# J68331A TRANSMITTER-RECEIVER BAY

CONTENTS



## 1. GENERAL

1.01 General: The TD-2 Radio System is a microwave radio relay system operating in the radio-frequency range of 3700-4200 mc and is designed for the transmission of television or multiplex telephone channels over distances of the order of several thousand miles. The basic unit of this system is the transmitter-receiver bay, which may be used as a single-channel one-way repeater at a repeater station or as separate transmitting and receiving equipments at a terminal.

1.02 Equipment Features:

(a) The J68331A Transmitter-Receiver Bay (see page 101) consists of a 9' duct-type framework. The depth of the bay is approximately 15" and the width 22-3/8". The bottom half of the bay is occupied by units arranged for 19" panels which project 9" from the front of the uprights. These units, starting at the bottom of the bay, are:

Transmitter Microwave Generator
40 mc Shifter (or Receiver Microwave Generator at Terminal Station)
Transmitter Control Unit
Receiver Control Unit

The upper half of the bay is occupied by the receiver IF and transmitter waveguide components and is enclosed with hinged-type casing doors. The receiver equipment mounted within this casing consists of the IF main amplifier, receiver converter and IF preamplifier unit, and the image suppression filter. The transmitting portion includes the buffer amplifier (at main stations and terminals only), modulator, amplifier, and directional coupler. The channel-dropping filters for the transmitter and receiver are mounted at the extreme top of the bay in a horizontal position and are arranged for waveguide coupling to the antenna for the first bay in the lineup, or to preceding and succeeding filters in adjacent bays for an intermediate frame of a lineup. A removable cover, held in place with quick release fasteners, is provided in front of the channel-dropping filters. A low-pressure air supply is required to provide forced air cooling to the 3-stage transmitter-amplifier 416A vacuum tubes, to the 416A tube of the modulator, to the 416A tubes in the microwave generator, to the 2C43 tubes in the microwave generator and to the 418A tube in the IF main amplifier.

(b) The local cable wiring between units on the bay is run in local cable forms stored in the ducts at the right and left side of the bay. Separate cables are provided for the receiver and the transmitter in order that only the wiring required need be furnished where only a receiver or a transmitter is furnished. The cable connections to the units are made by means of plugs and jacks to facilitate removal of the units for bench maintenance. Coaxial cables, with the exception of direct patches between units, are also stored in the regular wiring ducts. Application schematics of the interunit connections are shown on SD-59403-011, -12, and -013, pages 124, 125, and 126, respectively.

(c) Power Drain (max.)

| | |
|---|---|
| 250 Volts | 0.37 Ampere |
| 130 Volts | 0.43 Ampere |
| 12 Volts | 23.5 Amperes |

(d) Tube, Varistor, and Crystal Complement

| | Tube Types | | | | | | | | | | Varistors | | Crystals | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2C43 | 6AQ5 | 6AU6 | 313C | 396A | 404A | 416A | 417A | 418A | VR150 | 405A | 405B | KS-13978L1 | KS-13978L2 |
| Transmitter Modulator | | | | | | | 1 | | | | | | | |
| Receiver Converter | | | | | | | | | | | 2 | | | |
| IF Preamplifier | | | | | | | | 2 | | | | | | |
| IF Main Amplifier | | | | | | 6 | | 1 | 1 | | | | | |
| Receiver Control Unit | | | | 2 | 2 | | | | | | | | | |
| IF Buffer Amplifier | | | | | | | | | 1 | | | | | |
| Transmitter Amplifier | | | | | | | 3 | | | | | | | |
| Microwave Generator (Rec) | 2 | | 2 | | 1 | | 1 | | | 1 | | | 1 | |
| Microwave Generator (Trans) | 2 | | 2 | | 1 | | 2 | | | 1 | | | 1 | |
| 40 mc Shifter | | 1 | | | 1 | | | | | | | 2 | | 1 |

1.03 Circuit Description - General: A block diagram of the transmitter-receiver bay is shown on page 119. Application schematics of interunit connections are shown on pages 124, 125, and 126.

1.04 Circuit Description - Receiver: At a receiver, the incoming microwave signal from a distant station may contain any combination of one to six channel signals. This complex signal is received by a highly directive antenna and is carried through waveguide to the transmitter-receiver bay in the radio room. Located in the waveguide at the top of each frame is a receiving channel separation filter (network) which selects the particular signal required for that receiving channel. Frequencies for other receiving channels pass through the first filter and are dropped at successive filters in numerical order with the lower frequencies first. Six frames, lined up side by side with the horizontal filter runs across the top, provide for the maximum arrangement of six channels in one direction. The incoming single-channel signal, after leaving the channel separation filter, passes through a waveguide image suppression filter. This filter prevents IF interference due to the image frequency which is 140 mc removed from the incoming carrier. The local generated frequency, combined with the carrier to obtain IF, may be either 70 mc above or below the incoming carrier. Likewise, the image frequency, which produces an unwanted 70 mc IF, is also above or below the carrier in the same direction as the local generated signal. The output from the image suppression filter is coupled by waveguide to the receiver-converter and IF preamplifier unit. In this unit, the incoming signal is combined with the locally generated frequency from the receiver microwave generator or the 40 mc shifter which has a frequency of 70 mc removed from the incoming carrier. One of the products resulting from this combination is the desired 70 mc modulated intermediate-frequency signal which is amplified in the preamplifier section of the unit. The output of the preamplifier is patched by means of coaxial cable to the input of the main IF amplifier where additional IF gain is provided. An automatic gain control circuit is provided on the receiver control panel to compensate for fading and variations in transmission. The IF output from the main IF amplifier may be patched in the coaxial cable to the transmitter section of the transmitter-receiver bay when the bay is used as a repeater, or it may be cabled to the IF patching bay at terminals and main stations. By inserting distribution and switching amplifiers in this IF output circuit at the patching bay, switching, monitoring, terminating, and distribution taps may be provided for flexibility in establishing and maintaining a network.

1.05 Circuit Description - Transmitter: In the transmitter, the frequency-modulated IF signal from the IF main amplifier, at an auxiliary station, or from a buffer amplifier at a switching point, or from an FM transmitter terminal is introduced by means of coaxial cable to the transmitter modulator. In the modulator, the 70 mc IF signal is combined with the output of the local transmitter microwave generator to produce a signal of the frequency to be transmitted. At the output of the modulator is a waveguide bandpass filter which passes the desired microwave transmitting signal and rejects all other undesired products of modulation. This filter is coupled, by means of waveguide direct to the 3-stage microwave transmitter-amplifier which amplifies the signal to its final level. The amplified signal passes through the channel-dropping filter where it enters the transmitting system of filters which parallels the receiving group at the top of the frame. This channel may then be combined with a maximum of five other transmitter channels and is carried by means of a waveguide to the transmitting antenna. A directional coupler is introduced in the waveguide system after the transmitter-amplifier for sampling a small amount of power to provide a means for power measurement, and to energize alarms in the event of output failure.

1.06 Circuit Description - Beating-frequency Supplies: Two arrangements are provided for obtaining the local microwave frequencies required for combining with the received signal in the receiver converter to produce the 70 mc IF frequency and for combining with the 70 mc IF signal in the transmitter modulator to produce the signal of the frequency to be transmitted. The arrangement applicable to auxiliary repeater stations employs a single microwave generator and a 40 mc shifter. With this arrangement, the output of the microwave generator is fed to the 40 mc shifter, where the signal is divided, one part being fed through an attenuator to the transmitting modulator and the second part combined with a 40 mc source to produce a supply 40 mc removed from the microwave generator frequency, for use with the receiver converter. The primary advantage of the single generator, with the closely controlled 40 mc shift, is that any variation in the frequency of the generator from the nominal desired value does not affect the transmitted carrier frequency. Thus, in a long-haul system, the use of such an arrangement avoids cumulative carrier frequency drift. To illustrate this, assume an incoming 3730 mc signal. The local microwave generator may have a nominal frequency of 3840 mc. The generator output is fed to a 40 mc shifter of closely controlled frequency, to produce a new frequency of 3840 - 40 = 3800 mc. This is mixed in the receiver converter with the received 3730 mc signal to produce a 70 mc intermediate frequency. This 70 mc and the 3840 mc generated frequency are combined in the transmitter modulator to produce 3840 - 70 = 3770 mc transmitted carrier. It can be seen, therefore, that drift in the microwave generator frequency results in a corresponding change in intermediate frequency but not in transmitted carrier. When separate generators are used, any variation in frequency in the two separate generators may result in carrier-frequency variations. At terminals and main stations involving switching of circuits, the relationship between the received and transmitted signals may not be such that a single generator will suffice and, in general, more flexibility is desired. Two separate microwave generators are therefore provided: one to supply the converter and one to supply the modulator. Since less power need be supplied the converter than the modulator, the receiver microwave generator does not require the V6 stage (a 416A tube).

1.07 Transmission Characteristics: The transmission characteristics of the transmitter-receiver bay are as follows:

| | |
|---|---|
| Frequency Range | 3700-4200 mc |
| Frequency Transmission Band (0.1 db down) | 20 mc |
| Output Power | 0.5 watt |
| Min. Signal Input for Normal Output (Based on max. IF main amplifier gain of 63 db) | -57 dbm |

## 2. CHANNEL SEPARATION FILTER NETWORKS

2.01 General: The TD-2 Radio System is so designed that as many as six broadband channels may use the same antennas. This requires filtering equipment at the receiving end of the radio circuit to select the proper channel and prevent interference, and at the transmitting end to combine the various channels without causing cross-modulation. Such filters must be designed so that no one has any unfavorable reaction on the behavior of the others. With only two filters, this requirement is not serious. As the number of channels increases above two, however, it becomes more and more difficult to meet. The TD-2 system uses waveguide hybrid junctions in conjunction with band reflection filters.

2.02 Equipment Features: The channel separation network (see page 102) consists of a number of waveguide units in tandum, the 1400-type network (page 103) being used in the receiving branch and the 1401-type being used in the transmitting branch. Each network consists of two 1A Junctions, two 1300-type waveguide filters, one 400A Tuner and one 500A Termination. Different 1300-type filters are used for the different frequencies but for a given frequency the only difference between a 1400 and a 1401 network is in the assembly - the 1A Junctions being effectively turned over 180 degrees in one case compared with the other. The over-all dimensions of each of these networks with the movable arms of each 1A Junction facing inward are approximately 4-5/16" by 5-5/16" by 19" long.

| Network | Filter | Frequency - mc |
|---|---|---|
| 1400A & 1401A | 1300A | 3730 |
| 1400B & 1401B | 1300B | 3770 |
| 1400C & 1401C | 1300C | 3810 |
| 1400D & 1401D | 1300D | 3850 |
| 1400E & 1401E | 1300E | 3890 |
| 1400F & 1401F | 1300F | 3930 |
| 1400G & 1401G | 1300G | 3970 |
| 1400H & 1401H | 1300H | 4010 |
| 1400J & 1401J | 1300J | 4050 |
| 1400K & 1401K | 1300K | 4090 |
| 1400L & 1401L | 1300L | 4130 |
| 1400M & 1401M | 1300M | 4170 |

The principles of construction of the 1A Junction are shown in Fig. 1

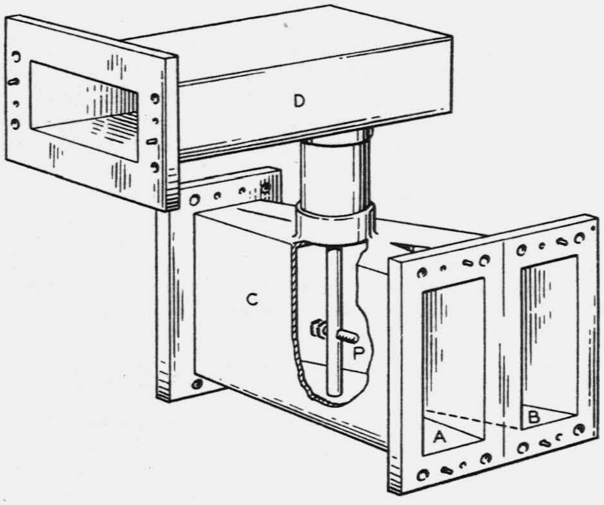


Fig. 1 - Principles of Construction of the 1A Junction

Here the A and B arms are in line with the C arm while arm D is connected to the A and B arms by a coaxial line, and may be turned in any direction. The central conductor of the coaxial connection projects into the Y junction space where arm C branches into arms A and B in such a way that the transverse probe P couples D to A and B but not to C.

The construction of one of the 1300-type band reflection filters is shown in Fig. 2.

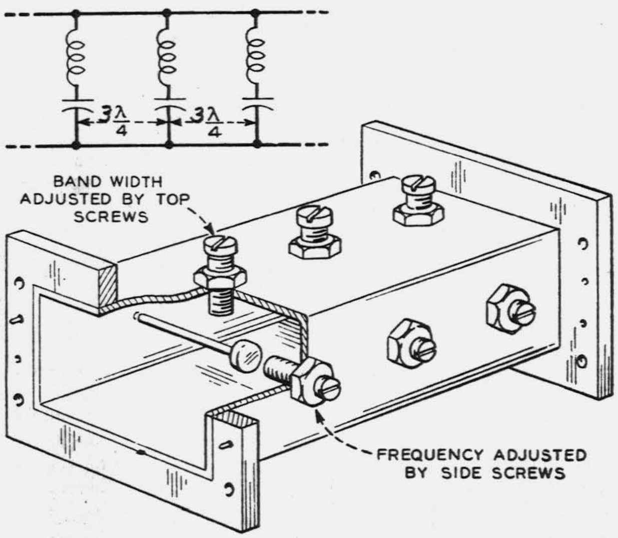


Fig. 2 - Principles of Construction of the Type-1300 Filter

Three probes spaced approximately three-quarters wavelength apart project into the section from one of the narrow sides, and near the opposite wall are tipped with capacitance discs. The capacitance of the disc, and consequently the resonant frequency of the circuit is adjusted by a screw in a wall opposite the disc. Other screws, inserted in the broad side of the guide opposite the probes, provide adjustable coupling by disturbing the symmetry of the field. Changing the distance these screws project into the guide changes the coupling and consequently the bandwidth of the series resonant circuit, which may be changed from infinity to any value within the range required. The D arms of the second hybrid of each channel-dropping filter, and both the D and C arms of the second hybrid of the last filter are terminated in dummy loads, while the D arm of the first hybrid of each filter connects to a channel transmitting amplifier, or to a channel image suppression band-pass filter.

2.03 <u>Circuit Description:</u> Each channel separation network consists of two hybrids and two band reflection filters as shown in the general block schematic of Fig. 3.

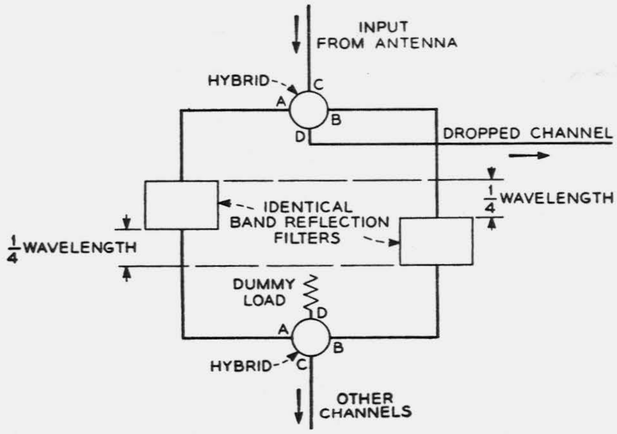


Fig. 3 - Block Diagram of Type-1400 Network

The waveguide hybrid is a 4-arm unit shown diagrammatically in Fig. 4. Input to arm C divides equally between arms A and B with no output to arm D. Although equal outputs are always obtained in arms A and B with an input to either C or D, the relative phase of the outputs in A and B differs in the two cases. When the input is from arm D, the outputs in arms A and B are in phase, while when the input is from arm C, the outputs in arms A and B are in phase opposition. This difference in phasing may readily be seen to result from the circuit

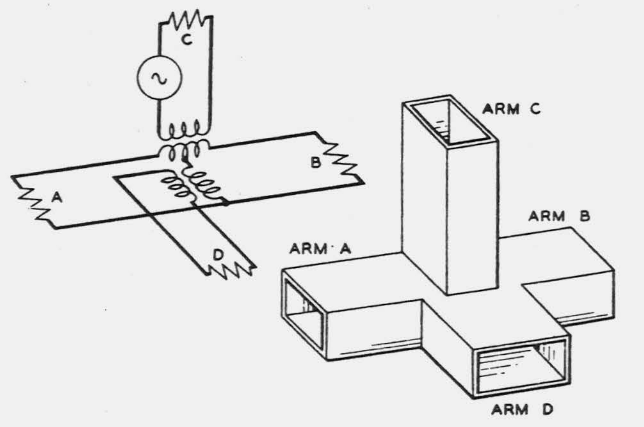


Fig. 4 - Diagrammatic Representation of the Hybrid Junction

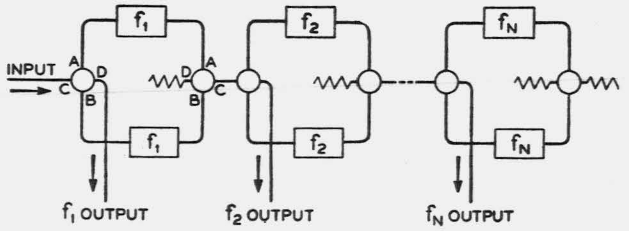


Fig. 5 - Block Diagram of a 3-section Channel Separation Filter

shown in the circuit equivalent of Fig. 5. With the input from branch C, current circulates around the series loop including A and B, and thus in the same direction in each of these two branches. If the current circulates in a clockwise direction in branch A, it also circulates clockwise in branch B. With the input from branch D, on the other hand, the current circulates in opposite directions in branches A and B; if it circulates clockwise in A, it circulates counterclockwise in B. Because of this action of the hybrid, equal and in-phase voltages applied across arms A and B result in no output to arm D and full output to arm C. If the input to arms A and B were in phase opposition, on the other hand, there would be no output in arm C and full output in arm D. With this behavior of the hybrid in mind, one may easily follow the action of the circuit shown in Fig. 5. Input to arm C at the top divides equally into arms A and B with no output to arm D.

The band reflection filters in arms A and B reflect one band of frequencies, which may be assumed to be that corresponding to channel 1, and pass all other frequencies. The unreflected frequencies continue on and enter the second hybrid by way of its arms A and B. Since the energies flowing in these two arms are in phase, they add in arm C to become equal to the input of arm C of the upper hybrid. No output is transmitted to arm D. The bands reflected from the filters in arms A and B, on the other hand, travel back to enter arms A and B of the upper hybrid. These reflection filters, however, are not symmetrically located in arms A and B. In the A arm, the connection between the filter and the lower hybrid is one-quarter wavelength longer than that between the filter and the upper hybrid, while in the B arm the connection between the filter and the upper hybrid is one-quarter wavelength longer than that between the filter and the lower hybrid. The band that is reflected by the filter in arm B thus travels a path one-half wavelength longer than that traveled by the band reflected in arm A - one-quarter wavelength before reflection and another quarter wavelength after reflection. As a result, the reflected waves reaching the upper hybrid are in phase opposition, and thus they add to give full output in arm D and have no effect on arm C. The net result of the arrangement shown in Fig. 3 is thus to transmit all but one frequency band, and to drop off that band for amplification. By connecting a number of such arrangements in tandem, as indicated in Fig. 5, each drops off one channel for amplification and passes the remaining channels on to the next section. For a 10-channel system, there will be 10 of these channel-dropping filters connected in tandem and each would supply one channel amplifier. A similar chain would be connected with the output sides of the channel amplifiers. A waveguide hybrid of the form shown in Fig. 4 would be awkward to use in a chain circuit such as Fig. 5 because of the large number of right-angle waveguide bends that would be required. As a result, a hybrid junction of the form shown in Fig. 1 was designed.

2.04 Transmission Characteristics:

Typical Standing-wave-ratio and Transmission Loss Characteristics (Based on Eight Filters)

| Frequency MC | VSWR DB | Transmission Loss DB |
|---|---|---|
| fo - 20 | .60 ± .40 | 1.00 ± .20 |
| fo - 15 | .40 ± .20 | .57 ± .07 |
| fo - 10 | .30 ± .10 | .49 ± .06 |
| fo - 5 | .20 ± .10 | .47 ± .04 |
| fo | .12 ± .06 | .46 ± .04 |
| fo + 5 | .17 ± .10 | .47 ± .05 |
| fo + 10 | .30 ± .20 | .49 ± .06 |
| fo + 15 | .45 ± .30 | .56 ± .10 |
| fo + 20 | .70 ± .60 | 1.00 ± .35 |

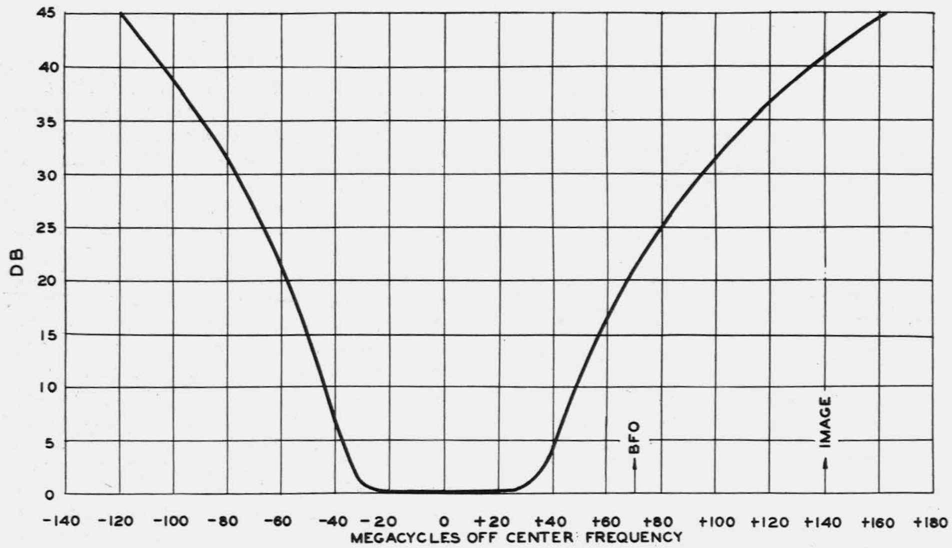


Fig. 6 - Typical Insertion Loss Characteristic of 1301-type Image Suppression Filter.

3. RECEIVER CONVERTER AND PREAMPLIFIER (J68330D)

(A) General

3.01 The receiver converter serves to convert the received microwave signal (in the 3700-4200 mc range) into a 70 mc intermediate frequency in order to facilitate amplification and reconversion to a microwave signal of a different frequency. The preamplifier provides about 12 db gain. The preamplifier is aligned and tested as an independent unit but the converter can only be tested in conjunction with a preamplifier, image suppression filter and a 400-type tuner. A photograph of the receiver converter and preamplifier is shown on page 104, and circuit schematics SD-59402 and SD-59407 are shown on pages 123 and 129, respectively.

(B) Receiver Converter

3.02 Equipment Features: The balanced microwave crystal converter consists of a section of waveguide 2" long with inside dimensions of 2.290" and 1.145" with two 405A Varistors mounted in short sections of 75 ohm coaxial tubes coupled to the waveguide. A fitting provides for a coaxial connection for the beating signal input. A sectional view of the shifter converter, which is similar to the receiver converter, is shown on Fig. 8. One lead from each of the varistors passes through the small coaxial tubes and out the bottom for connection to the preamplifier, to which the converter is rigidly attached by means of a support bracket. A 400-type tuner, the dimensions and adjustments of which are critical for the various frequencies, is mounted between the waveguide input for the microwave signal and the image suppression filter.

3.03 Circuit Description: The circuit schematic of the receiver converter is shown on SD-59407. The converter is a balanced microwave crystal modulator mounted in a combination coaxial and waveguide hybrid junction. The CR1 and CR2 varistors are matched into 75 ohm coaxial lines coupled into the H plane of the hybrid. The beating oscillator current from the 40 mc shifter is fed into the converter through a 75 ohm coaxial line projecting through the E plane of the hybrid. The double-ended varistors are placed in the coaxial lines in opposite polarity so that their IF in-phase outputs can be connected in parallel directly to the cathode of the first grounded-grid amplifier. The IF output from the varistors is brought out on a shielded pair of wires through the FL3 and FL4 IF filters. The latter isolate the RF and IF parts of the circuit. Second harmonic filters FL1 and F12 are included between the varistors and the waveguide to prevent second harmonic frequency generated in the varistors from getting back into the waveguide. The impedance matching section is used to improve the impedance characteristic as presented to the image rejection filter.

