Power Supply

The power supply (not shown) is a conventional full-wave rectifier, which provides the power required by the comparator circuits. It furnishes +250 volts d-c at 35 ma, and has a separate rectifier circuit that supplies the required 32 volts negative bias.

COMPARATOR-CONVERTER GROUP AN/URA-17

Comparator-Converter Group AN/URA-17 (fig. 10-8) is a completely transistorized equipment designed to perform the same functions in the frequency-shift RATT receiving system as the AN/URA-8B, just described.

Although present procurement of frequency-shift converters is confined to the AN/URA-17, there are relatively few installations compared with the large number of AN/URA-8B converters. The greater quantity of AN/URA-8B converters will continue in service for several more years before eventual replacement by the newer model described briefly in the following paragraphs.

GENERAL DESCRIPTION

The AN/URA-17 consists of two identical converter units, one of which is shown in close-up in figure 10-9. Each converter has its own comparator circuitry. This achieves a considerable reduction in size from model AN/URA-8B, wherein the comparator occupied a separate chassis. The physical size of the AN/URA-17 is further reduced through use of semiconductors and printed circuit boards. The complete equipment is less than half the size of the AN/URA-8B.

The comparator-converter can be operated with two radio receivers in either space-diversity or frequency-diversity receiving systems. When conditions do not require diversity operation, each converter can be used separately with a single receiver for reception of frequency-shift RATT signals. In this latter usage, the two converters can be operated in two independent communication circuits.

For diversity operation, the function switch (fig. 10-9) on both converters must be placed in the diversity position. The teletypewriter may be connected to either converter.

BLOCK DIAGRAMS

The simplified block diagram, figure 10-10, indicates the basic functions of converting the r-f frequency-shift signal into a signal for controlling the d-c loop of the teletypewriter. The frequency shifts of the audiofrequency output of the radio receiver are converted into d-c pulses by the action of the audiofrequency discriminator. The d-c pulses are fed into the loop keyer, which opens and closes the d-c loop of the teletypewriter in accordance with the mark and space characters received.

The principal functions of the circuits of the complete equipment are represented in figure 10-11. Two receivers and a teletypewriter are also shown, connected for diversity operation. The two converters are identical, and one is shown as a single block for simplicity.

RADIOTELETYPEWRITER TERMINAL SET AN/SGC-1A

Radioteletypewriter Terminal Set AN/SGC-1A is a tone-shift keyer/converter used for short-range RATT operation. Normally, it is used for communication on the VHF/UHF bands, but it can be used with any transmitter designed for voice modulation. The AN/SGC-1A is shown in figure 10-12, with blocks to indicate other equipments necessary for a complete tone-shift system.

In tone-modulation transmission, the d-c pulses of the teletypewriter code are converted into corresponding audio tones, which amplitude-modulate the transmitter. Conversion of the audio tones is accomplished by an audio oscillator in the tone converter, which operates at 700 cycles when the teletypewriter loop is in a closed-circuit (marking) condition, and at 500 cycles when the loop is in an open-circuit (spacing) condition.

An internal relay closes a control line to the radio transmitter, which places the transmitter on the air when the operator begins typing his message. The control line remains closed until after the message is transmitted.

When receiving messages, the tone converter accepts the mark and space tones from the radio receiver and converts the intelligence of the tones to the make-and-break contacts of a relay connected in the local teletypewriter loop. This action causes the local teletypewriter to print

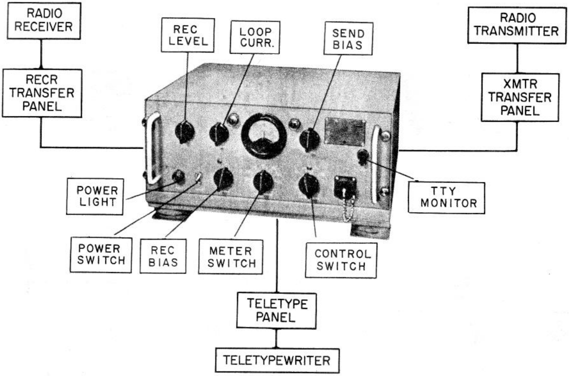


Figure 10-12.—Tone-shift keyer/converter AN/SGC-1A. 1.240

in unison with the mark and space signals from the distant teletypewriter.

RECEIVE CIRCUIT BLOCK DIAGRAM

All principal circuits of the AN/SGC-1A are shown in the system block diagram (fig. 10-13). The receive circuits are considered first in this discussion.

At the input of the receive circuit is the attenuator. It permits adjustment of the level of the incoming two-tone signal. A bandpass filter then passes audiofrequencies that fall between 400 and 800 cps and rejects all other frequencies. Following the filter is the amplifier-limiter stage.

The amplifier-limiter circuit provides a constant signal level to the remaining circuits of the converter. Its output is coupled to the frequency discriminator filter, which provides separate circuits for the selection of the mark (700 cps) and space (500 cps) frequencies.

Two germanium rectifiers at the output of the frequency discriminator filter rectify and convert the respective frequencies to a corresponding d-c voltage. This voltage then serves as the input to the individual direct current amplifiers. The amplifiers are connected so as to cause the receive relay to close its contacts when the incoming signal is 700 cps, and to open its contacts when the incoming signal is 500 cps.

One set of the contacts of the receive relay is placed in series with the local teletypewriter loop. Consequently, the receive relay is able to open and close the local teletypewriter loop, thus forming current pulses in the loop identical to those that originated at the transmitter.

Because the receive and send circuits of the tone converter are discussed separately the remaining portion of the block diagram (fig. 10-13) is discussed later in this section. Reference to this diagram is made at the appropriate point in this discussion.

