terminal but external to this circuit.

3.13 Channel Band Filter, Regulator, and Demodulator (Fig. 3 or 6) (See Section II, 1.11)

3.131 The filters (FL101) and (FL102) select the specific channel out of the group of 12 channels received from the group receiving circuit. The signal from the filter is applied to the input transformer (T103) of the regulator circuit through the adjustable pad consisting of resistors (R124) and (REG) potentiometer (R119). The (R1) test jack (J104) provides means for determining the level of the channel signals coming out of the band filter.

3.132 The regulator provides automatic gain control in order to maintain a fixed level at the input to the demodulator. It consists of a 2-stage amplifier, the gain of which is inversely proportional to the input level. The gain control is obtained by using part of the dc voltage output of the demodulator as bias for the first stage. The output of the channel band filter is connected to the grid of the first section of the double triode (V102) through input transformer (T103). The first stage is coupled to the second stage by means of inductor (L102), capacitor (C109), and resistor (R116). Unbypassed cathode resistor (R115) provides cathode bias and a slight amount of series feedback for the second stage. The output of the regulator is connected to the demodulator through output transformer (T102). A voltage divider, composed of resistors (R117) and (R118), provides an automatic-volume-control delay voltage which is positive with respect to ground. The dc voltage output of the demodulator is in series with the automatic-volume-control delay voltage but of opposite polarity. The algebraic sum of the two voltages is connected to the grid of the first section of (V102) through (R121) and the high side winding of (T103). As the dc voltage output of the demodulator is the larger of the two voltages, the result is a negative bias on the first grid. Resistor (R121) and capacitor (C112) provide the desired time constant for the dc feedback path. Regulation is obtained as follows: An increase in carrier input to the regulator increases the regulator output, which results in more dc voltage output of the demodulator. This makes the bias on the first grid more negative, reducing the gain of the first stage and restoring the output of the regulator close to its former value. A decrease in carrier input to the regulator gives the opposite effect. Resistors (R114) and (R120) limit the plate current of the first stage to a safe operating value in the event of loss of the carrier frequency. The (R2) test jack (J104) provides means for measuring the plate current flowing in resistor (R120). Capacitor (C111) is a filter capacitor.

3.133 The demodulator consists of diode units (CR102), (CR103), (CR104), and (CR105) connected as a full-wave balanced rectifier. The output of the demodulator is connected to the input of low-pass filter (FL42), and the voice signal is obtained at the output of this filter (Fig. 2). Capacitor (C108) provides an ac ground for terminal 7 of filter (FL42).

3.14 Channel Band Filter, Regulator, and Demodulator (Fig. 8 or 9) (See Section II, 1.11)

3.141 The filters (FL101) and (FL102) select the specific channel out of the group of 12 channels received from the group receiving circuit. The signal from the filter is applied to the input transformer (T103) of the regulating circuit through the adjustable pad consisting of resistor (R124) and (REG) potentiometer (R119). The (R1) test jack (J104) provides means for determining the level of the channel signals applied to the input transformer. The (B) test jack (J105) provides means for conveniently performing a filament activity test.

3.142 The regulator provides automatic gain control in order to maintain a fixed level at the input to the demodulator. It consists of a 2-stage amplifier, the gain of which is inversely proportional to the input level. The automatic gain control is obtained by using part of the dc voltage output of the demodulator as bias to control both stages. The output of the channel band filter is connected to the grid of the first section of the double triode (V102) through the adjustable pad and the input transformer (T103). The first stage is coupled to the second stage by means of inductor (L102), capacitor (C109), and resistor (R116). Unbypassed cathode resistor (R115) provides cathode bias and a slight amount of series feedback for the second stage. The output of the second stage is connected to the demodulator through output transformer (T102). A regulating diode (CR106) and thermistor (RT1) shunted by resistor (R135) provide an automatic-volume-control delay voltage which is positive with respect to ground. The thermistor, in addition to providing part of this voltage, provides temperature compensation for the diode. The dc voltage output of the demodulator is in series with the automatic-volume-control delay voltage but of opposite polarity. The algebraic sum of the two voltages is connected to the first section of (V102) through (R130) and the high side winding of (T103), and to the grid of the second section of (V102) through a voltage divider composed of resistors (R128) and (R129) and resistor (R116). As the dc voltage output of the demodulator is the larger of the two voltages, the result is a negative bias on both grids. Resistor (R130) and capacitor (C112) to the first stage, and resistors (R128) and (R129) in parallel and capacitor (C117) to the second stage provide the desired time constant for the dc feedback path. Capacitor (C117) is connected to ground through a voltage divider consisting of resistors (R133) and (R134) and a bypass capacitor (C118). This voltage divider provides sufficient bias on the capacitor to prevent it from reversing polarity in the event of low-level carrier-frequency signals. For the same reason, capacitor (C112) is connected to ground through the thermistor (RT1). Resistor (R132), in parallel with capacitor (C116) in series with the demodulator output, and shunt resistor (R126) provide optimum balance between the ac and dc load impedances. Regulation is obtained as follows: An increase in carrier input to the regulator increases the regulator output, which results in more dc voltage output of the demodulator. This makes the bias on both grids more negative, thereby reducing the gain of both stages and restoring the output of the regulator close to its former value. A decrease in carrier input to the regulator produces the opposite effect. Resistor (R131) limits the plate current of the first stage to a safe operating value in the event of loss of the carrier frequency. Capacitor (C111) is a filter capacitor.