3.04 Transmission Characteristics: The transmission characteristics of the converter are as follows:

| | |
|---|---|
| Input Frequency | 3700 to 4200 mc |
| Input Impedance Match | Return loss (W), 30 db over a 20 mc band located in the input frequency range. |
| Converter Balance | 25 db or more |
| Output Midband Frequency | 70 mc |
| Output Impedance | Approximately 140 ohms |

| | |
|---|---|
| Bandwidth | The over-all bandwidth of the converter plus preamplifier should be the same as that of the preamplifier, within the limits of the measuring equipment. |
| Conversion loss | 6 db |
| Noise Figure | The over-all noise figure of the converter working into a preamplifier having a noise figure of 5.7 db is 12 db. |
| Varistor Currents | 1.5 ma each |
| Beating Oscillator Power | 3 dbm or less |

(C) IF Preamplifier

3.05 Equipment Features: The IF preamplifier is assembled in a shielded chassis 4" wide by 1-5/8" deep and 13-7/8" in length. All the circuit elements are mounted within the shield chassis and are attached to its cover. The two vacuum tubes (417A), filament stabilizing resistors, the test input jack TST IN, the output jack OUTPUT, test points for measuring cathode voltages, grid bias and filament voltages, power receptacle, and means for making various alignment adjustments are on the outside of the cover. The power supplies required are:

| | |
|---|---|
| Filament Supply (Positive Grounded) | 10.8 ± 0.1 volt DC 0.6 ampere |
| Plate Supply | +134 to +137 volts, 58 ma |
| Bias Supply | 9 ± 0.2 volts, negligible current drain. |

Under emergency conditions the amplifier will operate on supply voltages as low as -9.7 and +116 volts.

3.06 Circuit Description:

(a) The IF preamplifier consists of two grounded grid stages in tandem and operates between a balanced crystal converter and a 75 ohm cable. Since the converter impedance is about 140 ohms and the first tube input is about 45 ohms there is a mismatch loss of 1.3 db. This reduces the preamplifier gain from an average matched gain of 13.2 db with new tubes to a working gain of 11.9 db. The preamplifier interstage network is a band-pass filter structure consisting of L7, L8, L9, C12, C17, C18, and C19. This filter is loaded on the primary side by R5 in parallel with the plate resistance of V1. Its secondary loading is provided by the input resistance of V2. A band-pass filter circuit consisting of R9, L10, L11, C13, and C14 serves to match the output of V2 to a 75 ohm line. The return loss (W) looking into the OUTPUT jack is 25 db or more over a 20 mc band centered at 75 mc. The grids of both V1 and V2 are grounded at IF but biased to +9 volts to provide DC feedback. Since the drop across cathode resistors R1 and R7 is in excess of 9 volts, each grid is negative with respect to its cathode. With this arrangement a small change in plate current produces a relatively large change in bias. This tends to keep the plate current and hence the gain nearly constant from tube to tube and over the life of each tube.

(b) Each tube filament is supplied with current through a close tolerance resistor. These resistors regulate the filament current so that substantially constant power is dissipated in each filament with normal variations in filament resistance. This results in prolonged tube life. A nominal resistance tube supplied with 10.8 volts through its resistor will have 6.1 volts across its terminals. Filament and plate power are fed to the tubes through ladder-type filter circuits using small chokes and 0.001 microfarad button mica capacitors. Test points TP1A and TP2A are provided to read the cathode voltages of V1 and V2. The actual grid biases may be measured between these points and test point C+ using a high resistance voltmeter (20,000 ohms per volt). The filament voltage may also be monitored using test points FIL A and GRD. A filament activity test may be made on each tube by decreasing the filament voltage and noting the corresponding change in grid bias.

(c) A test input jack TST IN is provided for checking the preamplifier alone. A 30 ohm resistor is connected in series with this jack to permit matching a 75 ohm cable. This causes a loss of 2.2 db so that the gain measured between this jack and the output is 11 db if the converter is disconnected If the converter is not disconnected there will be a slight additional loss due to bridging its impedance across the amplifier impedance. When the amplifier is used with its normal connection to the converter, it has 0.9 db more gain than the gain measured between the TST IN and OUTPUT jacks.

3.07 Transmission Characteristics: The transmission characteristics of the IF preamplifier are as follows:

| | |
|---|---|
| Midband Frequency | 70 mc |
| Bandwidth | 22 mc (at 0.1 db down points) |

| | | |
|---|---|---|
| Gain (Input from Converter) | 10.9 db | Min, with new tubes |
| (75 ohm source connected to TST IN jack) | 10.0 db | |
| Power Output | 1 mw (max) | |
| Noise Figure | 5.7 db | |
| Input Impedance from Converter | 45 ohms | |
| Input Impedance from TST IN | 75 ohms | |
| TST IN Return Loss | 25 db (min) | |
| Output Impedance | 75 ohms | |
| Output Return Loss | 25 db (min) | |

## 4. IF EQUALIZER

4.01 General: The inclusion of IF equalizers to compensate for phase distortion depends upon the particular circumstances under which the equipment is used. For short circuits, phase equalization is not necessary and even for longer circuits it may not be necessary to equalize at each repeater. The characteristics of the equalizers and the particular repeaters at which they will be installed is a matter for job engineering.

## 5. IF MAIN AMPLIFIER (J68330A)

5.01 General: This 8-stage amplifier provides the principal IF amplification for the repeater and, by means of automatic gain control, compensates for fading of the radio signal to keep the IF signal output constant. A photograph of the unit is shown on page 105 and the circuit schematic - SD-59401 - on page 122.

5.02 Equipment Features: The amplifier is assembled in a shielded chassis 4" wide by 1-5/8" deep and 24-1/4" in length. All the circuit elements are mounted within the chassis and are attached to its cover. The vacuum tubes (1-417A, 6-404A, and 1-418A), filament stabilizing resistors, input, output and monitoring jacks, test points for cathode-bias voltages, various alignment adjustments and the power receptacle are on the outside of the cover. The power supply requirements are as follows:

| | |
|---|---|
| Filament Supply (Positive Grounded) | 10.8 ± 0.1 volts DC 2.7 amperes |
| Plate Supply | +134 to +137 volts 0.24 ampere |
| Bias Supply | 9 ± 0.2 volts |
| Negative Gain Control Bias | 0 - 3 volts (adjustable) |

Under emergency conditions, the amplifier will operate with some degradation of its characteristics on supply voltages as low as -9.7 and +116 volts.

5.03 Circuit Description of Transmission Circuit: The IF main amplifier is an 8-stage amplifier operating between 75 ohm impedances. The bandwidth is approximately 20 mc (0.1 db down) and the full gain is at least 65 db with new tubes. The first stage of the amplifier is a conventional grounded grid circuit. Impedance matching between the 75 ohm input and the impedance looking into the cathode, approximately 45 ohms, is accomplished by the band-pass network consisting of C2, C6, C8, C12, C16, and L1 and L2. A band-pass filter, consisting of L5, L6, L7, and C9, the output capacitance of V1 and the input capacitance of V2, couples the plate of V1 to the grid of V2. Damping resistors R3 and R5 serve to terminate this filter. The pass-band has slight peaks at about 62 and 78 mc. Similar band-pass filters consisting of the corresponding elements, provide interstage coupling between the second to seventh stages, inclusive. A somewhat different band-pass filter, consisting of L53-L56 and C58-C60, and the associated tube capacitances, constitutes the interstage network between V7 and V8. The circuit is damped only on the plate side by R45. The pass-band of this stage has small peaks at 59, 70 and 80 mc. This, when added to the characteristic of the previous stages, gives a flat over-all band. The single damping of this interstage renders it sufficiently responsive to adjustment so that it can control the over-all amplifier band shape. A band-pass output circuit consisting of L62, L63, C70, C71, and R52 serves to match the output of the last tube to a 75 ohm line. A monitoring output is derived from a pad consisting of R54 and R55 bridged across the regular output. The monitoring output level is 26 db below the regular output.

5.04 Circuit Description of Gain Control and Bias Circuits: A rectified output is provided by the varistors CR1 and CR3 which are coupled to the regular output by C71. This rectified voltage is used as a measure of the output for gain regulating purposes. L71 and L72 and C77-C80 inclusive provide filtering on the rectified output leads RECT + and RECT -. The gain of the second to sixth stages, inclusive, is controlled by the negative bias (0-3 volts) provided externally on the AVC lead. A varistor CR2 is provided between this lead and ground. This serves to ground the AVC lead if the bias goes positive, thereby limiting the positive voltage applied to the grids. Small unby-passed cathode resistors R6, R13, R20, R27, and R34 provide some feedback on the gain controlled stages. This feedback reduces the variation input capacitance with changes in grid bias, thus minimizing detuning as the gain is changed. The gain control AVC bias may be derived from the rectified output, through suitable external circuits, so that the amplifier gain is automatically adjusted to maintain approximately constant output. The constant gain stages V1, V7, and V8 are provided with a 9 volt positive grid bias. The large cathode resistors R2, R41, and R47 used with these tubes provide a cathode bias in excess of 9 volts, so the grids remain negative with respect to the cathode. Under this arrangement, small changes in plate current produce relatively large changes in bias. This tends to keep the plate current, and hence the gain, more nearly constant from tube to tube, and over the life of each tube.

5.05 Circuit Description of Test Points, Power Supplies and Miscellaneous:

(a) Test points TP1A, TP7A, and TP8A are provided to read the cathode voltages of V1, V7, and V8, respectively. Similar test points are provided for V2 to V6, inclusive, and designated TP2B to TP6B, respectively. The latter are connected to read the voltage at the cathode end of the by-passed cathode resistors R7, R14, R21, R28, and R35. The actual cathode voltage differs by the drop across the unby-passed cathode resistors.

(b) Filament power is provided by two leads. FIL A lead serves V1, V7, and V8, and FIL B serves V2 to V6, inclusive. A filament activity test may be made on each tube by decreasing the filament voltage on the appropriate lead and noting the change in voltage at the corresponding test point. It will be noted that the test points for the tubes supplied by the FIL A lead are red and carry designations ending in A. The test points similarly associated with the FIL B tubes are black and are designated with a B. Each tube filament is supplied with current through a close-tolerance resistor. These resistors are R1, R8, R15, R22, R36, and R43 for V1 to V7, respectively. V8 requires twice the filament current and is supplied through R49 and R50 in parallel. These resistors stabilize the filament current to the extent that substantially constant power is dissipated in each filament regardless of normal variation in filament resistance. This results in prolonged tube life. A nominal resistance tube, supplied with 10.8 volts through its resistor, will receive 6.1 volts across its terminals. Filament and plate power and bias are connected to the various stages by way of feed-through type button mica condensers of 0.001 microfarad capacity. The various supply leads are connected from one stage to the next through small chokes. Four types of chokes are used: (1) a low resistance filament choke; (2) a low Q general purpose choke; (3) a high Q approximately resonant choke; and (4) a small high Q choke for screen leads.

(c) A special ground connection, designated METER RETURN is provided for use in connection with the filament activity test. Grounding of the meter used for cathode voltage measurements through this lead eliminates error due to filament current drop in the normal ground lead.

5.06 Transmission Characteristics: The transmission characteristics are as follows:

| | |
|---|---|
| Impedances - Input and Output | 75 ohms |
| Input and Output Return Loss | 25 db (min) |
| Midband Frequency | 70 mc |
| Bandwidth (0.1 db down at 40 db gain) | 20 mc |
| Gain Characteristic at 60 db gain | Downward slope (down 0.4 db at 80 mc) |
| Gain Characteristic at 25 db gain | Upward slope (up 0.2 db at 80 mc) |
| Output Range | +4 to +13 dbm |
| Gain Range - Full gain with new tubes | 65 db min, 74 db average |
| Min usable gain | 25 db |

## 6. RECEIVER CONTROL UNIT (J68330B)

6.01 General: The receiver control unit performs control and test functions for the receiver converter, the IF preamplifier, and the IF main amplifier. The unit provides: fused filament and plate power; bias voltages; regulation of the 70 mc output power of the IF main amplifier; means for making filament activity tests of the tubes of the preamplifier and IF main amplifier; means for measuring receiver converter crystal currents, plate supply and bias voltages, and certain test voltages in the AVC circuit. A photograph of the unit is shown on page 106 and the circuit schematic - SD-59405 - is shown on page 127.

6.02 Equipment Features:

(a) The receiver control unit is designed for mounting on a 19" duct-type bay. The space occupied is 7" high and the over-all depth is 9". The equipment is arranged for single-side maintenance and all apparatus, wiring, and controls are accessible from the front. Removal of the front cover, secured by quick release fasteners, allows access to those secondary controls not included in the main control area and permits the main control panel to be dropped forward 90 degrees for maintenance. All connections are made to this unit by means of multicontact plugs and receptacles.

(b) To the left of the exposed panel area are the filament circuit breaker FIL, the indicating 1-1/3 amp fuse for the +130 volt circuit and a spare, and a control key CONT for switching to either manual control (MAN) of gain or to automatic control (AUTO). Associated with the key is a lamp which lights when the key is operated to MAN. The control of output power with the key operated to AUTO is with the screwdriver adjustment AUTO. The potentiometer provided with the knob and marked MAN is the manual gain control. The meter may be connected to various circuits by means of the switch to measure the converter crystal currents CR1 and CR2, the gain control bias with manual and automatic operation, the +bias voltage, the rectified receiver output, the +130 volt supply, the grid bias of tubes not gain controlled (TST A), the cathode bias of the gain controlled tubes (TST B), the voltage at the plate of V1, and the cathode potential of V2. To the right are two keys for making the filament activity tests, TST A for tubes whose gains are not controlled and TST B for tubes whose gains are controlled. The lamp TST lights when either switch is thrown to TST. Inside the cover and at the top right of the unit are two screwdriver adjustments for the resistors which are introduced in making the filament activity tests and a screwdriver adjustment of the +bias. Also inside the cover are two 313C and two 396A vacuum tubes. The power supply requirements are as follows:

| | |
|---|---|
| Filament Supply (Positive grounded with 120 cycle ripple not to exceed 0.2 volt) | 10.9 ± 0.1 volts DC 4 amperes |
| Plate Supply | +134 to +137 volts 0.325 ampere |

These figures include the power required by the IF main amplifier and IF preamplifier which are supplied through the receiver control unit.

6.03 <u>Circuit Description of Filament Circuits:</u> Filament battery enters the circuit through terminal 2 of the PWR IN plug and through circuit breaker S5. An overcurrent condition causes operation of circuit breaker S5, which interrupts the normal current path from terminal 1 to terminal 2. The circuit between terminals 3 and 4 is then closed, connecting the -12 volt battery through resistor R26 to the -12V ALM lead, to operate an external fuse alarm circuit. The heaters of tubes V1 and V2 are supplied through resistors R4 and R9, respectively. These resistors reduce the filament voltage to a nominal 6.2 volts at the tubes, and serve to hold constant the filament power dissipated in each tube, regardless of normal variations in heater resistance. The tubes in the IF preamplifier, and those in the main amplifier which use positive bias, are supplied by the leads designated FIL A. A variable resistor FIL ADJ TST A (R30) short-circuited by switch S2 is provided to reduce the filament voltage as required for the filament activity test. The tubes in the IF main amplifier which do not employ positive bias are supplied by the lead designated FIL B. Variable resistor FIL ADJ TST B (R31) and its shorting switch S3 provide for dropping the filament voltage for the filament activity test. Lamp TST (I1) lights whenever shorting switch S2 or S3 is in the TST position, as a warning that the associated tubes are operating at reduced voltage.

6.04 <u>Circuit Description of Plate and Bias Supply:</u>

(a) The +130V battery supply enters the circuit through terminal 3 of the PWR IN plug, and through fuse +130V. An overcurrent condition will cause fuse operation and closure of contacts between terminals B and A of fuse mounting. This will supply +130 volt battery through R27 to +130V ALM lead, to operate an external fuse alarm circuit.

(b) Tube V4 has the characteristic of maintaining a constant voltage (nominally 60 volts) between its terminals 4 and 1. This voltage appears between the junction of R13 and R14 and ground. R14 and R34 (+BIAS) serve to divide this voltage still further, and the variable tap 3 on R34 (+BIAS) is adjustable to give 9 ± 0.2 volts on the C+ lead as bias for the IF amplifiers.

<u>Caution: Removing tube V4 when +130 volt supply is connected to circuit will cause a substantial increase in voltage on the C+ lead and may damage tubes in the associted IF amplifiers.</u>

6.05 <u>Circuit Description of Gain Controlling Circuit:</u>

(a) The IF main amplifier provides a rectified output which is proportional to its 70 mc output. This rectified output is used to measure the intermediate frequency output power. It appears in the receiver control unit on the leads RECT + and RECT -, is amplified, reversed in polarity, and applied to the IF main amplifier to control its gain. The action is such as to reduce changes in output to about 1 db over the normal range of input power. The rectified output is applied between the grid terminal 3 of V1 and terminal 3 of the potentiometer AUTO CONT. Resistors R7, R29, R36, and R37 and potentiometer AUTO CONT constitute a voltage divider between +130V and -12V. This divider provides a bias for the first section of tube V1. The total voltage on grid terminal 3 of V1 is then the sum of the rectified voltage and this bias, and is adjustable by means of the AUTO CONT potentiometer. The second section of V1 serves to provide a stabilized cathode-to-ground voltage for the first section of V1. The net grid-to-cathode voltage on the first section of V1 is then the difference between the grid voltage and this cathode voltage. Resistor R35 in series with grid terminal 7 of V1 serves to prevent oscillation. Voltage changes on grid terminal 3 of V1 are amplified about 24 db and appear as plate voltage changes of opposite polarity on plate terminal 4 of V1. Plate terminal 4 of V1 is coupled to grid terminal 3 of V2 through current limiting resistor R6. This section of V2 operates as a cathode follower. The voltage on cathode terminal 2 of V2 thus follows closely the voltage on plate terminal 4 of V1. In order to produce a negative voltage from the output of V2, a gas tube V3, having a constant voltage drop of about 60 volts, is placed in the cathode lead of the first half of V2. The negative terminal of this tube is returned to the -12 volt supply through R8. The junction of V3 terminal 1 and R8 then is normally between ground and -3 volts. This voltage is returned to the IF main amplifier on the AVC lead to control the amplifier gain. A filter consisting of R10 and C7 is inserted in the AVC lead to control the speed of response of the control system.

(b) The MAN-AUTO CONT key is provided to switch to manual gain control of the IF main amplifier. The necessary negative bias is derived from the -12 volt supply through R25 and is adjustable over a 0 to 3 volt range by means of the MAN CONT potentiometer. A filter consisting of L3, C9 and C10 is inserted in the -12 volt lead which supplies negative voltage to the automatic and manual bias circuits in order to attenuate battery charger ripple and noise from the 12 volt supply. This filter permits use of a supply having not more than 0.2 volt of 120 cycle ripple. Normally the -12 volt bias is obtained from the filament battery. An external strap between terminals 9 and 10 of the PWR IN plug is necessary to accomplish this. If it is desired to furnish this bias from a separate source, the strap is omitted and the bias supply connected to terminal 9.

6.06 Circuit Description of Metering Circuits:

(a) With switch S1 in the CR1 and CR2 positions meter M1 reads the current of the two varistors in the receiver converter. Full scale reading in these positions is 2.5 ma. Shunts R19 and R20 provide paths for these currents when switch S1 is in other positions.

(b) With switch S1 in the MAN and AUTO positions, meter M1 reads the bias voltage available from the manual and automatic gain controlling bias circuits. Full scale reading in these positions is 5 volts. R22 and R11 are the meter multiplier resistors for these positions, and shunts R21 and R12 are provided to maintain the circuit resistance nearly constant when the meter is switched.

(c) With switch S1 in the +BIAS position, meter M1 reads the voltage of the positive bias provided for the IF amplifiers. Full scale reading in this position is 10 volts. This bias, adjustable by means of potentiometer +BIAS, should be set at 9 volts. Resistor R17 is the meter multiplier for this scale.

(d) With switch S1 in the RCVR OUTPUT position, meter M1 reads the rectified output of the IF main amplifier. Full scale reading in this position is 2.5 volts. Resistor R1 is the meter multiplier for this position, and shunt R2 maintains a path for the rectified current when the meter is in other positions.

(e) With switch S1 in the 130V position, meter M1 reads the voltage of the nominal +130 volt supply. Full scale in this position is 250 volts. R18 is the multiplier resistor.

(f) With switch S1 in the TST A or TST B position, the positive side of the meter is connected to the FIL ACT TST lead. This lead is equipped with a test probe in the bay for use in making measurements at test points on the IF amplifiers. For TST A, full scale is 2.5 volts; the negative meter terminal is connected to the +9 volt bias lead, and R15 is the multiplier resistor. For TST B full scale is 0.25 volt, the negative meter terminal is connected to the METER RETURN lead, and the multiplier resistor is R16. The METER RETURN lead is grounded at the IF main amplifier, so as to eliminate the effect of ground potential difference between the main amplifier and the receiver control unit.

(g) With switch S1 in the V1 PLT or V2 CATH position, meter M1 will read the voltage at terminal 4 of V1 or terminal 2 of V2, respectively. Full scale is 100 volts, and R23 is the multiplier resistor. V2 CATH should read about 60 volts when the AUTO BIAS voltage is 0. V1 PLT should be less than 3 volts different from the reading at V2 CATH.

## 7. IF BUFFER AMPLIFIER (J68330F)

7.01 General: The buffer amplifier is a single stage IF amplifier used at main and terminal stations for providing a suitable termination to the IF patching cable connecting the buffer with patching or FM terminal equipment. The amplifier also provides gain control to adjust the IF signal power to that required by the modulator. The photograph of the amplifier is shown on page 107 and the circuit schematic - SD-59396 - is shown on page 120.

7.02 Equipment Features: The components of the IF buffer amplifier are mounted on a panel 4" by 10". The unit fits into a box 3-1/2" deep. The amplifier is a single stage unit using a 418A vacuum tube which is mounted on the face of the panel. To the left on the panel is the filament circuit breaker and the power plug. The FIL ACT switch reduces the filament voltage for filament activity tests when operated to TST. When so operated, the red light immediately below the switch is lighted. The 15-conductor jack marked TST is for connecting the 1AK Tube Test Set for making the filament activity tests. The +130 V indicating fuse is rated 1-1/3 amp. A position on the fuse mounting designated SP is provided for a spare fuse. Pin jacks labeled C+, B+, -11, GRD and K+ enable the grid bias, plate filament and cathode bias voltages to be measured. The screwdriver adjustment GAIN varies the cathode bias. Screwdriver adjustments labeled L1, L2, L3, and C1 affect the input circuit and L7, L8, and C14 affect the output circuit. The coaxial jacks INPUT and OUTPUT provide for connection from the distributing amplifiers or FM transmitter and for connection to the transmitter modulator by means of coaxial cables. The power requirements are as follows:

| | |
|---|---|
| Filament Supply (Positive grounded) | 10.8 ± 0.1 volts DC 0.6 ampere |
| Plate Supply | +137 volts 0.075 ampere |

Note: Under emergency conditions, the amplifier will operate with some degradation of its characteristics with supply voltages as low as -9.7 and +117 volts.

7.03 Circuit Description:

(a) The IF buffer amplifier is a single 418A tube amplifier with a transmission band approximately 20 mc wide centered at 70 mc. The circuit schematic is shown on SD-59396.

(b) In regard to the transmission path, the IF signal is transmitted to the buffer amplifier over a 75 ohm coaxial cable. The input to the amplifier consists of a pad, R1, R2, R3, and C18, followed by a band-pass network, C1, C2, L1, L2, and L3, and damping resistor R18. A band-pass output circuit consisting of L7, L8, L9, C14, C15, and R11 serves to match the output of the tube to a 75 ohm coaxial line.

(c) Associated with the bias and gain control circuits is a resistance voltage divider, R10 and R7, connected to the +130-volt supply. The voltage at the division point is applied to the grid circuit through a low-pass filter network, L11, C3, C4, C11, and R4. The cathode current flows to ground through R6, R15 and R20. R15 potentiometer GAIN can be varied to change the effective bias on the tube and thus controls the amplifier gain. R6 and R20 are fixed resistors which provide bias when the tube is operated at maximum gain. The cathode is bypassed by condensers C8 and C10. Bypass condenser C7 is used to provide additional filtering in the cathode circuit.

(d) Plate voltage is supplied to the plate circuit from the +130 volt supply through a low-pass filter network, C16, C13, and L10. Screen voltage is supplied to the tube from the +130 volt supply through the same low-pass network C16, L10, and C13, plus an additional section L6 and C12. Filament power is supplied to the tube from the -11 volt terminal through the resistors R8 and R9 in parallel and a low-pass network consisting of L5 and C9. The resistors stabilize the filament current to the extent that substantially constant power is dissipated in the filament regardless of normal variation in tube filament resistance values. This results in more uniform tube life. A tube of nominal resistance, supplied thus from an 11 volt source, will receive 6.3 volts across its terminals.