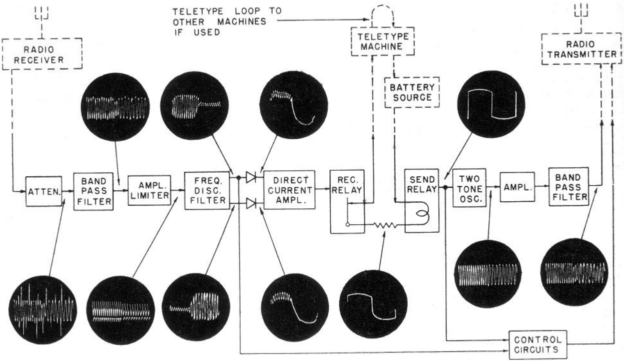


Figure 10-13.—Tone terminal, system block diagram.

OPERATION OF RECEIVE CIRCUITS

The audio signals (fig. 10-14) of 500 and 700 cps, respectively, are coupled from the receiver (preferably through a 600-ohm line) to the tone converter input by T1. Receive level attenuator E1 allows a 20-step attenuation of 2 db per step, thus giving a possible maximum attenuation of 40 db for the stronger signals. The degree of attenuation is determined by the setting of the receive level control on the converter front panel (fig. 10-12).

A 6-db pad comprising R1, R2, and R3 provides additional attentuation, and minimizes the effects of mismatch if the output impedance of the associated receiver is not 600 ohms. The signal then passes through control switch S3 in the AUTO or REC STBY positions (Contacts 8 and 9) to the input filter Z1.

Frequencies from 400 to 800 cps are attenuated no more than 2 db by the input filter. Frequencies above or below this range are attenuated as much as 40 db. The Z1 output is applied to the T2 primary.

Amplifier-Limiter

The signal from the T2 secondary is applied through grid limiting resistor R4 to the first amplifier-limiter (V1A) control grid. Upon reception of weak signals, the stage functions as a conventional amplifieer, applying its output through C3 and R10 to the second amplifier-limiter V1B. The signal subsequently is coupled (in the same manner) to the V2A and V2B control grids. The operation of all the stages is identical except V2B, which is discussed later.

The plate load resistors of the respective stages (R7, R9, R16, and R17) are made large to facilitate grid limiting. On strong, positive peaks, the grids of the tubes draw a current through their grid resistors, R4, R10, R13, and R18, respectively. The voltage drop developed across these resistors is such that the potential at the grid (negative) opposes the positive going input, and grid limiting occurs on this portion of the positive alternation. Strong negative input signals drive the grids to cut off, which limits the negative alternations. The cathode resistors are made large so that they operate the tubes in the midportion of their characteristic curves.

The fourth stage, V2B, utilizes different circuit constants in its plate and cathode to provide proper impedance matching for the discriminator filter circuit that follows. To correct for possible discrepancies in the positive and negative halves of the amplified (or limited) signal, degenerative action is accomplished across R20 in the V2B cathode.

Frequency Discriminator Filter Circuit

The frequency discriminator filter circuit, Z2, consists of two complementary bandpass filters in one container. Terminals 1, 2, and 3 connect to the section that passes 700 cps and a narrow band of frequencies above and below that center frequency. Terminals 3, 4, and 5 connect to the section that passes a similar band centering on 500 cps. Terminals 3 and 6 are connected together and grounded.

The input terminals of the two sections (terminals 1 and 4) are tied together and connected to the plate of the last amplifier-limiter, V2B. The internal capacitors of the filters (not shown) eliminate the need of a coupling capacitor.

The two incoming signals from the receiver may be at different amplitude levels. However, the action of the amplifier-limiter causes the signals to arrive at the discriminator filter circuit at a constant level. The output of the filter is either 500 or 700 cps with respect to the time of the mark and space signal input. The two frequencies do not appear at the filter output simultaneously. A small amount of leakage exists between the two filters, but not in sufficient amount to cause any appreciable harmful effect.

The mark tone, 700 cps, appears across terminating resistor R21, and the space tone, 500 cps, appears across R24. During the time the mark tone is being applied across R21, germanium diode CR1 conducts to charge C8 (on positive half cycles) to approximately 15 volts. During negative half cycles of this input, C8 loses some of its charge through R22. As the discharge resistor R22 is about six times as large as the charging resistance of CR1, the majority of the accumulated charge is retained by C8 until the end of the mark tone. At this time C8 discharges to the zero potential.

During the time the space tone is being received, the signal charges C9 through CR2 and R24. Capacitor C9 likewise discharges on negative half cycles through R25. As a result of the discharge of C8 and C9 during mark and space intervals, the d-c voltage developed across R22 and R25 is applied to the individual control grids of V3 and V4.

D-C Amplifier

The cathodes of the d-c amplifier pentodes, V3 and V4, are connected to opposite ends of the receive bias control R28. The arm of the control is connected to the common cathode resistor R27 so that it, too, is common to both tubes. Bias control R28 tends to equalize the two cathode currents, as discussed later. The screen voltage of both tubes is maintained at the same value by the action of R29, which tends to provide equal plate currents from V3 and V4.

Mark impulses applied through R23 to the grid of V3 cause the plate current to increase from approximately 2 ma to 22 ma. Space impulses applied through R26 to the grid of V4 cause a similar increase in the plate current of V4. The receive bias potentiometer R28 permits changing the relative amplitude of these impulses by varying the magnitude of the pentode plate currrents.

When the receive bias control is rotated in one direction, it increases the resistance in one cathode circuit while decreasing the resistance in the other. This action causes the cathode voltage of the first pentode to increase and causes the cathode voltage of the second pentode to decrease. Because the plate current of the pentodes is controlled by the grid-to-cathode voltage, a change in the cathode voltage by varying the receive bias potentiometer is very effective in changing the plate current of the two pentodes.

