

N3 CARRIER TELEPHONE SYSTEM CARRIER-FREQUENCY SUPPLY DESCRIPTION

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4. HARMONIC GENERATION AND SELECTION	16	1. GENERAL DESCRIPTION	
A. Harmonic Generation	17	A. Purpose	
B. Carrier Selection	19	1.01 The carrier-frequency supply described in this section furnishes the 16 carrier frequencies required for the N3 carrier telephone terminal. It is a compact transistorized assembly of equipment units that delivers adequate carrier power for the	
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operation of as many as 26 N3 terminals. A common carrier supply for many terminals achieves savings in space and battery current, and yields performance improvements which could not be realized economically if carriers were generated in the individual terminals. Noteworthy features include continuous monitoring to detect substandard performance, built-in automatic protection against service interruptions, convenient aids for easy maintenance, and alarms for all trouble conditions.

1.02 This section is reissued to update information on the -21 volt power supply distribution circuit and the secondary carrier distribution shelf and to make other miscellaneous changes. Arrows are used to indicate changes.

1.03 The N3 carrier system is designed as a transmission facility for message intertoll trunks and also for program, data, and other special service circuits. The N3 terminal multiplexes 24 single sideband channels for transmission over N-type facilities. Two independent 12-channel groups make up the 24-channel system. The basic modulation plan for the N3 terminal permits taking advantage of the high order of frequency stability of the common carrier-frequency supply to increase the operating flexibility of the N3 system. In describing the use of each of the 16 frequencies furnished by the carrier supply, the circuits in each terminal can be subdivided into three functional groupings: the channel units, the channel group units, and the group units.

1.04 The channel equipment includes 24 modems arranged in two groups, each group having 12 units. The modulators and demodulators require 12 carrier frequencies spaced at 4-kHz intervals: 148, 152, 156, 160, 164, 168, 172, 176, 180, 184, 188, and 192 kHz. Voice-frequency signals are modulated and filtered to give 12 single sideband channels which are combined to form a basic channel group falling in the range of 148 to 196 kHz.

1.05 The channel group equipment includes two channel group modems, each requiring a single carrier frequency. The channel group carriers are 232 and 280 kHz, respectively. Two channel group bands (148 to 196 kHz) are modulated with the appropriate carriers to place the two independent channel groups in adjacent frequency bands, 36 to 84 kHz and 84 to 132 kHz. The combination produces a group of 24 channels falling in the

standard N low-group frequency range of 36 to 132 kHz.

1.06 The group equipment requires one carrier frequency of 304 kHz. The high-group output signal is obtained by modulating the 36- to 132-kHz band with the 304-kHz group carrier to produce the desired high-group output between 172 and 268 kHz.

1.07 The one remaining carrier frequency, ~~256~~ kHz, is used in a modulator which is part of the N3-L junction equipment. This modulator shifts the frequencies in the N3 channel group band (148 to 196 kHz) to the A-type channel bank range of 60 to 108 kHz. Thus, the N3 and L systems can be interconnected at group frequencies rather than at voice frequencies with substantial reductions in cost.

B. Options

1.08 As the number of terminals connected to a common carrier-frequency supply increases, it becomes important to minimize the probability of service interruptions. The more vulnerable components of the N3 carrier supply have been assembled as plug-in units which can be replaced easily. The shelves on the bay frame have been equipped with pairs of receptacles wired so that plug-in components may be used in duplicate pairs to provide standby protection. One member of each pair of receptacles is designated REG (regular) because it occupies the preferred position and normally contains the working unit. The other receptacle of the pair is designated ALT (alternate) and normally contains the standby unit.

1.09 Detailed descriptions of each of the plug-in assemblies are given later in this section. However, the consideration of the several options will be facilitated by a listing of these plug-in components. They are:

-21 Volt Power Supply (J87245A)

4-kHz Generator (J99300BA)

Doubler Amplifier (J99300BE)

Dual Amplifier (J99300BD)

The 4-kHz generator is available without an internal oscillator as in List 1 (Mfg. Discontinued) or in

List 3. The List 2 (Mfg. Discontinued) and the List 4 generators have a 61A oscillator assembled as an integral part of the unit.♦

1.10 When duplicate units are provided, both the regular and alternate are maintained in operating conditions, and their outputs are monitored at all times. Automatic detection and switching facilities select one unit meeting specified limits from each pair of 4-kHz generators, dual amplifiers, and doubler amplifiers, and connect this unit into the system. Manual key switches for affecting a transfer between units of these pairs are provided as an aid in maintenance. A detailed description of the operation of these manual key switches is given later in this section. A trouble indicating lamp near each unit is lighted if the output is not within the prescribed limits, and the appropriate major or minor alarm is initiated.

1.11 As an economy measure for installations with only a few terminals, a skeleton assembly is operable with a single working unit plugged into one receptacle of each pair. Many of the plug-in units are interchangeable and relatively few spare units are needed. A minimum of five spare plug-in units is sufficient to provide standby protection for the essential carrier frequencies. Both manual and automatic switching between 4-kHz generators, dual amplifiers, and doubler amplifiers is inhibited when duplicate equipment is not installed. Manual and automatic switching is available with standby units. The trouble indicating lamps and the alarm facilities are retained for the skeleton system.

1.12 The basic design of the equipment provides for growth in the number of terminals connected to the carrier supply to the maximum of 26. Plug-in units to provide the desired amount of standby protection can be ordered and installed in the alternate positions. No changes in wiring are needed when installing an alternate unit.

1.13 The required 16 carrier frequencies are furnished and the carrier frequency supply becomes operative without any standby protection when a minimum of ten plug-in units are installed in the appropriate receptacles. The minimum complement of plug-in units must include the following:

1—-21 Volt Power Supply

1—4-kHz Generator

1—Doubler Amplifier

7—Dual Amplifiers

When this set of ten plug-in units is installed in the regular (REG) receptacles and a duplicate set of ten units is placed in the alternate (ALT) receptacles, the carrier-frequency supply has complete standby protection for all functions.

1.14 All of the amplifiers and the output monitoring circuits are energized by the internal -21 volt power supplies. The -21 volt power supply and the transfer relays used for switching the REG and ALT 4-kHz generator and dual and doubler amplifiers and vice versa are energized by the -48 volt office battery supply. Therefore, a reliable connection to the -48 volt office source and a working -21 volt power supply unit are essential. The addition of a second J87245A plug-in unit with its separate fuse will provide standby protection and will greatly reduce the probability of a major service interruption.

1.15 All of the carrier frequencies are derived from a harmonic generator excited by the 4-kHz primary frequency. Therefore, a reliable 4-kHz source and a working 4-kHz generator unit are essential. In offices where there is an L system carrier supply, the 4-kHz input should be taken from suitable taps on this supply. For this application, the J99300BA, List 1, ♦ or the List 3♦ unit should be used. Whenever an internal frequency source for a self-contained system is required, the J99300BA, List 2 ♦ or the List 4♦ 4-kHz generator unit should be used. This unit includes a crystal-controlled oscillator (61A) which is supplied as an integral part of the plug-in assembly. The addition of a second 4-kHz generator will provide standby protection and will greatly reduce the probability of a major service interruption. The standby 4-kHz generator should be excited independently from a second tap on the L system carrier supply or an addition 61A oscillator which is part of the standby unit.

1.16 The doubler amplifier receives a single input, 152 kHz, and delivers two independently regulated outputs to the primary distribution system, 152 kHz and 304 kHz. Since 304 kHz is required for the modulators and demodulators in the group units, a working doubler amplifier is essential. The addition of a second J99300BE plug-in unit will

provide standby protection and will greatly reduce the probability of a major service interruption.

1.17 Each dual amplifier receives two different input frequencies and delivers two independently regulated outputs to the primary distribution system. The dual amplifier plug-in units are interchangeable. The seven pairs of frequencies for the seven units are assigned to particular receptacles. One of the dual amplifiers delivers 168 kHz and 280 kHz. Another delivers 172 kHz and 232 kHz. Since these two units provide the channel group carriers, 232 and 280 kHz, working units in these positions are necessary for operation of N3 terminals. The other units provide channel carriers and a failure of a single unit disables two channels in each channel group. The provision of two spare dual amplifiers in the proper receptacles will provide standby protection for the two channel group carriers. A spare unit can be shifted to any other position when necessary.

C. Features

1.18 The equipment design employs transistors, miniature components, and modern techniques to achieve reliability, easy maintenance, and low cost. The more complex assemblies are constructed as plug-in units that can be replaced easily. The basic shop-wired equipment will always be provided with pairs of receptacles for regular and standby units and with automatic detection and switching facilities to select one unit from each pair. Spare plug-in units can be ordered and installed as alternates to provide the desired amount of standby protection.

1.19 The circuit design provides features to enhance reliability and to minimize service interruptions. Duplicate plug-in assemblies are maintained in an operating condition, and both units are monitored at all times. Automatic switching facilities select from each pair of 4-kHz generators, dual amplifiers, and doubler amplifiers and connect into the system one unit with an output within specified limits. Continuous supervision and evaluation detect substandard performance due to aging or other causes, and automatic switching between working and standby units provides means for quickly bypassing a fault. The failure of a plug-in unit disables the carrier supply for only a few milliseconds.

1.20 The circuit design also includes front panel test jacks and other features to aid preventive

maintenance. Manual switching facilities are provided so that either unit of a pair of 4-kHz generators, dual amplifiers, or doubler amplifiers can be made the working unit. The nonworking unit can always be removed and replaced without interrupting service. However, the removal of a **working** unit will initiate an automatic transfer to the standby unit and the service will be interrupted during the transfer time. Visual indication of the state of the system is provided at all times by index marks on the manual key switches and by a set of lights. Means are provided for automatically initiating both minor and major office alarms whenever faults are detected. Alarm reset buttons are also provided.

Caution: *The index mark on the manual key switch associated with the 4-kHz generators, dual amplifiers, and doubler amplifiers should always be directed toward the working unit before a spare unit is inserted. The arrow on the power supply key switch, if provided, should be in the vertical (NORM) position. The power supply key switch is omitted from current production of the switching and alarm panel.*

D. Description of Circuit

1.21 All of the required carrier frequencies are derived from harmonics of the 4-kHz primary supply frequency. The 4-kHz is obtained from either the internal 61A oscillator or from the standard L carrier 4-kHz primary distribution bus when it is available (1.15). The 4-kHz generator output is connected to the harmonic generator through the associated relay transfer circuit. The harmonic generator uses a saturable magnetic core inductor or "kick coil". Short pulses of current, rich in harmonics of the fundamental frequency, are produced. Bandpass filters are used to select the wanted carrier frequencies from the harmonic spectrum and to reject unwanted frequencies. A regulating amplifier for each carrier frequency maintains the required level for the primary distribution circuit. One distribution bus is provided for each of the 16 carrier frequencies. The bus for the group carrier and for each of the channel group carriers has provision for 26 taps. All others have 13 taps.

1.22 The 16 carrier supply frequencies range from 148 kHz (the 37th harmonic of 4 kHz) to 304

kHz (the 76th harmonic of 4 kHz). The outputs are sinusoidal voltages of an extraordinary degree of purity, the unwanted tones being at least 60 dB below the wanted carrier. Accuracy of the 16 carrier frequencies is ensured to within six parts per million by the high accuracy of the 4-kHz source.

1.23 All carriers are furnished to the terminal bays from the primary distribution unit which is part of the carrier supply bay assembly. Secondary distribution units are located on each 11-foot 6-inch high N3 terminal bay and on every other 9-foot and 7-foot high N3 terminal bay and are connected to the carrier supply by a cable. The J99300E distribution panel (Section 362-915-100) was used in early manufactured terminal bays. The ED-3C172-30 distribution shelf (Section 362-915-101) for plug-in distribution amplifiers is used in terminal bays of later manufacture. As many as 13 secondary distribution units can be connected to one primary distribution unit, and each secondary distribution circuit furnishes all carriers to the one or two N3 carrier telephone terminals in a bay.

1.24 The primary distribution circuit is energized by 16 regulating amplifiers, one being used for each carrier frequency. The level of each carrier is automatically maintained within ± 0.5 dB of the nominal value. The regulating amplifiers are adjusted during manufacture and no installation or routine adjustments are necessary.

1.25 Each secondary distribution circuit is energized through a cable from the primary distribution unit. Adjustable pads are provided in the secondary distribution circuit to compensate for the loss in the cable.

1.26 The J99300E secondary distribution panel provides adjustable loss pads to control the level of each carrier used by a modulator or demodulator. The pad loss can be varied in 0.5-dB steps from 0 to 1.5 dB by opening or shorting out resistors with screw-type switches.

1.27 The secondary distribution unit provides additional regulation for the carriers transmitted as line regulation pilots. The secondary carrier regulator output changes less than ± 0.05 dB for ± 1 dB changes in input.

Caution: *The carrier regulator outputs are adjusted during manufacture to an absolute level within ± 0.1 dB and since test equipment of the required accuracy is not generally available, no other adjustment should be attempted in the field.*

1.28 The ED-3C172-30 secondary distribution shelf provides mountings for nine single-module distribution amplifier plug-in units. Adjustable pads in the amplifier input circuit allow adjustment to within 0.25 dB of the desired amplifier output power. Additional regulation is provided for the carriers transmitted as line pilots. The regulated amplifier supplies a power level which is regulated to within ± 0.05 dB for the carrier signal transmitted to the high-frequency line.

E. Description of Equipment

1.29 The equipment for the N3 carrier-frequency supply is a composite assembly of panels for passive apparatus and shelves for active plug-in components. The shelves must be equipped with a minimum complement of plug-in units consisting of a power supply, a 4-kHz generator, a doubler amplifier, and seven dual amplifiers. Automatic protection of each plug-in unit can be achieved by adding a duplicate unit in its adjacent position. The degree of protection required is dependent upon the number of terminals and the importance of the circuits served.

1.30 The carrier supply equipment is assembled on a 23-inch duct-type bay frame and is completely shop wired. The assembly occupies 45 inches of vertical space in the bay frame. Figure 1 shows a completely equipped carrier supply as viewed from the front. Two cast aluminum shelves near the bottom of the figure are shown fully equipped with plug-in assemblies. These shelves are separated by the switching and alarm panel which contains all of the alarm lights for monitoring the individual units and the manual key switches for selecting either the regular or the alternate 4-kHz generator or dual or doubler amplifier. Each plug-in unit consists of a printed wiring board enclosed by a die-cast aluminum unit frame. It is equipped with a latch which serves both as a lock and as an extraction lever. Grooves in the shelf casting serve as "ceiling" and "floor" guides and orient the unit with respect to a connector which mates with tabs on the printed wiring board. The connector is positioned accurately in the vertical

rear portion of the shelf. The carrier supply uses the same shelves, unit frame, latch, and connector arrangements as the N3 terminal.

1.31 The shelves are wired so that every plug-in unit can be protected by a spare unit in the position adjacent to it. Similar units are interchangeable, and both the regular and the alternate units of a pair are energized. Each unit contains means for monitoring its output and a relay for indicating that the unit output is within preselected limits. Alarm lights for easy identification of a faulty unit are either directly over or directly under each plug-in position. A manual key switch for the selection of the regular or alternate 4-kHz generator, dual amplifier, or doubler amplifier is between each pair of lights and indicates which position is selected by means of a white index line. If one unit fails, the load is switched automatically to the other unit. The interconnecting logic circuit between positions is such that automatic or manual switching can occur only when a unit is protected by a working spare. The manual key switch associated with the regular and alternate -21 volt power supplies does not serve to select either supply as the working unit. This switch is disabled in switching and alarm panels modified to inhibit combining of the two -21 volt distribution circuits (6.14) and is eliminated from current production of the panel.