(e) Means are provided for testing filament supply, plate, cathode, grid and operating bias voltages of the tube. Provisions are also made for making filament activity tests. Access to the filament supply is provided by the -11 V jack J4 and the GRD jack J6. For measuring the +130 volt supply the B+ jack J3 and the GRD jack J6 are used. Jacks K+ and GRD (J5 and J6, respectively) provide access to the cathode circuit so that the DC cathode voltage can be measured with a high resistance voltmeter. Jack K+ is connected to the cathode through a low-pass filter circuit, C5, C6, R5 and L4. Access to the grid bias circuit is provided by jacks C+ and GRD (J2 and J6, respectively) so that the DC voltage applied to the grid can be measured with a high resistance voltmeter. The operating bias of the tube can be measured with a high resistance voltmeter if the positive side of the meter is connected to the K+ jack (J5) and the negative side to the C+ jack (J2). The 15-prong TST jack TS2, resistor R12, and FIL ACT TST switch S2 are used when making a filament activity test on the tube. The TST lamp I lights when the test switch is thrown to the TST position.

(f) If the filament circuit is overloaded due to a trouble condition, the FIL relay switch S1 operates to open the filament lead and transfer the -11 volts to an alarm circuit through R13. If the +130 volt supply is overloaded due to a trouble condition, the +130 fuse opens the supply to the amplifier and transfers the +130 volts to an alarm circuit through resistor R14.

7.04 Transmission Characteristics - The transmission characteristics of the IF buffer amplifier are as follows.

| | |
|---|---|
| Nominal Transmission Band | 60-80 mc |
| Input | +3 dbm |
| Nominal Output | +1 to +5 dbm |
| Input and Output Impedances | 75 ohms |

In the transmission band the gain increases slightly with frequency to compensate for a corresponding increase in loss with frequency in the patching cables.

## 8. TRANSMITTER MODULATOR (J68330L)

8.01 General: The transmitter modulator is employed to shift the modulated 70 mc intermediate frequency signal to the desired microwave frequency in the 3700-4200 mc band and at the same time provide a conversion gain of from 3 to 9 db and an output of +9 dbm. Photographs of the unit are shown on pages 108 and 109 and the circuit schematic - SD-59406 - is shown on page 128.

8.02 Equipment Features: The transmitter modulator assembly consists of a transmitter modulator cavity (similar to amplifier cavity, Fig. 7) in which are mounted a 416A vacuum tube, various components comprising impedance matching networks, a number of 2.290" by 1.145" waveguide components such as a waveguide-to-coaxial transducer, a 400B Tuner, a beating oscillator filter, a waveguide spacer unit, an output filter section, a 1303 Filter and a 400G Tuner. The over-all length of this assembly is 22.7" maximum. The beating oscillator input is connected by means of a transducer probe inserted in a transducer. The IF signal is inserted through a 477A coaxial jack. The output of the modulator is equipped with a standard flange for 2.290" by 1.145" waveguide. Battery and control leads are connected through a multicontact jack. A torque wrench (P-257211) is required to insert and remove the 416A tube from the cavity. A hex socket wrench and a special tool assembly (P-257207) are required for tuning. An air supply of 0.2 cu. ft. per minute is required for cooling. The power requirements are as follows:

| | | |
|---|---|---|
| Filament Supply | 6.3 volts | 1.8 amperes |
| Plate Supply | 250 volts | 15 ma |

8.03 Circuit Description:

(a) The circuit schematic of the transmitter modulator is shown on SD-59406. The modulator uses a 416A, grounded grid triode, vacuum tube V1 as a converter. The beating oscillator, having a frequency of f2, and the intermediate frequency, having a frequency of f1, are impressed on the cathode of the 416A tube. The tube is operated in a region where nonlinearity exists and as a result, the sideband frequencies (f2 ± f1) and the beating oscillator frequency f2, are obtained in the plate circuit of the tube. These frequencies along with the other modulation products will also appear in the cathode circuit. Trap circuits and by-pass circuits are used to reject the unwanted frequencies. The rejection of the unwanted frequencies in the input and output circuit affect the conversion gain and the impedance of the modulator; thus the spacing of the various rejection filters with respect to the cathode and plate circuit is critical with frequency.

(b) The beating oscillator is impressed on the cathode of V1 through a tuner, a band-pass filter, filter spacing unit and the cathode cavity. The tuner consists of two antiresonant circuits separated by 1/8 wavelength. The two rods act as inductances and the two screws as adjustable capacitances. The tuner is capable of tuning out a standing wave ratio of 8 db in magnitude and is adjusted to obtain an impedance match at the beating oscillator frequency. The beating oscillator filter is a single section resonant iris filter tuned to pass the beating oscillator frequency and reflecting the desired sideband frequency. The length of the filter spacing unit is such as to give optimum modulator conversion gain and impedance characteristics. The cathode cavity is loaded by the input conductance and the glass loss of the input of the tube. Tuning is effected by a capacitive screw CP1 in the input iris. Thus the input circuit is a single tuned circuit heavily loaded by the input conductance of the tube. Since no adjustment is available in the input conductance of the tube the circuit is designed so that the impedance seen at the input is always less than the characteristic impedance of the waveguide. The remaining match is obtained by the tuner.

(c) The 60 to 80 mc intermediate frequency is impressed on the cathode of V1 through an impedance transforming network which consists of L1, L2, C2, and C3 and serves to match the cathode of V1 to a 75 ohm line.

(d) The plate circuit of V1 connects to a resonant section of coaxial line with the high impedance end of the line located at the plate of the tube. A 1/4 wave coaxial transformer T1 is located at the low impedance point of this line transforming the impedance at this point to match a 47 ohm coaxial line. Variable loading resistances R1.1 and R1.2 are placed in the resonant section of line so as to vary the Q of the plate circuit to match the Q of the output filter section. The inductance of the resonant section of line may be changed to effect tuning by varying the position of the 1/4 wave transformer. The 47 ohm coaxial line terminates in a broadband transducer having variable capacitive loading CP2. Varying CP2 varies the coupling between the plate circuit and the transducer.

(e) The output filter section is a resonant iris filter having a band width of 80 mc at the 3 db down points, measured between characteristic impedances. The filter section in conjunction with the plate circuit of V1 forms a 2-section filter having a pass band of 20 mc to the 0.1 db down points centered at the transmitting frequency.

(f) The beating oscillator rejection filter is a 2-section rejection filter providing a loss of approximately 50 db at the beating oscillator frequency and having a standing wave ratio of 3 db or less at the transmitter frequency band.

(g) The tuner consists of two anti-resonant circuits separated by approximately 1/8 wavelength and capable of tuning out a standing wave ratio of 8 db in magnitude. The tuner is used to correct for the mismatch of the beating oscillator rejection filter at the pass-band frequency.

8.04 Transmission Characteristics: The transmission characteristics of the transmitter modulator are as follows:

| | |
|---|---|
| Output Pass-band (0.1 db points) | 20 mc in 3700 to 4200 mc frequency band |
| Conversion Gain | 3 to 9 db |
| Impedance Match - B.O. Input Circuit | 25 db (min) return loss |
| IF Input Circuit | 20 db (min) from 60 to 80 mc |
| B.O. Input Power | +23 dbm |
| B.O. Power in Output Circuit | -35 dbm max |
| Undesired Sideband Power in Output Circuit | -10 dbm max |
| Microwave Signal Output | +9 dbm |

9. TRANSMITTER AMPLIFIER (J68330K)

9.01 General: The transmitter amplifier is a broadband 3-stage microwave amplifier operating at 18 db gain which provides a transmitter output power of 1/2 watt. The amplifier consists of three cavities (in each of which is mounted a 416A tube), three 400-type tuners and an output filter section. A photograph of this unit is shown on page 110 and the schematic is shown on SD-59411, page 133.

9.02 Equipment Description:

(a) The transmitter amplifier consists of three stages of amplification each employing a 416A triode mounted in a cavity assembly, two interstage 400C Tuners, an input 400B Tuner and an output resonant iris-type filter. All these components are of the waveguide type and the whole constitutes one rigid assembly with an over-all length of 14-7/8". The unit is supported by means of threaded studs on the interstage tuners.

(b) The cavity assembly (Fig. 7 and photographs on pages 111 and 112) is made of silverplated brass with over-all dimensions of approximately 3-1/4" by 6" by 1-1/2". Unscrewing the cap and withdrawing the power plug permits the 416A triode to be inserted in the cavity. A special tool is required for inserting the tube to prevent tube damage. The input from the waveguide is fed into the cavity through a slot and coupled directly to the tube between the cathode and the grounded gird. The plate connection on the vacuum tube fits into a 3/16" rod which extends up into the output cavity as a probe. The 250 V plate supply is connected to the probe end of this rod by means of a quarter-wavelength wire. To this rod, which is hollow, is also connected the air supply through a teflon tube. The cooling air is thereby conducted directly to the plate cavity surrounding the tube. The output cavity is connected directly to the interstage waveguide tuner or to the waveguide filter. There are three controls on an amplifier cavity. About the inter-cavity conductor is a cylinder which acts as part of a transformer. Moving the cylinder along the conductor changes the plate tuning. This motion is accomplished by two shafts (indicated on Fig. 7 as Plate Tuning Control) which extend out through the walls of the

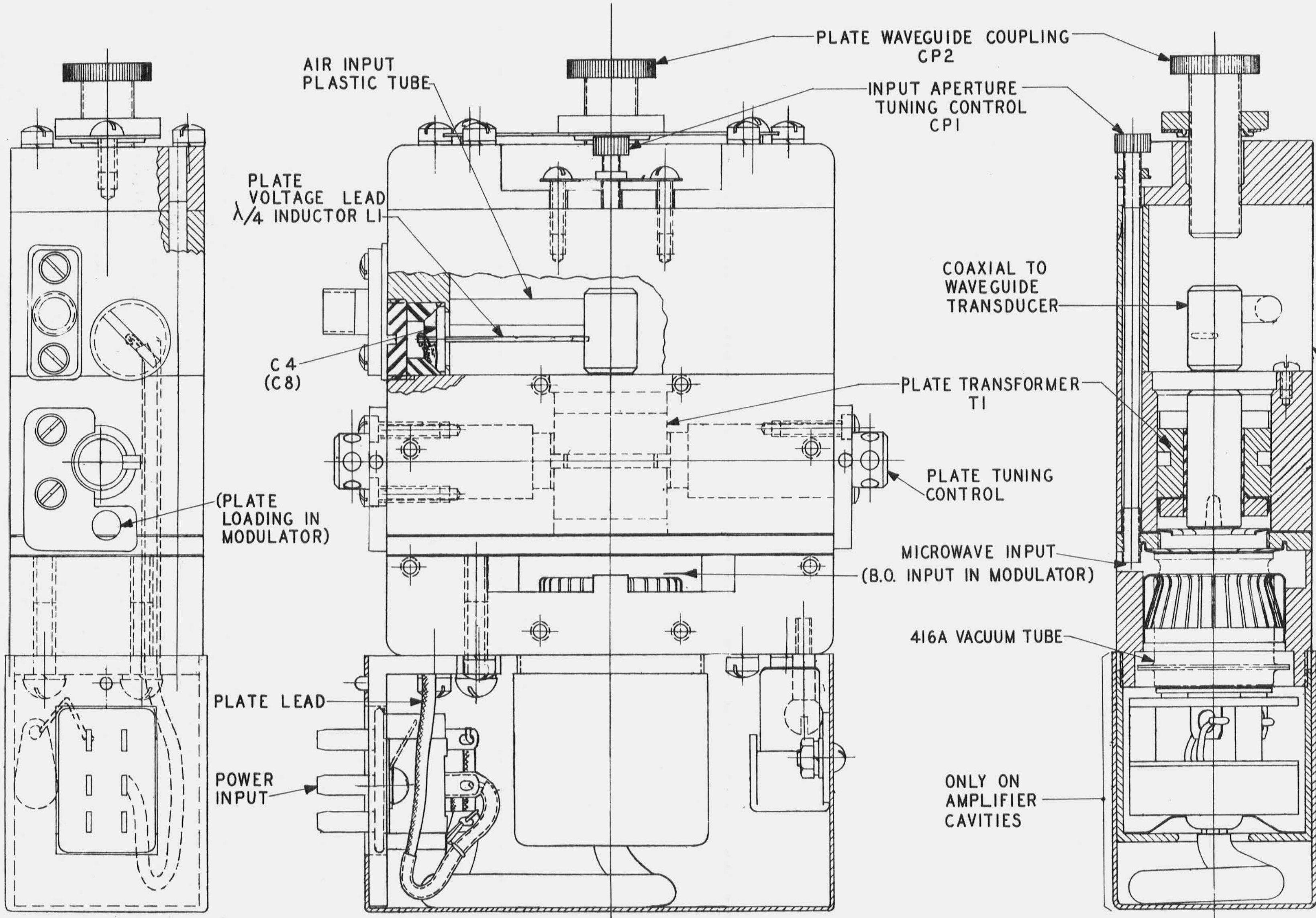


Fig. 7 - Sectional View of Amplifier Cavity
(Parenthetical notes refer to modulator cavity)

cavity and can be rotated by means of a yoke-like tool. On the inner face of each of these shafts is an eccentric plug which fits into a slot in the cylinder for translating the rotating motion of the shafts to a sliding motion of the cylinder. The rather large thumbnut((indicated on Fig. 7 as Plate Waveguide Coupling) affects the plate to waveguide coupling. Rotating the thumscrew varies the amount the screw protrudes into the cavity. A small thumbscrew (indicated as Input Aperture Tuning Control) varies the amount a tuning screw protrudes into the input slot. On the modulator cavity, there are two additional controls (Plate Loading) each of which slides a resistance coated mica card in and out of the plate cavity to vary the plate loading.

(c) The 400-type tuners are short sections of waveguide with adjustable tuning screws spaced an eighth of a wavelength apart and so positioned as to best match the impedance characteristics of the amplifier input and output cavities. The output filter section is a resonant iris-type waveguide filter with a tuning control.

(d) The power requirements are as follows:

| | | |
|---|---|---|
| Filament Supply | 12 volts | 5.5 amperes |
| Plate Supply | 250 volts | 90 ma |

9.03 Circuit Description:

(a) As shown on SD-59411, the circuit consists of three grounded-grid 416A triodes mounted in cavities with input and output tuning. Each stage is preceded by a tuner for matching its input impedance (capable of tuning out a standing wave of 8 db magnitude) and the last stage is followed by a filter section which flattens the band and provides an output impedance match over a broad band. The input impedance matching section consists of two anti-resonant circuits separated by approximately 1/8 wavelength and this combination separated approximately 1/8 wavelength from the input iris capacitive screw. The two rods act as inductances and the two screws act as adjustable capacitances.

(b) The input impedance of each cavity is matched to waveguide by a tuning screw at the input aperature plus an input tuner. The cavity is loaded by the input conductance and the glass loss of the input of the tube. Thus the input circuit without the impedance matching section is a single tuned circuit heavily loaded by the input conductance of the tube. Since no adjustment is available in the input conductance of the tube and since no loading resistance is provided in the input cavity, the circuit is designed so that the impedance seen at the input to the stage is always within the range of the impedance matching section. An impedance match can be obtained in the input circuit with a band of over 20 mc when both input and output circuits are matched. Because of the inherent feedback in a grounded grid triode, it is necessary to match both input and output several times to take care of the interaction.

(c) The plate circuit of each tube is matched to a 50 ohm coaxial line by means of a coaxial transformer which is movable to cover the frequency band and to accommodate variations in tube capacitance. Variation of the position of the 1/4 wave transformer changes the inductance of the resonant section of line for tuning. The 50 ohm coaxial line couples to waveguide by means of a transducer. Additional plate tuning is provided by means of capacitance loading from the end of the transducer probe to ground. This adjustment, CP2, takes care of variations in the resistive component of the plate impedance.

(d) The spacing between stages is such that the output circuit of one stage is coupled to the input circuit of the next stage in the proper phase to produce a flat-topped transmission.

9.04 Transmission Characteristics: The transmission characteristics are as follows:

| | |
|---|---|
| Frequency Range | 3700 to 4200 mc |
| Gain - as aligned | 18 db |
| - max | 28 db |
| Amplifier Band Width (0.1 db down) | 20 mc |
| Band Width per stage (3 db down) | 100 mc |
| Output | 27 dbm (1/2 watt) |
| Input Impedance - Return Loss | 20 db or more over 20 mc band |
| Output Impedance - Return Loss | 30 db or more over 10 mc band; 24 db or more over 20 mc band |
| Compression | 3 db (approx) with 1/2 watt output |
| Plate Currents | |
| Output stage | 30 ma |
| First and second stages | 25 ma |

10. TRANSMITTER CONTROL UNIT (J68330M)

10.01 General: The transmitter control unit serves the following functions:

controls the application of power to the transmitter modulator and the transmitter amplifier; provides means for controlling the bias on the 416A tubes in the transmitter modulator and the transmitter amplifier; provides means for measuring the plate current and grid bias of each of the 416A tubes; provides a meter for reading the output power of the transmitter and for originating an alarm in case of failure of the output power. A photograph of the unit is shown on page 113 and the circuit schematic - SD-59400 - on page 121.

10.02 Equipment Features: The 8-3/4" transmitter control panel is arranged for mounting on a 19" duct-type bay. The unit is designed for single side maintenance and all apparatus and controls are accessible from the front. The removal of the front cover, which is secured by quick release fasteners, permits the main control panel to be dropped forward 90 degrees for maintenance. The over-all depth of this unit is 9". All connections are made to this unit by means of multicontact plugs and receptacles. On the left of the panel are the screwdriver BIAS ADJ and FIL ADJ adjustments and the FIL V jacks for measuring the filament voltages of the modulator and the first stage of the transmitter amplifier. To the right are similar controls for the second and third amplifier stages. The sensitrol meter PWR OUT will magnetically lock up if the power drops to 10 db less than the normal output and will not restore without operating the RESET pushbutton. The PWR ADJ screwdriver adjustment makes possible the setting of the meter to 0 db with normal transmitter amplifier output. The ACO pushbutton cuts off the audible alarm. Below are pin jacks to enable the filament voltage to be measured. In the center is the filament circuit breaker. At the bottom-center is a 1-1/3 amp indicating fuse with a spare. To the right of center are the meter and switch which enable plate currents and bias voltages to be measured for each of the modulator and the three amplifier stages. When the key under the filament circuit breaker is in the normal position, the meter measures plate current. To measure bias, the key is operated to either the right or left depending upon the bias polarity. There is no OFF position of the meter switch.

10.03 Circuit Description:

(a) In following this circuit description, reference should be made to the circuit schematic - SD-59400.

(b) Filament Supply - Operation of the FIL circuit breaker S3 to the ON position connects the 12 volt supply to the heater circuits of the 416A vacuum tubes in the transmitter amplifier and the transmitter modulator. FIL ADJ rheostats R15, R17, R19, and R21 are provided for adjusting the heater voltages and jacks J1, J2, J3, and J4 are for reading the filament voltage.

(c) Plate Supply - Operation of the FIL circuit breaker S3 to the ON position also energizes the heater of the thermal relay K7 through the shorting interlocks in the power distribution plugs. In approximately 60 seconds, the normally open contact of the K7 thermal relay will close causing relay K5 to operate. The interlock of relay K5 with the filament circuit prevents the application of plate power to the 416A tubes without the 60 second delay. Relay K5 locks in the operated position through its "make" contact and closes the 250 volt DC circuit from the F1 fuse through the meter shunting resistors R5 to R8, the voltage dropping resistors R10 to R13, and the field coils of the K1 to K4 relays to the plates of the tubes. Meter switch S1 enables the plate currents of the various tubes to be measured. The PLT CUR key should be in "normal" position.

(d) Bias Supply - The -12 volt supply is also fed to the contacts of relays K1 to K4 through the FIL circuit breaker S3 and a simple filter. These relays are provided to control the application of bias to the grids of the tubes. These relays in their nonoperated position connect the cathodes of the tubes directly to ground. When the plate current of an individual tube has risen to a value of approximately 5 milliamperes, its respective relay will operate to connect a fixed resistance and a BIAS ADJ potentiometer in series, between the cathode and -12 volt battery. This circuit provides an effective positive bias on the grounded grid of the tube which tends to stabilize its plate current. The value of bias may be adjusted with the potentiometer. The bias voltage may be measured for each tube by means of the meter M1, the switch S1 and the key S2. The latter permits either positive or negative bias voltages to be measured.

(e) A Weston sensitrol relay PWR OUT is provided to read output power and to originate an alarm in the event of output power failure. A potentiometer PWR ADJ is provided as a means of adjusting the output power calibration of the sensitrol relay. A RESET key releases the sensitrol relay after it has operated due to no-power or low-power operation.

(f) An alarm cut-off key ACO cuts off the audible alarm.

## 11. OUTPUT MONITOR

11.01 General: The output monitor consists essentially of a directional coupler and a crystal monitor and is employed to monitor the transmitter output power and energize an alarm circuit in case of transmitter output failure. Removal of a termination provides a point at which the output characteristics of the transmitter can be measured. A photograph of this unit is shown on page 114 and the circuit schematic - SD-59421 - on page 134.

11.02 Equipment Features: The directional coupler, with waveguide terminations and a waveguide spacer, and the crystal monitor which comprise the output monitor, constitutes an assembly of 2.290" by 1.145" waveguide components. The through transmission path is a section of waveguide six inches long equipped with standard flanges. Two branch circuits are connected to the main transmission path through coupling holes in the wide faces of the waveguide. One branch is equipped with a crystal monitor assembly which rectifies and filters a fraction of the microwave power. This filtered output is used for indicating the power output and for connection to a low-power alarm. The other branch circuit is equipped with two 500A Terminations. The removal of one of these terminations permits the connection of monitoring or test equipment.

11.03 Circuit Description: As is seen from SD-59421-01 the directional coupler has two "side" circuits or branches which drain off a small amount of power (25 db down). The "E" and "F" arms are terminated so as to absorb any reflected power. Removal of the 500A Termination from the "C" arm provides a test point for measurements of repeater bay transmission characteristic. The "D" arm connects through a waveguide spacer to the crystal monitor and the microwave power which is drained off is rectified by the 406A Varistor. The rectified output of the crystal monitor is connected to the PWR ADJ potentiometer R26 and the sensitrol relay K6 in the transmitter control panel. With the transmitter output power at normal level R26 is adjusted to give a "0" reading on the sensitrol relay. When the transmitter output power has been reduced to 10 db below normal the contacts of the sensitrol relay will make, energizing the power failure alarm circuit. The relay contacts are magnetically locked; thus when power is restored it will be necessary to depress the reset key to restore the alarm circuit to normal.

11.04 Transmission Characteristics: The transmission characteristics of the directional coupler are:

| | |
|---|---|
| Direct Path Loss | 0 db |
| Output Loss (each low level branch) | 25 db |
| Directivity | 23.5 db or greater |
| Frequency Range | 3700 to 4200 mc |
| Input Power to Crystal | 2 to 5 dbm |
| Alarm Signal | 10 to down from normal output power |

## 12. MICROWAVE GENERATOR (J68330G)

12.01 General: The microwave generator provides a very stable crystal-controlled source of microwave beating oscillator frequency. Two slightly different versions of the microwave generator are available. The Transmitter Microwave Generator supplies both the transmitter modulator and the 40 mc shifter at repeater stations but only transmitter modulator at terminal stations. The Receiver Microwave Generator supplies only the receiver converter at terminal stations. The microwave generator consists of a temperature controlled crystal oscillator followed by a series of harmonic generator stages which multiply the frequency up to the microwave region. The microwave generator panel is shown in the photographs on pages 115 and 116 and the circuit schematic - SD-59409-011 - on page 131.

12.02 Equipment Features:

(a) The microwave generator equipment is designed to mount on a 19" duct-type bay. The removable front cover projects 9" from the mounting frame and the over-all depth of the unit is 12". The unit consists of a 19" by 10-1/2" by 3" deep chassis, well shielded by a cover on the back, and supporting from the front a hinged meter panel on which are mounted the controls required for routine operation and checking of the unit. The crystal and crystal oven, vacuum tubes, vacuum tube mounting assemblies, and relays are mounted on the front of the chassis. The circuit elements are contained within the shielded chassis, with all tuning adjustments accessible from the front. Means are provided for applying air from the supply pipe in the bay duct, through flexible hoses, to cool the last four vacuum tubes, V4, V5, V6, and V7. The microwave output appears at the jack on the short coaxial cable brought out from the lower end of the V7 vacuum tube mounting assembly. All power connections to this unit are made through a multicontact plug and jack. A receiving microwave generator does not have a V6 stage, the V7 stage in this case operating as a sextupler at an output level sufficient to provide beating oscillator voltage to the receiver converter. The transmitting microwave generator requires the addition of the V6 stage, which operates as a tripler, allowing operation of V7 as a doubler at a higher output level sufficient for the transmitter modulator.