Receive Relay Circuit

Relay K1 is a polar relay containing a permanent magnet and three controlling coils. The plate current of V3 and V4 is caused to pass through separate windings of the relay. The movable arm of K1 (contact 6) is operated under the influence of the coils to contact 7 for a mark input from the d-c amplifier, and to contact 4 for the spacing signal.

Current from V3 passes through the K1 coil (pins 8 and 1) and meter shunt R30 to the B supply. The current through the 8 and 1 coil of K1 causes the arm of K1 (contact 6) to make with contact 7 during mark. This action completes the teletypewriter loop from contact 7 of K1, through the keying filter comprising R73 and L1, through contacts 1 and 12 of S2 (section 4 rear), through J1 contacts 3 and 2 and R75 (compensating resistor), through contacts 4 and 5 of J1 and the loop current adjust R33, through meter shunt R35 and 2L and 1L of receive control relay K4, through coil 8 and 1 of the send relay K2, through the local teletypewriter keyboard and selector magnet, through the line current rheostat and power supply, through contacts 12 and 1 of S2 rear (section 3), to return to contact 6 of relay K1, thus completing the loop. Note again that the received signal passes through both the receive and send relays.

The spacing current from V4 passes through coil 3 and 2 of K1 to move contact 6 of the relay to make with contact 4. In this condition, the teletypewriter loop is open.

Components L1, R73, C10, C11, R74, and C12 collectively form a spark suppression and wave-shaping network. The network compensates for the inductive reaction peculiarity associated with some models of teletypewriters.

The third winding of receive relay K1 consists of only a few turns, which are shorted at the socket connections. During the time that the 8-1 and 3-2 coils produce collapsing fields, the shorted coil builds a field, which counteracts the changing flux. This action damps the coils to prevent possible oscillations. The damping permits high-speed keying without contact bounce.

Resistors R30 and R31 are used for measuring the plate current of V3 and V4. The voltage developed across these resistors is proportional to the plate currents, and is applied to the meter M1 through R32 and S2 (contacts 6 and 12 of section 1 rear) when the meter switch is in the PLATE CURRENT position.

Operation of Receive Bias Adjustment

All impulses from the teletypewriter keyboard, with the exception of the stopping impulse, should have the same duration. In the 7.42 unit transmission pattern, the duration of the impulses in machines geared for 60 wpm is 22 ms for the starting space, 22 ms for each portion of the 5-coded characters, and 31 ms (42% longer) for the stopping mark. The teletypewriter code and the 7.42 unit transmission pattern are explained in detail in chapter 12.

In the process of converting the intelligence from d-c pulses to tone, or any of the various methods used for communications, a distortion known as bias is often introduced. This distortion results in the mark and space impulses being elongated or shortened with respect to their normal length. The length of time for a teletypewriter letter is fixed by the mechanical gearing of the machine and cannot be altered or distorted. Individual mark impulses can be lengthened, however, while the space impulses are shortened simultaneously, or vice versa. If the marking impulses are longer than normal, the condition is known as marking bias. If the spacing impulses are too long, the condition is known as spacing bias.

A teletypewriter can operate with a considerable amount of bias in its signal. Exactly how much bias it can stand without misprinting is determined, for example, by the adjustment of its mechanism or the speed of its motor among other things.

To compensate for bias, the receive bias control must be adjusted properly. As considered earlier, the operation of this control caused the plate current of V3 and V4 to vary accordingly. Figure 10-15, part A shows the shape of the mark and space impulses when the incoming tones are evenly spaced groups of 700-cps and 500-cps signals. For the purpose of explanation, the space impulses are shown upside down to indicate the opposing action of the two plate currents upon the resultant flux in the receive relay. The ripples in the waveforms are due to the discharge of C8 and C9. They present no appreciable effect on the operation of the relay.

The ripples show that the space tone starts as soon as the mark tone ends, and vice versa.

The space-to-mark transition (S-M) closely follows the starting time of the mark tone. Likewise, the mark-to-space transition (M-S) closely follows the starting time of the space tone. These transitions take place immediately after the two plate currents of V3 and V4 are equal.

Figure 10-15, part B shows the effect when one plate current, V3, is increased and the other plate current, V4, is decreased by the operation of the receive bias control. The ripples show that the timing of the incoming tones has not changed. The S-M and the M-S transitions still take place when the two plate currents are equal, but it should be noted that the relative spacing on the timing axis has changed. As the length of time from the S-M to the M-S transition has increased, the relay armature would be operated to, and held against, the mark contact longer than normal, and the d-c signals to the teletypewriter would have marking bias. Rotation of the receive bias control in the opposite direction would cause these conditions to change conversely, and the signals to the teletypewriter would have spacing bias.

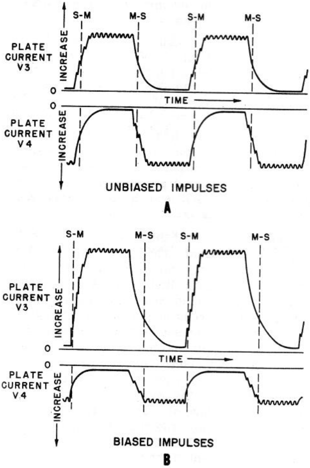


Figure 10-15.—Bias and unbiased teletypewriter impulses.

Under actual conditions, it would be undesirable to introduce either marking or spacing bias, and this explanation is intended only to illustrate how the receive bias control can compensate for a bias distortion that is introduced into the signal either internally or externally. Where the timing of the tone groups is distorted, or the amplitude of the rectified mark and space impulses is incorrect, the receive bias control usually permits sufficient compensation to correct the signal.

TRANSMIT CIRCUIT BLOCK DIAGRAM

The send relay circuit (fig. 10-13) energizes the transmit circuits when a message is to be transmitted. In the receive condition, the send relay is deactivated.

