

TYPE ON/K CARRIER TELEPHONE SYSTEM GENERAL DESCRIPTION

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1. GENERAL

1.01 This section describes the general features of the ON/K carrier telephone system.

1.02 The ON/K system was designed to add 12 channels of ON1 or 16 channels of ON2 carrier above the frequency band of a K carrier system, both working on the same cable pair.

1.03 The multiplex equipment that effects the stacking consists mainly of ON type terminal equipment in four-channel blocks. Additional equipment; line filters and the ON/K repeater were provided to complete the equipment needed for this system. The line filter and repeater function to separate the high ON/K frequencies from the low K frequencies, amplify them and recombine them with the amplified K signals at each K repeater section. The same ON/K repeater design is used at terminal stations to connect the ON terminals to the cable.

An adjustable deviation equalizer is provided as optional equipment.

1.04 The circuit description for the ON terminal groups is located in other practices in the 362 division of Bell System Practices.

1.05 Fig. 1 shows in block schematic form a typical ON/K carrier telephone system.

2. OVER-ALL SYSTEM

A. General

2.01 The 16 channel ON/K system and the 12 channel ON1/K system was designed for shorthaul use over the same cable pairs used for K carrier. The ON2/K occupies a frequency band of 68 to 132 kc; the ON1/K system the 80 to 136 kc band. Line filters are used to separate ON/K frequencies from K carrier frequencies at the input of each repeater, terminal, and junction and to combine these frequencies at the output. Repeaters are located at the same locations as the K carrier repeaters. Also, junctions must be located at K terminal or repeater locations. Only ON1/K can be extended over O carrier facilities. The system is designed to operate on cables arranged for single section crosstalk cable balancing. Approximately 100 db gain is provided for each cable section at the top of the frequency band. Equalization is provided for the 28 db slope of the cable characteristic over the 68 to 136 kc band. Fig. 2 gives a simplified block diagram of one section of ON/K and Fig. 3, the frequency arrangement for 16 channels of ON/K carrier.

B. Terminals

2.02 At the ON/K terminal, three or four ON carrier groups are connected on a 4-wire basis to a combining network. The combined band on the transmitting side is then amplified by the ON/K transmitting amplifier and connected, through the line filter, with the K carrier frequencies for transmission over the cable. The