(b) The 7" by 9" hinged panel supporting the meter and the controls is porvided with a lucite protective cover on the rear. On the left of the front of the panel are mounted the filament circuit breaker FIL, the two screwdriver adjustments for the filament voltages FIL V6 and FIL ADJ V7, and two jacks FIL V V6 and FIL V V7 for measuring the filament voltages. In addition to normal adjustments, these are also used for filament activity tests of these tubes without removing the unit from service. Below the circuit breaker are a 1/2 amp indicating fuse for the 250 volt circuit and an unwired spare SP. At the top is a screwdriver OUTPUT adjustment. The switch connects the meter to various circuits for measurements of plate currents of all tubes, and grid currents of V1, V3 and V4. At the upper right are the pin jacks for measuring +250, +150 and -11 volt supply voltages. The FIL ACT switches are for making filament activity tests on tubes V1, V2, V3, and V4 without removing the unit from service. When any of these switches are operated to TST, the red FIL TST lamp will light. The red lamp OVEN ALARM lights if the crystal oven thermostat or relay fails. The nonlocking pushbutton OVEN ACO cuts off the oven alarm relay.

(c) The power supply requirements are as follows:

| | | |
|---|---|---|
| Filament Supply (Positive grounded) | 11 volts | |
| Receiver Microwave Generator | | 6.25 amperes |
| Transmitter Microwave Generator | | 8 amperes |
| Plate Supply | 250 volts | |
| Receiver Microwave Generator | | 130 ma |
| Transmitter Microwave Generator | | 150 ma |

12.03 Circuit Description:

(a) The circuit schematic of the microwave generator is shown on SD-59409. The oscillator uses a double triode in a special type feedback circuit. The crystal operates at series resonance and is connected in a low impedance part of the circuit between the two cathodes of the double triode. A coil and condenser connected in series with the crystal serve to slightly alter the series resonance of the combination and allow the frequency of the oscillator to be varied over a ±0.003% range. The circuit will oscillate when the circuit in the plate of the oscillator is tuned to the frequency of the crystal. The crystal operates at the third overtone of the fundamental frequency of the quartz plate. A FREQ TST jack permits a small amount of energy to be taken out of the oscillator circuit for frequency check purposes. The frequency range covered by the oscillator with different plug-in crystals is 17.6 to 19 mc to correspond with the microwave output range of 3800 to 4100 mc. The crystal operates in an oven kept at 70 degrees C. A high temperature alarm is provided by a 2-contact thermostat TD2 which closes at 80 degrees C and energizes an OVEN ALM relay which lights an OVEN ALM lamp on the panel, puts gouund on the alarm circuit and opens the oven heater circuit. The alarm relay locks up until opened by a cut-off key, OVEN ACO. The 2-contact thermostat TD2 applies heat to the oven again when its temperature drops to 60 degrees C. In the event of failure of the heater or control relay windings or failure of control thermostat to close, the alarm relay will operate when the oven temperature falls to 60 degrees C.

(b) The first harmonic generator stage V2 consists of a miniature pentode operating as a frequency tripler. Its output frequency range is 52.8 to 57 mc to correspond with the oscillator frequency range. The second stage also consists of a miniature pentode V3 operating as a frequency doubler with an output frequency range of 105.6 to 114 mc. The third stage is a lighthouse triode V5 operating as a frequency doubler having an output frequency range of 211 to 228 mc. The fourth stage also uses a lighthouse triode V5 operating as a frequency tripler having an output frequency range of 633 to 683 mc. The fifth stage is a 416A triode V6 operating as a frequency tripler having an output frequency range of 1900 to 2050 mc. When the microwave generator is used for receiving only, this stage is omitted. The sixth stage also uses a 416A triode V7 operating as a frequency doubler (six times in the case of the receiver microwave generator) having an output frequency range of 3800 to 4100 mc. The OUTPUT potentiometer controls the output power of this stage by varying the cathode bias.

(c) Each stage of the generator except the last two has a series dropping resistance associated with a FIL ACT switch, which when thrown to TST position reduces the heater voltage by a sufficient amount in order to determine the condition of the tubes while in service. The last two stages V6 and V7 have jacks FIL V for plugging in an external filament voltmeter.

(d) Meter M1 together with meter switch S7 provides means of measuring the grid currents and plate currents of the oscillator tube and harmonic generator stages.

(e) The filament switch FIL applies the 11 volts to the circuit. It is a circuit breaker type of switch and when in the off position sends in an alarm. The last two stages V6 and V7 have FIL ADJ potentiometers for adjusting the filament voltage.

(f) The 250 volts cannot be applied to the circuit unless the FIL switch is on. With the FIL switch on, the heater of the thermal relay TIME DEL is energized. Approximately 60 seconds later the normally open contact of this relay will close, causing relay PLT to operate and apply 250 volts to the panel. If the 250V fuse is blown an alarm will be sent in. The 150 volts required for the oscillator V1 plate voltage is provided by the voltage regulator tube V8.

(g) Test jacks -11V, +150V and +250V are provided for measuring the 11 volts, 150 volts and 250 volts on the panel.

12.04 <u>Transmission Characteristics</u>: The transmission characteristics of the microwave generator are as follows:

| | |
|---|---|
| Output Frequency | 3800 to 4100 mc |
| Output Impedance | 75 ohms coaxial |
| Output Power - | |
| Transmitter microwave generator | 25 ±2 dbm |
| Receiver microwave generator | 6 dbm min. |
| Crystal Tolerance | ±0.003% |
| Crystal Oven Temperature Stability | ±1/2°C |
| Stability of Adjusted Generator | ±0.001% |

## 13. 40 MC SHIFTER (J68330H)

13.01 <u>General</u>: The 40 MC Shifter combines the frequency of the microwave generator with that of the 40 mc generator to produce the beating oscillator frequency which is supplied to the receiver converter. The shifter panel includes a waveguide directional coupler with variable attenuators in each of the two outputs, a 40 mc generator and control circuit and a microwave converter unit. The 40 mc shifter panel is shown in the photographs on pages 117 and 118. The circuit schematics - SD-59408 and SD-59410 - are shown on pages 130 and 132, respectively.

13.02 <u>Equipment Features</u>:

(a) The 10-1/2" 40 MC Shifter unit (J68330H) is designed to mount on a 19" duct-type bay. The over-all depth is 9". The shifter is comprised of the following units: J68330J 40 MC Generator and Shifter Converter, a transducer, a converter assembly and a directional coupler-attenuator assembly. Controls and provisions for metering and testing are mounted on a 9-7/8" by 7-1/8" panel. The equipment is arranged for single-side maintenance and all apparatus, wiring, and controls are accessible from the front. Microwave connections to this unit are made through coaxial cable to waveguide transducer fittings. Multicontact plugs and receptacles are used for power connections.

(b) The control panel mounts a circuit breaker for the filament supply and a fuse mounting for the 250 volt plate supply and their associated alarm circuits. Two screwdriver adjustments associated with the directional coupler-attenuator are used for adjusting the beating oscillator supplies to the transmitter modulator and the shifter converter. A switch connects the meter to various circuits for measuring the plate voltage, plate currents and the grid current of the oscillator, the plate and screen current of the doubler, and the converter crystal currents. There is a screwdriver control for reducing the 250 volt supply to the required +150 volts and one screwdriver control to adjust the 40 mc output. Test points are provided for checking the 250 volt supply, the -11 volt filament supply and one for the chassis ground. A FIL ACT switch permits measuring the filament activity of the generator tubes while the unit is in service.

(c) The directional coupler-attenuator consists of two double waveguide sections joined by means of waveguide flanges. The directional coupler section consists of two pieces of waveguide joined on the H plane (broad face of the waveguide). The lower section has provision for a probe input from the microwave generator and is the main or high-level component of the coupler and supplies microwave energy to the transmitter modulator. The top wall of this piece of waveguide is machined off. The upper portion of the coupler has two 400 mil slots, spaced approximately a quarter wavelength apart at midband, cut in the lower H plane of the waveguide. The first slot begins at the outer face of the flange and the quarter-wave dimension is taken from this surface. This branch is the secondary or low-level component of the coupler and its power is 7 db down from the main branch. The shorted end of this waveguide section has a termination inserted in it. The attenuator sections are similarly constructed of two pieces of waveguide with one of the adjoining walls removed. Each section contains a variable attenuator consisting of a diamond-shaped section of resistance material moved in the E plane by means of a screwdrive. At the terminated end of each section, provision is made for transducer coupling from waveguide-to-coaxial cable. The lower or high-level section supplies microwave energy to the transmitter modulator and the upper or low-level section feeds the shifter converter.

(d) The 40 MC Generator and Shifter Converter unit consists of a 5-3/4" by 2-3/4" by 2-1/8" chassis containing a completely shielded 40 mc oscillator-amplifier. The front face of this chassis mounts a 396A oscillator tube, a 20 mc crystal, a 6AQ5 doubler and four variable air condensers with screwdriver adjustments for tuning the oscillator, coupling and output circuits. Provision is made on the lower left corner for mounting the shifter converter. At this point the coaxial input to the converter is connected to the two output coupling condensers of the 40 mc generator. A sectional view of the shifter converter is shown on Fig. 8. Two 405A Varistors are mounted in short sections of 75 ohm coaxial tubes coupled to the waveguide. The varistor-carrying arms house movable coaxial transformers to match the coaxial and waveguide sections of the shifter converter at various frequencies. The 40 mc frequency from the 40 mc oscillator is fed to varistors by means of one lead to each inside the small coaxial tubes. A fitting provides for a coaxial connection for the microwave frequency from the directional coupler attenuator. The modulated output of the converter is in waveguide and a coaxial-to-waveguide transducer is mounted on the waveguide portion of the converter to carry the microwave energy to the receiver portion of the bay.

(e) The power supply requirements are as follows:

| | | |
|---|---|---|
| Filament Supply (Positive grounded) | 12 volts | 0.75 ampere |
| Plate Supply | 250 volts | 60 ma |

13.03 Circuit Description:

(a) The application schematic of the 40 MC Shifter and Generator is shown on SD-59408. Part of the output from the microwave generator is taken off through a waveguide directional coupler on this panel and fed into the 40 mc shifter converter through the receiver converter attenuator. The main part of the output from the microwave generator goes through the transmitter modulator attenuator before going to the transmitter modulator unit. The 40 mc generator output which is connected to the 40 mc shifter converter beats with the frequency of the microwave generator to produce frequencies in the output of the converter differing by 40 mc from that of the microwave generator frequency. A waveguide filter which is a part of the bay equipment but not mounted on this panel is connected to the output of the 40 mc shifter converter and selects the proper sideband frequency which is fed to the receiver converter. The directional coupler is a slot-type waveguide directional coupler with an attenuation of 7 db in the receiver branch. The waveguide attenuators are movable vane type with a range of approximately 8 db. The 40 MC Generator consists of a 20 mc crystal oscillator followed by a frequency doubler stage.

(b) The circuit schematic of the shifter and converter is shown on SD-59410. The oscillator uses a double triode V1 in a special type of feedback circuit. The 20 mc crystal Y1 operates at series resonance in a low impedance path, being connected between the two cathodes of V1. In order to oscillate, the tuned circuit in the plate must be tuned to 20 mc. The input circuit of the doubler stage is also tuned at 20 mc and is loosely coupled to the oscillator tuned circuit. A pentode V2, operated as a class C amplifier with large input drive, is used to obtain harmonic generation. A double tuned circuit in the plate of the pentode is tuned to 40 mc and matches the plate impedance to the low input impedance of the converter. The 40 mc power is fed into the converter through blocking condensers C30 and C31 and the DC varistor currents are fed through RF chokes L7, L8, L9, and L10, L11, and L12. An OUTPUT control R26 is included for adjusting the power supplied to the 40 mc shifter converter by changing the bias of the V2 cathode.

(c) The shifter converter is a balanced microwave crystal modulator mounted in a combination coaxial and waveguide hybrid junction. A sectional view of this converter is shown on Fig. 8. The varistors are matched into 75 ohm coaxial lines projecting through the H plane of the hybrid junction. The input signal is fed into the converter through a 75 ohm coaxial line projecting through the E plane of the hybrid junction. The varistors are placed in the coaxial lines in opposite polarity so that their 40 mc inputs are

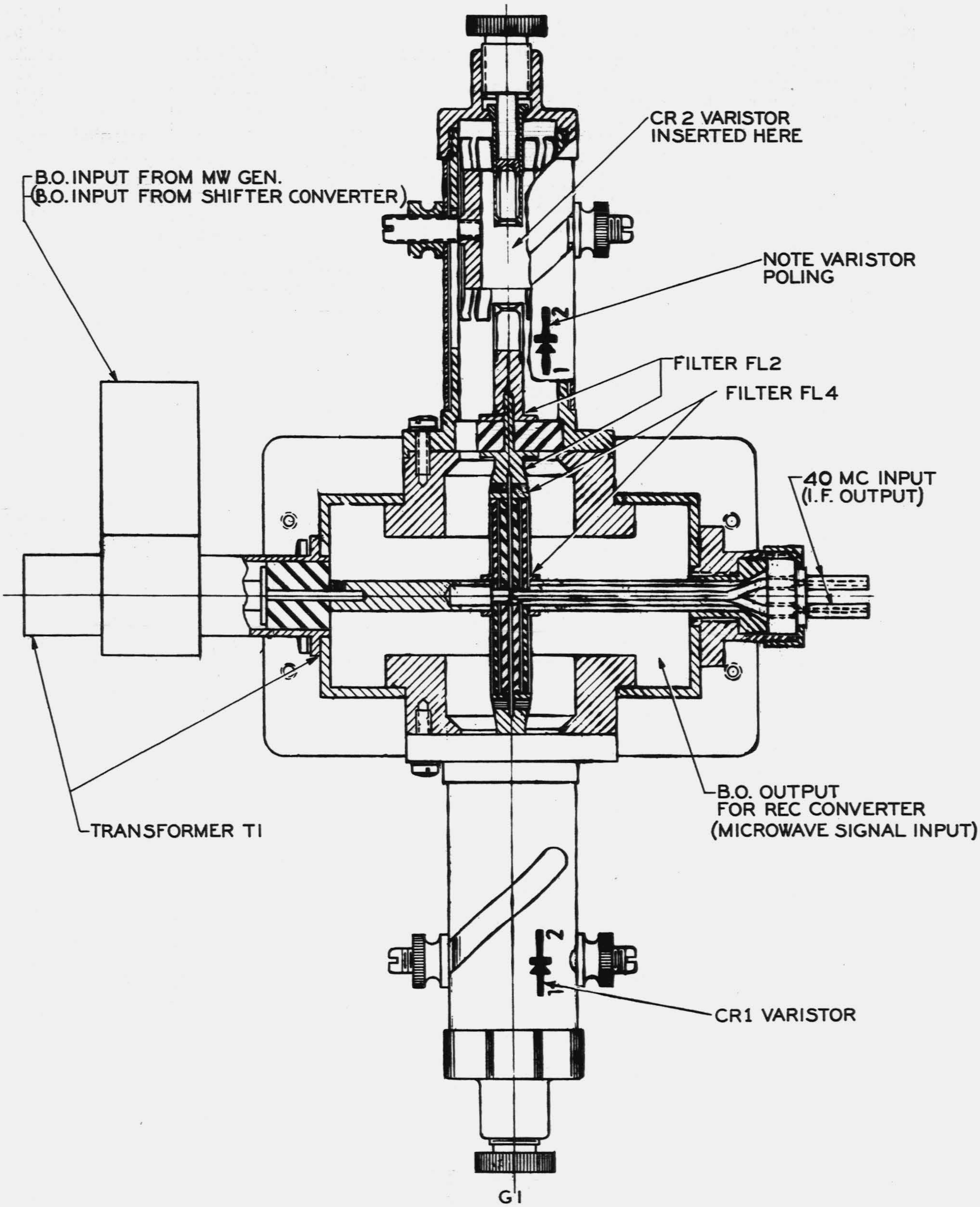


Fig. 8 - Sectional View of Shifter Converter
(Parenthetical notes refer to receiver converter)

connected in parallel. The 40 mc input to the varistors is brought in on a shielded pair of wires through an RF filter. Second harmonic filters are placed between the varistors and the waveguide to prevent second harmonic frequency generated in the varistors from getting back into the waveguide. RF wavetraps are included in the inputs to the varistors to isolate the RF and IF parts of the circuit. Adjustable inductances are included in the varistor coaxial lines to improve the impedance match of the varistors to the lines and to adjust the balance between the two varistors.

(d) The insertion of the +250V fuse F1 and the operation of the FIL circuit breaker to ON connect the 11 volts and 250 volts to the circuit. Alarms are associated with both fuse and circuit breaker. The 150V potentiometer R27 is used to adjust the plate voltage of V1 to 150 volts. The meter switch S1 permits the reading of the plate voltage of V1 and the grid and plate currents of V1 and V2 and crystal converter currents by means of meter M1. R19 to R24 are meter-shunting resistors. The FIL ACT switches when operated to the TST position reduce the heater voltage of V1 and V2 10 per cent and light the FIL TST lamp. This permits testing the condition of the vacuum tubes while in service.

13.04 Transmission Characteristics: The transmission characteristics of the 40 MC Shifter are as follows:

| | |
|---|---|
| Input Frequency | 3700 to 4200 mc |
| Output Frequency | 3700 to 4200 mc |
| Output Impedance Match - Return Loss | 11 db min |
| Balance | 20 db or more |
| Conversion Loss | 11 db |
| Varistor Currents | 60 ma each |
| Beating Oscillator Power | Approximately 0.5 watt |
| Oscillator Stability | 0.005 per cent (-20°C to +80°C) |

## 14. PHOTOGRAPH, DRAWING AND REFERENCE LISTS

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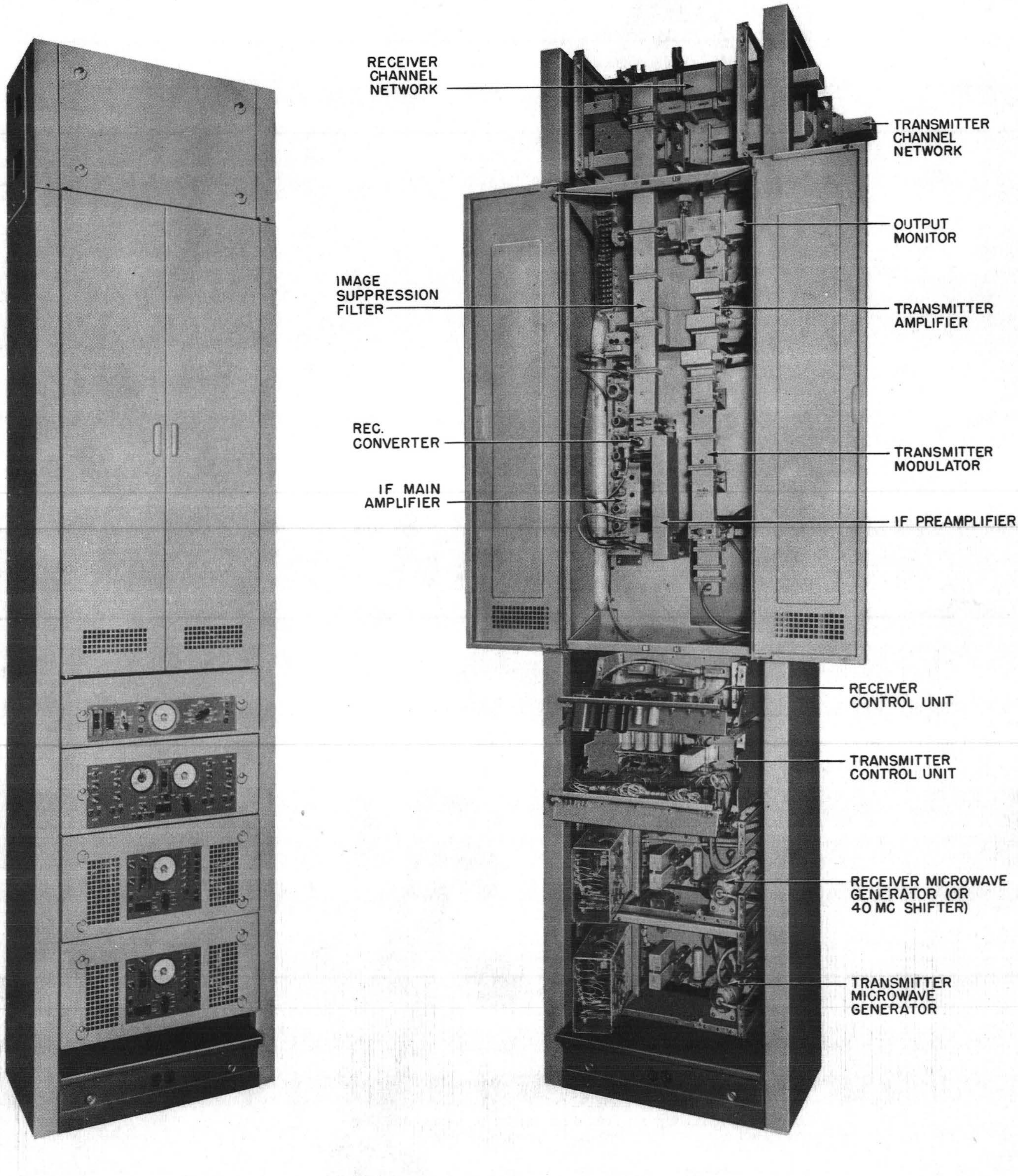
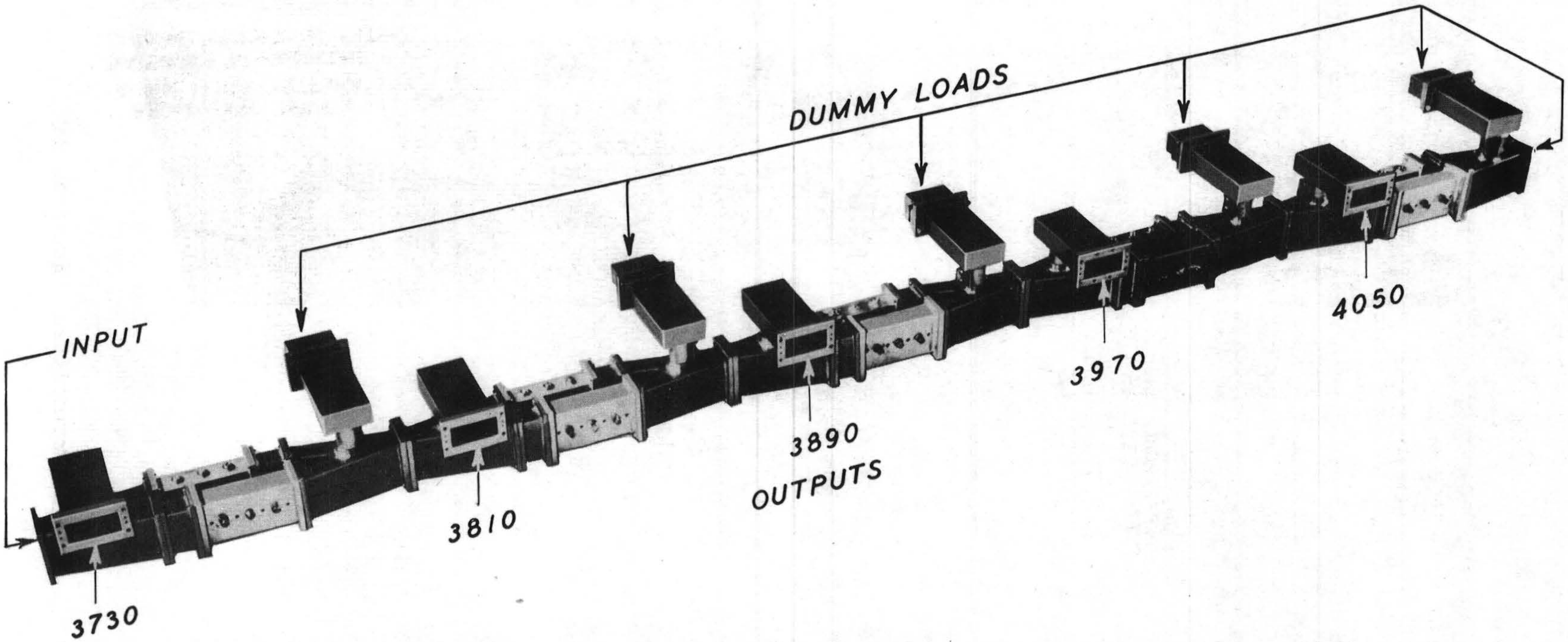
(C) References