A single, two-tone oscillator (multivibrator) provides the two tones of 500 and 700 cycles. A mark and space signal is represented at the oscillator output in the diagram.

Signals from the two-tone oscillator are amplified and applied through a bandpass filter to the associated transmitter. The filter passes frequencies from 400 to 800 cps with little attenuation. However, frequencies outside the filter range receive a correspondingly greater amount of attenuation with an increase in frequency on either side of the bandpass of the filter.

Signals from the frequency discriminator filter and the two-tone oscillator are applied to the control circuits, which include a transmit and receive control relay and their associated amplifier tubes (discussed later). These control circuits exert a direct influence on the transmit and receive circuits to provide the automatic switching action of the tone terminal.

OPERATION OF TRANSMIT CIRCUITS

For the following explanation of the transmit circuits of the AN/SGC-1A teletypewriter terminal, the reader is referred again to the schematic diagram, figure 10-14.

Send Relay Circuit

The send relay K2 is also a polar type relay with three coils. The current in the 8-1 winding (connected in the teletypewriter loop) is 60 ma in the mark condition and 0 ma in the space condition. In standby condition (neither receiving nor transmitting) the current in the 8-1 winding is reduced to 36 ma. Though this action is described in detail later, note that R36 (in series with the teletypewriter loop) causes the current to rise or fall from 60 to 36 ma, as determined by the shorted or open condition of the 1R-2R contacts of K3.

A current flowing through the 3-2 winding and the voltage dividers R63, R62, and R61, is steady at 30 ma. The send bias control R63 provides a method of adjusting this bias between 20 and 40 ma. The second winding (3-2) is hereafter referred to as the space winding.

In the standby condition, the 30-ma current in the space winding (3-2) produces a magnetic flux that is weaker and made opposite to that flux produced by the 36-ma closed teletypewriter loop current in the 8-1 winding. The resultant flux holds the send relay armature (6) against the mark contact (7). The third winding produces a damping action in the same manner as presented in the discussion of the receive relay K1.

Although the preceding discussion is relative to the standby condition, the same action of the coils is repeated during the marking condition, except that the loop current is increased to 60 ma. For space, the teletypewriter loop current drops to 0, and the unopposed flux produced by the spacing winding (30 ma) moves the relay armature (6) to the space contact (4). When a message is typed, the loop current is changed rapidly and repeatedly from 0 to 60 ma and back to 0 again. The resultant flux is reversed continually, and the relay armature is switched continually from mark (pin 7) to space (pin 4) and back again. In the receive condition, the 30-ma current in the space winding is reversed by the action of the receive control relay K4, which operates to make 4R-5R and 2R-1R contacts. Thus, the flux of the space winding is reversed so that it now aids the flux produced by the teletypewriter loop current. Regardless of the loop current, therefore, the resultant flux of the send relay is always in the same direction. The reversal of the space winding current constitutes the interlocking feature that prevents the send relay from operating when receiving a message.

Receive Control Relay

Twin triode V10 has one of its sections, V10A, connected as a diode. One end of the receive control relay is tied to the 250-volt B supply, and the other end is connected through current limiting resistor R77 to the plate (pin 6) of the V10B triode. The relay is energized when plate current flows. The plate current is controlled by the bias voltage on grid 7 of V10B. In general, two factors determine the bias applied at this grid. The grounded or ungrounded condition of the transmit control relay (contact 1L and 2L) is the first determining factor, and the presence or absence of an incoming signal at the V10A cathode is the second.

In standby, no signal is received, and the transmit control relay (contacts 1L and 2L) connected to the grid of the triode, is open. Under these conditions, C19 assumes a positive charge from the +105-volt supply. In the voltage divider comprising R58, R57, and the grid-to-cathode resistance of V10B, R58, and R57 assume more than 99 percent of the voltage drop. This limits the cathode-to-grid positive voltage to less than 1 volt. With this grid potential, V10B conducts heavily through R77 and the solenoid of K4 to operate its contacts.

Now, suppose that the receive circuit begins to receive a signal. The mark frequency taken from the frequency discriminator filter output is applied through R56 to the V10A cathode. Negative half cycles of the input cause V10A to conduct. The circuit containing R56, V10A, and C19 forms a much shorter time constant (when V10A conducts) to charge C19 negative than does the circuit comprising C19, R57, and R58, which tries to charge C19 positive. As a result, the higher current in the lower time constant circuit (when V10A conducts) charges C19 negative with respect to ground. The charge is cumulative on alternate half cycles of the signal until C19 assumes a sufficient charge to cut off V10B. This action deenergizes K4 to place it in the receive condition. A short time after the last mark cycle (ending the receive condition), C19 completely discharges and assumes a positive charge. Tube section V10B again conducts to energize the receive control relay K4. The time of the discharge of C19 is determined by the time constant of C19, R57, and R58. This circuit forms a long time constant discharge path.

In the transmit condition the transmit control relay K3 is energized. (This is discussed later.) Energized K3 shorts the grid-to-ground potential developed by C19. The cathode and grid of V10B are therefore at ground potential, allowing plate current to flow through the K4 solenoid. Thus, the receive control relay is energized during transmission. Because the transmit control relay K3 keeps both ends of C19 at ground potential, any incoming signal from the frequency discriminator filter cannot charge C19 in an attempt to deenergize the receive control relay.

Only in the receive condition will contacts 1R-2R and 4R-5R of K4 be closed. The 1L-2L contacts of the transmit control relay K3 are open at this time. This action causes the send relay space winding current to be reversed. Thus, contacts 7 and 6 of the send relay K2 are constantly held closed throughout the receive condition. Note that the receive control relay K4 is always energized except when the terminal is in the receive condition.