3.143 The demodulator consists of diode units (CR102), (CR103), (CR104), and (CR105) connected as a full-wave balanced rectifier. The output of the demodulator is connected to the input of low-pass filter (FL42) through resistor (R132) and capacitor (C116) in parallel, and the voice signal is obtained at the output of this filter (Fig. 2). Capacitor (C119) provides an ac ground for terminal 7 of filter (FL42).

3.2 O and ON Carrier (Fig. 4 and 5)

3.21 Modulator and Transmitting Band Filter

3.211 The compressed voice signals from Fig. 1 or 7 are connected through Fig. 2 to the modulator input pad, which consists of (R201), (R202), and (R203). (C201) causes a small amount of shaping of the voice-frequency characteristic. The 3700-cycle signaling tone from the transmitting signaling circuit (described in 5.1) in Fig. 2 is applied to the modulator at the output of this pad. Inductor (L201) provides a low impedance to voice-frequency current and a high impedance to the carrier-frequency current. Modulation is produced in the (MOD) diode unit (CR201). Carrier voltage applied between terminals 8 and 4 and 1 and 5 causes the modulator to act as a switch, alternately opening and shorting the transmission path. This periodic interruption at the carrier frequency produces upper and lower sidebands. Sidebands are also produced around the harmonics of the carrier. (C202) provides a high impedance to voice frequencies and provides a low-impedance path for the sidebands. Resistor (R204), in conjunction with potentiometer (T), provides a matching pad between the modulator and the band filter (FL201). Potentiometer (T) provides a means of adjusting the transmitted sideband level. Resistor (R216) reduces impedance variations at the filter input as potentiometer (T) is varied. Filter (FL201) selects the proper sideband and attenuates the carrier leak from the modulator. Resistor (R215) makes the terminating impedance for filter (FL201) the proper value. Resistors (R206) and (R207) reduce the change in carrier supply voltage to the other modulator, operating at the same carrier frequency which would be caused by the removal of the channel unit.

3.22 Receiving Band Filter, Demodulator, and Demodulator-Amplifier

3.221 The receiving band filter [lower half of (FL201)] receives carrier currents from a twin-channel unit associated with the carrier terminal and selects the proper carrier currents for operation with the channel in question. The output of this filter is applied through series padding resistors (R213) and (R214) to the (DEM) diode (CR202). Capacitor (C205) furnishes a low-impedance path for the carrier currents but provides a high impedance for the voice frequency produced in the demodulator. This demodulator receives single-sideband carrier currents and demodulates them to voice frequency. The voice frequencies are then applied to the input of an amplifier at the 600-ohm terminals of input transformer (T202). Resistor (R212) and the (R) potentiometer (R210) terminate (T202) properly, and (R210) acts as an output level control for the amplifier. Grid bias for (V201) is furnished by the drop across (R208), (R209), and (C204); and the 300-ohm portion of (T201) furnishes negative feedback in the demodulator-amplifier to stabilize the gain. Resistor (R211) furnishes a dc return for the grid circuit of (V201). Capacitor (C203) provides a low impedance path for the voice-frequency currents but blocks the 130 volts dc from entering the expandor unit. Test jack (R) furnishes a test point where the output of the demodulator-amplifier may be measured.