1.32 The other panels that make up the carrier supply are the harmonic generator and carrier filter panel, the switching relay panel, the primary distribution panel, and the fuse and alarm panel. Fifteen crystal filters select the wanted carrier frequencies from the harmonic spectrum produced by the nonlinear inductor in the harmonic generator. The selected frequencies are amplified, regulated, and monitored for output power in the dual and doubler amplifier units. Nine wire-spring relays transfer the outputs of the amplifiers from a working load to a dummy load and vice versa. Two separate -21 volt distribution circuits are provided when both regular and alternate -21 volt power supplies are installed. The regular -21 volt power supply will power all regular units and the alternate -21 volt power supply will power all alternate units. Previously, when only one -21 volt power supply was provided, a microswitch at the rear of the unequipped power supply position activated and combined the two -21 volt buses. The microswitches are disconnected in switching and alarm panels modified to inhibit combining of

the two -21 volt distribution circuits (6.14) and are eliminated from current production of the panel. Preliminary distribution to 13 distribution cables and final filtering are accomplished in the primary distribution panel. All pairs are distributed from wire-wrap terminals mounted on the front edge of printed circuit cards. Distribution cable pairs are connected directly to the terminals on the cards by the installer, thus eliminating the need for a separate terminal strip. Final distribution and level adjustment are accomplished through a secondary distribution panel mounted on each 11-foot 6-inch high N3 carrier terminal bay or on every other 9-foot or 7-foot high N3 carrier terminal bay.

2. CARRIER-FREQUENCY GENERATION

2.01 The Bell System standard channel format for single sideband systems is assembled with carriers spaced uniformly at 4-kHz intervals. Thus, all of the carriers required for the N3 Carrier Telephone System are multiples of 4 kHz. The carrier supply starts with a primary source of a 4-kHz sine wave. Harmonics are produced by converting the sinusoidal waveform into sharply peaked pulses having a broad frequency spectrum. The output of the harmonic generator circuit contains all of the desired harmonics and a great many unwanted harmonics of 4 kHz. The wanted frequencies are selected by means of crystal filters, amplified, and delivered to a primary distribution circuit. The 16 carrier frequencies are fed through cables to the secondary distribution circuits located on the terminal bays.

2.02 The schematic block diagram, Fig. 2, shows the essential components of the carrier supply circuit. The important relationships can be placed in evidence by analyzing the parts separately.

A. Primary Frequency Source

2.03 The primary frequency source for the carrier supply comprises a 4-kHz oscillator and an amplifier. The oscillator may be omitted in offices where the L system carrier supply is available. The built-in oscillator is provided as part of the 4-kHz generator unit whenever an internal frequency source for a self-contained system is required. Duplication of the oscillator and amplifier circuits provides for protection against failure in a particular office. Each amplifier is equipped with monitoring facilities which determine whether the output current is within proper limits. A relay initiates office

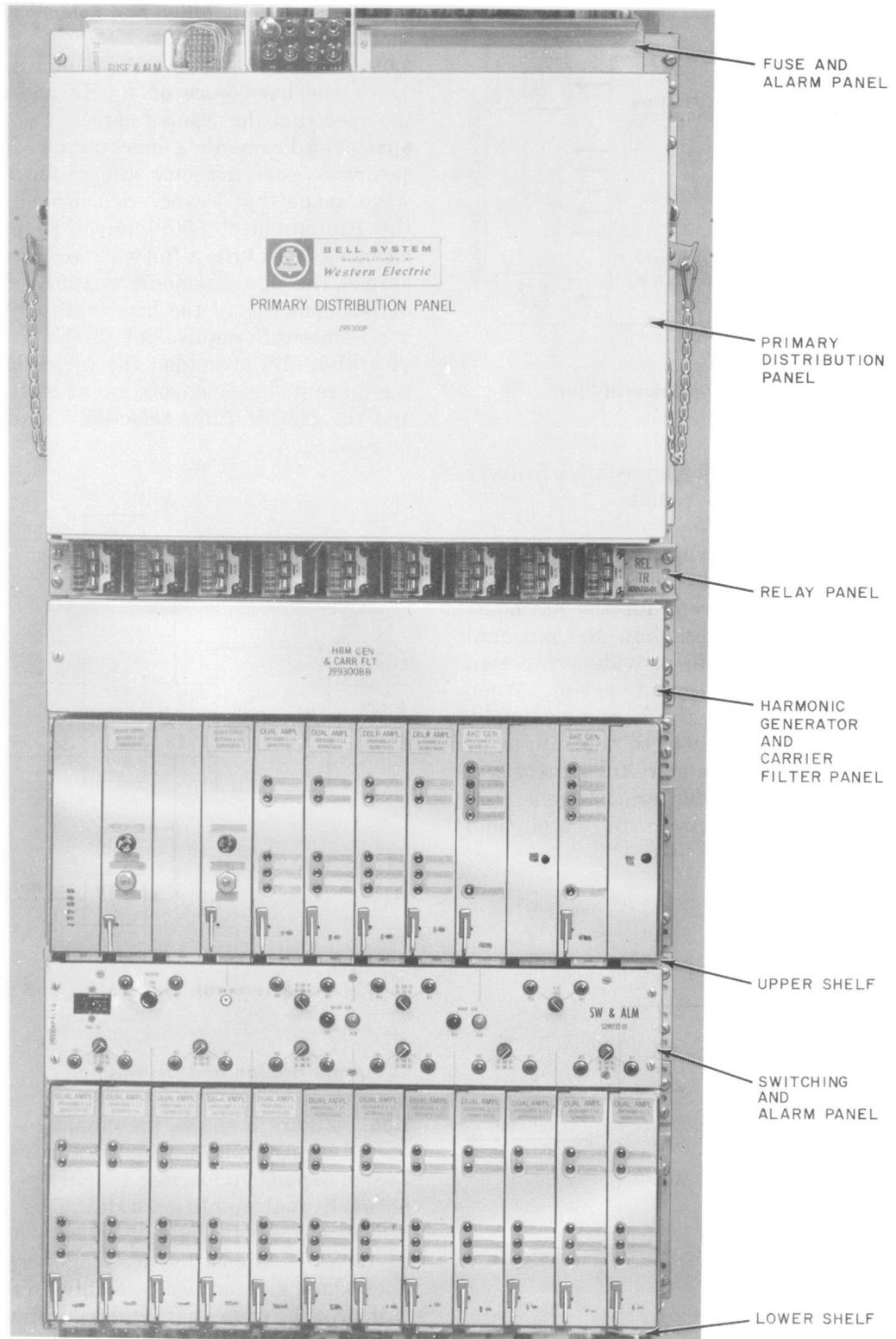


Fig. 1—N3 Carrier Supply

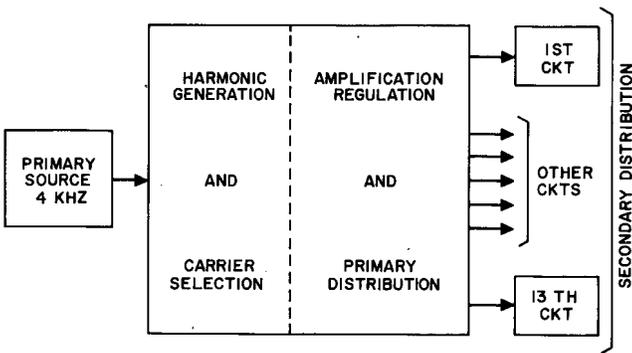


Fig. 2—Carrier Supply—General Plan

alarms and automatic switching transfers whenever the output is not within proper limits.

2.04 The schematic block diagram, Fig. 3, shows the essential components of the circuit which provides the excitation current for the harmonic generator. The dotted lines show the optional standby equipment that will provide protection against failure of a fully equipped system. When the 4 kHz is available from the L carrier supply, the signal will be fed directly to the inputs of two amplifiers. Both amplifiers are fully energized. The working amplifier drives the harmonic generator, and the standby amplifier delivers full output into a resistive termination.

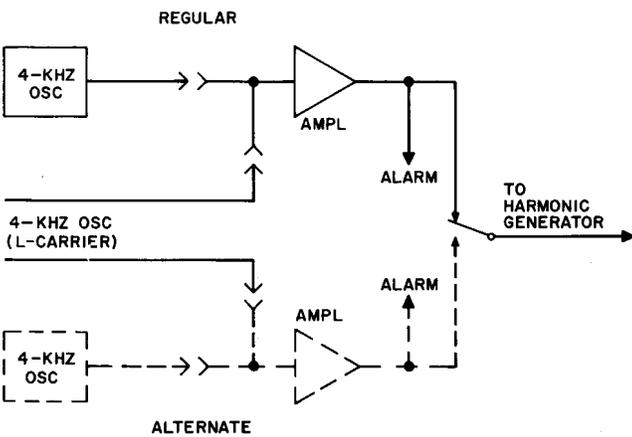


Fig. 3—Primary 4-kHz Source

B. Harmonic Generation and Selection

2.05 Figure 4 shows the circuit which generates the harmonics of 4 kHz and selects from the spectrum the wanted carrier frequencies. The passive harmonic generator circuit employs a saturable core inductor and produces an output wave shape that is very rich in odd harmonics of the fundamental frequency. To produce even harmonics of 4 kHz, a full-wave rectifier is connected across the odd harmonic output. The rectifier output contains all the harmonics of 8 kHz, which are numerically equivalent to the even harmonics of 4 kHz. By arranging the filters in two groups, the unwanted components are at least 8 kHz away, and the pickoff filter selectivity requirements can be relaxed.

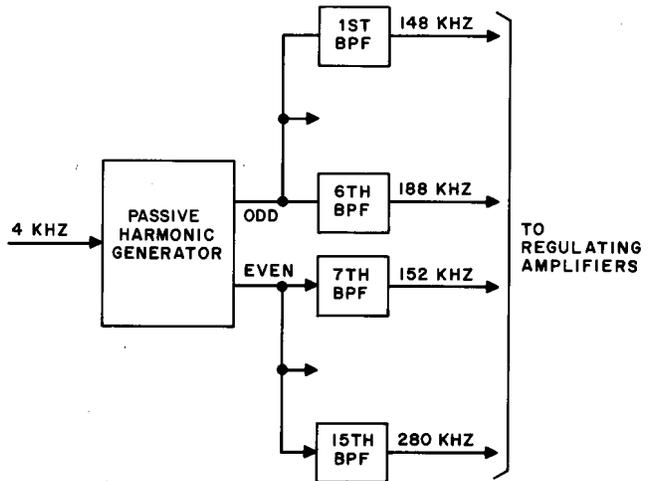


Fig. 4—Harmonic Generation and Selection

C. Amplification and Distribution

2.06 Figure 5 shows the circuit used to amplify, regulate, and distribute the carrier frequencies. Two independent carrier amplifiers are provided on each dual amplifier unit. This arrangement utilizes space efficiently and allows one monitoring circuit to be shared by two amplifiers. The dotted lines show the optional standby equipment which will provide protection against failure of a fully equipped system.

2.07 In a fully equipped system, one amplifier in the regular unit and one amplifier in the alternate unit receive inputs from the same bandpass

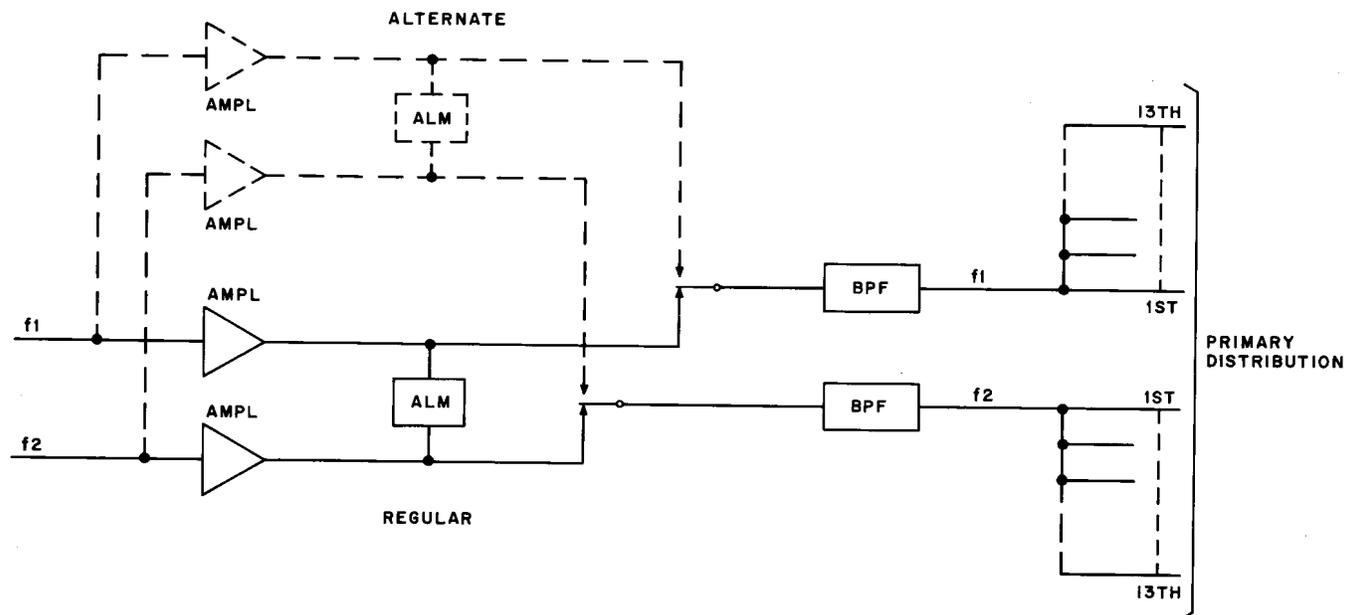


Fig. 5—Amplification and Distribution

filter. The second amplifier in the regular unit and the second amplifier in the alternate unit receive inputs from another bandpass filter. The two amplifiers on a plug-in assembly share a switching and alarm circuit but otherwise function independently. Each amplifier accepts any input within a relatively wide amplitude range and delivers to the distribution system an output that is almost constant.

2.08 Control of the output is achieved by operating the transistors in a switching mode. Each transistor is alternately cut off and saturated to produce a truncated sine wave. The output filter selects the wanted frequency and suppresses its harmonics so that the voltage delivered to the primary distribution bus is a relatively pure sine wave. In addition to being regulators, these circuits are relatively efficient in comparison with Class A amplifiers.

3. PRIMARY FREQUENCY SOURCE

A. 4-kHz Generator Circuit

3.01 The 4-kHz generator is a plug-in equipment unit which includes an amplifier and monitoring facilities to determine whether the output current is within proper limits. The primary function of the circuit is to provide current to excite the

harmonic generator. A second important function is to provide information to the switching and alarm system whenever the excitation current is not adequate to excite the harmonic generator properly. The excitation current is obtained by amplifying the output of an oscillator with a negative feedback stabilized amplifier. The 4-kHz input current for the amplifier is provided either by the 61A oscillator which is an optional component of the assembly or from a tap on the L system carrier supply.

B. Oscillator

3.02 In offices where the L carrier supply is not available, the 4-kHz base frequency is generated by a 61A oscillator. This oscillator is provided when needed as part of the 4-kHz generator assembly. The output of the 61A oscillator is compatible with that provided by the L base frequency generator. The balanced output is adjusted to be between +0.5 and +1.5 dBm when the load resistance is 135 ohms. The harmonic distortion is at least 35 dB below the fundamental at the output.

3.03 The 61A oscillator is comprised of an oven with its associated temperature control circuit, an oscillator utilizing an 8-kHz crystal unit, a

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frequency divider circuit, and a 4-kHz output circuit. Figure 6 is a block diagram showing the relationships between the several parts.

3.04 The crystal unit selected to control the frequency of the oscillator is an 8-kHz, 60-degree NT plate mounted in an oven. The oven temperature is maintained at approximately 65°C which is 5°C above the highest expected ambient temperature. When the 61A oscillator is subjected to ambient temperatures ranging from 20° to 60°C, the changes from nominal frequency do not exceed one part per million. However, frequency changes due to aging of the crystal unit may be as great as 10 parts per million per year. Therefore, a manual control provided on the generator assembly should be used periodically to adjust the frequency. System frequency errors will not exceed six parts per million if semiannual checking and adjustment procedures are maintained.