Contacts 5L and 6L of K4 are closed during transmit and standby (as shown), shorting pins 6 and 7 of the receive relay K1, so that the teletypewriter loop is closed at this point. Contacts 3L and 4L supply 6.3 volts to the receive indicator lamp when in the receive condition. Contacts 1L and 2L short R36 (in the teletypewriter loop) in the receive condition, allowing the loop current to rise from 36 to 60 ma through the K1 solenoid during mark.

Transmit Control Relay

Twin triode V11 functions in much the same manner as V10 to control the action of the transmit control relay K3. Plate current passes through the K3 solenoid when V11A is conducting. The grid bias of V11B is determined by the position of control switch S3 and the position of the send relay K2.

The cathode of the diode section of V11B is connected through R60 to the output of the audio oscillator V5. The oscillator functions continuously upon the application of the B supply voltage, and a continuous audio voltage is applied to the V11B diode.

In the transmit position of control switch S3 (as shown), mark and space signals in the teletypewriter loop pass through the solenoid of the send relay K2. A positive 105 volts from the voltage regulator V9 charges C20 positive with respect to ground through R76 and the S3 contacts. The positive potential of C20 is applied to the control grid (pin 2) of V11A, allowing the tube to pass an energizing current through the solenoid of K3.

The 1R-2R contacts of K3 short R36 in the teletypewriter loop to allow the 60-ma mark current. Contacts 3R and 4R close the control line to the transmitter during transmit condition, which places the transmitter on the air. Contacts 5R and 6R close the output circuit during transmit condition so that the outgoing signal tones may be applied across the T4 primary.

The 3L-4L contacts complete the circuit to the transmit indicator lamp, and contacts 1L-2L ground the grid of V10B, which causes it to operate the receive control relay.

With control switch S3 in the AUTO position, an incoming signal causes the terminal to change from standby condition to receive. Keying the local teletypewriter causes the terminal to change from standby condition to transmit.

In standby and receive condition, the send relay K2 connects its armature (6) to the mark contact (7) so that the space contact (4) is open. In this condition, the only voltage applied to the V11B diode is the oscillator a-c voltage. On negative half cycles of this input, V11B conducts to charge C20 negative with respect to ground. This negative voltage is applied through grid limiting resistor R59 to the V11A grid. This section of the tube cuts off, thus preventing the flow of plate current through the solenoid of K3. This relay is therefore deenergized during standby and receive conditions.

Because K3 is not energized, its contacts 1L and 2L are open. The incoming signal at the V10A cathode cuts off V10B and deenergizes the receive control relay K4. Thus, contacts 4R and 5R complete the space winding circuit of K2 so that its current is reversed, and the armature of the send relay is held in the mark or receive condition.

When a message is typed locally (S3 in the AUTO position), the armature of the send relay intermittently applies positive 105 volts to the space contact (4). This voltage charges C20 through R76 and contacts 1 and 2 of S3. The positive voltage thus developed across C20 is applied through R59 to the V11A triode, and K3 is energized. Contacts 1L and 2L of K3 are now closed, and V10B conducts to energize K4. The current through the send relay now changes back to its original direction because the 1R-2R contacts of K4 are closed again. This allows the armature to move between pins 7 and 4 under the influence of the teletypewriter characters.

In the ADJ FREQ position of control switch S3, all contacts are open except contacts 9 and 11. These contacts connect the output circuit of the terminal to the input so that the mark and space tones produced by the oscillator are fed into the receive circuit. The receive circuit separates the mark and space tones and applies rectified signals to the d-c amplifier in the same manner as discussed. When each tone is at its correct frequency, it receives a minimum of attenuation in passing through the discriminator input filter. When the signal is rectified, therefore, it produces a maximum voltage at its corresponding frequency. With maximum voltage applied to the d-c amplifier, the circuit produces a maximum of plate current. With the circuit connected in this manner, the mark and space frequency adjust controls can be set for optimum operation.

Two-Tone Oscillator

The circuit of V5 is designed to produce the 700- and 500-cps mark and space frequencies used to modulate the frequency of the associated r-f transmitter. Both the mark and space frequency adjust controls are provided to exact the respective frequencies.

Disregarding the circuit comprising R42, C15, and C16, and completing the V5A grid circuit, the oscillator can be described as that of a conventional cathode-coupled multivibrator. If we, therefore, assume V5A to be conducting, C14 discharges through R43, the common cathode resistor R44, and the conducting resistance of V5A, to return to C14. The negative voltage across R43 toward the V5B grid cuts off this section of the tube until after the complete discharge of C14. At this time, with the plate voltage of V5B at the B supply value and zero voltage across R43, V5B begins slight conduction.

Because the conduction of V5A has developed a large fixed bias voltage across R44, the current through R41 is small at the beginning of the V5B conduction. However, the small conduction of V5B is sufficient to raise the R44 bias voltage, which, in turn, moves the operating point of V5A down on its characteristic curve. The rise in plate voltage of V5A charges C14 through R43, thus aiding the V5B conduction. The latter tube section then moves almost instantaneously up its characteristic curve to the saturation point. The circuit remains in this condition until a positive trigger pulse is applied to the V5A grid.

The null network comprising R42, C15, and C16 couples all but one of the harmonic frequencies from the V5A plate through C14 to the V5A grid. In effect, the circuit cancels one frequency or presents a null to the V5A grid at this frequency.

All frequencies passed by the network appear at the grid, and the same signals simultaneously appear at the cathode as a result of plate current flow. Signals applied to the grid and cathode at the same time and 180° out of phase do not affect the plate current of the tube. These frequencies are therefore degenerated. Because the null frequency is applied only at the cathode (caused by plate current through R44), it has effect on the plate current. The null signal voltage across R44 acts as the trigger input for V5A. Grid leak components C14 and R43 have very little effect on the frequency of the oscillator.