3.222 For a type O or ON channel, the transmitting and receiving band filters are in the same can, which may be oriented in either of two positions as determined by:

(a) Type of terminal, i.e., whether type O low-group transmitting (LGT), high-group transmitting (HGT), or type ON group 1, 2, 3, 4, 5, or 6.

(b) Channel order, i.e., whether the channel is an upper or lower sideband of the associated twin-channel carrier.

(c) Channel number.

3.223 For message channels 1 and 4, where the associated channel twin is <u>not</u> a program channel, the 529A filter, "M" option, Fig. 5, is used. For this code, one filter selects the band 180 to 184 kc while the other selects the band 192 to 196 kc.

3.224 For message channels 2 and 3, the 529B filter, "N" option, Fig. 5, is used. In this case, one filter selects the band 184 to 188 kc while the other selects the band 188 to 192 kc.

3.225 For message channels 1 and 4 <u>adjacent</u> to program channels (i.e., where the channel twin is a program channel), the 568B filter, "BG" option, Fig. 5, is used. This filter is similar to the 529A but provides more attenuation in the suppression bands, as required for working near a program channel.

4. EXPANDOR (FIG. 2)

4.1 General

4.11 The expandor performs a function complementary to that of the compressor. In it, speech signals having a volume range one half as great as normal, due to having been compressed at the transmitting end of the circuit, are expanded into their normal range of volumes. This is accomplished by considerably attenuating the low volumes and slightly amplifying the high volumes so that a listener at the expandor output hears the normal volume range. Thus, line noise and crosstalk are also reduced in volume in the interval between speech bursts and during weak speech passages.

4.12 The speech transmission path of the expandor circuit consists of a low-pass filter (to keep 3700-cps signaling frequency from entering the expandor); a fixed pad consisting of resistors (R81) to (R84), (EXP) level control potentiometer (R79), and resistor (R80); a variolosser made up of diode units (CR51) and associated apparatus; and finally a one-tube feedback amplifier consisting of tube (V43) and associated apparatus. Part of the input speech signal is amplified by another feedback amplifier consisting of tube (V44) and associated apparatus, and rectified by a full-wave rectifier circuit consisting of diodes (CR45) to (CR48) and associated apparatus. The rectified current from this circuit is applied to the variolosser circuit longitudinally. The variolosser is a balanced attenuator, the loss of which is adjusted automatically at a syllabic rate by the rectifier current in such a way that a 1-db increase in input voice signal causes the variolosser attenuation to decrease approximately 1 db. Thus, the db output change is twice the db input change.

4.2 Variolosser Network

4.21 Voice signals and noise, after passing through the input low-pass filter, pad, and level control, are impressed across the primary of input transformer (T45) through capacitor (C54). From one of the secondary windings of input transformer (T45), they pass through the variolosser network consisting of a 6-diode unit assembly (CR51) and resistors (R69), (R70), and (R72) to (R77). This network is a balanced attenuator with resistors (R74) and (R75) as fixed series elements; resistors (R69), (R70), (R76), and (R77) as fixed shunt elements; and the diodes in assembly (CR51) as variable series and shunt elements. The resistance of these diodes, and hence the loss of the attenuator, varies under control of dc bias inserted longitudinally between the junction of (R69) and (R70) and the junction of (R76) and (R77) from the control rectifier circuit, which in turn is energized by a portion of the input voice power. An additional dc bias component is supplied to terminals 6 and 8 of the diode assembly through diode (CR49). The auxiliary bias controls the shaping of the variolosser characteristic at higher outputs. The level at which the bias becomes effective is determined by the dc voltage divider (R37) to (R40), option "H", or (CR50) and (R78), option "G", and by the dc voltage supplied to (CR51) through (R72) and (R73). (R100) provides additional bias control. This network has a high, fixed loss for outputs below -51 dbm at the transmitting toll switchboard and, for outputs above -51 dbm, a loss which is very nearly inversely proportional to the change in input; that is, for an increase in input of 1 db, the loss decreases 1 db so that output signals increase 2 db. This re-establishes the normal range of speech volume and lowers the output amplitude of unwanted disturbances.