ON/K TERM. APPL. SCHEM
SD-95230-01

ON/K REP. APPL. SCHEM.
SD-95229-01

ON/K TERM. APPL. SCHEM.
SD-95230-01

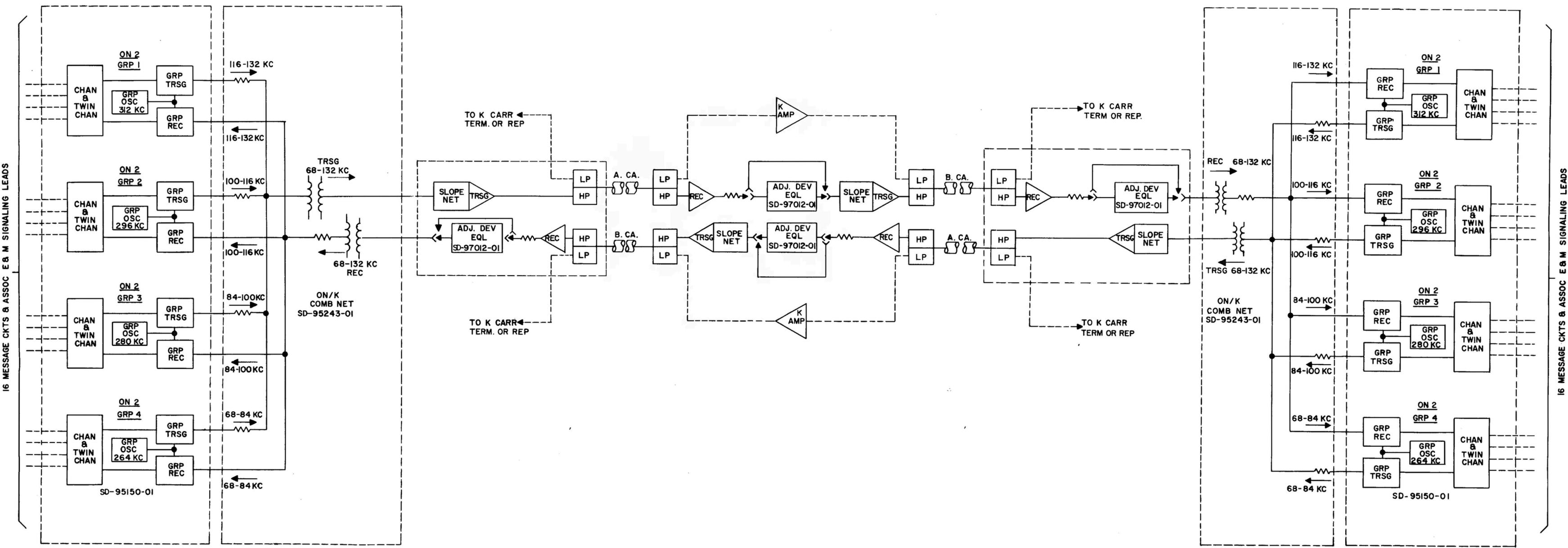


Fig. 1 - ON/K Carrier Telephone System Block Schematic

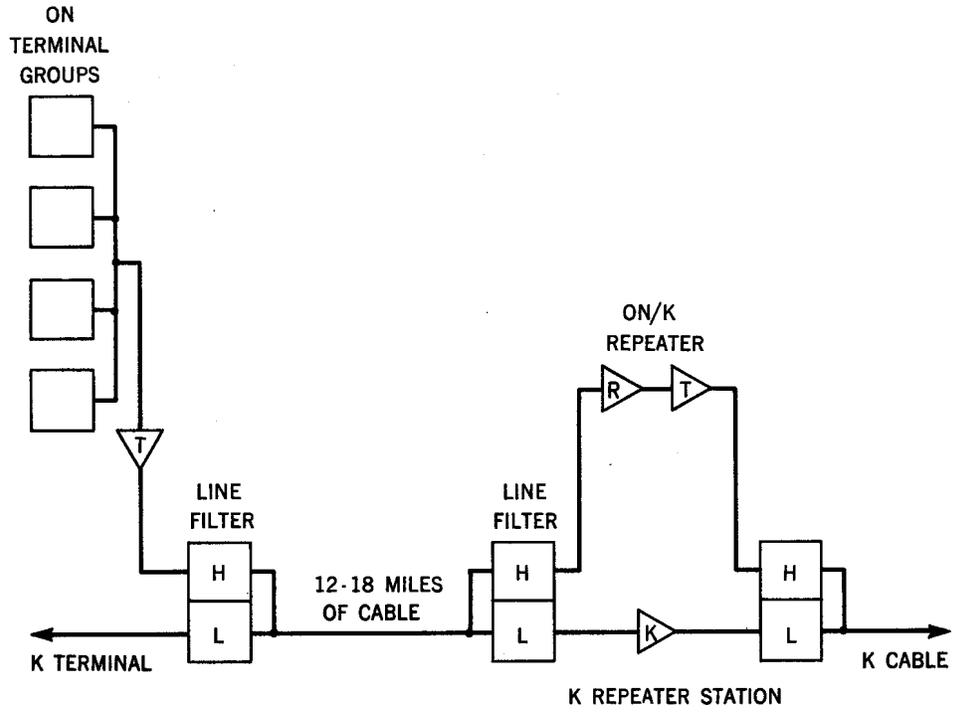
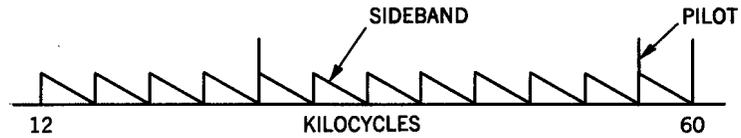


Fig. 2 - Block Diagram of One Section of ON/K

K CARRIER
(12 CHANNELS)



ON K CARRIER
(16 CHANNELS)

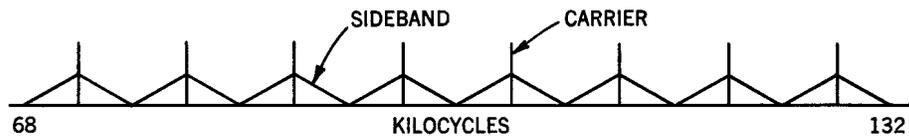


Fig. 3 - Frequency Arrangement for 16 Channels on ON/K

received band is separated from the K carrier band by the line filter, its level and slope adjusted when required with span pads or artificial lines and then amplified to the proper level by the ON/K receiving amplifier. The combining network then provides for connection to the carrier groups.