3.05 The oven temperature is maintained near 65°C by using the proportional control method. The amount of heat added by the heating element R within the oven is proportional to the difference between the oven and the ambient temperatures. Thus, heat is added within the oven at the same rate that it is being transferred to the outside air. The oven temperature sensing element is the thermistor RT1 embedded in the crystal heat sink. This temperature-sensitive resistor forms one arm of a bridge network in the oscillator section of the temperature control circuit. Its comparison arm is a stable wire-wound resistor.

3.06 The 8-kHz oscillator schematic diagram is shown in Fig. 7. It uses two transistors in the forward gain path and a crystal unit in the feedback path. The phase network is a low-pass

filter section operating near its cutoff frequency of 8 kHz, thus giving the proper phase shift and eliminating the possibility of oscillation at unwanted modes of the crystal unit.

3.07 Transistor Q6 is connected as an emitter follower to increase the input resistance of the circuit in order to maintain a small crystal current while providing sufficient emitter current to drive the second stage. Transistor Q7 is connected as a common emitter amplifier. This stage is self-limiting at about 12 volts peak-to-peak collector output voltage. The two transistors together provide 180 degrees phase shift. Since the phase network (C13, L1, C14) provides 180 degrees phase shift near 8 kHz, the condition for oscillation requires 0 degrees phase shift in the feedback circuit. Therefore, the crystal is operated near the series resonant frequency as a positive reactance in series with the variable capacitor (C15, C16) which is available for frequency adjustment.

3.08 Since an 8-kHz crystal unit has been used in order to avoid the relatively large size of a 4-kHz plate, one stage of frequency division is necessary. Figure 8 shows the circuit used. Transistors Q8 and Q9 are connected as a Schmitt trigger circuit that produces an 8-kHz square wave. Transistors Q10 and Q11 are connected as a bi-stable flip-flop stage with a diode steering circuit. Since the flip-flop reverses at an 8-kHz rate and since two reversals are required to complete a cycle, the output square wave will vary at one-half the rate of the input wave.

3.09 Transistor Q8 is biased so that a 4-volt peak-to-peak signal from the oscillator will cause the circuit to trigger. Thus, it serves as a buffer stage which permits considerable decoupling

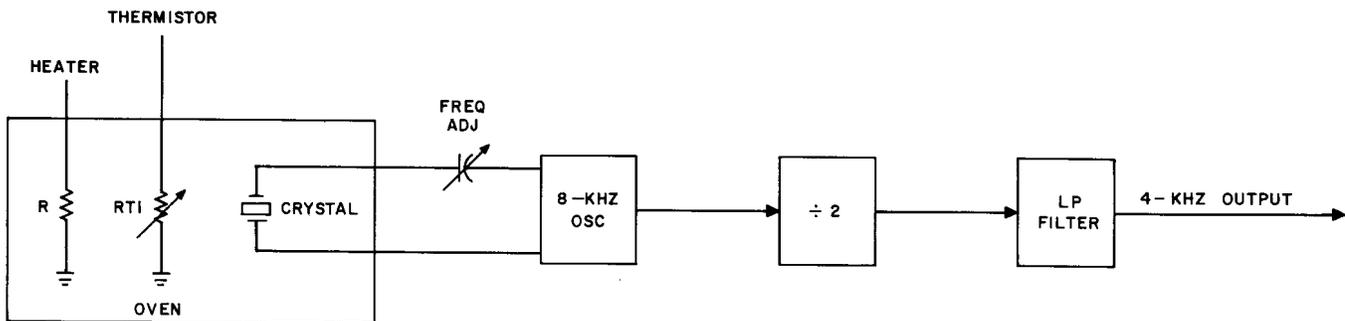


Fig. 6—61A Oscillator, Block Diagram

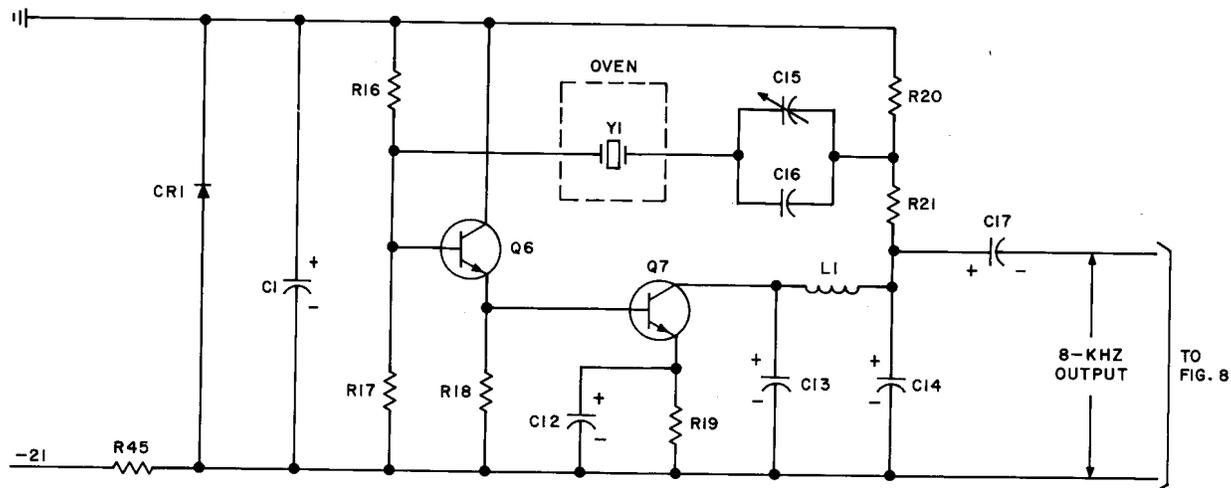


Fig. 7—8-kHz Oscillator

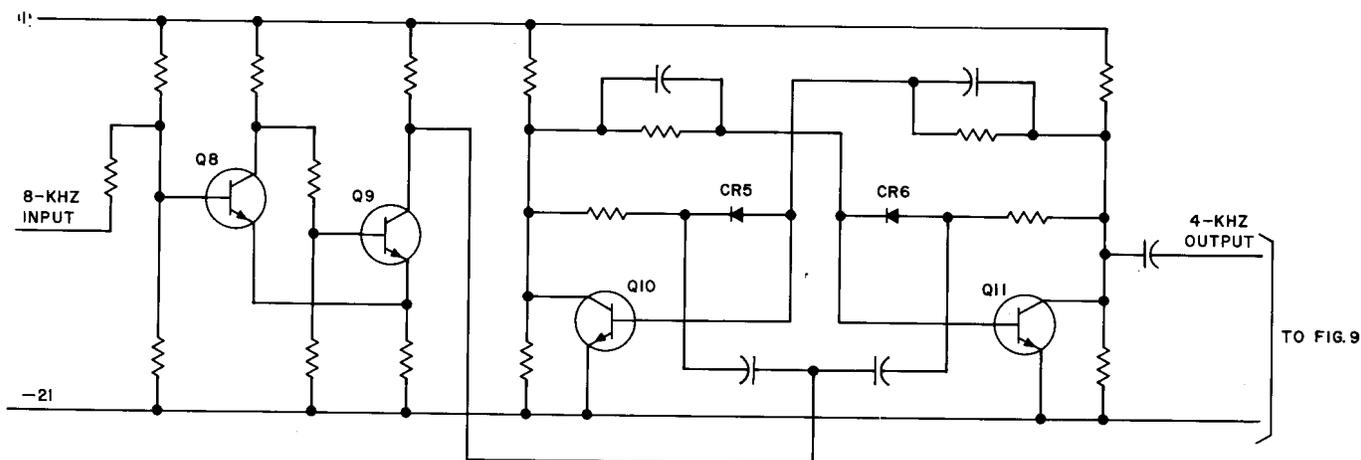


Fig. 8—Frequency Divider

from the oscillator while maintaining an adequate margin to ensure triggering.

3.10 Figure 9 shows the circuit used to produce a 4-kHz sine wave from the square-wave output of the divider. Transistor Q12 is used as an amplifier, the output being taken from a variable resistor in the collector circuit. A low-pass filter is used to couple the signal to the output transformer in order to select the 4-kHz fundamental and to discriminate against harmonics. Harmonics in the output are at least 35 dB below the fundamental. The amplifier is adjusted to deliver +1 dBm into a 135-ohm load.

C. Oven Control Circuit

3.11 The frequency stability of the oscillator is enhanced when the crystal unit is enclosed in a temperature-controlled oven. When current flows through a resistor within the oven, heat is generated and the inside temperature rises. Heat is transferred from the oven to the ambient air, and an equilibrium condition is established when heat is generated within the oven and transferred to the outside at the same rate. An equilibrium temperature for the oven, somewhat above the highest expected temperature for the ambient air, can be maintained within close limits by a method

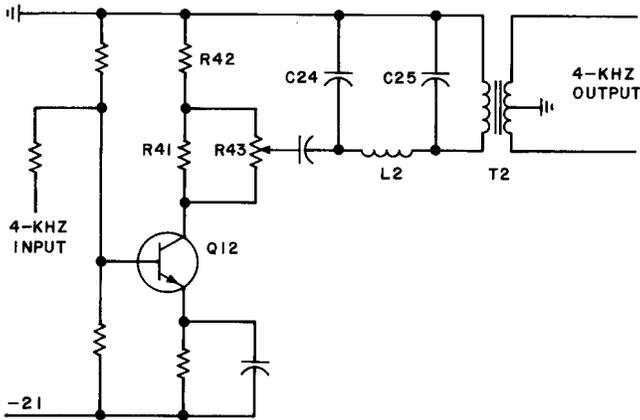


Fig. 9—4-kHz Output Circuit

known as proportional control. Amplification of the current in the control loop permits a very small change in oven temperature to produce a large change in the power delivered to the heater. Thus, compensation for the heat loss to the ambient air is provided and control of the oven temperature is achieved.

3.12 The performance characteristics of the oven temperature control circuit can be described with reference to the simplified model shown in Fig. 10. The essential quantities have been defined as follows. Let T represent any given ambient air temperature between the limits T_{max} and T_{min} which specifies the range of air temperatures within which temperature control is required. Also, let t represent the oven temperature between t_{min} and t_{max} that exists when the air temperature is T and the equilibrium condition has been established.

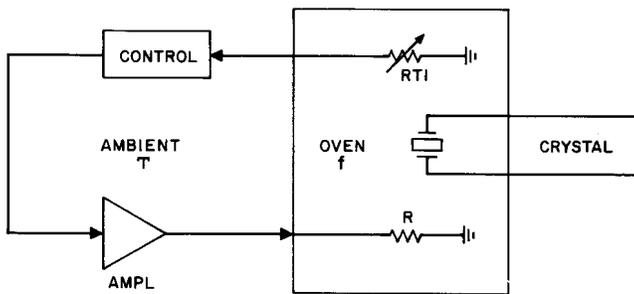


Fig. 10—Oven Temperature Control

3.13 Assuming that the rate of heat transfer is proportional to the temperature difference between the oven and the ambient air, the minimum power (W_{min}) delivered to the heater is

$$W_{min} = k (t_{min} - T_{max})$$

where k is a constant of proportionality that involves thermal quantities. If the ambient air temperature is T_{min} and if the control circuit provides the maximum power it is capable of delivering to the heater, the maximum electrical power (W_{max}) converted into heat is

$$W_{max} = k (t_{max} - T_{min})$$

If the ambient air temperature is T_{max} and if no power is delivered to the heater, the oven temperature will be T_{max} also. To retain control, it is necessary to deliver power sufficient to raise the oven temperature to t_{max} which should be somewhat above T_{max} , or in this case about $5^{\circ}C$.

3.14 Changes in oven temperature control the power delivered to the heater, and the power converted into heat can be described by the equation

$$W = W_{min} + A\beta[k (t_{max} - t)]$$

where $A\beta$ is a factor representing the gain in the control loop. In a well designed control system, t_{min} should not be much less than t_{max} and in 3.15 it will be convenient to assume that the difference between t_{max} and t_{min} is negligible.

3.15 After the equilibrium condition is established, the rate of heat flow into the oven must equal the rate of heat flow out of the oven. Thus, equating the expression for power converted into heat inside the oven (derived in 3.13 and 3.14) to the corresponding expression for heat transferred to the outside air

$$k(t_{max} - T_{max}) + A\beta k(t_{max} - t) = k(t - T)$$

$$(t_{max} - t) = \frac{T_{max} - T}{1 + A\beta}$$

This equation shows the most important characteristic of the proportional control feedback system. For any given change in ambient air temperature the change in oven temperature can be made very small by making $A\beta$ large. As the ambient air temperature changes, the oven temperature also changes to provide a control signal. However, as

shown in the equation above, these changes can be made very small if the control loop gain is large.

3.16 The schematic diagram, Fig. 11, shows the circuit that provides the high gain required to produce precise control of oven temperature. Transistors Q1 and Q2 together with a feedback circuit through hybrid transformer T1 are connected so that oscillations are produced. The magnitude depends upon the amount of unbalance between resistor R9 and the resistance of thermistor RT1 which is inside the oven. The frequency of the oscillation is relatively unimportant but circuit values have been chosen to place it between 7 and 8 kHz. When the oven temperature is low, the resistance of the thermistor is high and oscillations of large magnitude are produced. As the oven temperature rises toward the desired value, the thermistor resistance decreases and approaches the resistance of R9, and the magnitude of oscillation decreases.

3.17 The oscillator output is rectified by diodes CR2 and CR3 which are connected in a voltage-doubler circuit. The current from the rectifier is amplified by transistors Q3, Q4, and Q5. The amplified current flows through the heater resistance and generates heat inside the oven, the amount of heat being dependent upon the error signal measured by thermistor RT1.

D. 4-kHz Amplifier

3.18 The 4-kHz amplifier is used to amplify the current provided either by the local oscillator or by the L system carrier supply. The current gain of the amplifier is sufficient to deliver adequate output current to excite the harmonic generator. Since the harmonic generator includes a saturable magnetic core inductor, its input impedance changes depending upon the magnitude of the input current. Therefore, the amplifier uses negative feedback to maintain an output current amplitude that is relatively insensitive to changes in the impedance of the load. If the voltage fed back to the input mesh is proportional to the output current, the amplifier will approximate a constant-current source for exciting the harmonic generator. The amplifier also has a balanced structure which tends to make the output current waveform almost free of even-order harmonics of 4 kHz which would degrade the performance of the harmonic generator. The simplified schematic diagram on Fig. 12 shows the circuit used for the amplifier.

3.19 Input transformer T1 is a 3-winding transformer terminated by resistors. It presents an impedance of 270 ohms to the input source. A 270-ohm resistor is connected in parallel with the amplifier input so that the combination presents an impedance of 135 ohms to the 4-kHz source when the input is furnished by the L carrier supply.