4.3 Output Voice Amplifier

4.31 Voice signals from the variolosser pass through input transformer (T43), are fed directly to the control grid of electron tube (V43), and are amplified and transmitted to the primary of output transformer (T42). Resistors (R60), (R62), and (R63) provide dc bias for the tube, which reaches the grid through resistor (R64) and the secondary of transformer (T43). One output winding of transformer (T42) feeds a portion of the output of (V43) back to the input through (R60), (R62), and (C48). The other output winding of this transformer is connected to the receiving voice circuit. The dc screen supply is fed directly, and the plate supply is fed through the primary winding of output transformer (T42). Capacitor (C61) in the plate circuit shapes the feedback characteristic to improve the high-frequency singing margin. The filament voltage for this is furnished by the -40 volt supply in series with that of tube (V44).

4.4 Control Amplifier and Rectifier

4.41 The control circuit for the variolosser network consists of an amplifier tube (V44), associated circuit elements, a rectifier, diodes (CR45) to (CR48), and associated elements. A part of the input signal is fed from one of the secondary windings of input transformer (T45) directly to the control grid of electron tube (V44) and is amplified and fed to output transformer (T44). One winding of output transformer (T44) supplies feedback to the cathode of tube (V44) via the network consisting of (R61) and (R67). (R61) is also the cathode bias resistor for this tube. Resistor (R65) is the grid return resistor and provides a dc path for the cathode bias from resistor (R61) to the control grid through one winding of transformer (T45). Capacitor (C50) is a blocking capacitor for this dc circuit and also acts as an ac bypass capacitor from the low potential side of the grid winding of (T45). Resistor (R71) and capacitor (C53) in the grid circuit, and capacitor

(C49) in the plate circuit shape the feedback characteristic to improve the high-frequency singing margin. The dc screen supply is fed directly, and the plate supply is fed through the primary of output transformer (T44). To furnish the rectifier current for the vario-losser network, signals from one secondary winding of output transformer (T44) are fed through limiting resistor (R66) to a full-wave rectifier (CR45) to (CR48). The output of the rectifier is shunted by the capacitor (C51), which determines the timing characteristic required for proper operation of the variolosser. From the +130 volt dc supply, a biasing current flows through the limiting resistors (R72) and (R73); through the shunting diodes (terminals 2, 3, 5, and 7, 9, 12) in the variolosser network, producing high loss; and through limiting resistor (R78) to the -40 volt heater supply. Current from the rectifier (CR45) to (CR48), acting to reduce this high loss, follows two paths:

(a) From the rectifier through resistors (R74) and (R75), resistors (R76) and (R77), and back to the rectifier.

(b) From the rectifier through diodes (CR49) and (CR50), through the shunt diodes (terminals 6 and 8 to 7, 9, 12 and 2, 3, 5) and two of the series network diodes (terminals 7, 9, 12 to 10 on one side and 2, 3, 5 to 4 on the other), and back to the rectifier through resistors (R76) and (R77).

Current flowing through path (a) lowers the impedance of the series network diodes, while current in path (b) opposes the bias on the shunt diodes [coming from the +130 volt supply through (R72) and (R73)], raising their impedance. Both effects add to reduce the total network loss. Diode (CR49) prevents current in the shunt diode bias from backing up into the series diode circuit and rectifier. Diode (CR50) acts to control the signal level at which the shunt elements of diode (CR51) begin to operate.

4.42 The filament of tube (V44), in series with that of the output amplifier tube (V43), is supplied from the -40 volt source referred to in 3.12.

5. SIGNALING

5.1 Transmitting

5.11 To accomplish signaling, a 3700-cps tone is transmitted in both directions during the idle circuit period and removed for a busy circuit or off-hook indication. Dial pulses produce bursts of 3700-cps tone, each burst having a duration approximately equal to that of the corresponding dial-contact open interval. The 3700-cycle tone is generated in a common oscillator located in either the low-group transmitting or the low-group receiving unit in N1 carrier, and in the group-oscillator unit in O or ON carrier. The 3700-cycle tone is supplied to all channel units of the terminal. Tone in the transmitting direction is supplied through resistors (R41) and (R42) and diodes (CR41) and (CR42) to the primary of transformer (T41). This tone is controlled as follows: When the channel circuit is idle, current from the voltage divider, comprising resistors (R45) and (R51) in parallel to +130 volts and (R46) to ground from the associated trunk circuit on the "M" lead, is fed through the balanced windings of transformer (T41) to diodes (CR41) and (CR42), through resistors (R41) and (R42), and back to ground through the balanced windings of the output transformer of the 3700-cps oscillator in the associated group unit. The positive voltage on the diodes biases them to low impedance and allows the 3700-cps tone to pass through them to transformer (T41) and thence to the channel modulator.