C. ON/K to ON Junction

2.03 The ON/K system may be connected to an ON1 or ON2 system. At the junction location, which must also be a K repeater or terminal location, the received ON/K frequencies are separated from the K frequencies by line filters, amplified by an ON/K receiving amplifier, the level adjusted by span pads and/or artificial lines for connection to the ON/K to ON carrier connecting circuit.

2.04 In the connecting circuit, the signal level is further reduced by a pad to that required for the input to an ON repeater. For ON1/K to ON1 carrier, a level control oscillator with an adjustable output level is connected to the circuit to supply an artificial load to replace that of ON1 groups 4 and 5. The oscillator is not used for ON2/K because its output frequency lies in the ON2 carrier group 4 band. In the ON to ON/K direction, the output of the ON repeater is reduced in level by a pad in the ON/K to ON connecting circuit and then connected to the input of an ON/K transmitting amplifier for pre-equalization and level regulation. The output of the transmitting amplifier is connected to the output line filter where it is combined with the K system output. Fig. 4 shows in block form a typical ON/K to ON junction.

D. ON/K to O1 Junction

2.05 The ON1/K system may be connected to an O system. At the junction location, which must also be a K carrier repeater or terminal, the received ON1/K frequencies are separated from the K frequencies by a line filter, amplified by the ON/K receiving amplifier, adjusted for proper level and connected to the cable side input of an ON1 group 1 junction and then to the open wire facilities. In the open wire to ON/K direction, the O group is connected to the ON1 junction. The junction output is connected to the ON/K transmitting amplifier for

pre-equalization and level regulation and to the output line filter where it is combined with the K system output.

E. Channel Order

2.06 Channel order in the ON/K system is similar to that in the ON system and is determined in a similar manner. Due to the way the channel filters are assembled in pairs in each can, if the received channel order is four to one, the transmitting channel order must be one to four. Therefore, if a group is transmitting channel order "A" from one ON/K terminal, it must be transmitted channel order "B" from the other.

3. ON/K AMPLIFIERS

A. General

3.01 The fact that up to 18 miles separate K repeaters, extreme signal level differences between the two carrier-frequency bands result. These level differences occur because the cable loss is very high (over 100 db) between K repeater stations at the higher frequencies used for ON/K. A tenth of a watt of carrier power must be delivered to the cable at the output of each repeater. This power level is rather high for telephone work. But even so, its magnitude is attenuated by the cable to one hundred-thousandth of a microwatt at the next repeater point.

3.02 To make up for the 100 decibel cable loss between repeater stations, the ON/K repeater amplification is also 100 decibels. This is a power ratio of ten-billion to one, which required very careful circuit and equipment design to avoid oscillation and crosstalk. For example, a stray hundred-thousandth of a microwatt picked up at the repeater input would drive the output stage to full power.

3.03 To control crosstalk and prevent self-oscillation, high-level signals must be kept physically remote from low-level ones. In the line facilities, the normal K-carrier feature of separate cables for the two directions of transmission eliminates serious problems of crosstalk. In the ON/K repeater, separation is achieved by dividing amplification into two pieces, a receiving amplifier feeding a transmitting amplifier. In a two-way repeater, two