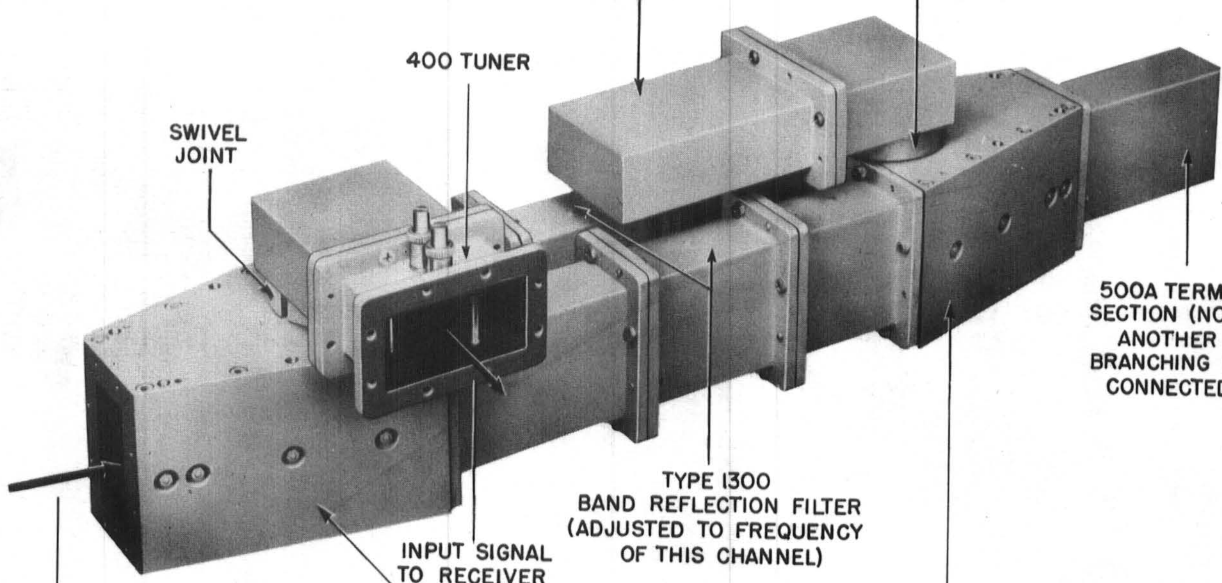
SECTION R90.300 TD-2 Radio System



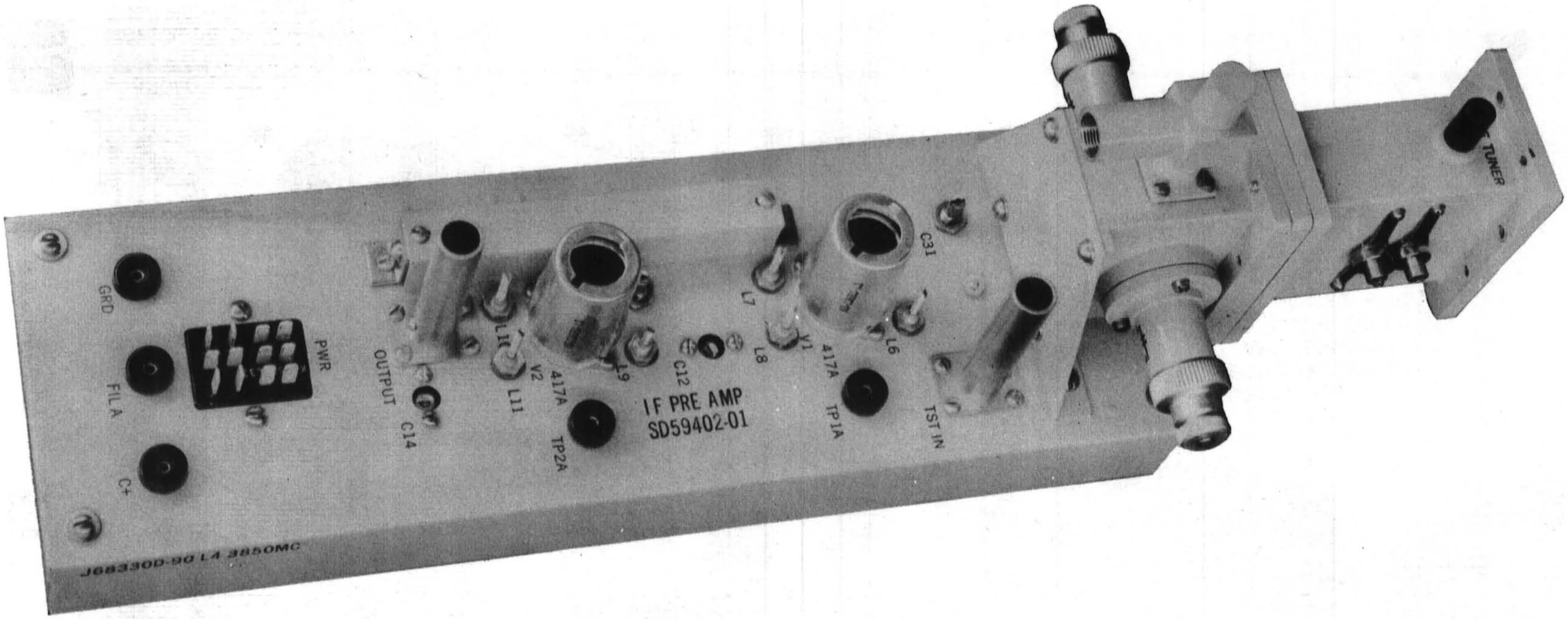

J68331A Transmitter - Receiver Bay



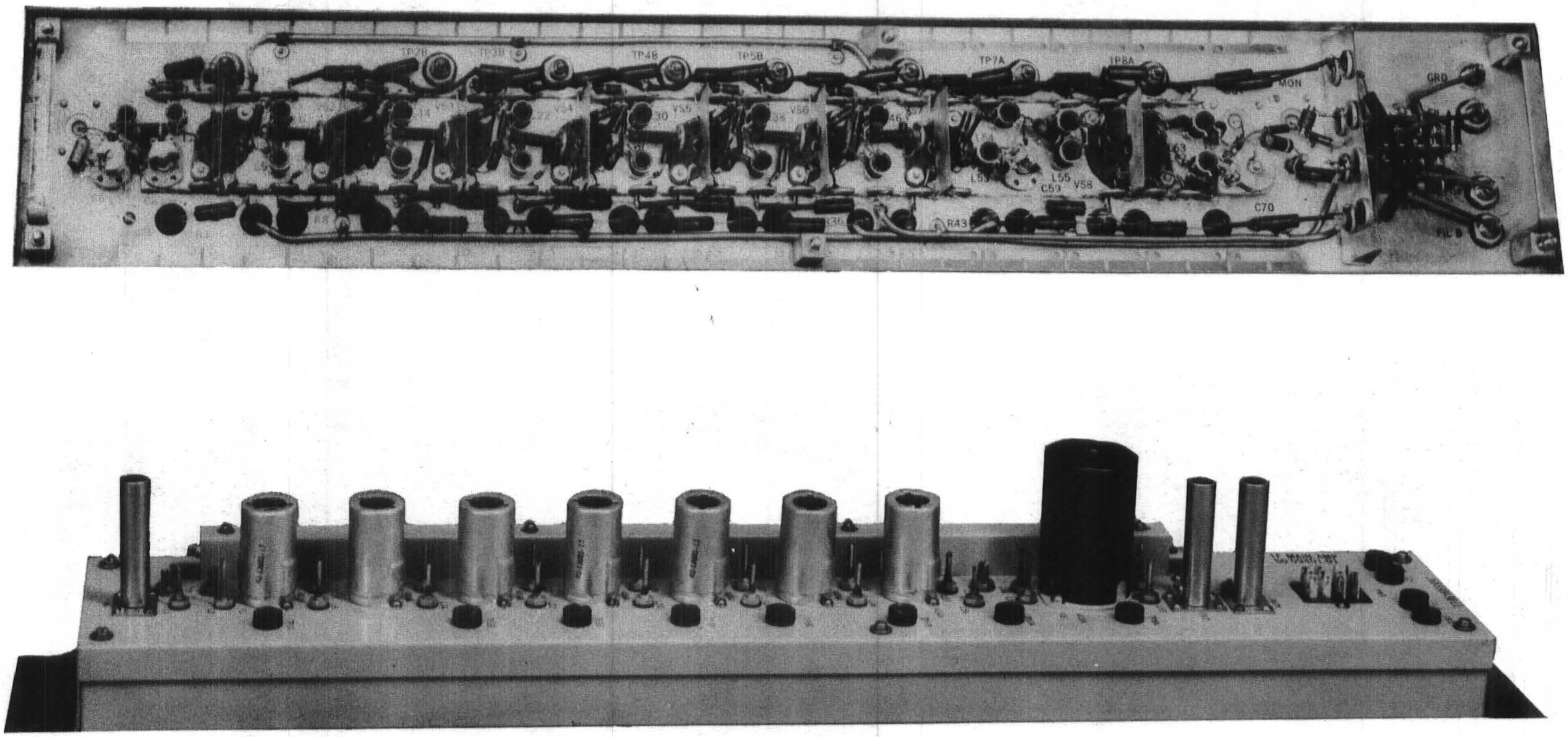

Preliminary Model of Five - Chanel Separation Filter



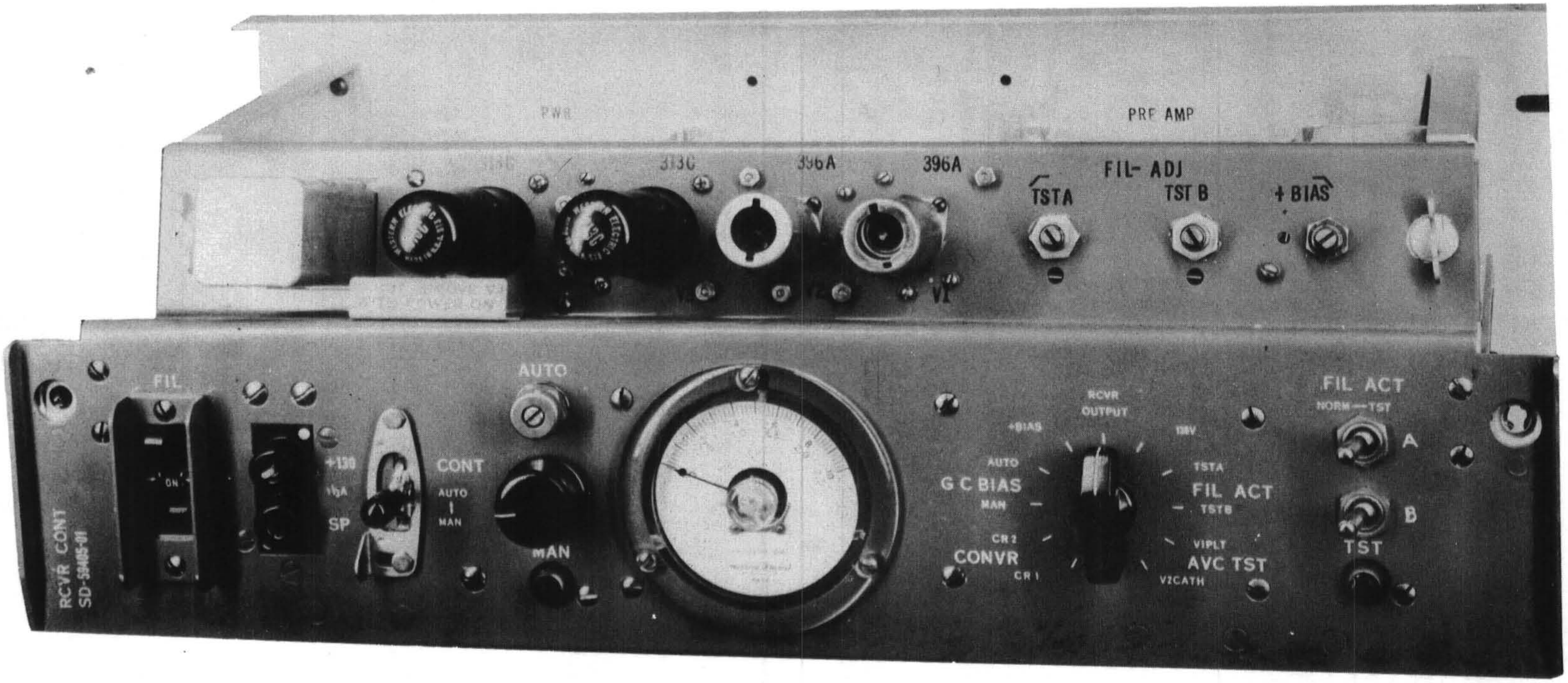

Single Unit Separation Filter (Type 1400 or 1401 Network)