5.12 In type N1 carrier, (R47), (R89), (C55), and (R99) are used to couple the keyed 3700 cps to the modulator. (R47) and (R89) terminate transformer (T41). (C55) provides attenuation to harmonics of 3700 cps. (R99) acts as a pad to reduce the 3700-cps level and prevents the signaling circuit from shunting down the voice input to the channel modulator. A test point (TP4) is provided between resistors (R47) and (R99) to furnish a means for measuring the 3700-cps output from the keyer or for shorting this output to ground, without loading the keyer or modulator input circuit. Capacitor (C42) acts to reduce transients in the envelope of the 3700-cps tone during the pulsing period.

5.13 In type O or ON carrier, (R47) and (R89) terminate transformer (T41). Keyed 3700-cps currents are applied to the channel modulator through capacitor (C63). Test point (TP5) is brought out to provide a means of measuring the 3700-cycle output and for shorting this output to ground. The use of test point (TP5) is identical to that in N1 carrier.

5.2 Receiving

5.21 The receiving circuit consists of a bandpass filter (FL41) tuned to the sending frequency of 3700 cps; a voltage amplifier stage, terminals 2, 3, and 4 of (V41); a multivibrator type of limiter (V42); a cathode-follower stage, terminals 6, 7, and 8 of (V41); a voltage doubler rectifier circuit consisting of diodes (CR44) and (CR52) and associated capacitors and resistors; a delay network consisting of capacitors (C44) and (C62) and resistor (R48); a dc voltage amplifier (V45); and a polarized pulsing relay (K41). In this circuit, supervision and dialing signals, indicated by the presence or absence of 3700-cps tone on the input, are converted to opens and closures of contacts on the pulse relay. Certain types of interferences are discriminated against.

5.22 Signal tone from the demodulator is separated from the voice currents in the 3700-cps bandpass filter (FL41). Tone at this output is applied to the control grid, terminal 3, of the amplifier section, terminals 2, 3, and 4 of (V41), through capacitor (C58). The (SIG) potentiometer (R59) controls the gain of this amplifier stage by varying the negative feedback at the cathode. Resistor (R97) is the grid return resistor which provides a dc path from the cathode bias resistor (R96) to the control grid. Resistors (R85) and (R86) comprise a voltage divider, with (S1) test jack (J42) connected to their junction, furnishing means for measuring roughly one fourth of the filter output voltage. Test point (TP3) provides means for shunting down the filter output voltage as required in certain line-up tests.