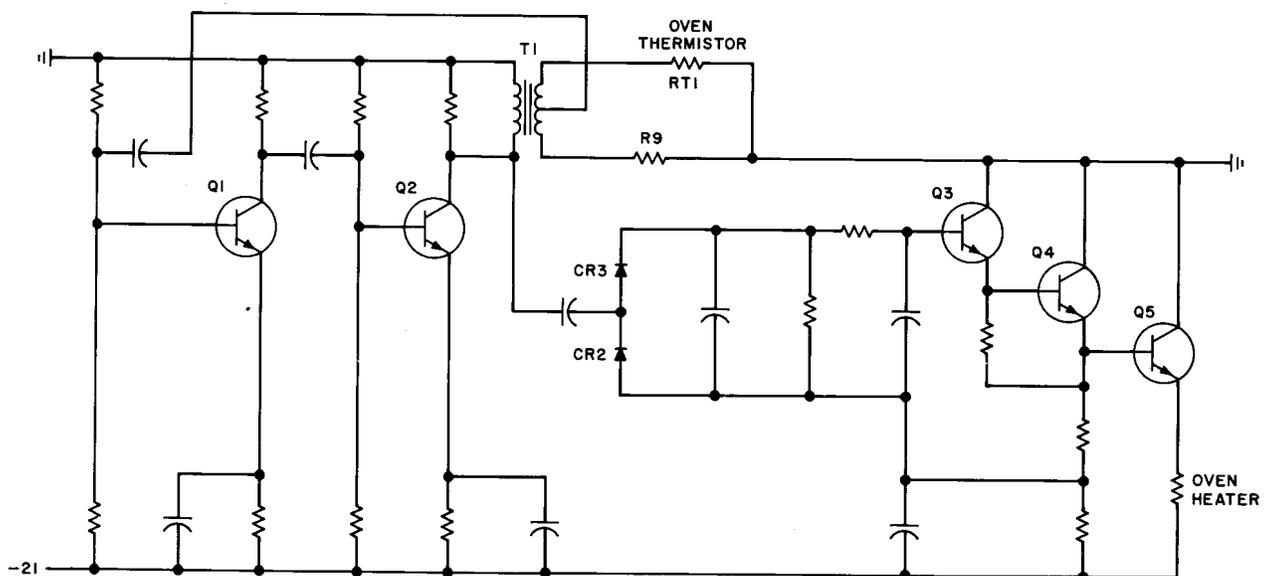


Fig. 11—Temperature Control Circuit

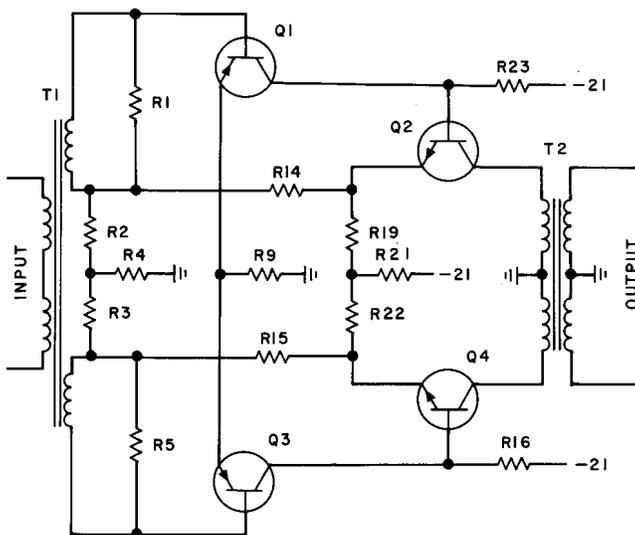


Fig. 12—4-kHz Amplifier

The oven alarm circuit and the amplifier input in parallel combination present an impedance of 135 ohms to the 61A oscillator when it is furnished. The transformer has two separate secondary windings which are connected to the bases of transistors Q1 and Q3 so that the base currents have equal magnitudes and opposite phases. The separate windings permit both bias voltages and signal feedback voltages to be developed across resistors R2, R3, and R4. The input voltages from the transformer and the voltages fed back from the output stage are added algebraically in the base-emitter meshes to form the net input voltage to the first stage.

3.20 Output transformer T2 serves to combine the output currents of transistors Q2 and Q4 and to provide a balanced-to-ground voltage across the load. This circuit, commonly called a push-pull circuit, has another important property. The even-order distortion products in the current waveforms tend to cancel.

E. Monitoring Circuit

3.21 The circuits monitoring the harmonic generator excitation current and the 61A oscillator oven temperature are part of the 4-kHz generator assembly. Detectors are used to derive currents proportional to deviations in the quantities being monitored. These currents are combined through

logic circuits and are used to operate a trigger circuit. Whenever the deviations produce a current that exceeds the preselected threshold of the trigger circuit, it operates and in turn operates the sensing relay. Operation of the relay indicates that either the oven temperature is out of limits, the excitation current is below a specified minimum, or the 4-kHz waveform is unsymmetrical. The relay contacts are used by the switching and alarm circuit to activate audible and visual alarms and to initiate an automatic transfer to a standby unit if one has been provided.

3.22 The 4-kHz current sensing circuit is shown in Fig. 13. It consists of two voltage-doubling peak rectifiers which measure separately the ac components of the voltage drops across the two emitter resistors in the output stage of the 4-kHz amplifier. The total current through each resistor includes the dc emitter current and the ac signal current. Capacitors C8 and C9 block the direct current. When the ac voltage across the Q2 emitter resistor R19 becomes negative with respect to ground, a pulse of current flows through diode CR5, and capacitor C8 is charged to the peak voltage. The terminal of C8 connected to the emitter becomes negative with respect to ground. At the peak of the next half-cycle, a positive voltage is added to the voltage across C8 and a pulse of current flows through CR1. Capacitor C11 is charged to almost twice the peak voltage of the ac wave. The capacitor discharges through the resistors of the summing amplifier shown in Fig. 15 and described in 3.24. If the charging time constant is much less than the discharging time constant, the voltage across C11 is a measure of the 4-kHz current output of transistor Q2. Diodes CR2 and CR6 and capacitors C9 and C12 are used in a similar circuit to measure the current for transistor Q4. Both rectifier output voltages are positive with respect to ground, this being the polarity required by the logic circuit which is described in 3.24. Pin jacks J1 and J2 are provided to permit measurement of the voltages from the front panel of the unit.

3.23 The oven temperature sensing circuit is shown in Fig. 14. Two resistors and a transformer are connected in a bridge circuit which is excited by the 61A oscillator. The resistance of thermistor RT2 depends upon the temperature inside the oven. Resistor R6 is placed in the opposite arm of the circuit and is adjusted to balance the bridge circuit at the nominal temperature

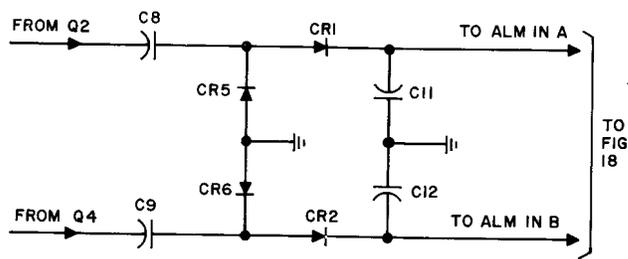


Fig. 13—4-kHz Sensing Circuit

of the oven. If the thermistor resistance either increases or decreases due to a change in oven temperature, the circuit becomes unbalanced and a voltage appears across transformer T3. To avoid heating of the thermistor, the 4-kHz signal current is low and amplification is necessary. The feedback amplifier shown in Fig. 14 comprises two stages which include transistors Q5 and Q6. Resistors R12 and R13 form a feedback circuit which makes the amplifier gain insensitive to variations in the parameters of the transistors. A voltage-doubling peak rectifier, similar to the one described in 3.22, produces a negative voltage across C7 that is proportional to the magnitude of the unbalance voltage. Diode CR9 is used as a gate. When the oven temperature is within acceptable limits, this diode is back-biased, and therefore is nonconducting. When the oven temperature exceeds the allowable deviation from normal, the voltage across C7 becomes sufficiently negative to cause diode CR9 to conduct. Current then flows into the summing amplifier described in 3.24.

3.24 The summing amplifier, which performs several essential functions in the logic circuit, is shown in Fig. 15. Transistors Q7 and Q8 comprise a balanced amplifier having both differential and common mode gain. Pin jacks J3 and J4 on the front panel of the unit can be used to measure the output voltages at the two collectors. Variable resistor R45 can be adjusted to make the two collector voltages equal, and variable resistor R27 serves to adjust the magnitude of both voltages together. Since the circuit is symmetrical, it is relatively insensitive to changes in the transistor parameters due to changes in temperature. Diodes CR7 and CR8 are part of a logic circuit which selects the least negative of the two collector voltages and connects the output to the trigger

circuit described in 3.25. When the input voltages, ALM IN A and ALM IN B, are both positive and increase in magnitude together, the collector voltages decrease together. The common mode gain of this circuit is sufficient to actuate the trigger whenever the 4-kHz amplifier output current decreases below the selected threshold. When the input voltages, ALM IN A and ALM IN B, become different in magnitude, the differential voltage is amplified to cause large equal and opposite changes in the collector voltages. One collector voltage becomes sufficiently small to actuate the trigger whenever the 4-kHz amplifier output currents become unequal. The oven alarm input is connected to the base of Q8 through a diode gate. If the voltage becomes sufficiently large, one collector voltage decreases sufficiently to actuate the trigger.

3.25 The monitoring circuits have a common output: namely, the contacts on relay K1 which are part of the switching and alarm system. The trigger circuit that causes the relay to operate is shown in Fig. 16. A trigger circuit uses both positive and negative feedback to establish thresholds for operation and release of a relay. Adjustment of the relay is not critical since the current in the coil is either zero or large enough to operate the relay reliably. Only these two states are stable. When the threshold is crossed, the state is reversed by the regenerative action of the circuit. By eliminating marginal operation of the relay (ie, the normal spread between operate and release currents), the transition from operate to release, or vice versa, always proceeds rapidly. This feature is essential when the control signal is a slowly varying quantity.

3.26 The trigger circuit includes transistors Q9 and Q10 together with biasing and feedback resistors. The input circuit includes varistors RV1 and RV2 and avalanche diode CR12 which are shown in Fig. 15. The varistors provide temperature compensation for the diode, and the series combination produces a constant voltage drop. By subtracting this voltage in the coupling circuit, the sensitivity of the system is enhanced. Resistors R36, R37, and R38 complete a feedback loop which may be either positive or negative depending upon the input voltage and the current gains of the two transistors. The circuit has been designed so that in the absence of an input signal, transistor Q9 is conducting and Q10 is cut off. When the input

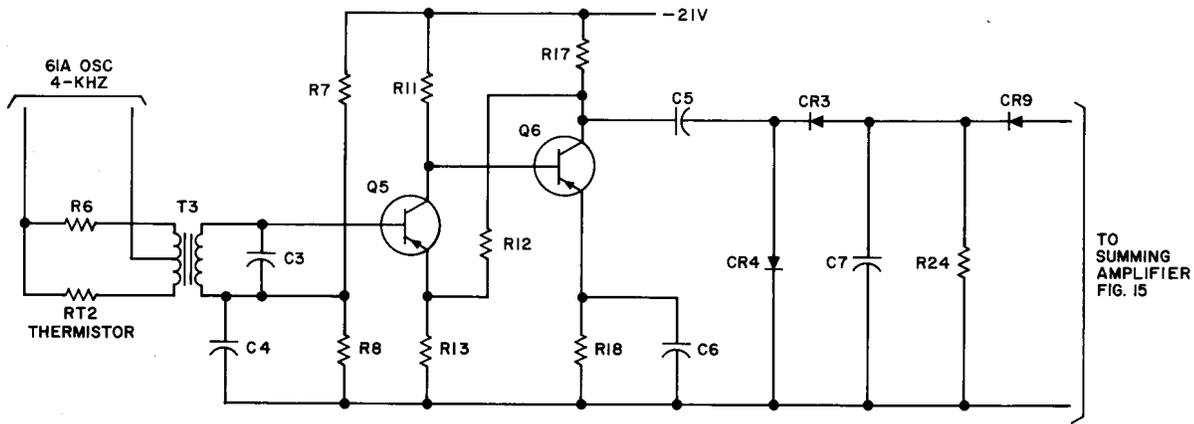


Fig. 14—Oven Temperature Sensing Circuit

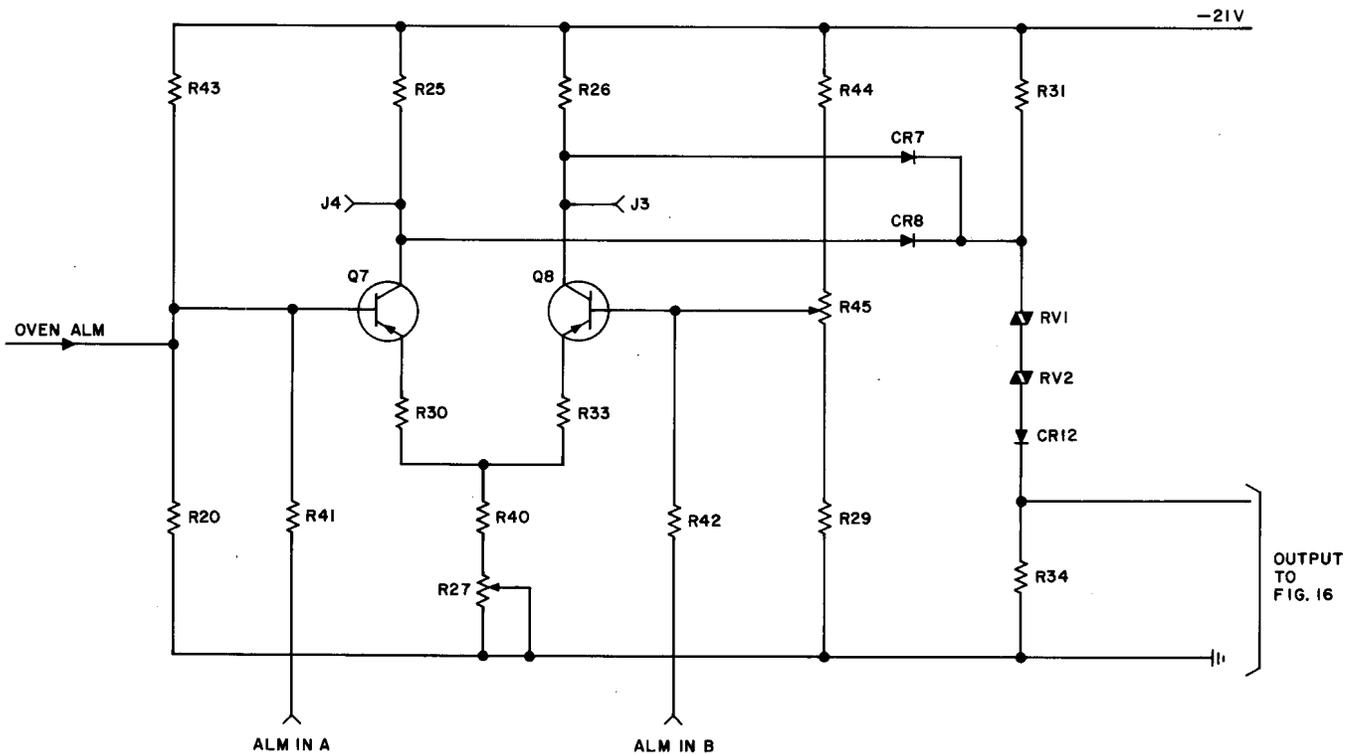


Fig. 15—Summing Amplifier

voltage becomes sufficiently small, the collector current in Q9 decreases. Current through R37 to the Q10 base causes the transistor to begin to conduct. The collector current of Q10 increases until the net gain around the 2-transistor loop exceeds unity. Since this is a positive feedback loop, regeneration occurs and the process proceeds rapidly until transistor Q9 is cut off by the voltage

across R36. Since Q10 is conducting heavily, relay K1 operates with minimum transition time.

4. HARMONIC GENERATION AND SELECTION

4.01 The harmonic producer which provides the carriers for the N3 carrier supply has been designed to generate simultaneously a number of

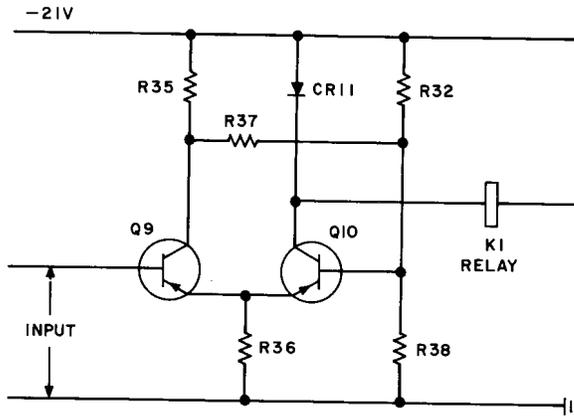


Fig. 16—Trigger Circuit

harmonics of approximately the same amplitude. Although harmonics of a waveform can be produced readily in many different ways, the harmonic power that is obtainable usually decreases rapidly with the order of the harmonic. For example, the periodic square wave contains all harmonics of odd order; but the amplitude of the 3rd harmonic is only 1/3rd of the fundamental, the 5th harmonic is 1/5th, the 39th is 1/39th, etc. Analysis of other waveforms shows that the power obtainable at high order harmonic frequencies is relatively much greater if the periodic waveform is large during only a small fraction of the period. Therefore, the harmonic producer has been designed to generate very narrow pulses because such a waveform is rich in high-order harmonics.