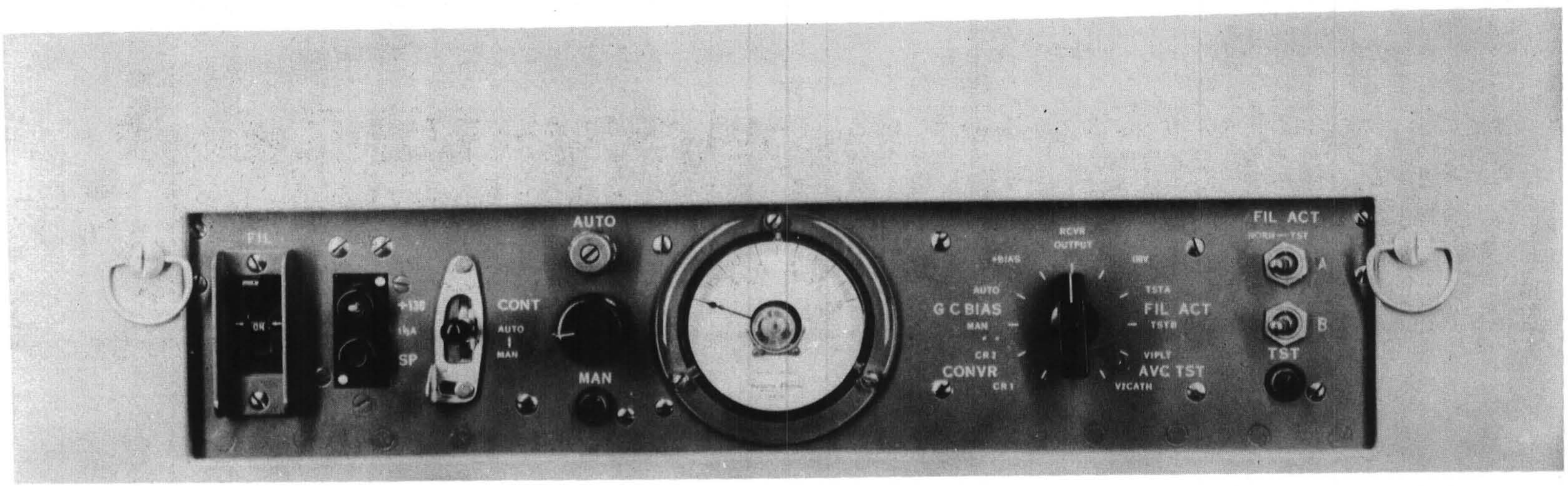



J68330D Receiver Converter and IF Preamplifier

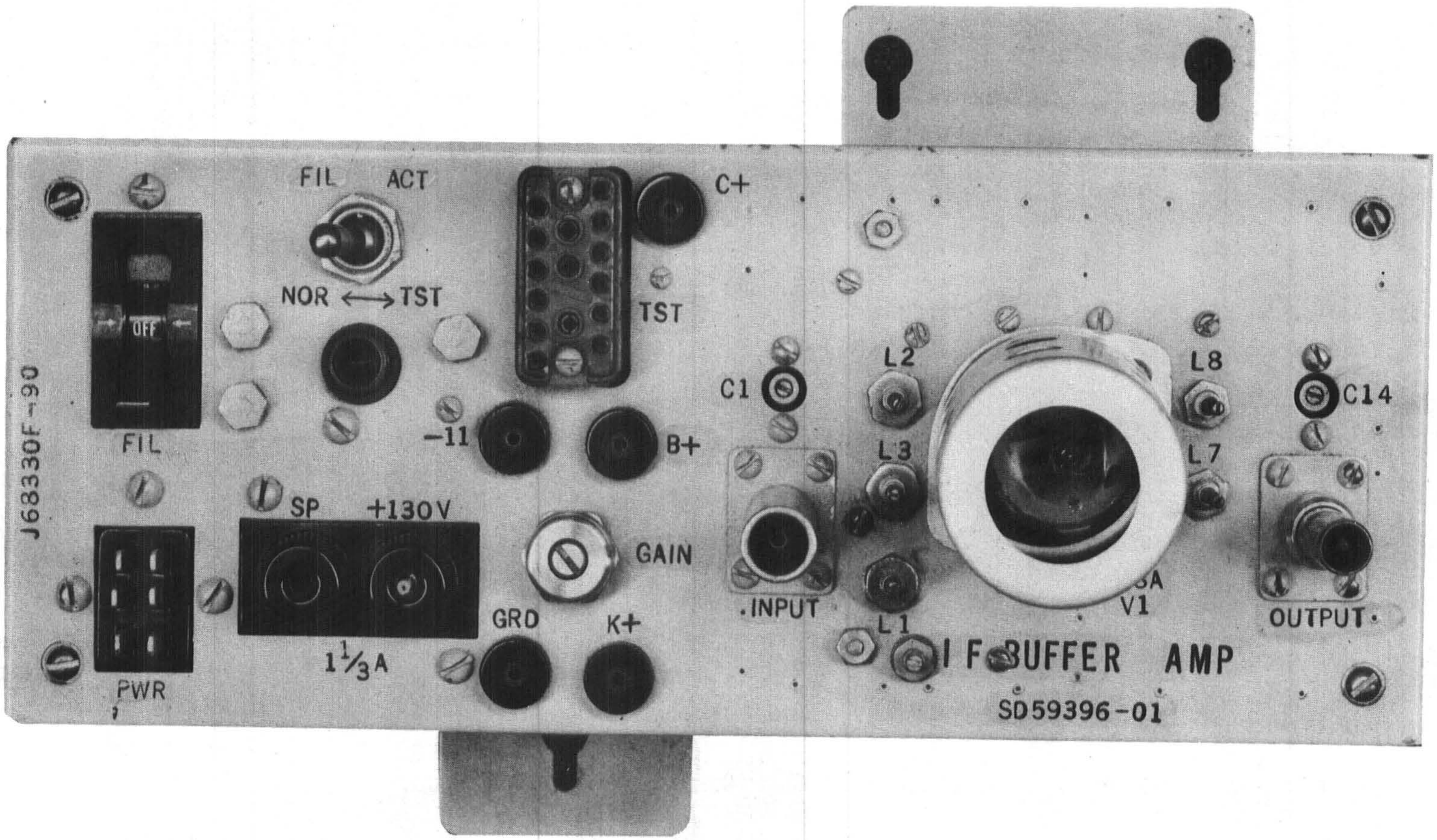


J68330A IF Main Amplifier

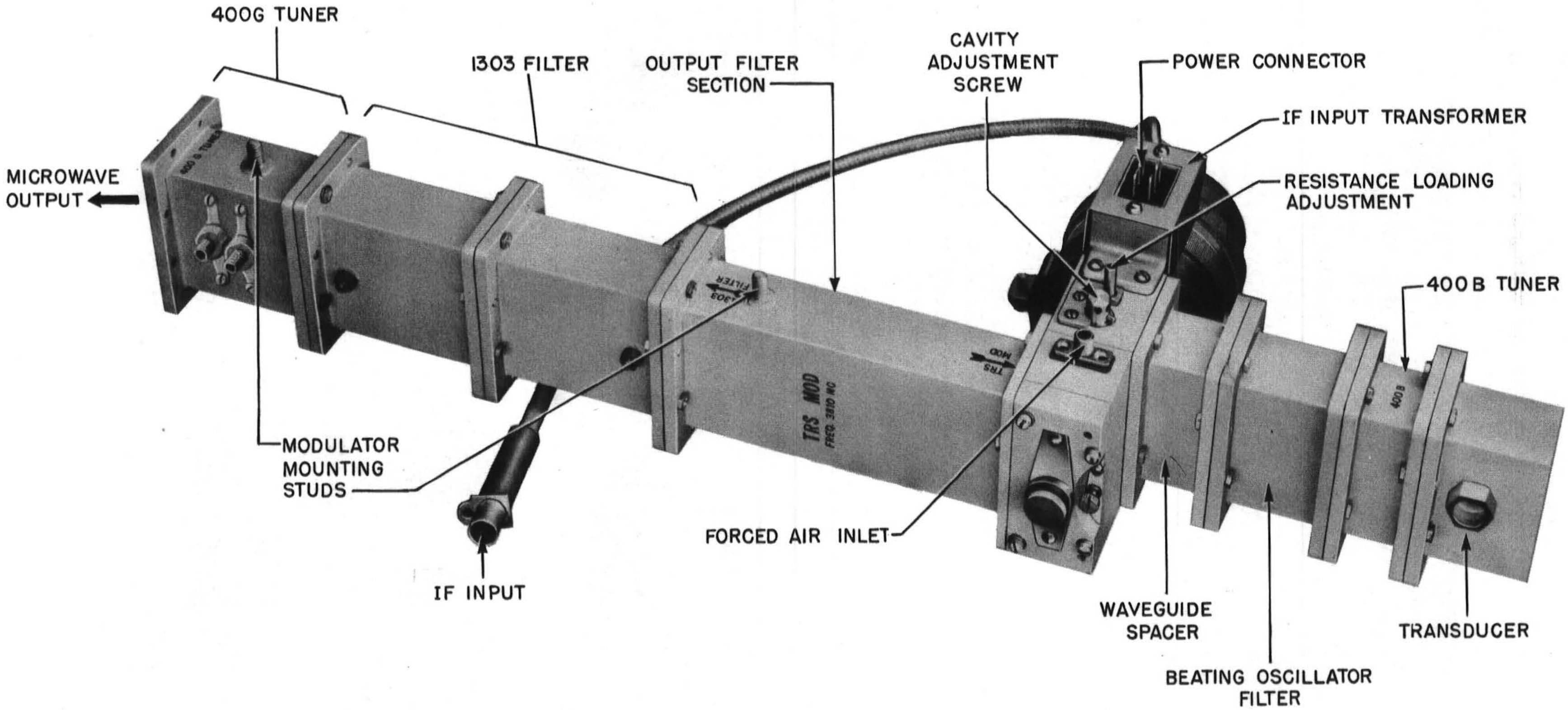


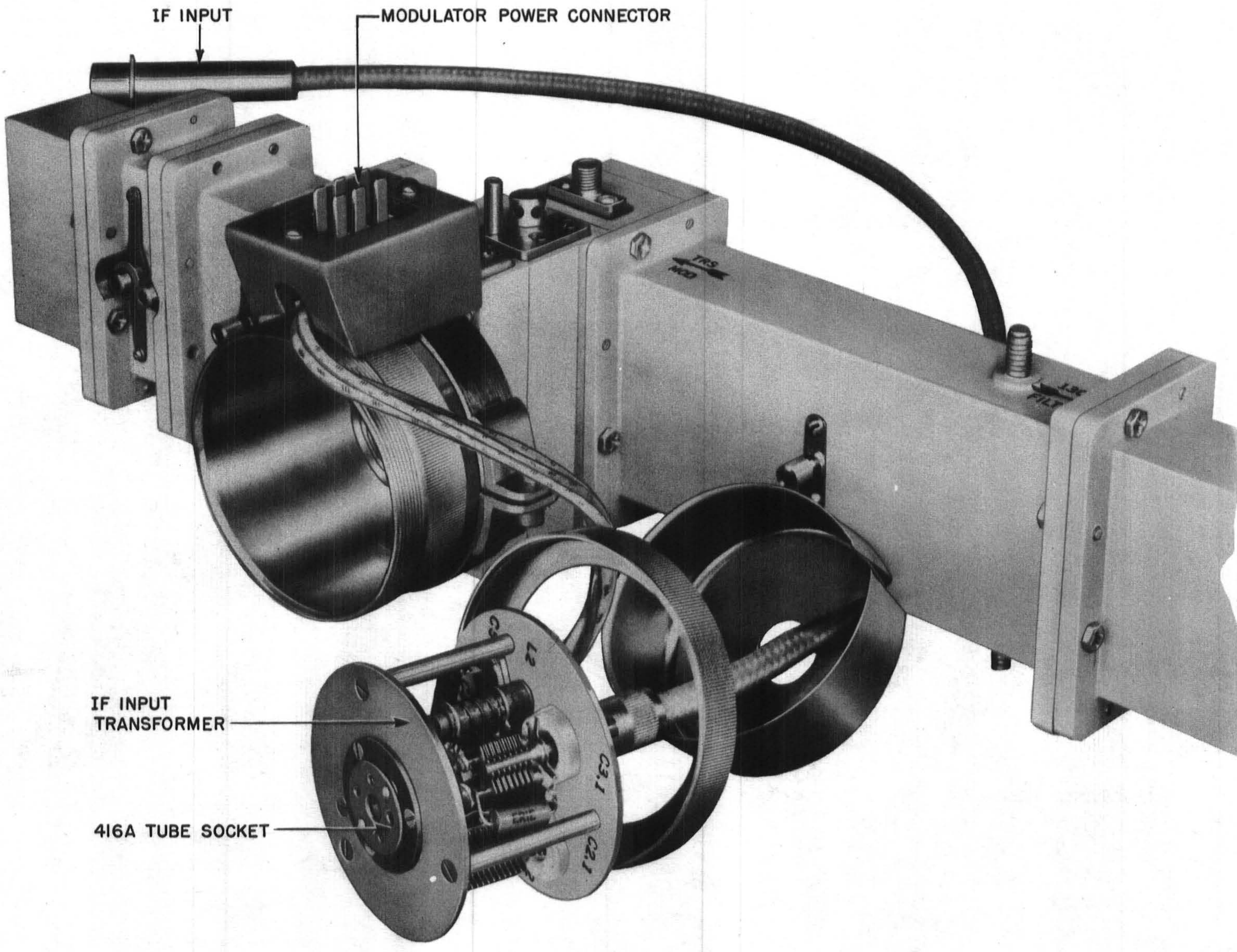

J68330B Receiver Control Unit



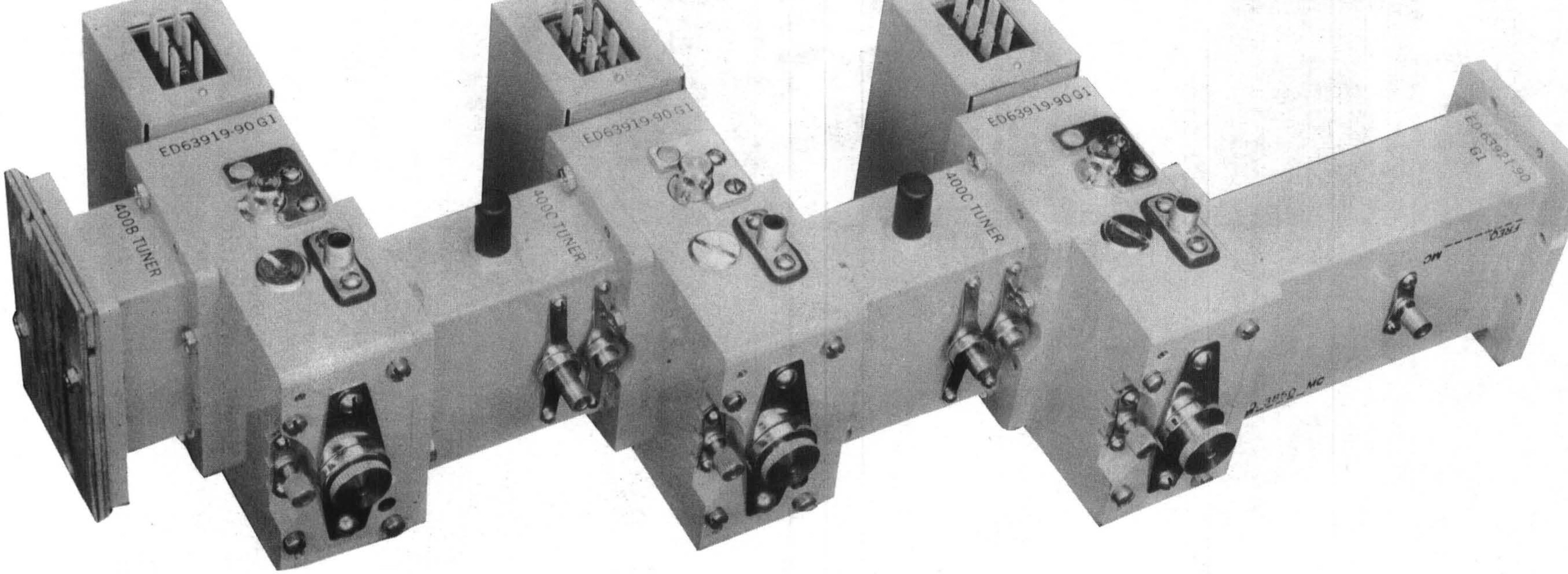

J68330F IF Buffer Amplifier



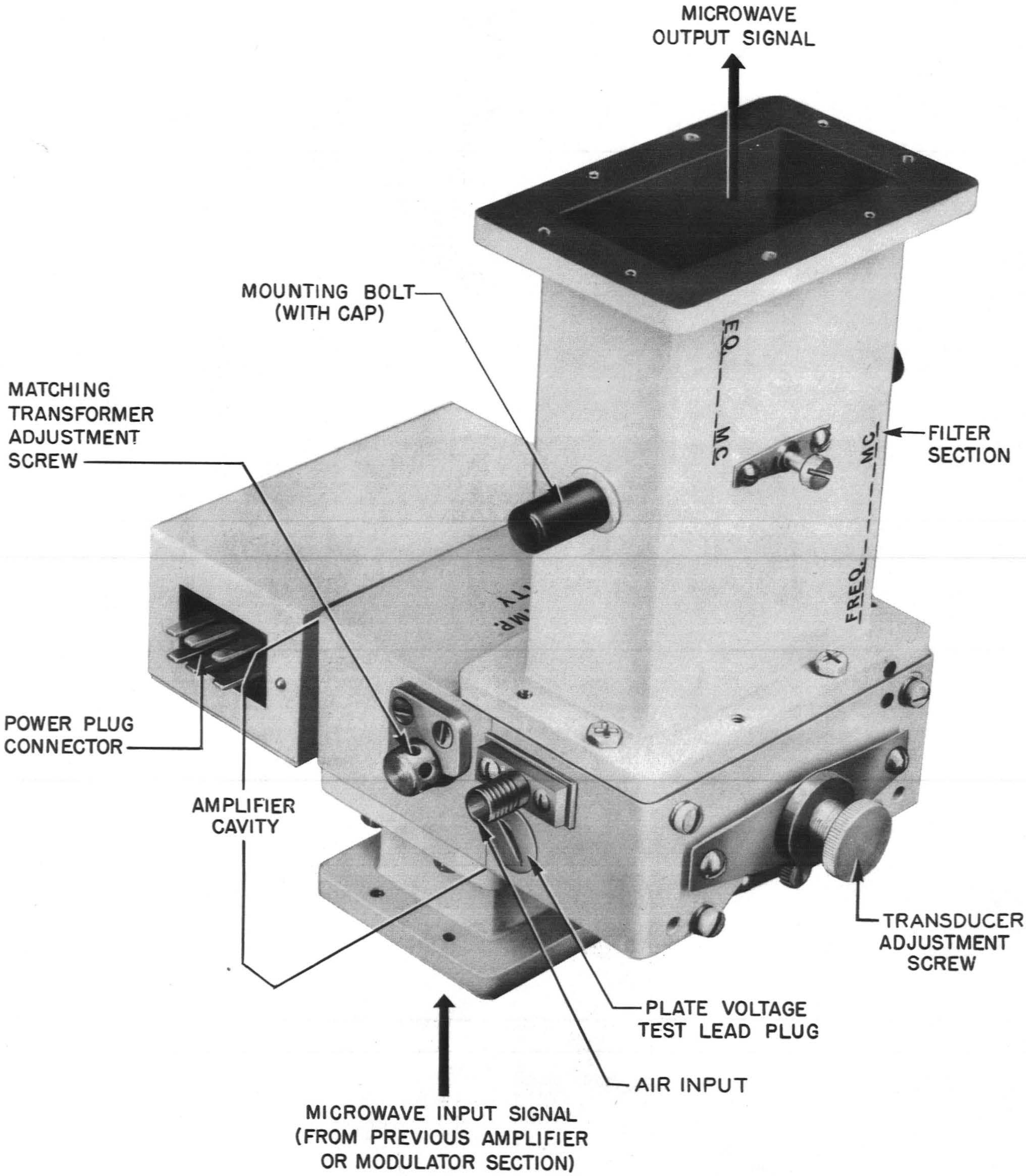

J68330L Transmitter Modulator and Filter



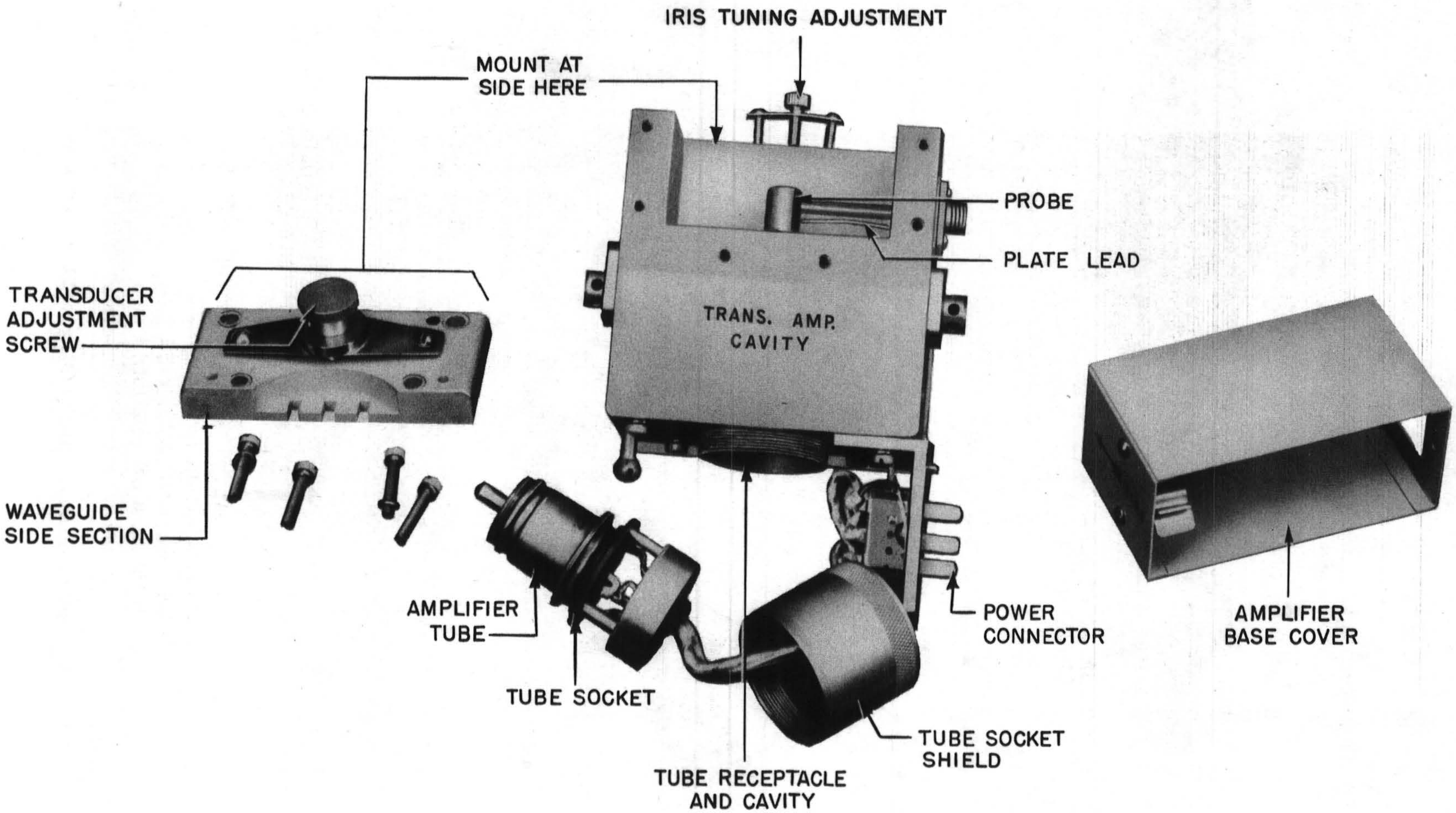

J68330L Transmitter Modulator and Filter - Exploded View



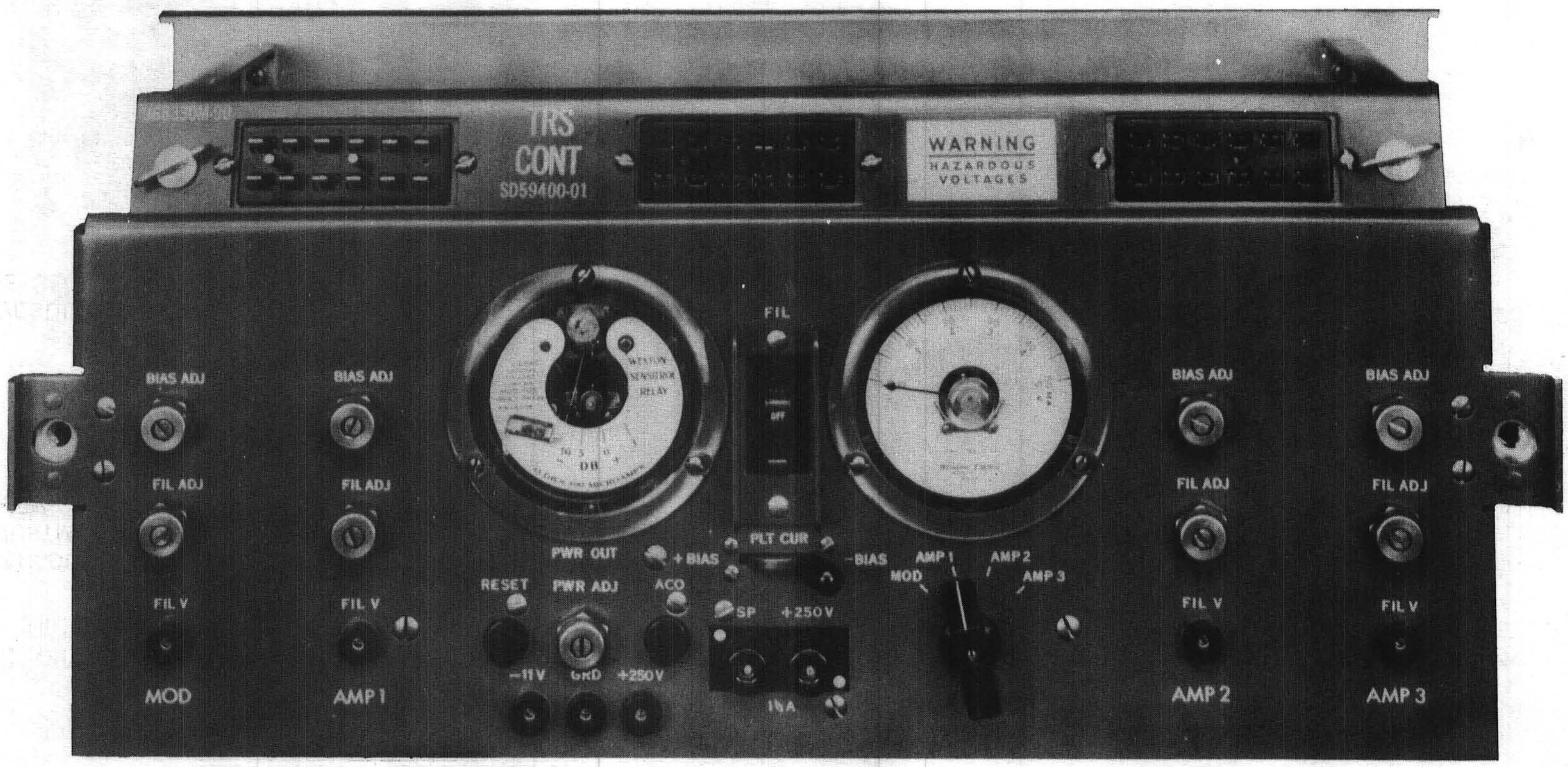

J68330K Transmitter Amplifier - Assembled Amplifier



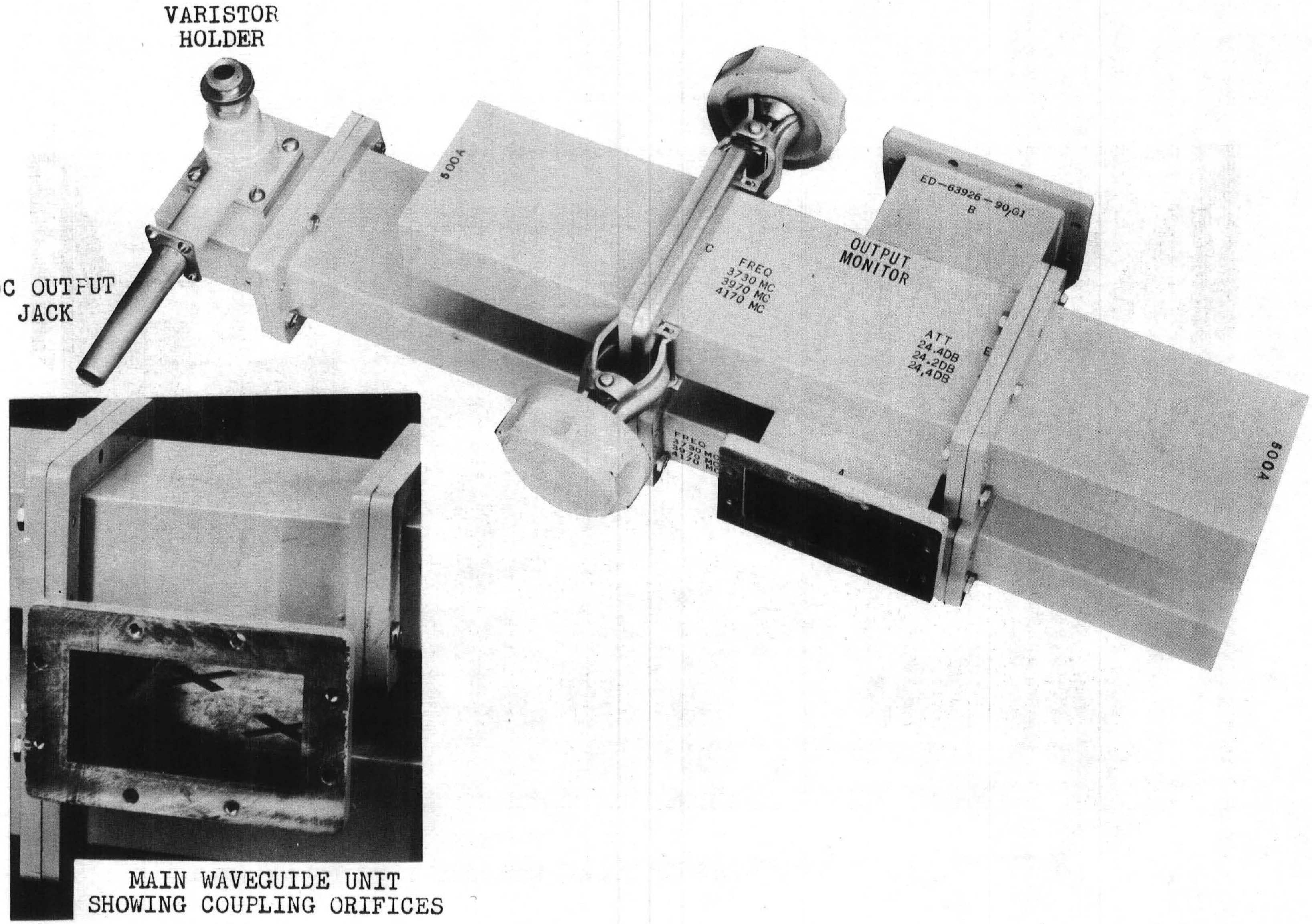

J68330K Transmitter Amplifier - Single Stage of Amplifier



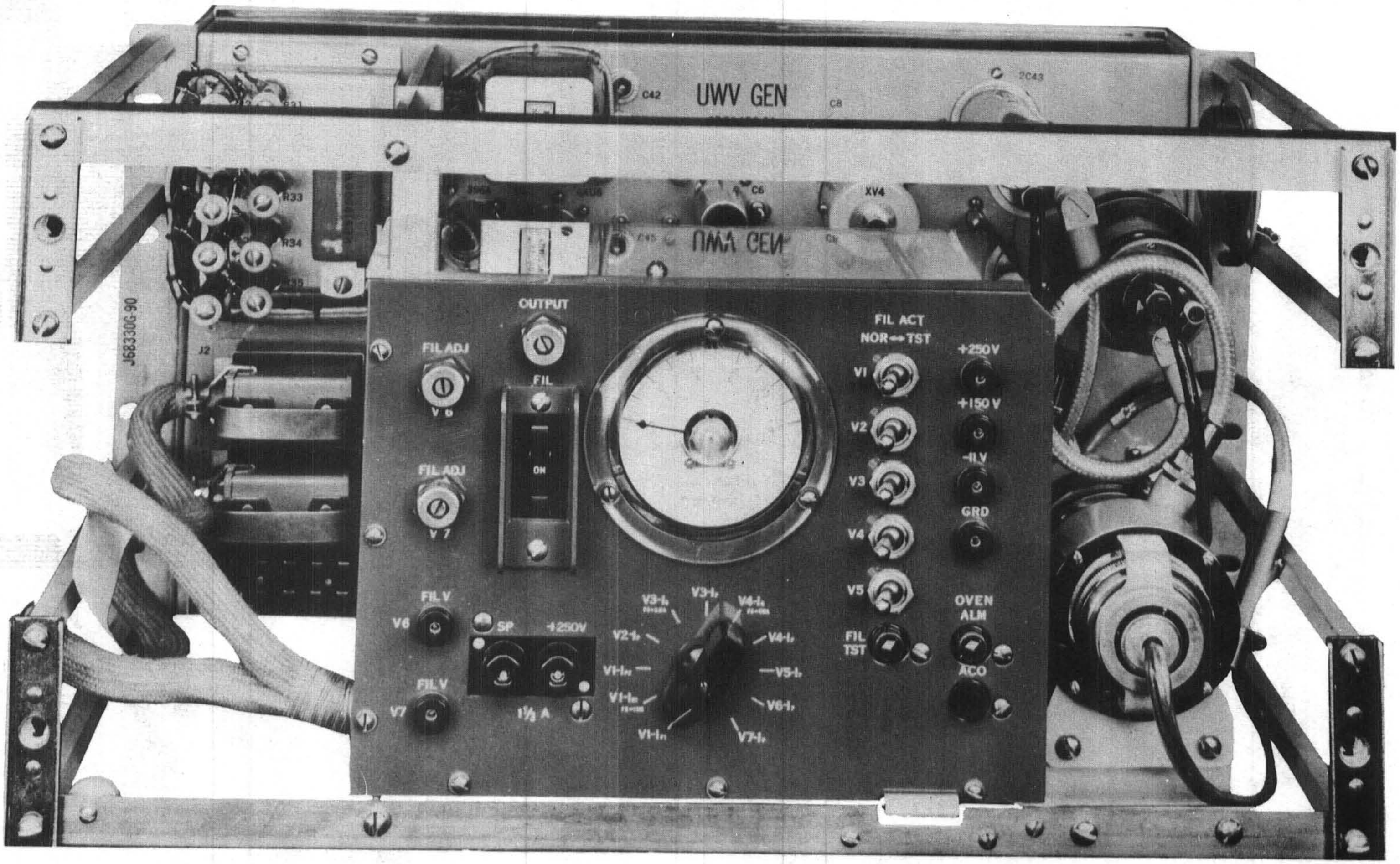

J68330K Transmitter Amplifier - Cavity - Exploded View



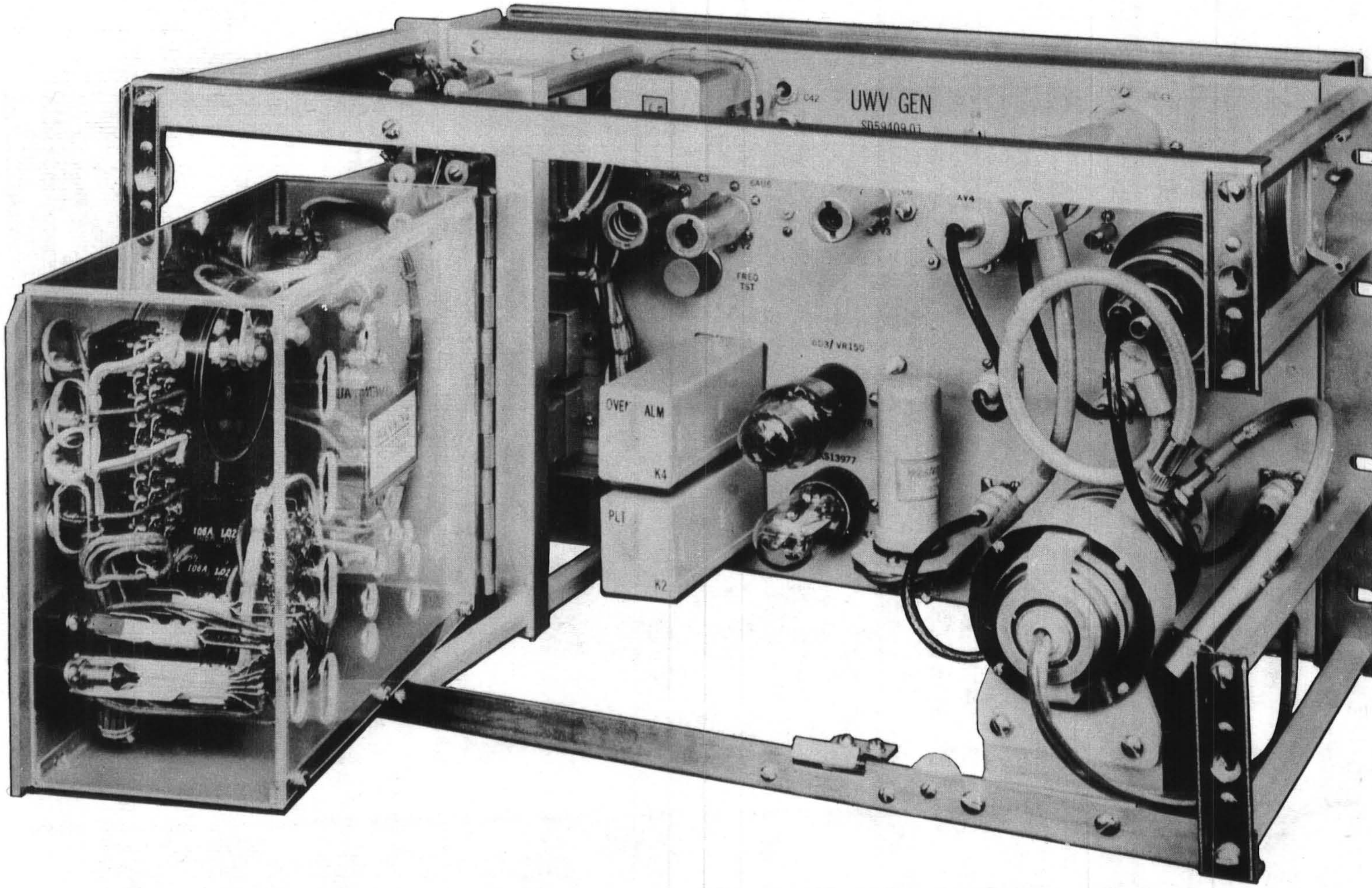

J68330M Transmitter Control Unit



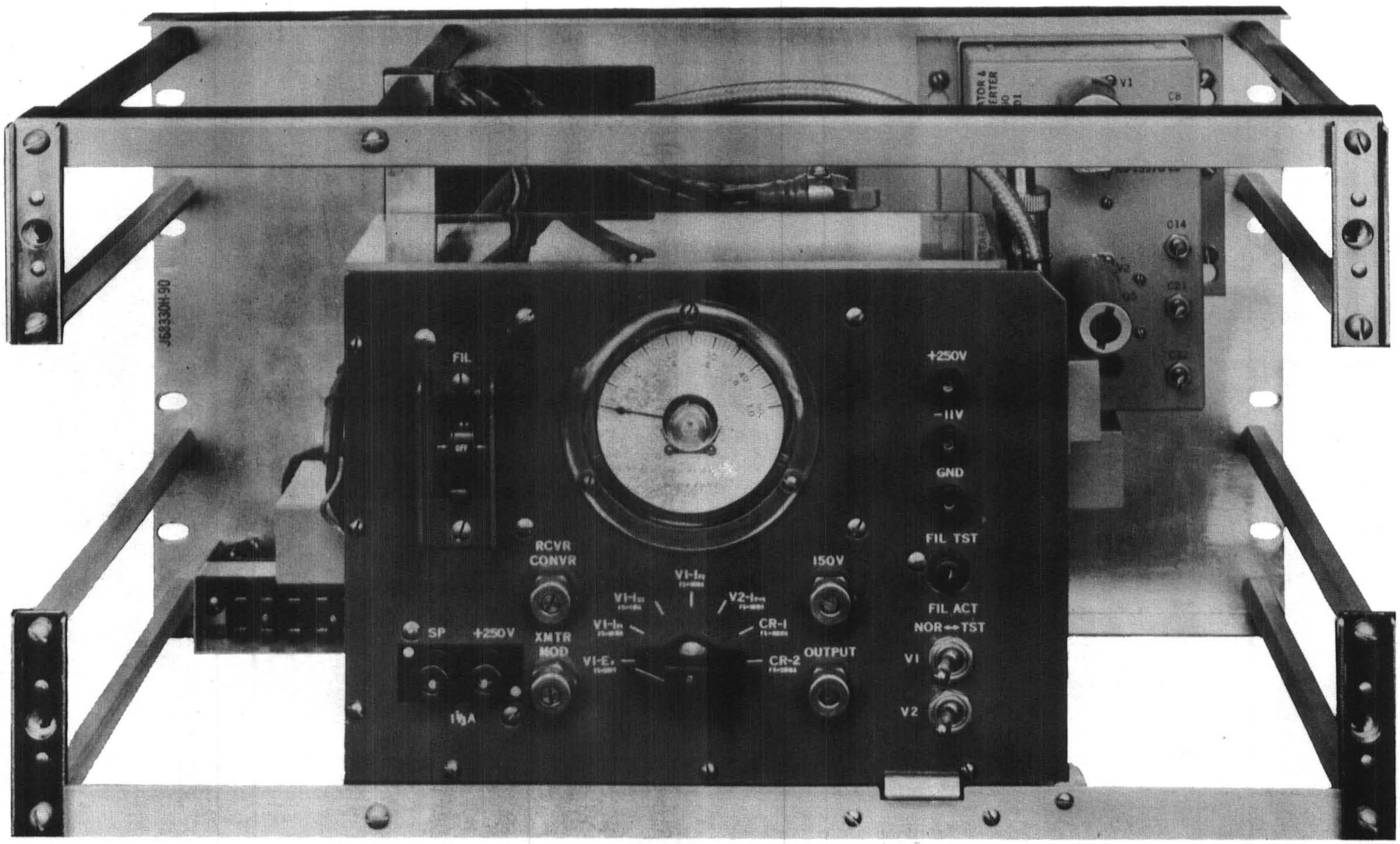

Output Monitor



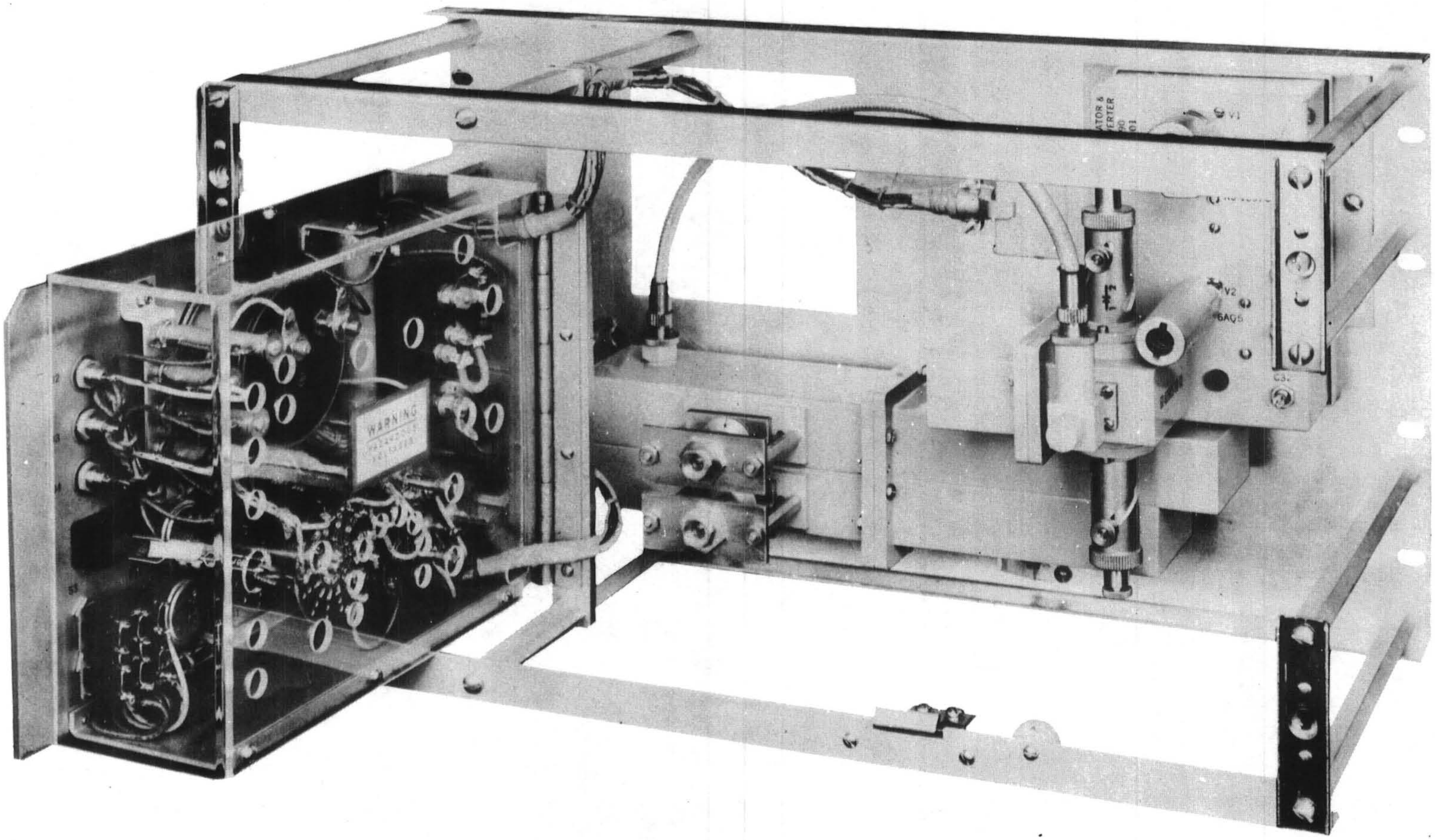

J68330G Microwave Generator - Front View - Cover Off




J68330G Microwave Generator - Inside View

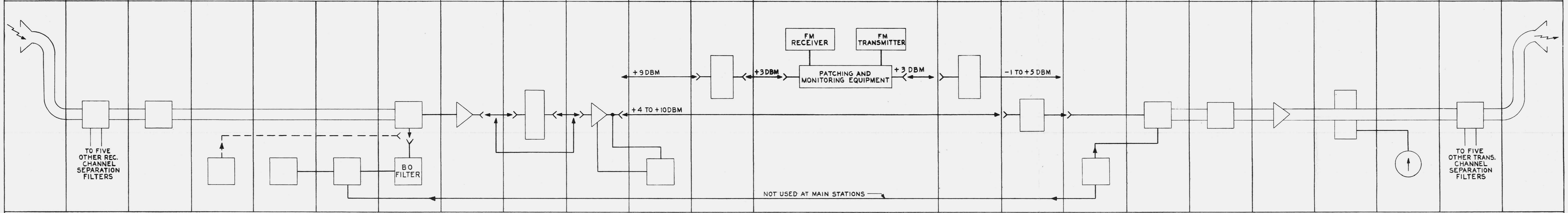



J68330H 40 MC Shifter - Front View - Cover Off




J68330H 40 MC Shifter - Inside View

RECEIVER PORTION OF TRANSMITTER-RECEIVER BAY — TERMINAL OR MAIN STATION EQUIPMENT — TRANSMITTER PORTION OF TRANSMITTER-RECEIVER BAY




| Unit | Functions | Level and Power Diagram |
|---|---|---|
| RECEIVING ANTENNA | RECEIVES TOTAL MICROWAVE BAND FROM 3700 MC TO 4200 MC. ANTENNA IS DESIGNED TO GIVE 39DB GAIN AND 2° DIRECTIVITY. | -73* / -96** ; -34 / -57 |
| RECEIVER CHANNEL SEPARATION FILTER | PASSES DESIRED MICROWAVE CHANNEL TO ASSIGNED BAY. ALL OTHER MICROWAVE CHANNELS DIRECTED TOWARDS FOLLOWING CHANNEL SEPARATION FILTERS. | |
| IMAGE SUPPRESSION FILTER | REJECTS IMAGE FREQUENCY THAT IS 140 MC REMOVED FROM DESIRED MICROWAVE SIGNAL. | -35 / -58 |
| RECEIVER LOCAL MICROWAVE GENERATOR (MAIN STATION ONLY) | QUARTZ CRYSTAL CONTROLLED HARMONIC GENERATOR PRODUCES LOCAL MICROWAVE FREQUENCY THAT IS 70 MC REMOVED FROM INCOMING MICROWAVE SIGNAL. | |
| 40 MC SHIFTER — 40 MC GENERATOR (AUX STATION ONLY) | QUARTZ CRYSTAL CONTROLLED 40 MC OSCILLATOR AND AMPLIFIER | |
| 40 MC SHIFTER — CONVERTER (AUX STATION ONLY) | COMBINES 40 MC SIGNAL WITH COMMON MICROWAVE SIGNAL TO PRODUCE LOCAL MICROWAVE FREQUENCY THAT IS 70 MC REMOVED FROM INCOMING MICROWAVE SIGNAL | -35 / -58 |
| RECEIVER CONVERTER | COMBINES INCOMING MICROWAVE SIGNAL WITH LOCAL MICROWAVE FREQUENCY TO PRODUCE 70 MC IF SIGNAL. THE BO FILTER SELECTS PROPER SIDEBAND AND REJECTS UNWANTED SIDEBANDS | -41 / -64 |
| IF PREAMPLIFIER | PROVIDES IF AMPLIFICATION DIRECTLY AT OUTPUT OF CONVERTER TO GIVE LOWER NOISE FIGURE. (TO AVOID NOISE PICKUP) | -29 / -52 |
| IF EQUALIZER | COMPENSATES FOR PHASE DISTORTION | -30 / -53 |