5.23 The first stage of (V41) is resistance-coupled to the first grid, terminal 3, of multivibrator (V42) by resistor (R95); capacitor (C47); and resistors (R57), (R94), and (R50). Resistors (R94) and (R57) also form a voltage divider to furnish a positive voltage with respect to ground for the grid. The difference between this positive voltage and cathode bias, determined by the drop across (R58), fixes a threshold above which the input voltage must rise before this half of (V42) conducts plate current. (R50) is a limiting resistor, the purpose of which is to prevent grid current from flowing on the peaks of input signals. The two halves of (V42) function as a multivibrator to give a 3700-cps square-wave output of constant amplitude in response to an input sine wave of 3700 cps of variable amplitude. For input voltage below a certain value, no output is obtained. Above this threshold value, however, a constant amplitude of 3700-cps square wave is obtained. An input just below the threshold must be increased only about 0.3 db to produce a full, constant amplitude output. With no input 3700-cps tone to the grid (terminal 3), this section of (V42) is cut off due to approximately 10 volts negative grid-to-cathode bias, resulting from 35 volts cathode bias, negative toward grid. Since the cathode of the two halves of (V42) are connected together, the cathode voltage is determined by current through the other half of the tube, normally conducting, and 25 volts drop across (R57), positive toward grid. As the input 3700-cps sine wave rises above the threshold voltage on a positive half-cycle at the grid of the input section of (V42), plate current begins to flow, making the voltage at the grid (terminal 7) of the output section more negative due to the drop of voltage across (R93). This section up to this point has been conducting due to a 1- to 2-volt negative grid-to-cathode bias [35-volt cathode bias, negative toward grid, and 34-volt grid-to-ground voltage, positive toward grid, established by the (R56), (R98), and (R93) voltage divider]. Capacitor (C43) across (R98) acts to spread the rise and fall of the voltage on the grid of the output section by offsetting the interstage shunt capacity. The lowering of voltage on the grid of the output section of (V42) causes the plate current to drop, reducing the drop across the common cathode resistor (R58), making the grid-to-cathode voltage of the first section more positive, and increasing the plate current, which in turn causes the grid-to-cathode voltage of the output section to go even negative. This regenerative action is cumulative and very swift, so that almost instantly the output section is driven to cutoff and the voltage at this plate rises suddenly to the full +130 volts of the supply voltage and remains there, where only a moment before it was approximately 35 volts below this. The input section remains conducting; and the output remains cut off until the input sine wave has risen to its peak and dropped to a value in the neighborhood of the threshold value, at which time the plate current in the input section begins to drop, reducing the amount of negative grid-to-cathode voltage on the output section. When this voltage is no longer sufficient to produce cutoff, plate current flows, causing the drop across the common cathode resistor (R58) to rise, in turn lowering the plate current in the input section. This action is likewise cumulative, so that almost instantly the input section is driven to cutoff and the output section to full plate current, causing the plate voltage of the output section to drop approximately 35 volts and remain there during the negative half-cycle of the input wave. This entire cycle of events is repeated on subsequent cycles of input wave so that, on each burst of 3700-cps sine wave corresponding to a dial "open" or "on-hook" signal, there is a burst of 3700-cps square wave of constant amplitude at the plate of the second stage of (V42).

5.24 The output of (V42) is resistance-coupled by means of resistors (R92) and (R55) and capacitor (C57) to the grid (terminal 7) of the cathode-follower section (terminals 6, 7, and 8) or (V41). This section, by virtue of cathode-follower action, acts as a high impedance on the grid side and low impedance on the cathode side, transmitting faithfully the input 3700-cps square wave to the low-impedance voltage-doubler rectifier connected to the cathode. Resistor (R54) is the cathode bias and load resistor for this section of (V41).

5.25 Capacitor (C46), diodes (CR44) and (CR52), resistor (R52), and capacitor (C44) comprise a voltage-doubler rectifier which converts the bursts of 3700-cps square waves at the output of the cathode follower to pulses of direct current, these pulses having approximately the same duration as the corresponding dial- or switchhook-open intervals. The voltage divider, consisting of (R53), (R87) to the -40 volt supply, and (R88) to ground, provides negative voltage for the dc amplifier (V45) grid via rectifier load resistor (R52) and delay network resistor (R48). When the square wave at the cathode-follower input is in the negative part of the cycle, the junction of diodes (CR44) and (CR52) is more negative than the junction of resistors (R53) and (R88) so that (CR52) is a high-resistance condition, but current flowing in the forward direction of diode (CR44) charges (C46) so that the end toward (CR44) and (CR52) is positive. When the square wave reaches the positive half-cycle, the junction of (CR52) and (CR44) is more positive than the junction of resistors (R53) and (R88) so that (CR44) is in the high-resistance condition, but current flowing in the forward direction of (CR52) charges capacitor (C44). The ultimate charge of (C44) is determined by the peak of the positive half-cycle of square wave plus the positive charge on capacitor (C46) built up during the negative half-cycle, which is the reason for calling this a voltage doubler circuit. During the next negative half-cycle, while (C46) is being recharged, (C44) discharges slowly through resistor (R52), also transferring charge to capacitor (C62) through (R48); but the discharge time is quite long in comparison with the interval between cycles, so there is very little change in voltage across (C44) before the subsequent square-wave positive half-cycle occurs to transfer more charge to (C44). Thus, while a train of 3700-cps square waves corresponding to a dial pulse or switchhook open are impressed on the input to the rectifier, a dc voltage is rapidly built up across (C44). Also during this time, a charge is slowly being built up on delay capacitor (C62) from (C44) through resistor (R48). Tube (V45), a triode-connected 408A pentode, is a dc amplifier biased beyond cutoff [by the drop across (R88) fed to the grid via (R52) and (R48)] when there is no 3700-cps input to the signaling unit. The time constants of the delay circuit are such that the grid voltage of (V45) reaches a value above cutoff approximately 15 milliseconds after the beginning of the train of 3700-cps waves at the rectifier input. This causes plate current to flow in (V45) and operate polar relay (K41). Hence, a group of square waves shorter than 15 milliseconds duration (such as might be caused by momentary surges on the line) will not cause tube (V45) to draw plate current to operate the relay. However, legitimate dial-open intervals about 50 to 60 milliseconds long are more than enough to cause relay operation. The test points (TP1) and (TP2) at the ends of resistor (R44) provide means for measuring the dc voltage across (R44) to indicate the relay secondary winding current. (REL CURR) potentiometer (R43) affords means for adjusting this relay current.