A. Harmonic Generation

4.02 A simplified schematic circuit used for the simultaneous generation of a number of harmonics of approximately equal amplitudes is shown in Fig. 17. The essential circuit element is nonlinear inductor L4, a coil which is operated with sufficient magnetizing force to drive its core material well into the saturated region. That is, the inductance of the coil is large when the current through it is small, and is small when the current through it is large. Only odd harmonics are generated when the core of the nonlinear coil is unpolarized, as is the case here.

4.03 Starting with a source of 4 kHz as the fundamental frequency, an amplifier provides a sinusoidal current through inductor L4 which causes the core to saturate during each half-cycle.

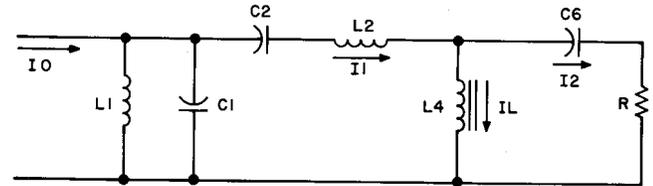


Fig. 17—Simplified Harmonic Producer

The shunt resonant circuit (L1, C1) is tuned near the fundamental frequency and serves primarily to remove any second harmonic that may be generated in the amplifier. The series resonant circuit (L2, C2) is inserted to maintain a sinusoidal current through inductor L4 as well as to tune out the circuit reactance at 4 kHz. The circuit including L4, C6 and the load impedance R is so proportioned that highly peaked current pulses rich in harmonics flow through it. A qualitative analysis of the operation of this circuit is given in 4.06. Two current pulses of opposite polarity are produced during each cycle of the fundamental wave, the duration of each being a small fraction of the fundamental period. The waveform shown in Fig. 18 represents the current in the load during successive cycles of the 4-kHz wave. The selectivity of the circuit causes the saturable core inductor to be driven by a symmetrical current wave, thereby equalizing the spacing between positive and negative pulses and ensuring the generation of odd-order harmonics only.

4.04 Although the carrier supply requires both even and odd harmonics of the 4-kHz base frequency, it is advantageous to start with a spectrum containing only odd harmonics. The component frequencies are spaced at intervals of 8 kHz instead of 4 kHz. Therefore, the requirements for a filter to select one harmonic component can be less severe since the unwanted frequencies are separated from the wanted frequencies by at least 8 kHz.

4.05 To produce even harmonics, a full-wave rectifier is connected across the odd harmonic supply, with load impedance chosen so that it will take about half of the available odd harmonic power. The rectifier output, in which alternate pulses are reversed in sign so that all pulses occur with the same polarity, has a fundamental frequency of 8 kHz and contains all of its harmonics. The component frequencies are spaced at intervals of 8

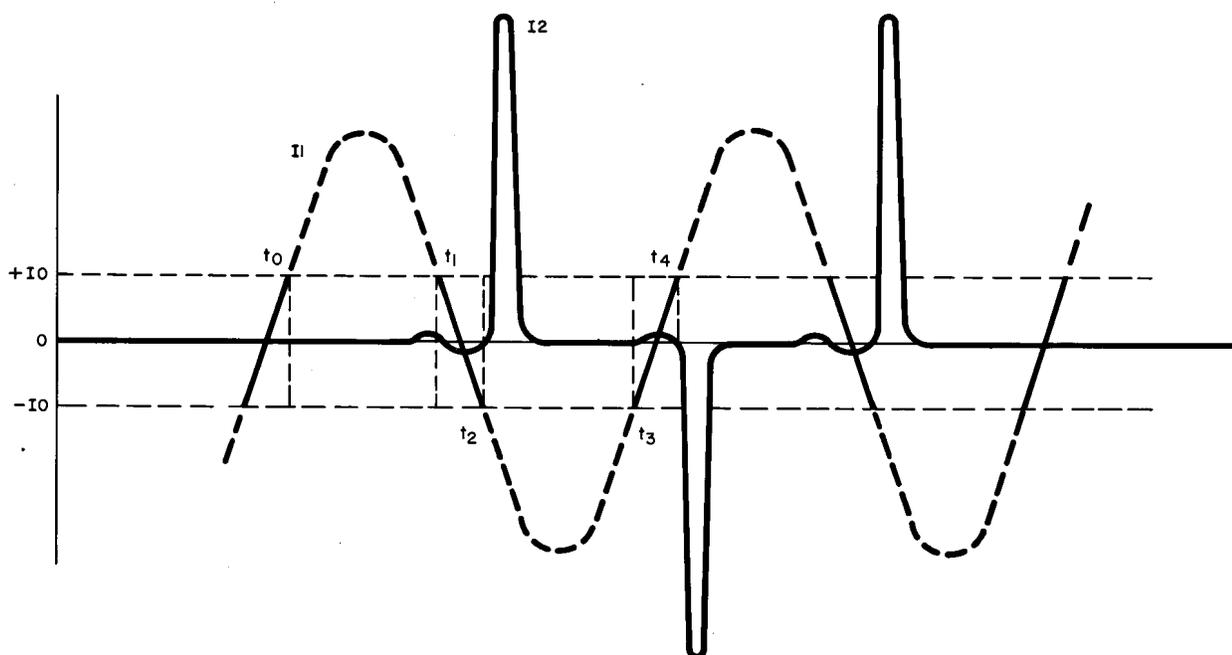


Fig. 18—Typical Pulse Waveform

kHz and each component is numerically equal to the even harmonics of 4 kHz. Thus, again the requirements for filters to select these frequencies also can be less severe.

4.06 The analysis of the operation of the harmonic generating circuit shown in Fig. 17 meets with difficulties since a high degree of nonlinearity is involved in working the inductor well into its saturated region. However, the main performance features may be reproduced by utilizing the properties of inductor L4 as a switch. Switching occurs at the time when the current through the coil passes through one of the critical values ($\pm I_0$) where the inductance changes due to the saturation of the core. It is convenient to assume that the inductance is large (L_0) when the current magnitude is less than I_0 and is small (L_s) when the current magnitude is greater than I_0 . This is a simplified representation of the nonlinear inductor, but it will serve to place in evidence a mechanism for generating the waveform shown in Fig. 18.

4.07 The course of events that enables the circuit shown in Fig. 17 to produce the sharply peaked waveform shown in Fig. 18 can be described as follows. The primary current I_1 is assumed to be sinusoidal, the circuit impedance being so large

that changes in the magnitude of L4 do not affect the waveform. Throughout the interval (t_0, t_1), the current I_1 is large and the inductance of L4 is L_s , a small value. During this interval the secondary circuit is practically isolated from the primary circuit and I_2 is very small.

4.08 The current I_2 in the secondary circuit (L4, C6, and R) remains small until the current through L4 reaches the critical value I_0 at time t_1 . The switching occurs at this time and the inductance becomes L_0 , a large value. The current through L4 decreases and the current I_2 becomes almost equal to I_1 . Thus, capacitor C6 is charged much more rapidly than in the preceding interval.

4.09 Charging continues until the current in L4 becomes $-I_0$ at time t_2 . At this time, the inductance returns to the low saturation value L_s and the voltage drop across L4 becomes very small. Again the secondary circuit is practically isolated from the primary circuit and capacitor C6 discharges through L_s and the load impedance. The form and duration of the sharply peaked discharge pulse characteristic of this type of harmonic generator are determined by the values of the elements just mentioned.

4.10 The pulse dies away before the end of the interval (t_2 , t_3), and the relationships described in 4.08 are restored. However, all polarities are now reversed and the next pulse produced will have opposite polarity as shown in Fig. 18.

4.11 A schematic diagram of the harmonic generator circuit actually used in the carrier supply is shown in Fig. 19. This circuit differs in detail from the simplified circuit used to explain the operation. The circuit configuration is balanced with respect to ground, and the nonlinear inductor L4 is tapped to produce better impedance matching. The function of L4 in the harmonic generation process was described above. A full-wave rectifier is connected across the odd-harmonic output to produce the even harmonics of 4 kHz that are needed for the carrier supply. Impedance correcting networks are added across both the odd- and the even-harmonic outputs to improve the circuit impedance of the load consisting of banks of bandpass filters.

B. Carrier Selection

4.12 Bandpass filters using crystal units to obtain narrow passbands with adequate out-of-band loss are used to select the wanted frequencies from the harmonic frequency spectrum. Six filters with their inputs in parallel are connected to the odd-harmonic output terminals of the generator. Similarly, nine filters are connected to the even-harmonic output terminals. The odd-harmonic

frequencies selected are 148, 156, 164, 172, 180, and 188 kHz. The even-harmonic frequencies selected are 152, 160, 168, 176, 184, 192, 232, 256, and 280 kHz.

4.13 The schematic diagram of a carrier pickoff filter is shown in Fig. 20. The code number and the carrier frequency selected by each filter are listed in Table A for convenient reference.

4.14 A typical insertion loss characteristic of one of the filters is shown in Fig. 21. Sufficient discrimination is provided to assure having the unwanted adjacent carriers at least 60 dB below the wanted frequency signal at the filter output.

5. CARRIER AMPLIFICATION AND DISTRIBUTION

5.01 The carrier supply is required to have sufficient power capacity to supply 26 N3 carrier telephone terminals. Since the single frequency output from each of the crystal filters is necessarily low, amplification is required. A single amplifier for each frequency delivers sufficient power to the primary distribution bus. The harmonic generation and selection process yields tones of the required purity but the available power is subject to moderate variation. Therefore, each amplifier has been designed to provide regulation as well as power gain. It accepts any input within wide limits and delivers an output within the narrow limits required for the N3 carrier telephone terminal.

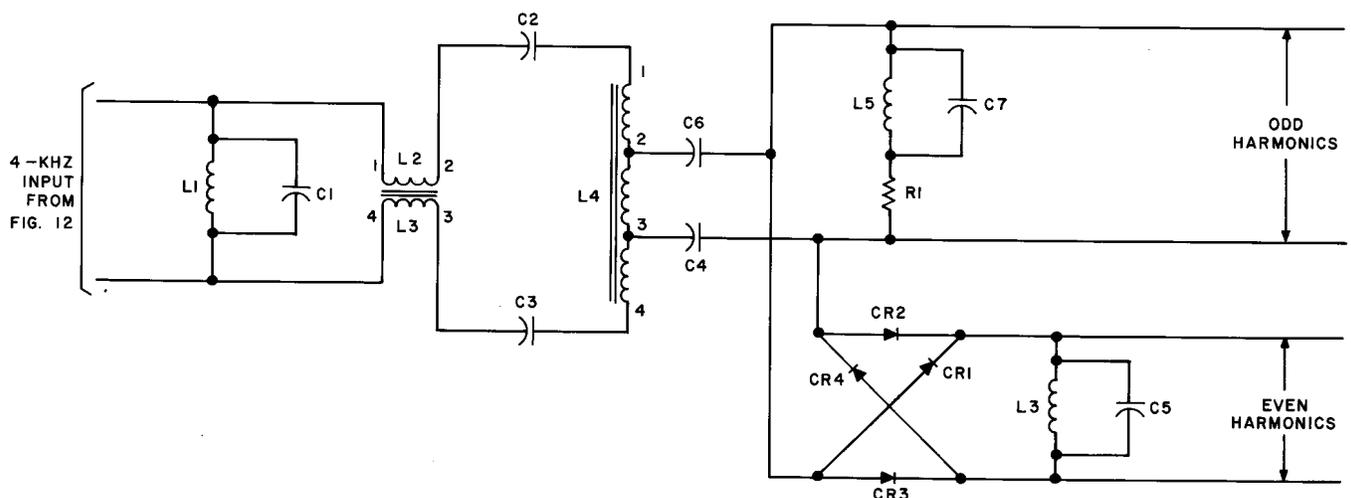


Fig. 19—Harmonic Generator Circuit

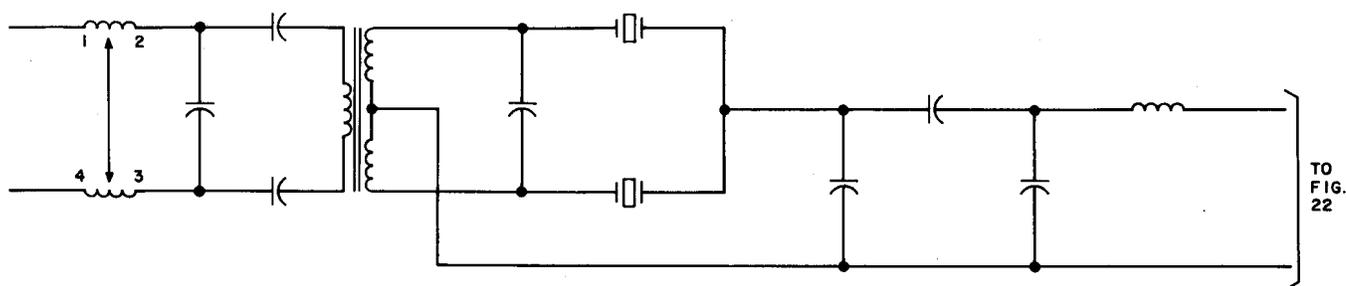


Fig. 20—Typical 646-Type Circuit

TABLE A

EVEN HARMONICS		ODD HARMONICS	
FREQ	CODE	FREQ	CODE
152	646B	148	646A
160	646D	156	646C
168	646F	164	646E
176	646H	172	646G
184	646K	180	646J
192	646M	188	646L
232	646N		
256	646P		
280	646R		

5.02 Two independent amplifiers and a monitoring circuit which is shared by the two amplifiers comprise a plug-in unit assembly. If the output voltage of either amplifier deviates sufficiently from the normal voltage required by the system, the monitoring circuit causes a relay located on the unit to operate. The relay contacts are part of the switching and alarm system that provides supervision and control.

5.03 The carrier supply provides means for maintaining in an operating condition pairs of duplicate equipment assemblies. Two monitoring circuits together with a switching system select from each pair of amplifiers and connect into the system one unit with an output within specified limits. Reliability is enhanced by providing standby

units, but the carrier supply is operative even when duplicate plug-in equipment is not installed.

5.04 Fifteen of the required 16 frequencies are selected by filters. The one remaining frequency, 304 kHz, is derived from 152 kHz by a frequency doubler. Two different plug-in assemblies are used to amplify the carrier frequencies. One of the plug-in assemblies has been designated as the dual amplifier unit. Seven regular dual amplifier units are required and as many as seven alternate units may be provided. The other assembly is called the doubler amplifier unit. One regular doubler amplifier unit is required and one alternate unit may be provided.

5.05 The dual amplifier is comprised of two independent amplifiers and a common monitoring circuit. The doubler amplifier is comprised of two amplifiers, a common monitoring circuit, and a frequency doubler.

A. Dual Amplifier Circuit

5.06 The simplified schematic drawing on Fig. 22 shows one of the two independent amplifiers of a dual amplifier assembly. Although the amplifier must provide sufficient power gain to satisfy the requirements of the carrier system, an important feature is the ability to regulate the amplitude of the output voltage. Regulation is adequate for any input voltage within the range of +6 dB to -9 dB from the normal voltage.