| MAIN IF AMPLIFIER | PROVIDES ADDITIONAL IF AMPLIFICATION (APPROX. 63DB FULL GAIN; GAIN FOR NO FADE APPROX. 40 DB) | +4 TO +10 |
| AUTOMATIC VOLUME CONTROL | AUTOMATICALLY REGULATES GAIN TO CONSTANT OUTPUT OF +4 TO +10 DBM DEPENDING UPON MODULATOR REQUIREMENTS | |
| 6 DB PAD | | |
| | | |
| IF BUFFER AMPLIFIER | | +10 / +4 |
| 5 DB PAD | 5 DB LOSS | |
| COMMON TRANSMITTER LOCAL MICROWAVE GENERATOR | QUARTZ CRYSTAL CONTROLLED HARMONIC GENERATOR PRODUCES LOCAL MICROWAVE FREQUENCY. ALSO PROVIDES LOCAL MICROWAVE SIGNAL FOR USE WITH 40 MC SHIFTER. | +5 / -1 |
| TRANSMITTER MODULATOR | A 416A VACUUM TUBE MODULATOR COMBINES 70 MC IF FM SIGNAL WITH LOCAL MICROWAVE FREQUENCY TO PRODUCE MICROWAVE TRANSMITTING. SIGNAL, 4 TO 8 DB GAIN. | +9 |
| TRANSMITTER FILTER | PASSES ONLY DESIRED FM MICROWAVE SIDEBAND | +9 |
| TRANSMITTER AMPLIFIER | A THREE STAGE (416A'S) VACUUM TUBE AMPLIFIER AMPLIFIES TRANSMITTED SIGNAL 18 DB. | +27 |
| DIRECTIONAL COUPLER | WAVEGUIDE COUPLING OBTAINS SAMPLING OF OUTPUT POWER AND SAMPLES OUTPUT POWER FOR OVERALL BAY TRANSMISSION TESTS AND CONVERTS IT TO D-C BY MEANS OF A VARISTOR. | +27 |
| POWER OUTPUT MONITOR | VISUALLY INDICATES AMOUNT OF OUTPUT POWER AND ALSO INITIATES ALARM IF POWER DROPS 10 DB OR MORE. | |
| TRANSMITTER CHANNEL SEPARATION FILTER | PASSES THIS MICROWAVE SIGNAL TOWARDS ANTENNA AND COMBINES THE SIGNAL WITH SIGNALS FROM OTHER CHANNELS TO BE TRANSMITTED. | +26 |
| TRANSMITTING ANTENNA | TRANSMITS TOTAL MICROWAVE BAND FROM 3700 MC TO 4200 MC. ANTENNA IS DESIGNED TO GIVE 39DB GAIN AND 2° DIRECTIVITY. | +65 |

* SIGNAL OVER 30 MILE PATH WITH NO FADING - PATH LOSS ASSUMED TO BE 138DB.
** MIN. SIGNAL WHICH CAN BE FULLY COMPENSATED WITH IF AMPLIFIER OUTPUT OF +10 DBM; ≡ 23DB FADE

LEVEL & POWER DIAGRAM FIGURES IN DBM.

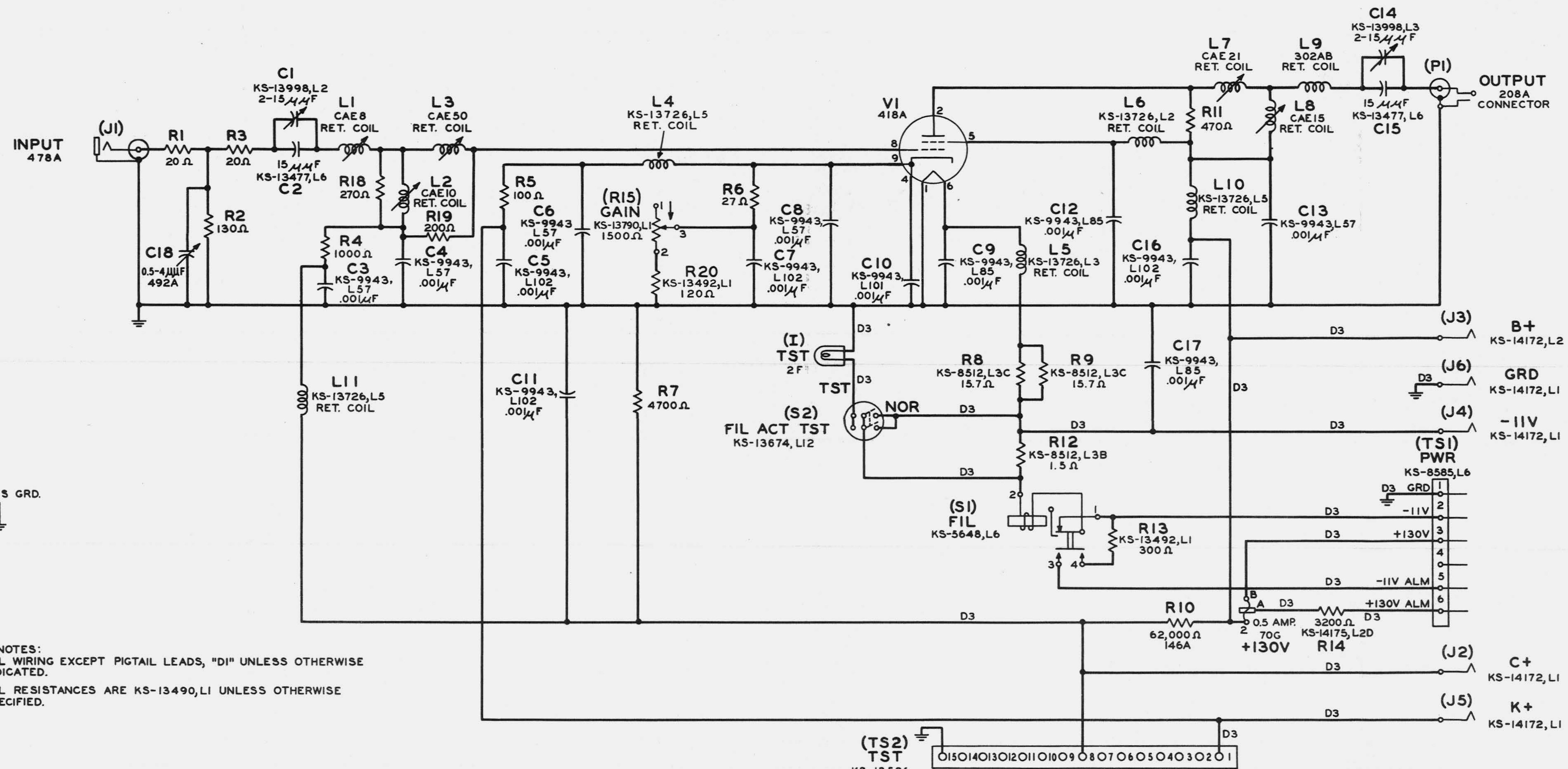
TD-2 RADIO TRANSMITTER-RECEIVER

ES-882613

| DWG. ISS. | EE OR CD ISSUE | DATE ISSUED | APPROVED |
|---|---|---|---|
| 1 | 1 | 4-8-49 | G.N.T.R |
| 2-A | 2-A | 6-8-49 | G.N.T.K |
| 3-A | 2-A APP. 1-A | 9-1-49 | G.N.T.K |
| 4-AR | 3-AR | 11-22-49 | G.N.T.K |

FIG. 1

IF BUFFER AMPLIFIER




CIRCUIT NOTES:

101. ALL WIRING EXCEPT PIGTAIL LEADS, "D1" UNLESS OTHERWISE INDICATED.

102. ALL RESISTANCES ARE KS-13490,L1 UNLESS OTHERWISE SPECIFIED.

EQUIPMENT NOTES:

201. THE PLACEMENT OF APPARATUS AND ARRANGEMENT OF CRITICAL WIRING MUST BE IN ACCORDANCE WITH EQUIPMENT REQUIREMENTS.

| LAST RES. AND COND. USED ON THIS DWG. | |
|---|---|
| R20 | C18 |
| R16 AND R17 NOT USED. | |

ED-63539-01 EQUIPMENT INFO.

SD-59396-01

TOLL SYSTEMS

TD RADIO

IF BUFFER AMPLIFIER CKT.

(IF BUFFER AMP)

AT&TCO STANDARD

O

SD-59396-01

BELL TELEPHONE LABORATORIES, INC.

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SD-59396-01

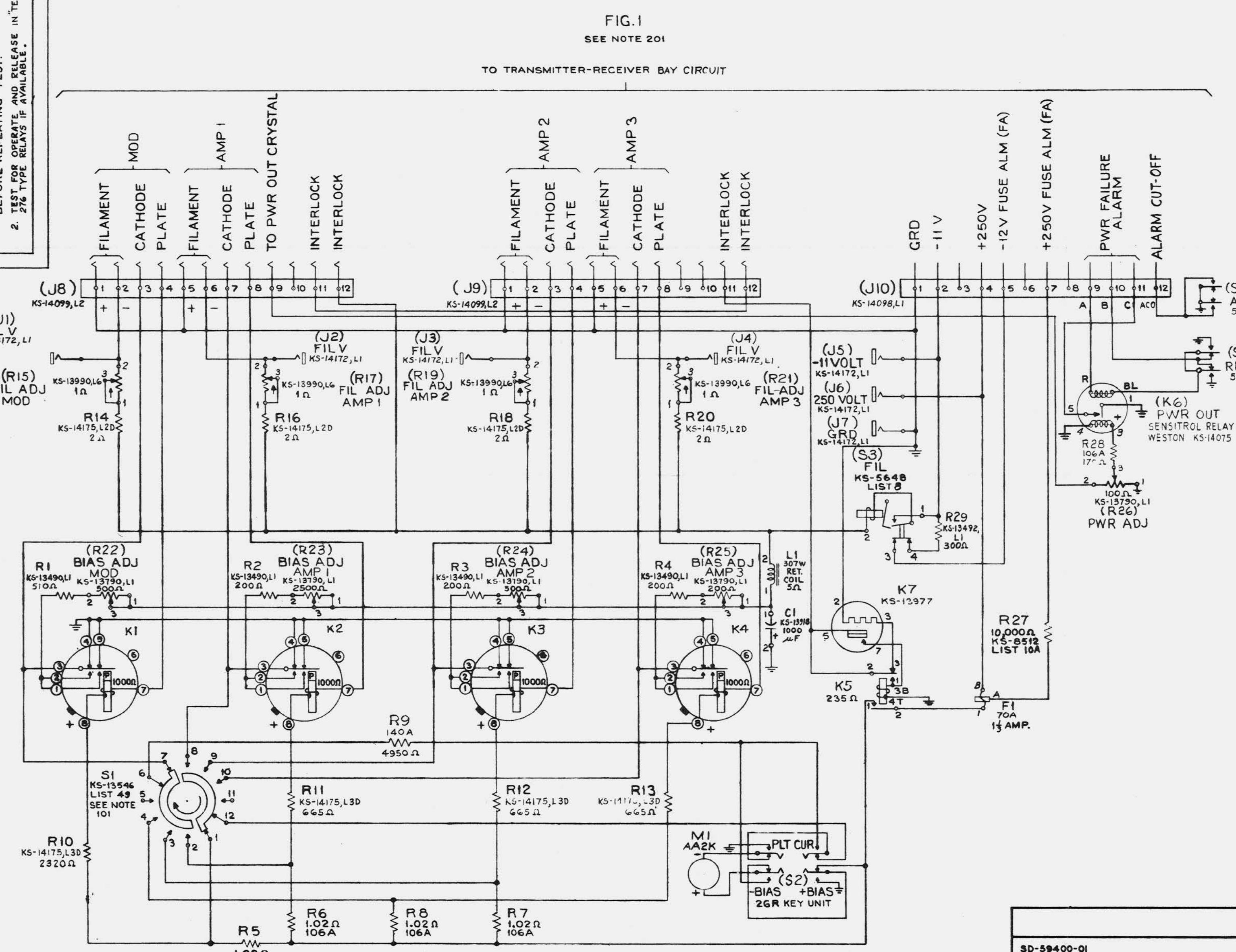
CIRCUIT NOTES:
101. SWITCH VIEWED FROM FRONT OR SHAFT SIDE.