5.26 With no current in the secondary winding of (K41) (no 3700-cps input), the armature closes contacts 4 and 5 by the biasing action of current through the primary winding from the +130 volt supply through potentiometer (R49) and parallel resistors (R90) and (R91) to ground. (BRK) potentiometer (R49) is used for adjusting the bias of the pulse relay. Since ground is normally supplied over the "G" lead connected to contact terminal 4, this results in ground being applied to the "E" lead, indicating an "off-hook" or "dial-contact-closure" condition to the associated trunk equipment. Capacitor (C45) acts as contact protection for contacts 4 and 5 to limit the voltage surge developed by sudden breaking of the relay contacts. When the relay primary winding is energized under "on-hook" or "dial-contact-open" conditions (3700-cps input present), the relay armature moves to open the bridge between contacts 4 and 5 (removing ground from the "E" lead to the associated trunk equipment) and to introduce a bridge between terminals 1 and 2. Closure of contacts 1 and 2 short-circuits resistor (R53) which raises the current through, and hence the voltage across, resistor (R88) so that the grid of (V45) is made more negative. At the conclusion of a dial-open interval or on restoration of "on-hook" condition (3700-cps input interrupted), delay capacitor (C62), which held the grid of (V45) biased above cutoff, discharges slowly through resistors (R48), (R52), and (R88) to ground, lowering the grid voltage and lowering the plate current of tube (V45) until relay (K41) releases, opening contacts 1 and 2 and reclosing contacts 4 and 5. This makes the grid bias of (V45) less negative by opening the short circuit across (R53), and reconnects ground to the "E" lead. Tube (V45) is gradually restored to the cutoff condition. The interaction between the relay and the grid bias of (V45), in which the bias is changed when relay contacts 1 and 2 close, serves to advance the point at which the grid voltage drops sufficiently to cause the relay to release to a steeper portion of the (C62) capacitor discharge-time characteristic. This tends to equalize the relay operate and release times from one dial pulse to another. The complete action of the delay network, dc amplifier, and relay circuit is twofold: First, it produces ground pulses on the "E" lead of approximately the same duration as the time between bursts of 3700-cps square wave (corresponding to legitimate dial pulses) at the output of the cathode-follower section of (V41), but delayed by roughly 15 milliseconds; and second, by rejecting inputs shorter than 15 milliseconds, it avoids the removal of ground from the "E" lead, due to unwanted line surges.

5.27 Tubes (V41) and (V42) have -40 volt heaters and are supplied directly from the -40 volt source described in 3.12. Tube (V45) has a -20 volt heater which is connected in series with that of (V101) or (V201) via plug (PBJ) and jack (JBJ).

SECTION III - REFERENCE DATA

1. WORKING LIMITS

1.1 None.

2. FUNCTIONS

2.1 N1 Carrier

2.101 Modulates a voice-frequency channel to a carrier-frequency double-sideband channel in a 164- to 260-kc range, with carrier transmitted (see Section II, Part 3).

2.102 Generates the channel carrier required and provides means for adjusting the magnitude (see Section II, Part 3).

2.103 Amplifies the voice signals applied at the input of the unit and compresses their volume range so as to raise the signals of lowest level well above noise and crosstalk levels. Gain adjustment is provided. (See Section II, Part 2.)

2.104 Selects one specific shannel from a group of 12 carrier channels received from the distant terminals by means of channel band filters (see Section II, Part 3).

2.105 Controls automatically the transmission of the carrier-channel signals to provide a constant carrier level at the input of the demodulator. Input level adjustment is provided. (See Section II, Part 3.)