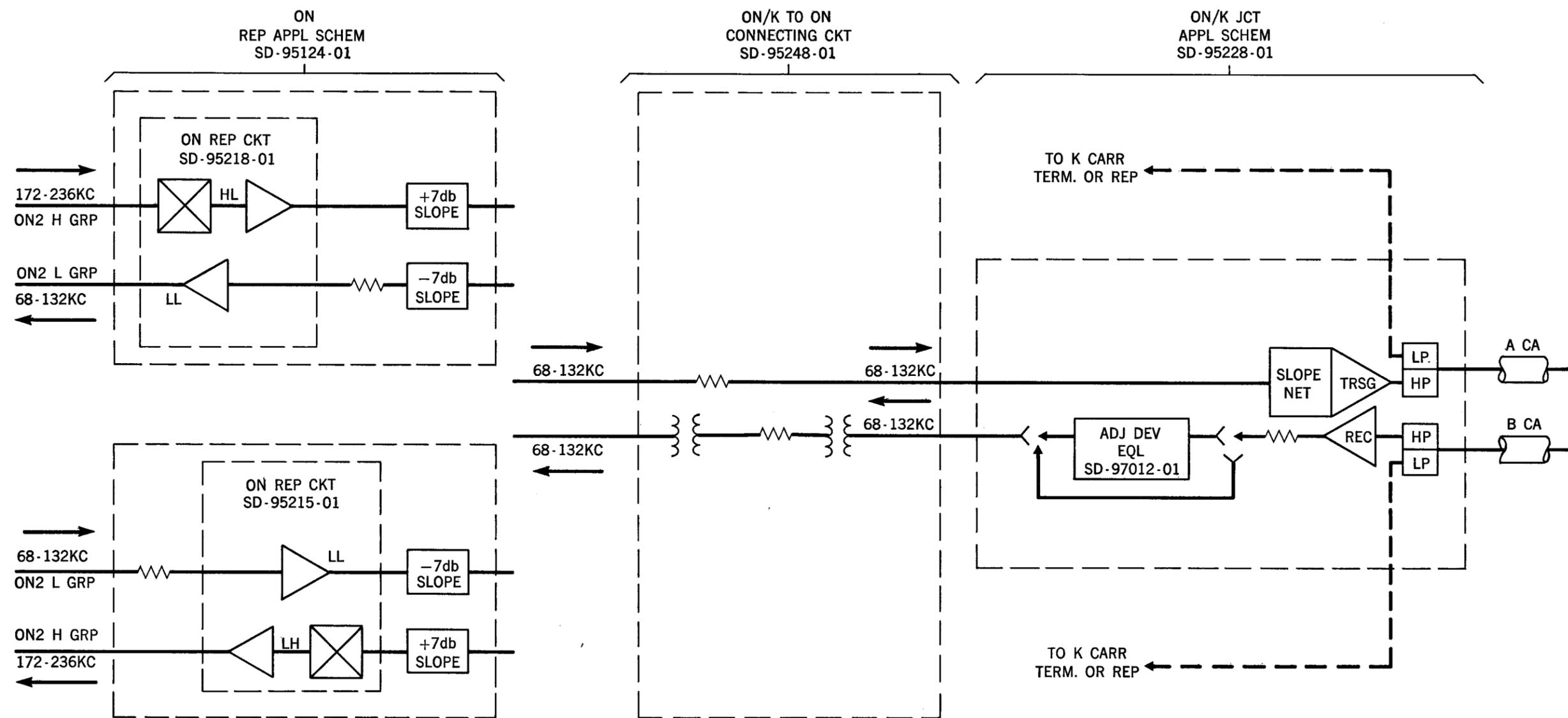


Fig. 4 - Block Diagram of a Typical ON/K to ON Junction

receiving amplifiers (low-level signals) are separated from two transmitting amplifiers (high-level signals) by an interposed fuse-panel. In addition, low-level signals are cabled down one side of the mounting bay and high-level cabling goes up the other so that the bay itself assures separation. Also, special shields are used between adjacent bays. Besides controlling cross-talk, separation of the amplification function into two pieces, permits the use of the same amplifier designs at terminals, where the transmitting amplifier alone amplifies the ON terminal levels for transmission to the cable, and the receiving amplifier alone, amplifies signals received from the cable.

3.04 The separation of amplifiers also permits branching off of the ON/K to type ON or O carrier system for extension over a branch cable or open-wire for ultimate termination at a point remote from the K cable.

B. Transmitting Amplifier (See Fig. 5)

3.05 The transmitting amplifier provides 43 db of gain at 132 KC. The amplifier has two stages with a 418A power output tube to handle the high power output (22 dbm). This output is required for adequate signal-to-noise ratio. A

thermistor regulator in the feed-back network assures an output that is stable within plus or minus 0.5 db for variations in input power of up to plus or minus 10 db. Because the thermistor is sensitive to ambient temperature a compensating network is furnished. The feed-back circuit is connected as series feed-back at the input, and high-side hybrid feed-back at the output. Also, a network is employed in the feed-back circuit to equalize the deviations from the desired characteristics in the basic slope equalizer, and the line filters. The basic slope equalizer which is mounted on the amplifier chassis, is used to pre-equalize for the cable frequency characteristic of the following line section. Thus, all channels are equal in level at the input to the next repeater.