5.07 During the operation of the circuit, transistors Q2 and Q3 are alternately in one or the other of two states of conduction: either full conduction, wherein the collector-to-emitter voltage is very small and the current is large, or minimum conduction, wherein very little current flows with

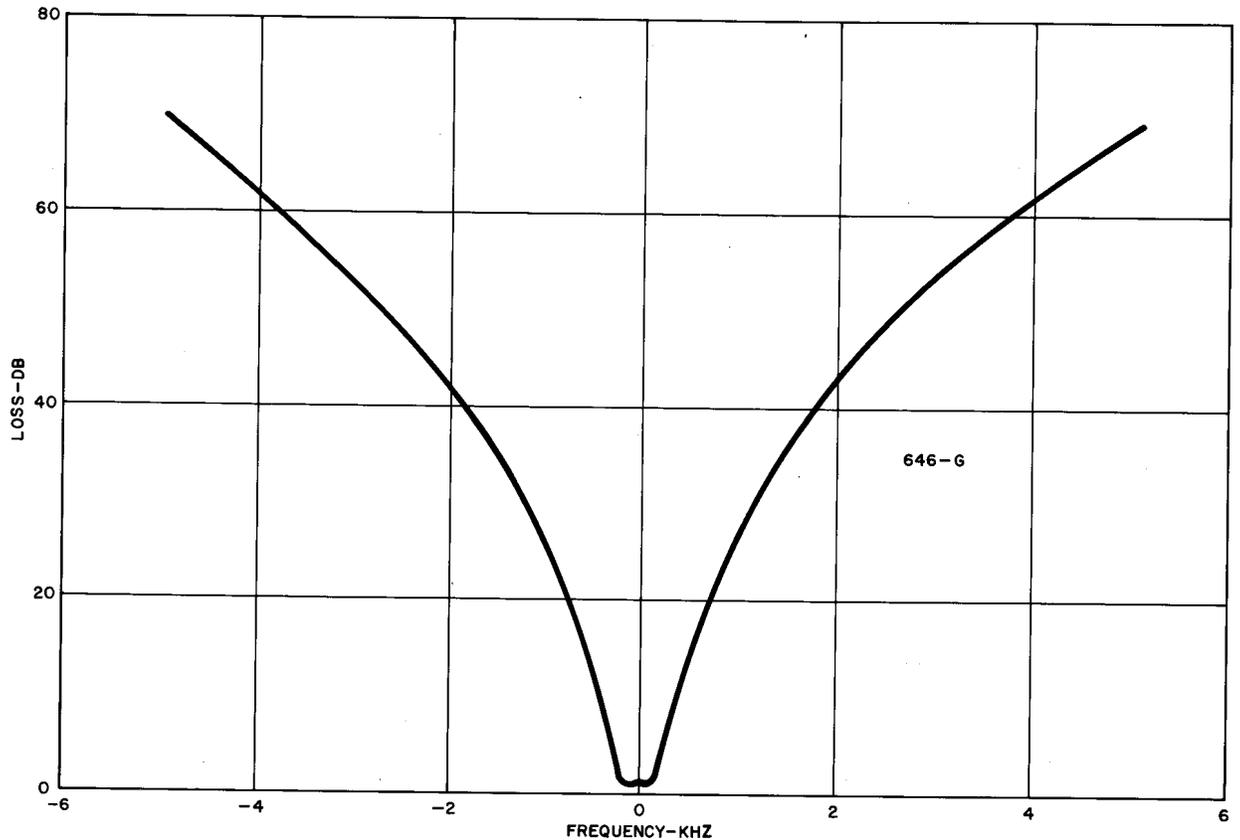


Fig. 21—Insertion Loss Characteristics of 646-Type Filter

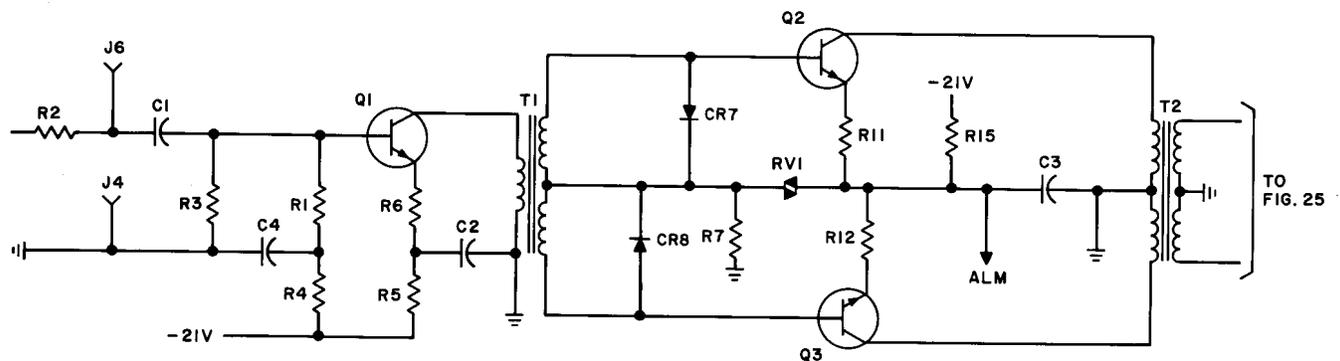


Fig. 22—Regulating Amplifier

the full voltage present at the transistor terminals. Alternating current is created in the output circuit of transformer T2 when the transistors alternately switch the voltage from one half of the primary winding to the other. The magnitude of the output voltage is controlled by resistor R15.

5.08 Transistor Q1 is used to provide sufficient gain to bring the weakest anticipated input voltage to a level sufficient to operate Q2 and Q3 as switches. The output voltage of the first stage is proportional to its input voltage and is relatively free from distortion of the waveform.

5.09 Transformer T1 provides voltages in phase opposition into the two base meshes from two secondary windings which are terminated by diodes CR7 and CR8. These diodes enhance the drive to the base for low-level signals and limit the drive for high-level signals. The amplitude at which conduction starts has been reduced by the forward bias developed across RV1. This forward bias is maintained by current flowing from the -21 volt supply through R7, R15, and RV1.

5.10 Resistor R15, together with trimming resistors as required by a factory adjustment, provides the means for adjusting the output voltage. Capacitor C3 and resistor R15 serve as a low-pass filter to provide a voltage proportional to the average direct current flowing in the circuit.

5.11 Transformer T2 serves to create alternating current in the load when the transistors alternately switch from conduction to cutoff. The output is delivered to a bandpass filter which is part of the primary distribution circuit. The unwanted harmonic voltages are suppressed, leaving a relatively pure sine wave of the wanted frequency. By placing the filter in the primary distribution unit, the plug-in amplifier assemblies can be made alike. They can be used interchangeably in all positions requiring the dual amplifier.

B. Doubler Amplifier Circuit

5.12 The doubler amplifier assembly differs from the dual amplifier in only one respect. A frequency doubler provides an input for one of the two amplifiers. One of the two amplifiers receives an input of 152 kHz from the crystal filter

that selects this frequency from the harmonic spectrum. The other amplifier receives an input of 304 kHz from the frequency doubler which also receives an input of 152 kHz from the crystal filter.

5.13 The simplified schematic drawing on Fig. 23 shows the frequency doubler circuit. Transistors Q11 and Q12 are used in a full-wave rectifier circuit. When the input voltage is sufficient, the transistors are alternately driven from cutoff to saturation. If the inductor is adjusted so that the antiresonant circuit L1, C22 is tuned to 304 kHz, the second harmonic of 152 kHz will be selected and all other harmonics will be suppressed. The voltage is then used as an input to a limiting amplifier that operates in the manner described for one of the dual amplifiers.

C. Monitoring Circuit

5.14 The two regulating amplifiers in the dual amplifier unit and the two regulating amplifiers in the doubler amplifier unit all use the circuit shown in Fig. 22. The summing amplifier shown in Fig. 24 is used in the monitoring circuit for both units. The output of the summing amplifier is connected to a trigger circuit like the one shown in Fig. 16. Therefore, a description of the summing amplifier circuit alone will be sufficient to describe the operation of the monitoring circuit for a pair of limiting amplifiers.

5.15 Although the output voltage across transformer T2 shown in Fig. 22 could be rectified and used as a measure of the output of an amplifier, it is more convenient to use the voltage across

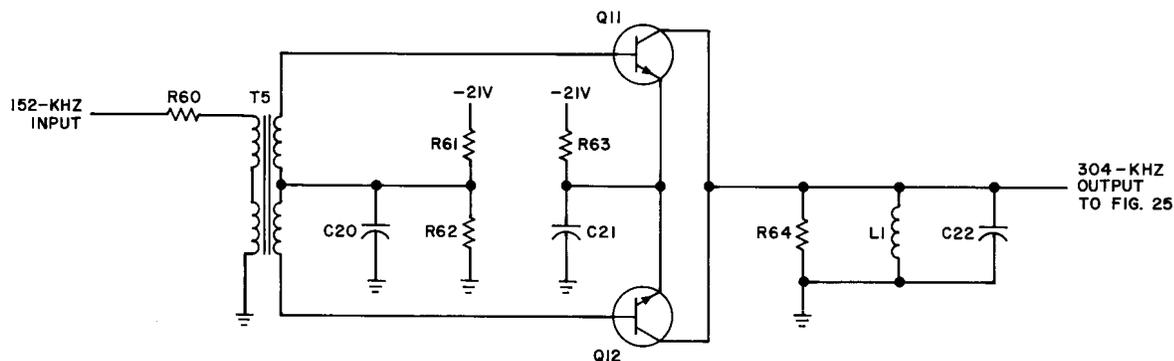


Fig. 23—Frequency Doubler Circuit

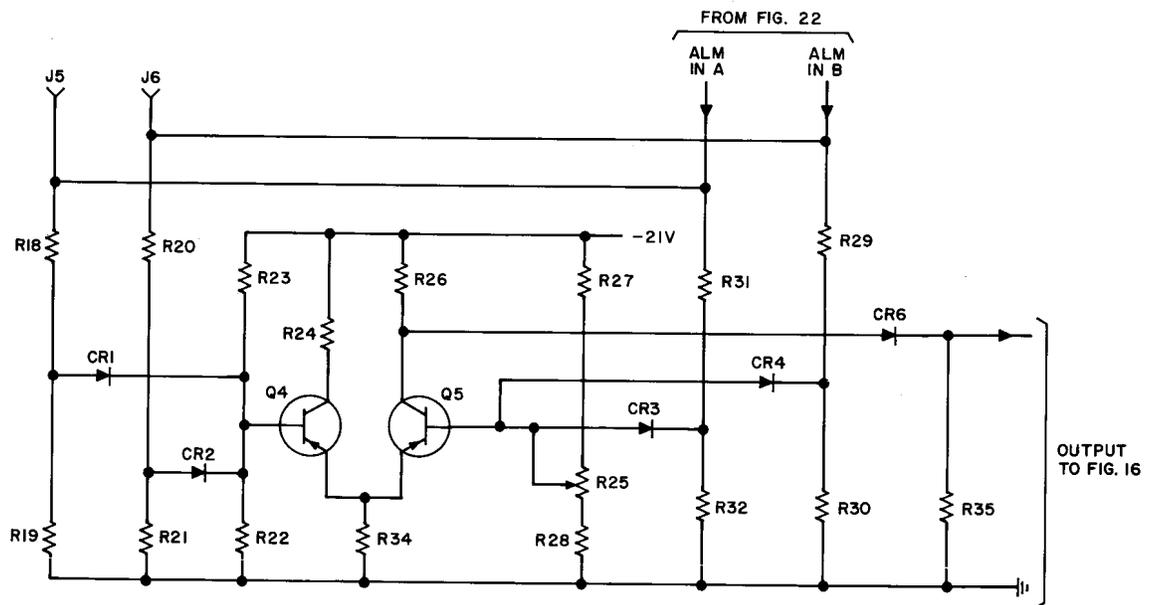


Fig. 24—Summing Amplifier Circuit

capacitor C3. This voltage differs from the -21 volt battery by the voltage drop across resistor R15 due to the average direct current flowing through the transistors. The instantaneous magnitude of the input signal which causes limiting to start is controllable by design. The time from a particular zero crossing of the input sine wave to the time when limiting starts will depend upon the input amplitude. A change in this transition time due to low-input voltage causes the average direct current through R15 to decrease. Thus, an increase in the voltage across capacitor C3 provides an indication that the input voltage is low. Certain failures in the amplifier, for example, a collector-to-emitter short circuit in a transistor, can cause the current to be abnormally high. High transistor current increases the voltage drop across resistor R15. Thus, a decrease in the voltage across capacitor C3 provides an indication that the current in the output stage is high. Due to the correlation between the ac output voltage and the dc voltage across the capacitor, the monitoring circuit can be adjusted so that the K1 relay operates whenever the amplifier output is not within prescribed limits.

5.16 Transistors Q4 and Q5 form a summing amplifier having both differential and common mode gain. For example, an increase in voltage on the Q4 base causes the Q4 collector voltage to

decrease and the Q5 collector voltage to increase. Voltage changes on the Q5 base produce corresponding changes in the collector voltages. The base of transistor Q5 is biased by resistors R27 and R28 together with a trimming adjustment provided by potentiometer R25. The output which causes the trigger circuit to operate the relay is taken from the collector of Q5. The coupling circuit includes the avalanche diode CR6. The gain of the circuit is enhanced by subtracting the constant voltage drop across this diode. When a signal applied to the base of Q5 increases in magnitude, the collector current increases, the collector voltage decreases in magnitude, and the trigger circuit is caused to operate at the desired threshold. When a signal applied to the base of Q4 decreases in magnitude, the emitter current decreases. The voltage drop across the common emitter resistor R34 decreases and causes Q5 to draw more current. The collector voltage decreases in magnitude and the trigger circuit is caused to operate. Thus, the trigger can be operated either by an increasing voltage on Q5 or a decreasing voltage on Q4.

5.17 Diodes CR1 and CR2 together with the associated resistors form a logic circuit. They are normally nonconducting. If the voltage on either the ALM IN A or the ALM IN B leads decreases sufficiently, one diode conducts and applies a signal to the base of Q4. Diodes CR3

and CR4 together with the associated resistors also form a logic circuit. The diodes are normally nonconducting. If the voltage on either lead increases sufficiently, one diode conducts and applies a signal to the base of Q5. Thus, the logic circuits permit using one summing amplifier to monitor two regulating amplifiers. The phase inversion described in 5.16 permits the circuit to establish both upper and lower limits and to operate the relay whenever the signal is not between the limits.

5.18 The trigger circuit which causes the relay to operate is the same as that described in 3.25 and shown in Fig. 16. The contacts on the relay are used for supervision and control. These functions will be described in the switching and alarm section.

D. Primary Distribution

5.19 The primary distribution system provides the means for connecting N3 terminal bays to the carrier supply. The circuit includes 16 bandpass filters, one being used for each carrier frequency. Each filter suppresses the unwanted harmonics generated in the regulating amplifier and delivers a sinusoidal waveform having the wanted carrier frequency to a multiplicity of resistance loads. The resistance loads are connected to the distribution bus through capacitors that are part of the filter structure.

5.20 The principal function of each filter is to suppress harmonics, and a low-pass filter would be adequate for this purpose. However, the network used is an impedance-transforming bandpass filter designed for insertion between a source impedance R_0 and an impedance R_0/N which represents N loads connected in parallel. The output loads are independent circuits, and it is important to provide isolation between them so

that one will not react upon another. This has been accomplished by placing a capacitor in series with each load. The design permits using the same value of capacitance in all the distribution circuits. By designing the filter to include the capacitor, sufficient isolation is achieved without loss of power.

5.21 A simplified schematic of the primary distribution circuit is shown in Fig. 25. The filter is adjusted to present to the limiting amplifier a resistive termination of 115 ohms when each output tap is terminated in a resistance of 115 ohms. One tap on the distribution bus is isolated from another by not less than 20 dB.

5.22 The primary distribution system provides distribution buses for connecting the 16 carrier frequencies to 13 N3 terminal bays. The bus for each of the 12 channel carriers and for the N3 to L translation carrier has provision for 13 taps. The capacitors and the resistors shown in Fig. 25 are mounted on a card having terminals for wire-wrapped connections on one edge. Each resistor is supplied as a dummy load which is to be cut out of the circuit when a working load is connected. The bus for the group carrier and for each of the channel group carriers has provision for 26 taps. Two similar cards for each frequency provide 13 taps each.

5.23 The harmonic suppression circuits were designed as bandpass filters so that an impedance transformation could be incorporated in the structure. The design permits using capacitors of the same value on all of the primary distribution cards. The other filter elements are added as a subassembly. The code number of the subassembly and the carrier frequency selected by each filter are listed in Table B for convenient reference.