2.106 Demodulates the double-sideband carrier channel down to voice (see Section II, Part 3).

2.107 Expands the volume range of the received voice-frequency signal to compensate for the compression introduced at the transmitting end, thus restoring the original volume range and, in the process, lowering noise and crosstalk disturbances. Input level adjustment is provided. (See Section II, Part 4.)

2.108 Amplifies the expanded signal (see Section II, Part 4).

2.109 Provides means in Fig. 1 for connecting to a voice-frequency circuit on a 2-wire or 4-wire basis by optional strapping of a built-in resistance hybrid circuit, or only on a 4-wire basis in Fig. 7 (resistance hybrid not furnished). Fig. 1 has been rated "Mfr Disc." for N carrier and "A & M Only" for O and ON carrier. Fig. 7 is now rated "Standard" for N, O, and ON carrier. In all cases, an adjustable output pad is provided. (See Section II, 2.2.)

2.110 Supplies a signaling channel for relaying over the carrier system dc signaling indications. Adjustments for sensitivity and relay-operating characteristics are provided. (See Section II, Part 5.)

2.2 O and ON Carrier

2.21 Modulates a voice-frequency channel to a carrier-frequency single-sideband channel in the 180- to 196-kc range. The modulator output level may be adjusted. (See Section II, 3.2.)

2.22 Amplifies the voice signals applied at the input of the unit and compresses their volume range so as to raise the signals of lowest level well above noise and crosstalk levels. Gain adjustment is provided. (See Section II, Part 2.)

2.23 Selects one specific channel from a group of four carrier channels by means of channel band filters (see Section II, Part 3).

2.24 Demodulates the single-sideband carrier channel down to voice frequencies and then amplifies the voice. The amplifier output level may be adjusted. (See Section II, Part 3.)

2.25 Expands the volume range of the received voice-frequency signal to compensate for the compression introduced at the transmitting end, thus restoring the original volume range and, in the process, lowering noise and crosstalk disturbances. Input level adjustment is provided. (See Section II, Part 4.)

2.26 Amplifies the expanded signal (see Part 4).

2.27 Provides means for connecting to voice-frequency circuits on a 2-wire or 4-wire basis by optional strapping of a built-in resistance hybrid circuit, or only on a 4-wire basis (resistance hybrid not furnished). In all cases, an adjustable output pad is provided. (See Section II, 2.2 and Section III, 2.109.)

2.28 Supplies a signaling channel for relaying over the carrier system dc signaling indications. Adjustments for sensitivity and relay-operating characteristics are provided. (See Section II, Part 5.)

3. CONNECTING CIRCUITS

3.1 N1 Circuits

3.11 High Group Transmitting Circuit - SD-95119-01

3.12 Low Group Receiving Circuit - SD-95120-01

3.13 Low Group Transmitting Circuit - SD-95129-01

3.14 High Group Receiving Circuit - SD-95130-01

3.15 Application Schematic for Terminal - SD-95121-01

3.2 O and ON Circuits

3.21 Twin Channel Circuit - SD-95151-01

3.22 Group Trsg Circuit - SD-95153-01

3.23 Terminal Application Schematic - SD-95150-01

SECTION IV - REASONS FOR REISSUE

CHANGES

B. CHANGES IN APPARATUS

B.1

Superseded	Superseded by
In Fig. 8	
1 - Resistor (R104) 145A 0.11 megohms	1 - Resistor (R104) 145A 27,400 ohms
1 - Resistor (R127) KS-13490, L1 0.11 megohms	1 - Resistor (R127) KS-13490, L1 62,000 ohms
In Fig. 9	
1 - Resistor (R104) 145A 0.332 megohms	1 - Resistor (R104) 145A 75,000 ohms
1 - Resistor (R127) KS-13490, L1 0.11 megohms	1 - Resistor (R127) KS-13490, L1 62,000 ohms

B.2 Removed

In Fig. 8

1 - Resistor (R122)
145A
82,500 ohms

In Fig. 9

1 - Resistor (R122)
145A
0.2 megohms

D. DESCRIPTION OF CIRCUIT CHANGES

D.1 Option "BR" was added to Fig. 8 and 9. Previously option "BS" on Fig. 8 and 9 was not rated "Mfr Disc."

All other headings under Changes, no change.

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