C. Receiving Amplifier

3.06 The receiving amplifier which gives approximately 57 db of gain across the frequency band, is a two stage feed-back amplifier (two 408A tubes) with slope adjustment, plus a low-pass filter. Operation of the amplifier is similar to that of the transmitting amplifier, the main difference being in the feed-back network and the output tube. The receiving amplifier has no basic slope equalizer. The feed-back circuit

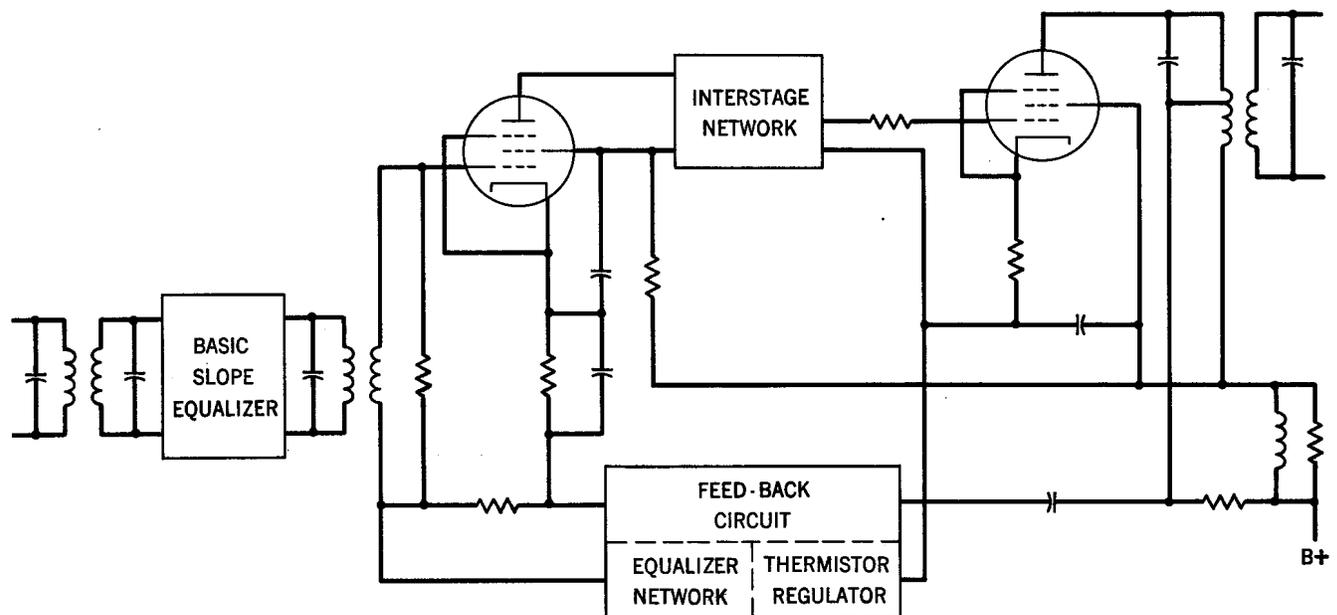


Fig. 5 - Block Schematic of Transmitting Amplifier

includes the manufacturer's flat gain adjustment and a field slope adjustment. The slope steps, which do not affect the total output power, have slope variations of 0 db, -1 db and -2.8 db. Slope adjustment compensates for unit replacement, component aging and cable build-out deficiencies. The power output level of the receiving amplifier is about -25 dbm per carrier.

4. EQUALIZATION

4.01 When K carrier cable sections are less than 18.2 miles in length, artificial lines are used to compensate for integral miles and span pads for fractional miles. Span pads, however, compensate only for the flat level difference leaving a small slope error.

4.02 The ON and K carrier frequencies are combined or separated by a line filter. This filter is a balanced network with a low-pass section which passes K carrier frequencies (12 to 60 kc) and a high-pass section which passes ON carrier frequencies (68 to 136 kc). The impedance level at the low-pass, high-pass, and line sides of the filter is 135 ohms.