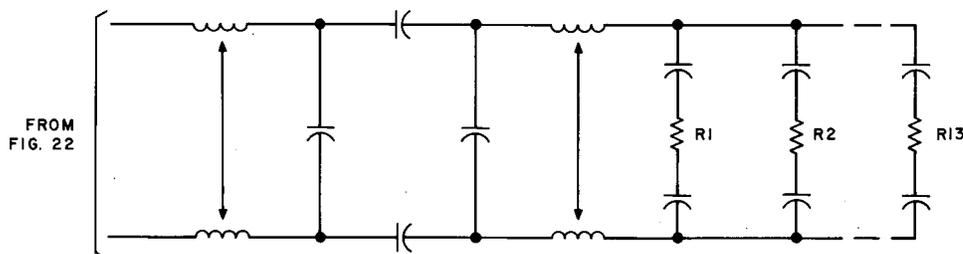


Fig. 25—Primary Distribution Circuit

TABLE B

FREQ IN KHZ	FILTER CODE	FREQ IN KHZ	FILTER CODE
148 152	647A 647B	180 184	647J 647K
156 160	647C 647D	188 192	647L 647M
164 168	647E 647F	232 256	647N 647P
172 176	647G 647H	280 304	647R 647S

6. SWITCHING AND ALARMS

6.01 The principal function of the switching system is to select one 4-kHz generator or dual or doubler amplifier with an output within specified limits from each pair of duplicate units and to connect it into the system. The required switching is accomplished by a single relay having the necessary number of sets of transfer contacts. For convenient reference, the two 4-kHz generators or dual or doubler amplifiers of a pair have been designated REG (regular) and ALT (alternate), REG being assigned to the preferred position in the bay since normally it will be the working unit. When the relay operates, the load is transferred from REG to ALT and a dummy load is transferred from ALT to REG. When the relay releases, the load is transferred from ALT to REG and the dummy load is transferred from REG to ALT. Thus, either unit may be made the working unit and its mate made the standby unit.

6.02 Another important function of the switching system is to aid the supervision and maintenance of the carrier supply. A warning light near each unit is switched on whenever the output of that unit is not within specified limits. A minor alarm is initiated whenever either a REG or an ALT unit goes out of limits; a major alarm is initiated whenever both REG and ALT units go out of limits. No minor alarms are provided for the power supplies; a major alarm is initiated whenever either the REG or the ALT power supply unit goes out of limits.

6.03 The description of the complete switching and alarm system necessarily includes

components that are not part of the switching and alarm panel assembly. For example, a relay located on each plug-in unit reverses its state whenever the output of that unit is not within specified limits. The relay contacts are essential parts of the complete switching and alarm system. Therefore, a simplified functional information drawing has been prepared to aid in the description of the complete circuit. Essential details have been shown for convenient reference, and components which also appear on other drawings for individual plug-in units have been enclosed in double-line boxes. Figure 26 shows a typical system which is used for all units.

6.04 Although the symbols are defined and the operation of the circuit is described below, a few comments on these figures may be helpful. When both the REG and ALT amplifiers are operating within prescribed limits, their monitoring relays are in the released state. Therefore, the normally closed contacts show the connections made to the switching and alarm circuit during this condition. The transfer relay, shown in Fig. 26 and designated K(), is in the released state and connects the REG amplifiers to the working load and the ALT amplifiers to the dummy load. The manual switch designated S() L key in the REG position causes the REG amplifiers to be connected to the working load, providing the REG amplifiers are operating within prescribed limits. The relays designated K1 in the regular and alternate power supplies are shown as they appear when the outputs of the power supplies are within prescribed limits.

A. Switching Circuit

6.05 The complete switching circuit for the carrier supply necessarily includes many components. However, each pair of REG and ALT amplifiers uses the same plan of operation. The schematic diagram for the configuration of the contact network in the control path for the transfer relay is shown in Fig. 26. The input conditions that initiate and control the action of the transfer relay are derived from the contacts of a relay on the REG amplifier, contacts of a relay on the ALT amplifier, a manual key on the switching and alarm unit (designated S), and contacts of K1 power supply alarm relay in both regular and alternate power supplies.

6.06 Analysis of overall requirements for the switching circuit operation leads to the choice

of shunt control of the transfer relay; that is, relay operation when the control path opens even though it has the disadvantage that the current drain through the shunt path performs no useful work. The schematics represent normally open contacts by crosses and normally closed contacts by bars. Contacts designated REG are those associated with the relay in the REG amplifier. Contacts designated ALT are those associated with the relay in the ALT amplifier. Contacts designated S are on the manual transfer key. In its normal state (REG), the key causes the REG amplifier to be connected to the load.

6.07 Figure 26 is a simplified schematic of the operate circuit of a transfer relay. When the manual transfer key switch (designated S) is in the REG position and the outputs of both amplifiers are within limits, current flows from ground through contacts of the K1 power supply alarm relay in the regular power supply, contacts of the K1 alarm relay in the regular amplifier, contacts of the S () L key on the switching and alarm unit, resistor R, and contacts of the K1 power supply alarm relay in the alternate power supply to the -48 volt battery. The transfer relay is prevented from operating by this shunt circuit. When the key switch is placed in the ALT position, current flows from ground through a path in the ALT amplifier through the relay winding, resistor R, and contacts of the K1 power supply alarm relay in the alternate power supply, to the -48 volt battery. The relay operates and transfers the load to the ALT amplifier. However, the relay cannot be operated unless the ALT amplifier is plugged in to provide the path to ground. Operation is also inhibited if the ALT amplifier is out of limits and the ALT relay has been operated.

6.08 Figure 26 shows two shunt paths for making the ground connection to the junction of the resistor and the relay winding to prevent the relay from operating. The left-hand path will open if the REG amplifier fails since the REG relay will operate and open its normally closed contact. The transfer relay operates to cause an automatic transfer from REG to ALT. The left-hand path will also be opened if the S key is opened manually, and the transfer relay will operate to cause a manual transfer from REG to ALT. If the ALT amplifier is out of limits, a manual transfer to the ALT amplifier is inhibited. With the S key in the ALT position, the transfer relay releases to cause an automatic transfer from ALT to REG if

the ALT amplifier goes out of limits. Thus, an automatic transfer is effected when the working amplifier fails, providing the standby amplifier is within limits.

6.09 If both REG and ALT amplifiers go out of limits, the right-hand path becomes effective, and the S key can be used to select either amplifier. Thus, the manual transfer can be effected either when both amplifiers are outside limits or when both amplifiers are within limits. This feature is desirable since the system may still be usable if one of the amplifiers is not too far out of limits. The contacts of K1 power supply alarm relay, in either regular or alternate power supplies, allow all transfer relays to change state when a power supply fails. If the amplifier transfer relays are deenergized, thereby selecting regular amplifiers, failure of the regular power supply, and therefore failure of -21 volts to all regular amplifiers, break all shunt paths and the transfer relays energize if an alternate amplifier is present. If the amplifier transfer relays are energized, thereby selecting alternate amplifiers as the working amplifiers, failure of the alternate power supply, and therefore failure of -21 volts to all alternate amplifiers, interrupt the -48 volts to the transfer relays. The transfer relays deenergize and connect the regular amplifiers to the working load. The transfer to regular amplifiers results regardless of the condition of the regular amplifiers. This is the reason that the regular position is preferred in a partially equipped carrier supply.

6.10 A momentary service interruption occurs if the working unit of a pair is removed from its receptacle. The manual transfer key associated with the 4-kHz generators, dual amplifiers, and doubler amplifiers should be used to transfer the load to a second unit before the first unit is removed. Although the removal of a working unit causes an automatic transfer, there will always be a short interruption of the carrier frequency during the switching time of the transfer relay. The loss of carriers can be avoided by proper use of the manual transfer keys.

B. Monitoring Circuit Relay

6.11 A monitoring circuit relay is located on each plug-in assembly. These relays provide the inputs to the switching and alarm system. Whenever the sensing circuit detects an abnormal condition, the relay is caused to operate. One contact provides

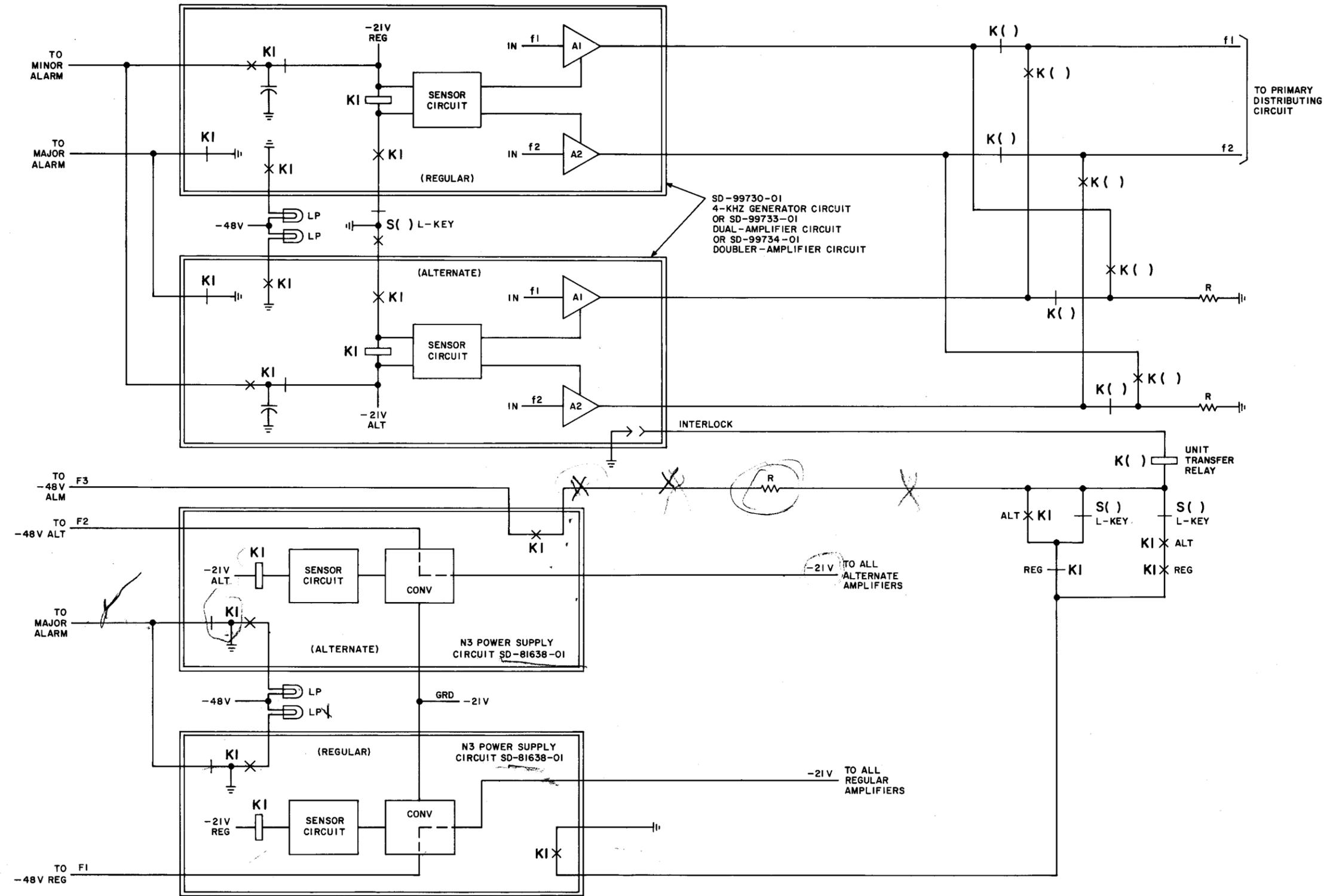


Fig. 26—Switching and Alarm Circuit

ground for a lockup circuit so that a marginal condition cannot cause a succession of changes of state. Another contact provides ground for the light on the control panel that shows which unit is out of limits. Other contacts provide inputs to the minor alarm circuit, the major alarm circuit, and switching circuit.

6.12 All of the monitoring circuit relays and the sensing circuits which drive them are operated from the -21 volt power supply. Therefore, these relays cannot be operated if the power supply fails. An indication of failure of the -21 volt power supply is provided by reversing the normal state of the monitoring circuit relay in the power supply units. In these two units only, the relays are normally operated and are caused to release whenever the regulated voltage is out of limits. Because there are two separate -21 volt distribution circuits, the contacts of the power supply alarm relay K1 are used to initiate a transfer of all regular amplifier outputs to the working load in the event of an alternate power supply failure. The alternate amplifier outputs are transferred to the working load when there is a regular power supply failure.

C. Transfer Relays

6.13 The transfer relay for the 4-kHz generators and the eight transfer relays for the carrier amplifiers are wire-spring relays. A dual amplifier unit includes two independent amplifiers, each having an output balanced with respect to ground. Thus, four transfers for the working load and four transfers for the dummy load are required for each pair of units as shown in Fig. 26. The 517AJ relay has four continuity transfers which are used for the working load and four sequence transfers which are used for the dummy load. Assuming initially that REG is working and ALT is connected to the dummy load, as the relay operates the transfer proceeds as follows: (1) REG and ALT are connected together and to both working load and dummy load, (2) dummy load is removed from ALT and connected to REG, and (3) ALT is connected to the working load, thus completing the transfer. Both units are connected to the working load during the transition time and there is no loss of carrier. The dummy load is also connected during almost all of the transition time.

6.14 Each -21 volt power supply is connected to a separate -21 volt distribution circuit. ♦In

carrier-frequency supply bays of early manufacture, the two -21 volt distribution circuits were combined when one power supply was removed through the contacts of a microswitch associated with the removed power supply. Dummy load resistors were provided to ensure a minimum load on each power supply. However, should either of the -21 volt distribution circuits experience an accidental ground and the failed power supply be removed for maintenance, the good power supply would be switched to the grounded distribution circuit and total failure of the carrier-frequency supply would result. To eliminate this potential service hazard, a modification was made to inhibit combining the two -21 volt distribution circuits through either of the two microswitches. Current manufacture of the carrier-frequency supply bay will include this modification, eliminating the microswitches and the power supply switching key. ♦

6.15 The sequence of operations described above causes a small transient in the carrier output when a dual amplifier is switched. The carrier increases less than 3 dB for a time interval less than 5 milliseconds. When the 4-kHz generators are switched, a somewhat longer interruption may occur depending upon the relative phases of the two oscillators.

6.16 The transients described above represent the results for a manual transfer between two amplifiers with normal outputs. The time required for an automatic transfer after a working unit goes out of limits is much longer. The sensing circuit and the relay require time to operate before the switching action can be initiated. Therefore, automatic transfers will cause interruptions of 40 to 50 milliseconds in duration. The fully protected system restores carriers after a failure but this takes some time.

D. Alarm Circuit Relays

6.17 Both the major and the minor alarm systems include a relay operated by a flip-flop circuit and means for generating a driving pulse whenever a monitoring relay operates in any of the protected units. The flip-flop circuit shown in Fig. 27 has two stable states. The current through the relay is either zero or sufficient to operate the relay. A short negative pulse of current into the base of transistor Q3 causes Q1 to be cut off and Q2 to conduct heavily, thereby releasing the relay. Regenerative feedback action causes a rapid

transition during the time when both Q1 and Q2 are conducting simultaneously. Local negative feedback via resistor R5 makes one transistor circuit stable when the other transistor is cut off. A reset button connects ground to the base of Q2. This causes Q2 to be cut off and Q1 to conduct and reoperate the relay. The circuit is thus prepared to receive a pulse from any of the amplifier units and to indicate an alarm. Current production includes components C1, CR2, CR3, R10, R12, and R13. These components make the circuit less susceptible to false alarms. In addition, resistor R11 is eliminated and the code of transistors Q1, Q2, and Q3 changed to improve performance at elevated temperatures.