Send relay K2 changes the oscillator frequency. This accomplished by shorting R47 in the following manner. A potential of approximately 2 volts positive is developed across R48 as a result of a current flow through R48 and R49 to the + 105-volt supply. This establishes a 2+volt potential at the bottom end of diode CR4. When K2 is in the mark condition (contact 7), another current flows from ground through R39, R38, the send relay contacts (7 and 6) and R37, to the +105-volt supply. Approximately +4 volts is developed across R39, which is applied to the arrow of CR3. The two diodes, CR3 and CR4, therefore conduct during mark condition to short R47. Thus, the null network resistance is decreased, and the oscillator frequency rises to 700 cps. With R46, R80, and R48 in the circuit, the mark frequency can be adjusted to exactly 700 cps by the mark frequency adjust control R46.

During space condition, armature 6 of K2 is disconnected from the +105 volts at its contact 7. The two diodes (CR3 and CR4) do not conduct as a result of the +2 volts still applied to the bottom end of CR4. In effect, then, the diodes are not in the circuit, and the full resistance of R47 is placed again in the null network circuit. Likewise, the oscillator frequency decreases to 500 cps. The proper setting of the space frequency adjust R47 at this time corrects the space frequency output.

Tone Amplifier

Mark and space tones from the oscillator at the V5B plate are coupled by C17 to tone amplifier V6. This amplifier comprises a single stage twin triode with the two sections of the triode parallel-connected to provide low plate resistance. The input level of the tones is adjustable by means of the send level potentiometer R50 in the grid circuit. Resistor R52 and capacitor C18 decouple the plate of V6 from the B supply. Degeneration, because of the unbypassed cathode resistor R51, aids in maintaining the two frequencies at approximately the same level. The amplified tones are coupled to the output circuit through plate transformer T3.

Output Circuit

The signal at the T3 secondary is applied to a bandpass filter, Z3. The filter passes frequencies from 400 to 800 cps with an attenuation no greater than 2 db. Frequencies outside this range receive greater amounts of attenuation, depending on its harmonic frequency.

The filter output is applied to a 6-db pad comprising R53, R54, and R55. This circuit is identical to the 6-db input pad and functions to minimize the effects of a possible mismatch between the terminal and radio transmitter.

Before the signal can reach the impedance matching transformer T4, it must pass through the 5R-6R contacts of the transmit control relay K3. These contacts are closed when a message is transmitted. The secondary of T4 is tapped for matching to either a 600- or 50-ohm output impedance.

METERING CIRCUITS

Meter M1 is a d-c (zero center) milliammeter requiring a current of 1 ma for full-scale deflection. The 100-0-100 and -10 to +5 dbm scales are shown on the meter. The meter is switched into the circuit by meter switch S2.

In the SEND-BIAS position of S2 the send bias control R63 may be adjusted so that the meter reads zero, indicating proper length of the mark and space tones being transmitted. Switch contacts 8 and 9 of S2 (section 2 front) are closed in the SEND BIAS position to parallel R69 and R65. This connection places a positive potential (of a predetermined value) at the negative side of meter M1. The positive side of the meter is connected through a current limiting resistor R66 and a filter section comprising C23 and R67. The filter section is connected to the mark contact (pin 7) on the send relay K2.

The third impulse of a spacing signal represents a current in the loop, and the first, second, fourth, and fifth impulses are no-current signals. If the space bar on the teletypewriter keyboard is held down, the send relay armature moves back and forth between its mark and space contacts. A positive 105 volts is applied to the mark contact (7) from the B supply when the armature is in the mark condition. This positive voltage is applied to the metering circuit. When the armature is on the space contact (4), the positive voltage is not applied to the metering circuit.

On mark impulses, C23 acquires a charge from ground through R67 and R37. During the spacing impulses, C23 may discharge through R65 and R69 (in parallel) through the meter and R66 to the positive side of C23. Because of the fast movement of the send relay armature, the voltage on C23 stabilizes at a value that depends on the relative length of the mark and space impulses. If the space impulse is too long, the voltage on C23 has more time to leak off, and the voltage applied to the meter from C23 is low. Conversely, if the space impulse is too short, the voltage applied to the meter is too high. The result is that when the mark and space impulses are of proper relative length, the C23 voltage and the positive voltage applied to the negative side of the meter are the same. In this condition, the meter reading will be zero.

In the SEND LEVEL position of S2 (one clockwise rotation of all sections), the send level potentiometer R50 may be adjusted so that the meter indicates the proper level of the signals fed to the transmitter. Potentiometer R50 controls the level of the signal applied to tone amplifier V6.

With S2 in the SEND LEVEL position, the output of bandpass filter Z3 (passing through the output 6-db pad) is applied through section 3 front of S2 (contacts 5 and 6) through R71 to a bridge rectifier CR5. The rectifier changes the signal to d-c pulses, which are applied through section 2 rear of S2 (contacts 2 and 12) to meter M1. The circuit path is completed through contacts 12 and 2 of section 1 rear, the bridge circuit CR5, and ground, to return to the filter Z3.

The LOOP CURRENT position of S2 switches the proper components for metering and adjusting the loop current. With the switch in this position, the R34-R35 junction is connected by S2 to the negative side of M1 through contacts 3 and 12 of section 2 rear. Section 1 rear (contacts 12 and 3) connects the positive side of M1 to the R35-R36 junction. In this manner, the meter and multiplier resistor R34 are placed across R35.

The voltage developed by R35 is proportional to the current flowing in the teletypewriter loop circuit. Loop current rheostat R33 now can be adjusted so that the meter reads 60 on its upper scale when the terminal is in the transmit condition.