4.03 There are several sources of systematic transmission level deviations in the ON/K system. The major equalization problem is an impedance mismatch caused by inserting the input line filter between complex impedances (the cable and the input side of the ON/K receiving amplifier). This mismatch is greatly increased when artificial lines are inserted between the filter and the amplifier.

4.04 The accumulation of many of those small deviations could result in undesired performance of the ON/K system. Therefore, an adjustable deviation equalizer is available to equalize system deviation to within specified limits. The equalizer comprises eight series resonant circuits, four of which are effectively parallel resonant circuits because of their location in the feed-back network of the amplifier stage. It was found that the use of the amplifier stage is the most practical method of obtaining series and parallel resonant circuits with minimum interaction, and with a 7 db pad it produces unity flat gain for the entire network. Because a low gain is desired, the feed-back circuit is unusual in that only a shunt network is used

and the signal is fed back from the top of the output transformer to the control grid of the tube.

4.05 The deviation equalizer will equalize transmission level deviations up to ± 4 db for any high level peaks and any four low level peaks within the ON1/K and ON2/K frequency bands. A channel frequency characteristic improvement is obtained by inserting the equalizer after the ON/K receiving amplifier. A noise and crosstalk improvement is obtained by inserting the equalizer at a repeater location at the input to the transmitting amplifier.

5. ORDER-WIRE AND ALARM FACILITIES

5.01 The alarm circuit in each ON/K terminal group is the same as in a type O1 terminal. For detailed information on this circuit, refer to the descriptive section in this division on O terminals. Alarms in the ON junctions and the ON/K-to-ON junction repeaters are the same as on a normal ON system. For more detailed information, refer to the descriptive section in this division on ON systems.

5.02 The ON/K repeaters are equipped with power failure alarms which connect to the K carrier alarm systems at main or auxiliary stations.

5.03 Order-wire arrangements are available as a part of the K carrier system. For a system that branches to an O1 or ON system, the order-wire arrangements of these systems may be used.

6. POWER SUPPLIES

6.01 The ON terminals and junctions require dc power at -48 and +130 volts. Each terminal and junction is equipped with alarm-type fuses for heater and plate circuits. For a complete description of the terminal and junction power supply, refer to the descriptive practice in this division on ON terminals. A level control oscillator in the ON/K to ON connecting unit may be powered from either a +130 or +152 volt battery supply and has a 0.055 amperes current drain. Table I gives the current drains for the terminal and junction.

TABLE I

	-48V	+130V
Current per terminal group (4 channels equipped, no level control oscillator)	1.75 amp (max)	0.450 amp (max)
Current per junction group (no level control oscillator)	0.50	0.164
Current per level control oscillator	0.05	.005

6.02 Arrangements for powering the ON/K transmitting and receiving amplifiers are shown in Fig. 6. At K carrier main and terminal stations, the ON/K receiving amplifiers use a +130 volt plate supply whereas the transmitting amplifiers employ +130 volts and -24 volts for the plate supply. Both amplifiers use a +152 volt plate supply at K auxiliary stations. Each terminal, repeater, and junction mounting is equipped with alarm-type fuses for the heater and plate circuits. The deviation equalizer uses +130 volts for both plate and heater supply. A built-in resistor reduces the +130 volts to 19.25 volts for the heater supply. At K auxiliary stations an ED-92484-30, G7 voltage dropping panel is used to drop the +152 volt supply to +130 volts.

6.03 The ac heater supply is also shown on Fig. 6. A 19.25 volt supply is required for the 408A tube (2 per receiving and 1 per transmitting amplifier) and a 6.1 volt supply is required for the 418A tube (output tube of transmitting amplifier). An ac supply is used in preference to dc to eliminate the power waste caused by using dc dropping resistors. The normal heater voltages of 6.3 and 20 volts were lowered to the values stated above to provide for longer tube life. A ±0.1 volt tolerance is maintained on the heater voltages to insure the longer tube life. A center tap on the 19.25 volt winding of the heater supply transformer provides 9.62 volts ac for the thermistor heater in the transmitting amplifier. Taps are provided on the