6.18 As shown in Fig. 28, the operation of the monitoring relay in any one of the units transfers a capacitor charged to -21 volts to the minor alarm bus. All of the units can be connected to a common bus and any one of the capacitors can deliver a pulse to the flip-flop. The charged capacitor connected to the alarm bus discharges through a resistor and causes the flip-flop circuit to release the minor alarm relay. A warning light is displayed on the switching and alarm panel and office alarms are activated by contacts on the K2 relay. A second pulse from another unit has no effect on the circuit unless the reset button has been depressed. After the alarm circuit has been reset, a second minor alarm pulse will produce a second minor alarm even though the first trouble has not been cleared.

6.19 The major alarm system includes a means for generating a pulse whenever both an R and an A relay operate to indicate failure of both units of a pair as shown in Fig. 29. A pulse is generated only when both A and R relays are operated. This circuit also operates whenever the working unit fails if no standby unit is provided. When both units of a pair are working, the relays are released and current flows from ground through the parallel combination of closed R and A contacts and through resistor R1 to the battery. If either the R or the A relay operates, current continues to flow through the shunt path. However, if both the R and A relays operate, the shunt path is opened and current flows through resistors R21, R2, and R1. A pulse of current flows through the emitter-to-base junction of Q3 and charges capacitor C1. This causes the flip-flop circuit to release the major alarm relay. The alarm features are described in 6.17.

E. Visual Indicators and Controls.

6.20 Manual controls and visual indicators of the states of the carrier supply units are conveniently located on the switching and alarm panel. The plug-in units are arranged in pairs on two shelves, one above the control panel and the other below it. Lamps designated REG and ALT are associated with the corresponding units. These lamps are directly below the units on the upper shelf and directly above the units on the lower shelf. A lighted lamp indicates that the sensing

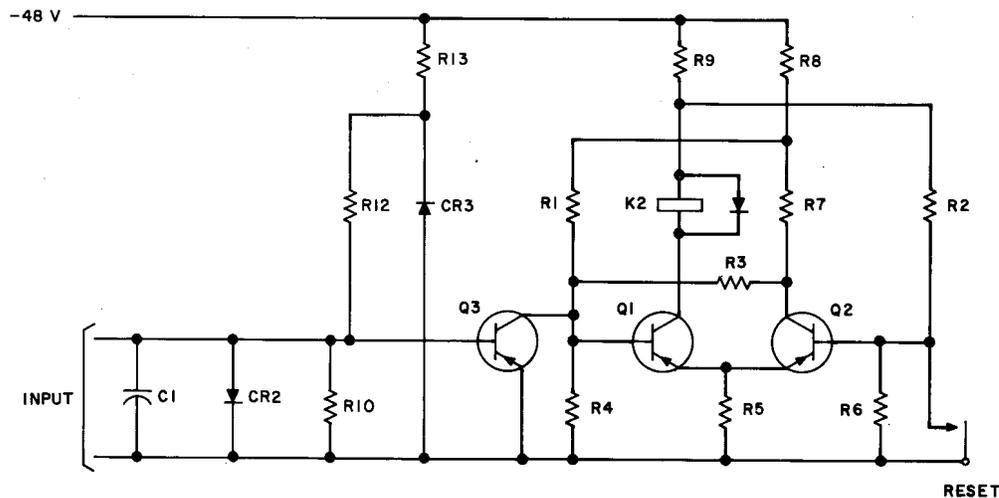


Fig. 27—Alarm Relay Circuit

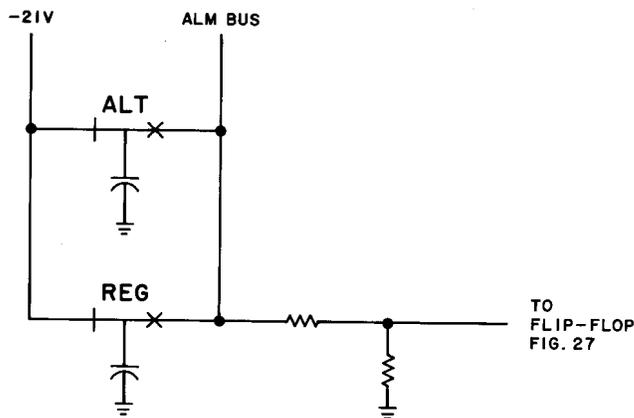


Fig. 28—Minor Alarm Pulse Generating Circuits

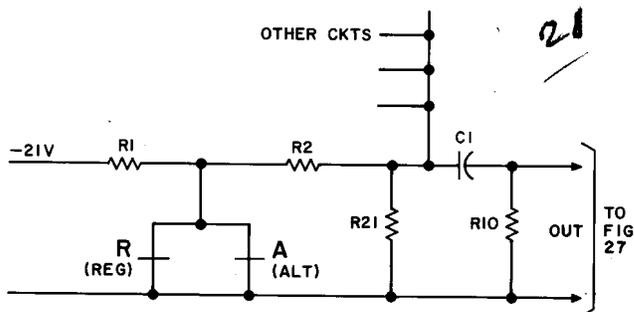


Fig. 29—Major Alarm Pulse Generating Circuit

relay in the associated unit has been operated and that the output of the unit is not within limits. Designations for each pair of units and the manual transfer key switch are between the lamps of each pair. A white bar on each key switch associated with the 4-kHz generators, dual amplifiers, and doubler amplifiers points toward the lamp of the working unit. The arrow on the power supply key switch, if provided, should be in the vertical (NORM) position (6.14). The power supply key switch is omitted from current production of the switching and alarm panel.

6.21 Since the lamps are directly associated with particular units, the location of a faulty unit is facilitated. The plug-in feature makes replacement with a spare unit an easy operation. The index mark on the key S associated with the 4-kHz generators, dual amplifiers, and doubler amplifiers should always be turned toward the working unit (indicated by an extinguished lamp) when the

defective unit (lamp lighted) is removed. The relay lockup feature is available only on the unit indicated by the manual transfer key. The lockup ground on the nonworking amplifier is removed when the manual key is transferred to the working unit. Therefore, after a failure the key should always be turned to the working unit.

6.22 A lamp and a reset button for the major alarm circuit are located near the center of the control panel. The lamp and the connected office alarm circuits are activated whenever either the REG or the ALT unit of the pair of power supplies is out of limits or whenever both REG and ALT units of a pair of amplifiers are out of limits. Thus, a major alarm means that at least one of the carrier frequencies or one of the power supplies is out of limits.

6.23 A lamp and a button key for the minor alarm circuit are located on the control panel. The lamp and the connected office alarm circuits are activated whenever either a REG or an ALT unit of a pair is out of limits. Thus, a minor alarm means that at least one unit is working without standby protection.

6.24 After being activated, the alarm will continue to indicate, and clearing the trouble will not return the indicator circuit to normal. To achieve maximum protection, the alarms should be reset promptly. Depressing the reset button releases the office alarms and extinguishes the major (or minor) alarm light on the switching and alarm panel. The lamp under (or over) the defective unit is not extinguished until the out-of-limit plug-in unit is removed from the carrier supply. If the reset button is operated, a second trouble will be indicated even if the first trouble has not been cleared.

7. DIRECT CURRENT POWER SUPPLY

A. Primary Source of Power

7.01 The primary source of power for the carrier supply is the -48 volt plant battery. An internal source of power for the amplifiers is provided by the -21 volt power supply which converts the variable battery voltage to a precisely regulated -21 volts.

7.02 The transfer relays, the indicator lamps, the minor alarm circuit, and the major alarm

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circuit are energized directly from the -48 volt battery. The 4-kHz generators, the dual amplifiers, and the doubler amplifiers are energized by the -21 volt power supplies.

7.03 All circuits perform satisfactorily with battery voltages between -44 and -52 volts. Although the -21 volt power supply unit regulates satisfactorily for battery voltages between -40 and -56 volts, the switching transfer relays require battery voltage between -44 and -52 volts for proper operation. Battery noise should not exceed +56 dBrnC (decibels above reference noise with C message weighting), and the 120-Hz ripple component should not exceed 300 millivolts rms.

7.04 The normal current drain from the battery will vary between 1.5 amperes for a skeleton carrier-frequency supply and 2.5 amperes for a supply with a complete complement of REG and ALT units. The maximum current drain will not exceed 3.6 amperes when all indicator lights are on and the transfer relay circuits are drawing maximum current.

B. Fuse and Alarm Circuits

7.05 Leads from the plant battery are connected to the carrier-frequency supply through a terminal strip on the fuse and alarm panel. This terminal strip also provides means for connecting the alarm circuits to the office alarms and for connection to the 4-kHz taps on the L multiplex when the external 4-kHz source is used.

7.06 Battery power is distributed from the fuse and alarm panel through three circuits. Each circuit has a fuse, a blown-fuse indicator light, and may contain a connection for a fuse alarm at a remote location. A schematic circuit for the power distribution system is shown in Fig. 30.

7.07 The REG and ALT -21 volt power supplies are protected by the F1 and F2 fuses, respectively. If a fuse blows, the sensing circuit on the power supply unit detects a low-voltage condition and initiates a major alarm.

7.08 All of the 48-volt circuits in the switching and alarm system are protected by the F3 (70B) fuse. A blown fuse will cause an alarm.

7.09 A test jack on the switching and alarm panel may be provided for use with the J99300AU

N3 switching set. This test jack is protected by the F4 (70C) fuse. Failure of this fuse will not initiate an office alarm.

C. Direct Current Power Converter and Regulator

7.10 Since the types of transistors selected for the carrier-frequency supply cannot be operated efficiently with supply voltages much greater than 20 volts, a dc-to-dc converter is used to convert the -48 volt input from the plant battery to -21 volts. The precisely regulated -21 volt power supply to the amplifiers assures that the carrier-frequency output voltages will be relatively insensitive to variations in the plant battery voltage. The efficiency of the converter exceeds 80 percent.

7.11 The J87245A power supply unit is used as one of the plug-in assemblies for the carrier-frequency supply. When so used, the unit has been designated as the -21 volt power supply. Since this unit is also used in the N3 carrier terminal, a detailed description is given in Section 362-903-100.

7.12 Regulation and voltage transformation are accomplished by using a transistor as a switch. A control circuit causes a transistor to conduct and to be cut off periodically at a nominal switching rate of 10 kHz. The output voltage is determined by the fraction of the total cycle during which the transistor is conducting. A large smoothing capacitor is charged by the current pulses, and the dc output voltage is proportional to the integrated area of the pulses.

7.13 The regulator circuit compares a fraction of the output voltage, provided by a voltage divider, with a reference voltage provided by an avalanche diode. The comparison circuit changes the current pulse duration so that the desired voltage is maintained. By a screwdriver adjustment of a potentiometer, the output voltage is set to the required value. The circuit automatically maintains this voltage thereafter.

7.14 The power supply contains input and output filters to prevent noise created by the switching action from appearing on the input and output leads. The power supply also includes over-voltage protection and an alarm circuit that detects both high and low output voltages.

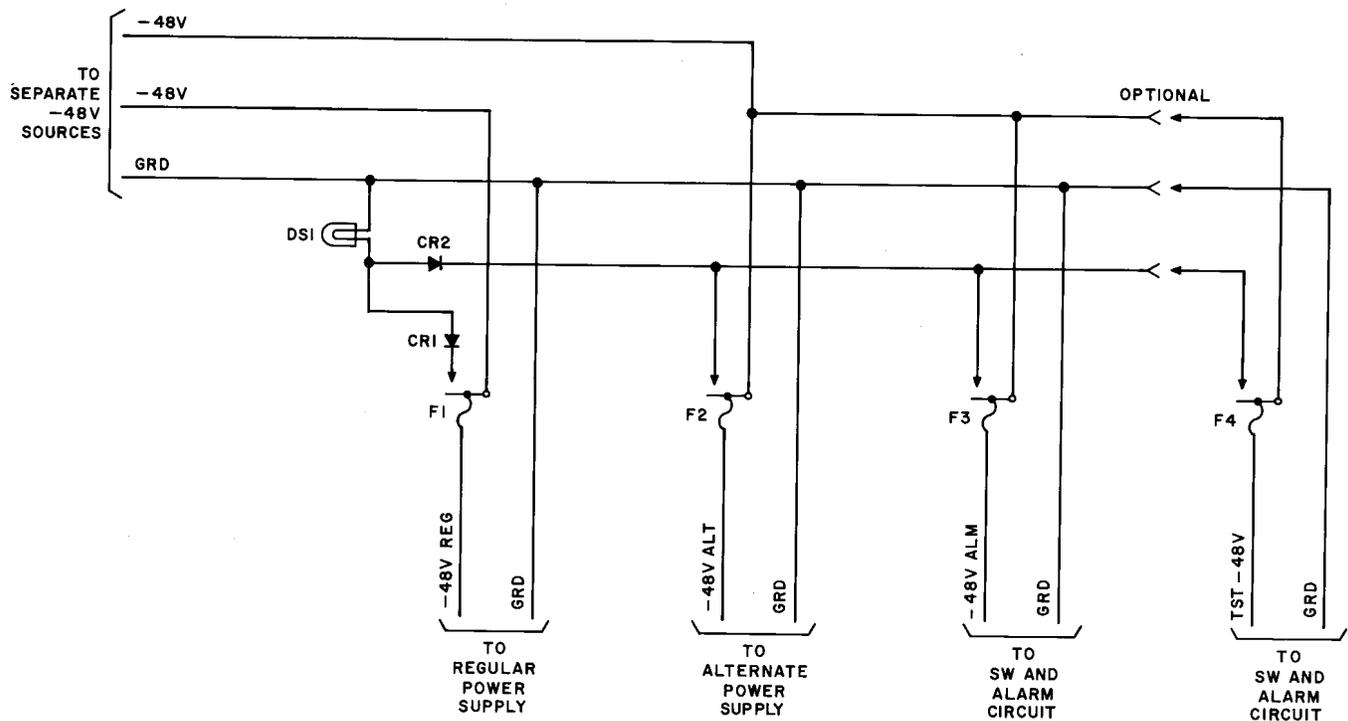


Fig. 30—Power Distribution System

D. Monitoring Circuit

7.15 A high-voltage indicator circuit and a low-voltage indicator circuit are used to provide input information for the switching and alarm system for the carrier supply. This circuit is described in Section 362-903-100. A relay is normally operated when the voltage is between -20.2 and -21.8 volts. A circuit using three transistors causes the relay to release whenever the voltage is not within these limits. The low-voltage alarm (LV ALM) and the high-voltage alarm (HV ALM) adjustments are made with the power supply unit plugged into the J99300AU N3 switching set. An adjustment that can be made from the front panel with a potentiometer designated ADJ VOLTS permits setting the output at the desired voltage.

8. PERFORMANCE

8.01 The performance specifications for the components of the carrier supply have been listed in Table C for convenient reference.

9. DRAWINGS

9.01 The schematic drawings listed below (but not attached) include details pertinent to the carrier supply described in this section.

NUMBER	SUBJECT
SD-81638-01	Power Supply Circuit
SD-99730-01	4-kHz Generator Circuit
SD-99732-01	Switching and Alarm Circuit
SD-99733-01	Dual Amplifier Circuit
SD-99734-01	Doubler Amplifier Circuit
SD-99735-01	Application Schematic
SD-99736-01	Secondary Distribution Circuit

TABLE C

61A Oscillator	
Output frequency	4 kHz
Frequency stability	± 6 parts per million periodic check required
Output level	+1 dBm ± 0.5 dB, 135 ohms
Harmonic distortion	-35 dB
Temperature range	0° to 60° C
-21 Volt Power Supply	
Output voltage	-21.0 ± 0.1 periodic check required
Alarm voltages	-21.0 ± 0.8
Total noise	12.0 millivolts rms
Output current	0.7 ampere minimum 4.0 amperes maximum
Input voltage	40 volts minimum 56 volts maximum
Primary Distribution Circuit	
Channel carriers	+11.0 dBm ± 0.5 dB, 115 ohms
Group carriers	+8.0 dBm ± 0.5 dB, 115 ohms
Unwanted frequencies	-60 dB