In the OFF position of S2, contacts 4 and 12 of section 2 rear and contacts 4 and 12 of section 1 rear short meter M1. If vibration causes the meter pointer to move, the meter coil develops a back voltage, which dampens its movement.

The RECEIVE LEVEL position of S2 connects a circuit very similar to that already discussed for the send level position. In this position, the output of the receive level attenuator (passing through the input 6-db pad) is applied from R2 to contact 9 of section 3 front. Because contacts 9 and 6 are shorted in this position, the input signal is passed from contact 3, through a section of the bridge rectifier CR5, contacts 5 and 12 of section 2 rear, to the negative side of M1. The d-c current (rectified by CR5) leaves the positive side of the meter and passes through contacts 12 and 5, another section of CR5 to ground, to return to E1. In this condition, the receive level attenuator may be adjusted until the meter reads 0 dbm.

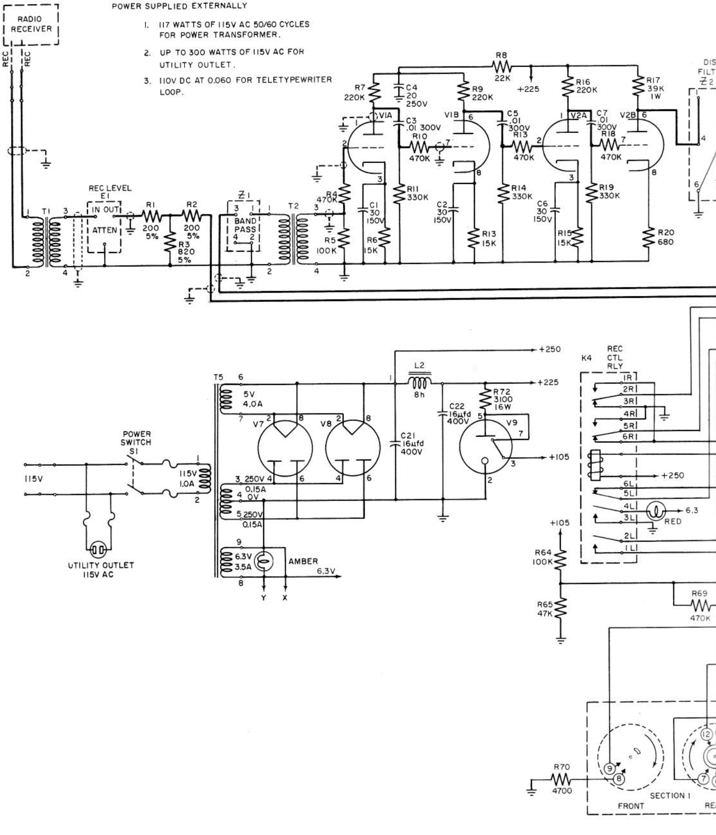
In the PLATE CURRENT position of S2, switch contacts 12 and 6 of section 2 rear and 12 and 6 of section 1 rear connect meter M1 across the d-c amplifier metering resistors R30 and R31. The current through these resistors is in opposite directions, so the voltage applied to the meter is equal to the difference of the potentials across R30 and R31.

In effect, the meter reads the differential plate current. The differential current for mark signals causes the meter to read to the right, and space signals cause a deflection to the left. The current reading of the meter represents the current effective in producing the magnetic flux in the receive relay.

The meter connection in the RECEIVE BIAS position is similar to that already discussed for the send bias position. Resistor R65 again applies a positive potential to the negative terminal of M1. Resistor R65 is not paralleled by R69 as in the SEND BIAS position of S2. The positive terminal of the meter connects through contacts 12 and 7 of section 1 rear, through R66 to C23. Resistor R67 is now connected through contacts 1 and 2 of section 3 rear to the armature 6 of receive relay K1. When the armature is in the MARK position, a positive voltage from the +105-volt supply charges C23 through R67, R73, contacts 1 and 2 of section 4 rear, and R68. When the receive bias control is adjusted properly, the positive potential on both sides of the meter will be equal, permitting it to indicate a zero reading.

POWER SUPPLIED EXTERNALLY

1. 117 WATTS OF 115V AC 50/60 CYCLES FOR POWER TRANSFORMER.
2. UP TO 300 WATTS OF 115V AC FOR UTILITY OUTLET.
3. 110V DC AT 0.060 FOR TELETYPEWRITER LOOP.