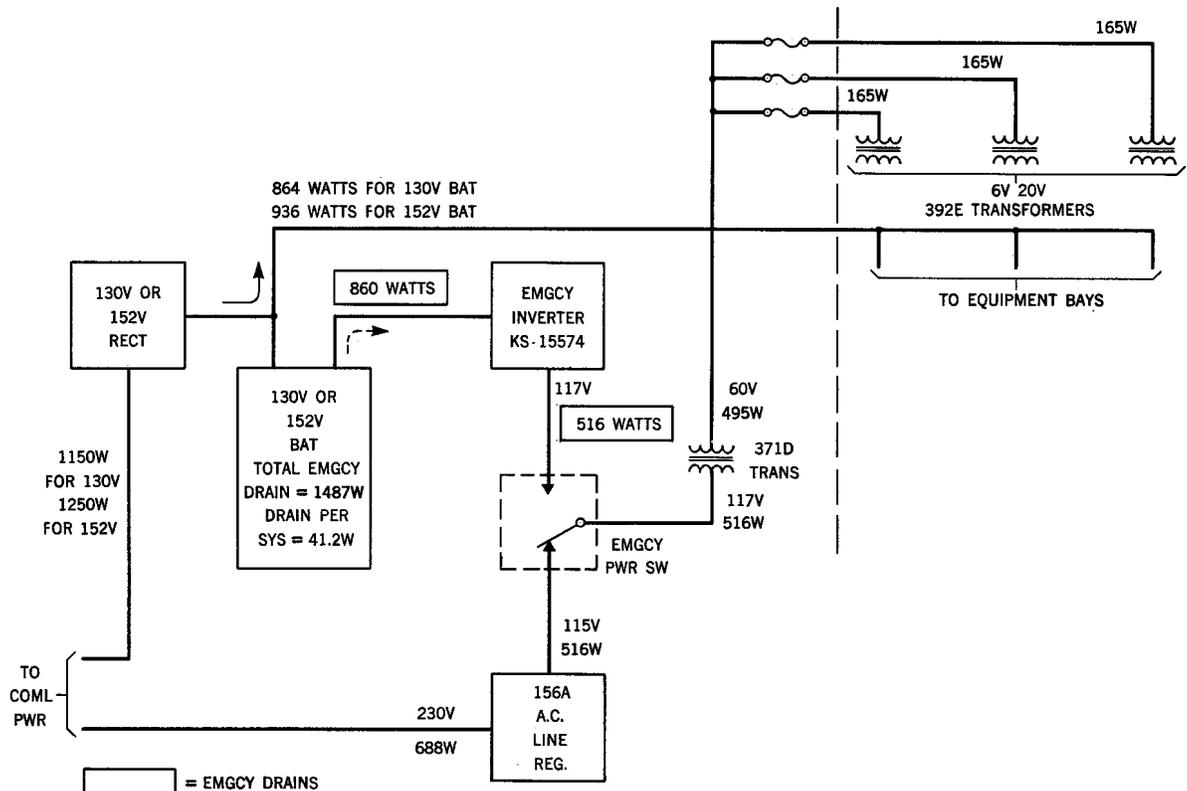


Fig 6 - Power Arrangements for ON/K Equipment

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power transformers to set the 6.1 volts and 9.6 volts supplies. Power requirements of the potentiometers are used to adjust the 19.25 and ON/K system are shown in Table II.

TABLE II

	AVERAGE CURRENT	-24V BAT. (AMPS)	BAT. FOR PLATE SUPPLY (AMPS)	AC FIL 230V (WATTS)	FILEMG 152V OR 130V DC (AMPS)
At +152V Locations	Per Terminal or ON/K Junctions (2 amplifiers)		0.080	9.5	0.061
	Per Repeater (4 amplifiers)		0.160	19.0	0.121
	Per ON/K to ON1 Conn Equip		0.060		
At -24V & +130V Locations	Per Terminal or ON/K Junctions (2 amplifiers)	0.059	0.080	9.5	0.061
	Per Repeater (4 amplifiers)	0.118	0.160	19.0	0.121
	Per ON/K to ON1 Conn Equip		0.060		
At +152V or at -24V and +130V Locations	Per Equalizer (1 tube)		0.013 0.048 (For Fil.) (Supplied by Plate bat.)		