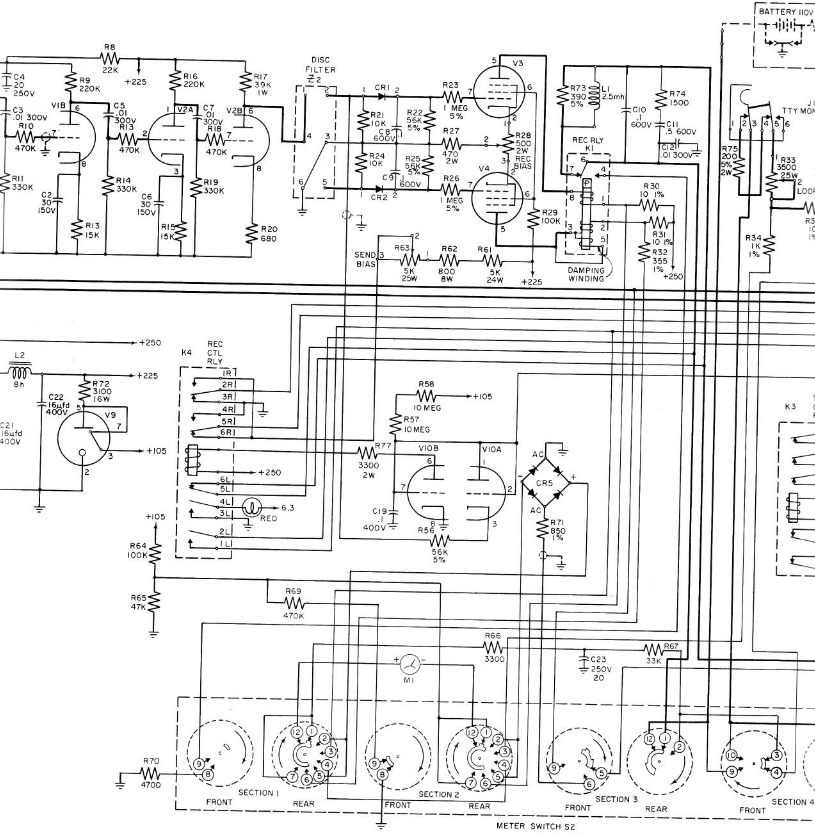


Figure 10-14.—Tone terminal, schematic diagram

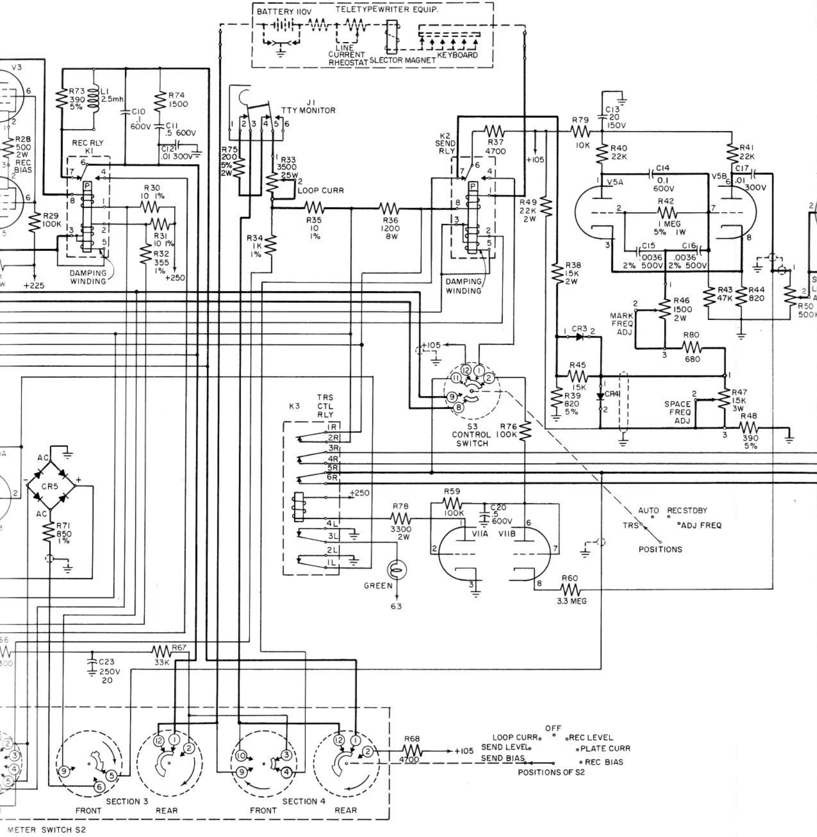


Figure 10-14.—Tone terminal, schematic diagram.

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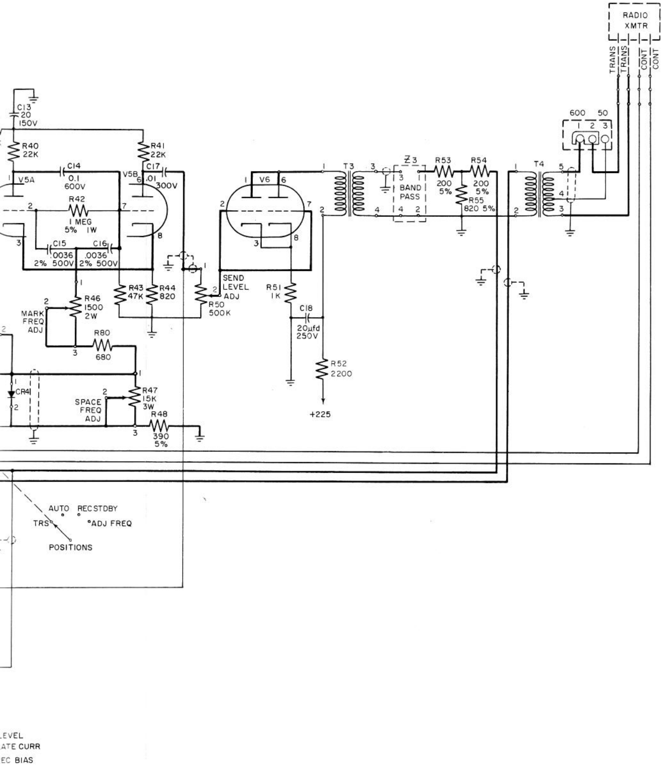
RADIO
XMTR
TRANS
TRANS
CONT
CONT
600
50
1 2 3
C13
20
150V
R40
22K
R41
22K
C14
0.1
600V
V5A
V5B
C17
.01
300V
R42
1 MEG
5% 1W
C15
.0036
2% 500V
C16
.0036
2% 500V
R43
47K
R44
820
R46
1500
2W
MARK
FREQ
ADJ
R80
680
CR4
SPACE
FREQ
ADJ
R47
15K
3W
R48
390
5%
SEND
LEVEL
ADJ
R50
500K
V6
R51
1K
C18
20µfd
250V
R52
2200
+225
T3
Z3
BAND
PASS
R53
200
5%
R54
200
5%
R55
820 5%
T4
AUTO
REC STDBY
TRS
ADJ FREQ
POSITIONS
LEVEL
ATE CURR
EC BIAS