EQUIPMENT NOTES:
201. RELAYS (K1) TO (K4) SHALL BE MOUNTED VERTICALLY WITH BASE DOWN (± 30°)

CIRCUIT REQUIREMENTS – TRANSMITTER CONTROL CIRCUIT (TRS CONT) – SD-59400-01

TEST NOTES:
1. TEST RELAY (K7) FOR OPERATION BY CLOSING (S3) AND OBSERVING OPERATION OF (K5) WHICH SHOULD OPERATE ON 11 VOLTS ± .25 VOLTS IN MIN. OF 50 SECONDS AND MAX. OF 120 SECONDS. ALLOW 6 MINUTES BEFORE REPEATING TEST.
2. TEST FOR OPERATE AND RELEASE IN "TEST SET CKT." FOR 276 TYPE RELAYS IF AVAILABLE.

FIG. 1
SEE NOTE 201




S1
SEE TABLE A

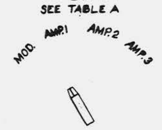



TABLE A

| (S1) POINT SETTING | SWITCH CONTACT |
|---|---|
| MOD | 1,6,7,12 |
| AMP 1 | 2,5,8,12 |
| AMP 2 | 3,4,9,12 |
| AMP 3 | 4,5,10,12 |

(S2)
PLT CUR
2GR KEY UNIT
-BIAS +BIAS

ED-63219-01 EQUIPMENT INFO.

SD-59400-01

TOLL SYSTEMS
TD-2 RADIO
TRANSMITTER CONTROL CKT

(TRS CONT)

AT&TCO STANDARD

SD-59400-01

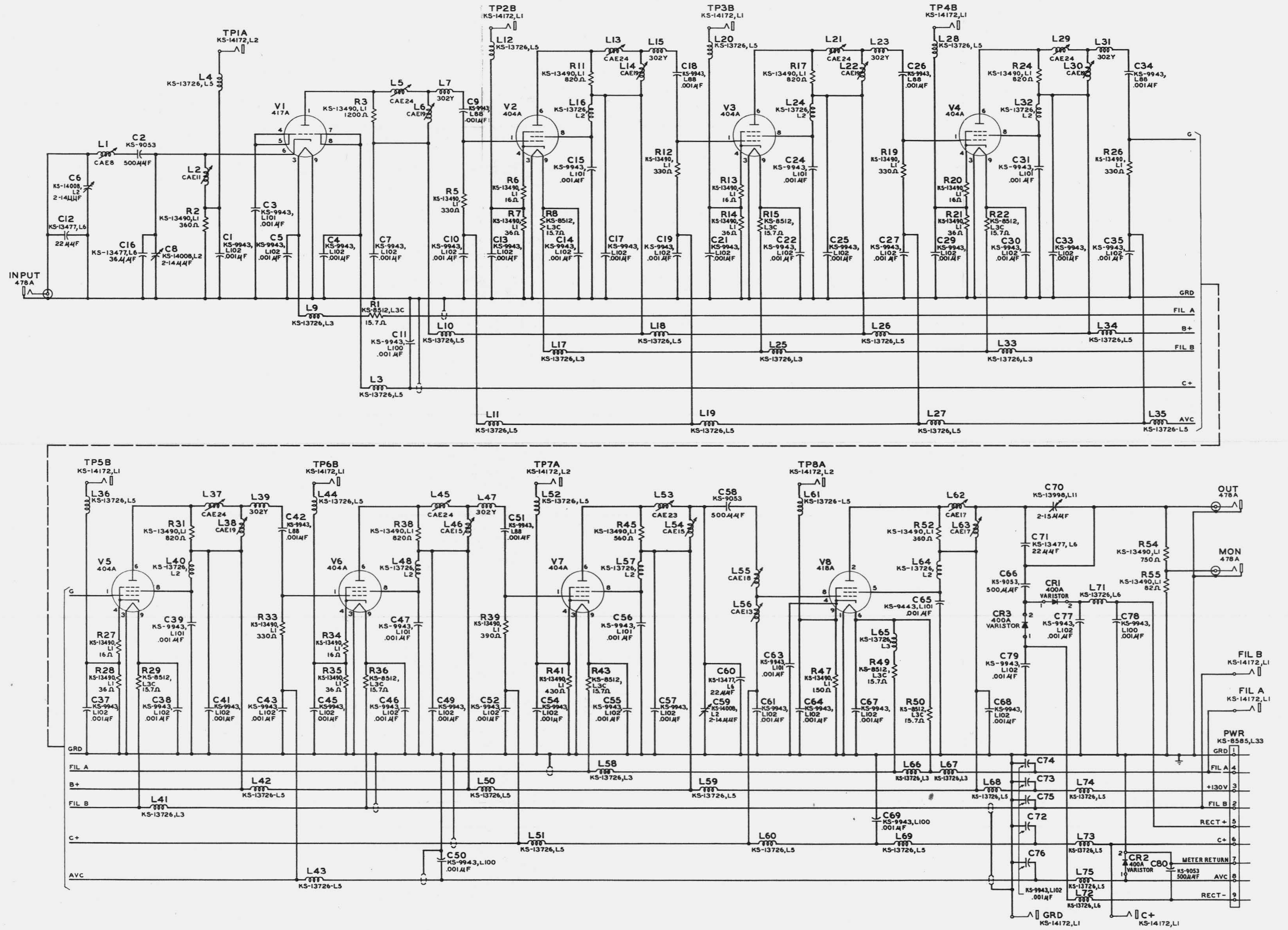
BELL TELEPHONE LABORATORIES, INC.

R1

SD-59400-01

| DWG. ISS. | EE OR CD ISSUE | DATE ISSUED | APPROVED |
|---|---|---|---|
| 1 | 1 | 1-7-49 | G.N.T. K. |
| 2-A | 1 APP. 1-A | 1-27-49 | G.N.T. K. |
| 3-A | 2-A | 5-20-49 | G.N.T. K. |
| 4-A | 2-A APP. 1-A | 5-27-49 | G.N.T. K. |

FIG. 1




| LAST RES., C, AND COIL USED ON THIS DWG. | | |
|---|---|---|
| R55 | C80 | L75 |
| NOT USED | | |
| R4, R9 | C20 | L8 |
| R10, R16 | C23 | L49 |
| R18, R23 | C28 | L70 |
| R25, R30 | C30 | |
| R32, R37 | C32 | |
| R40, R42 | C36 | |
| R44, R46 | C40 | |
| R48, R51 | C44 | |
| R53 | C48 | |
| | C53 | |
| | C62 | |

⏚ CHASSIS GRD.

SD-59401-01

ED-63930-01
EQUIPMENT INFO.

SD-59401-01

TOLL SYSTEMS
TD RADIO
IF MAIN AMPLIFIER CKT.
(70 MC MID-BAND)

(IF MAIN AMP)

AT&TCO
STANDARD

R2

SD-59401-01

BELL TELEPHONE LABORATORIES, INC.

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| DWG. ISS | EE OR CD ISSUE | DATE ISSUED | APPROVED |
| --- | --- | --- | --- |
| 1 | 1 | 1-5-49 | G.N.T. K. |
| 2-A | 1 APP.1-A | 1-27-49 | G.N.T. K. |
| 3-A | 2-A | 3-2-49 | G.N.T. K. |

CIRCUIT NOTES:

101. ALL WIRING IS "DI" UNLESS OTHERWISE INDICATED.

102. PROVIDE TUNER AS FOLLOWS:

| FREQUENCY | TUNER |
| --- | --- |
| 3730 | 400D |
| 3770 | 400E |
| 3810 | 400E |
| 3850 | 400F |
| 3890 | |
| 3930 | |
| 3970 | |
| 4010 | |
| 4050 | |
| 4090 | |
| 4130 | |
| 4170 | |

103. USE SPACERS PER ED-63543-01, AS DETERMINED BY TEST REQUIREMENTS.

FIG. 1
IF PREAMPLIFIER
70 MC MIDBAND FREQUENCY
SEE NOTE 101

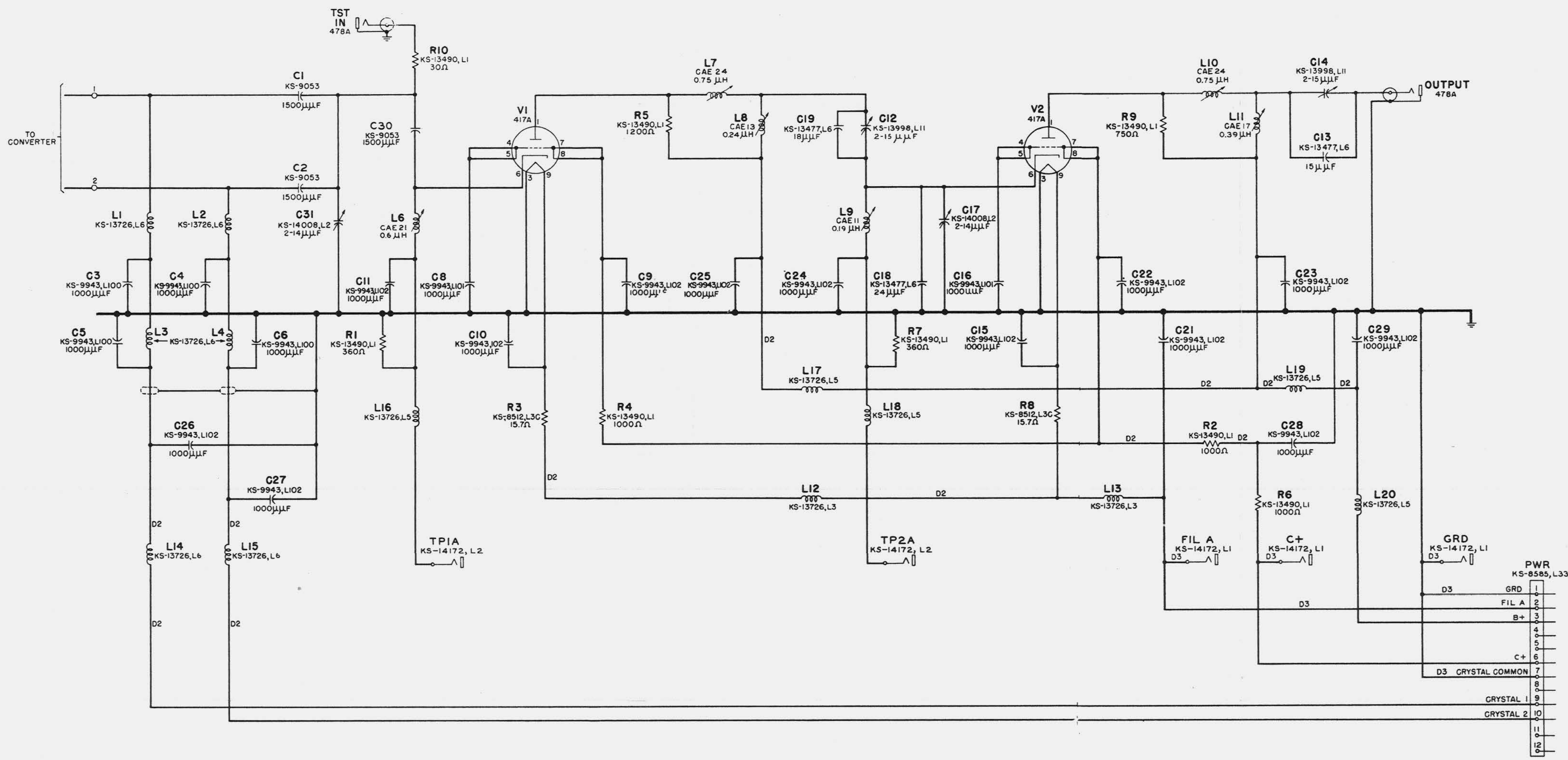
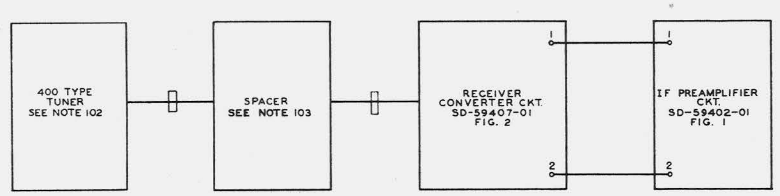



FIG. 2
RECEIVER CONVERTER & IF PREAMPLIFIER CKT.




CHASSIS GRD.

| LAST RES. AND COND. USED ON THIS DWG. | |
| --- | --- |
| R10 | C31 |
| | |
| | |
| | |
| | |
| (C7) & (C20) WERE NOT USED. | |

ED-63926-01
ED-63929-01
EQUIPMENT INFO.

SD-59402-01

TOLL SYSTEMS
TD RADIO
RECEIVER CONVERTER &
IF PREAMPLIFIER CKT

AT&TCO STANDARD

SD-59402-01

BELL TELEPHONE LABORATORIES, INC.

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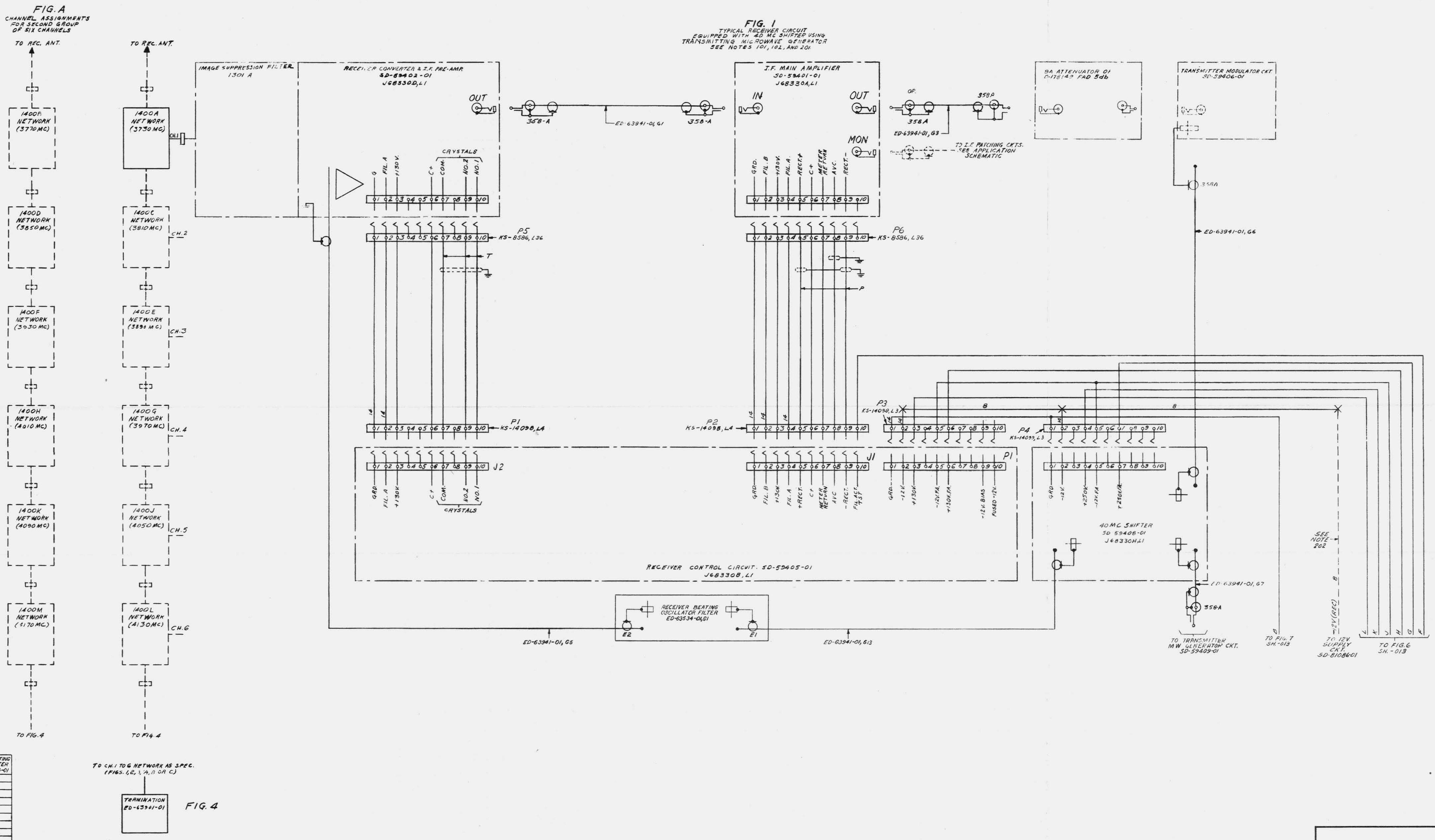
R2

| DWG. ISS. | EE OR CD ISSUE | DATE ISSUED | APPROVED |
|---|---|---|---|
| 1 | 1 | 1-18-49 | G.N.T. K |
| 2-A | 1 APP.1-A | 1-27-49 | G.N.T. K. |
| 3-A | 1 APP.2-A | 2-16-49 | G.N.T. K. |
| 4-A | 1 APP.3-A | 3-22-49 | G.N.T. K. |
| 5-A | 1 APP.4-A | 4-8-49 | G.N.T. K. |
| 6-A | 2-A | 5-20-49 | G.N.T. K. |

CIRCUIT NOTES:

101. THE 1400 AND 1401 TYPE NETWORKS SHALL BE CONNECTED TOGETHER IN TANDEM IN NUMERICAL ORDER (WITH RESPECT TO FREQUENCY) WITH THE NETWORK OF LOWEST FREQUENCY NEAREST TO THE ANTENNA. NETWORKS OF ANY OF THE INDICATED FREQUENCIES MAY BE USED FOR ANY CHANNEL PROVIDED THEY ARE CONNECTED AS STATED ABOVE.

102. THE TERMINATION PER ED-63901-01 SHALL BE CONNECTED TO THE LAST NETWORK IN THE LINE.




EQUIPMENT NOTES:

201. WIRING AND EQUIPMENT SHALL BE PROVIDED IN ACCORDANCE WITH TABLES "A", "B", AND "C" AS SPECIFIED FOR EACH FIG. 1, 2 OR 3.

202 (a) ONE POWER FEEDER FOR EACH VOLTAGE REQUIRED SHALL BE PROVIDED FOR BOTH THE RECEIVER (FIG.1) AND TRANSMITTER (FIG.3) OF A BAY (J68331A) AT AUXILIARY STATIONS, IN WHICH CASE FURNISH "X" AND OMIT "Y" WIRING.

(b) ONE POWER FEEDER FOR EACH VOLTAGE REQUIRED SHALL BE PROVIDED FOR EACH RECEIVER (FIG.1) AND FOR EACH TRANSMITTER (FIG.3) OF A BAY AT TERMINAL AND MAIN STATIONS, IN WHICH CASE FURNISH "Y" AND OMIT "X" WIRING.

(c) THE +130V. POWER FEEDER FOR THE BUFFER AMPLIFIER (FIG.3) IS NOT REQUIRED AT AUXILIARY STATIONS.

203. FURNISH "Z" OPTION ONLY WHEN FIG.1 OR 2 IS FURNISHED.

TABLE A

RECEIVER EQUIPPED WITH 40 MC SHIFTER AND USING TRANSMITTING MICROWAVE GENERATOR (FIG.1)

| REC. FREQ. | NETWORK | IMAGE SUPP. FILTER | CONV. & I.F. PRE-AMP. J68330D | I.F MAIN AMP. J68330A | 40 MC SHIFTER J68330H | REC. CONT. UNIT J68330B | REC. BEATING OSC. FILTER ED-63534-01 |
|---|---|---|---|---|---|---|---|
| 3730 | 1400A | 1301A | L1 | L1 | L1 | L1 | G1 |
| 3770 | 1400B | 1301 B | L2 | L1 | L1 | L1 | G2 |
| 3810 | 1400C | 1301 C | L3 | L1 | L1 | L1 | G3 |
| 3850 | 1400 D | 1301 D | L 4 | L1 | L1 | L1 | G4 |
| 3890 | 1400E | 1301E | L 5 | L1 | L1 | L1 | G5 |
| 3930 | 1400F | 1301F | L 6 | L1 | L1 | L1 | G6 |
| 3970 | 1400G | 1301G | L 7 | L1 | L1 | L1 | G7 |
| 4010 | 1400H | 1301 H | L 8 | L1 | L1 | L1 | G8 |
| 4050 | 1400 J | 1301 J | L 9 | L1 | L1 | L1 | G9 |
| 4090 | 1400K | 1301K | L 10 | L1 | L1 | L1 | G10 |
| 4130 | 1400L | 1301L | L 11 | L1 | L1 | L1 | G11 |
| 4170 | 1400 M | 1301M | L 12 | L1 | L1 | L1 | G12 |

| OPTIONS ON THIS DWG. | | | |
|---|---|---|---|
| FIGS. | | | |
| 1 | 6 | | |
| 2 | 7 | | |
| 3 | | A | |
| 4 | | B | |
| 5 | | C | |
| APP. OR WIRING | | | |
| Z | | | |
| Y | | | |
| X | | | |

ED-63924-01 EQUIPMENT INFO.

SD-59403-01 3 SHEETS

TOLL SYSTEMS
TD-2 RADIO
APPLICATION SCHEMATIC
FOR
TRANSMITTER-RECEIVER BAY

AT&T CO STANDARD

SD-59403-01I

BELL TELEPHONE LABORATORIES, INC.

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SD-59403-01I

FIG. B
CHANNEL ASSIGNMENTS
FOR 2ND. GROUP OF SIX CHANNELS

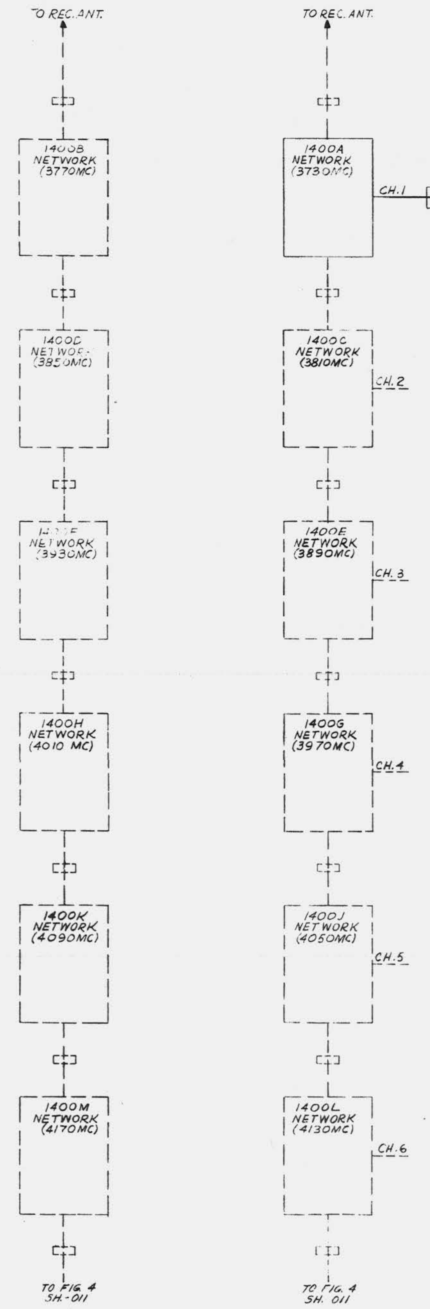


FIG. 2
TYPICAL RECEIVER CKT.
EQUIPPED WITH RECEIVING MICROWAVE GENERATOR
SEE NOTES 101, 102 & 201

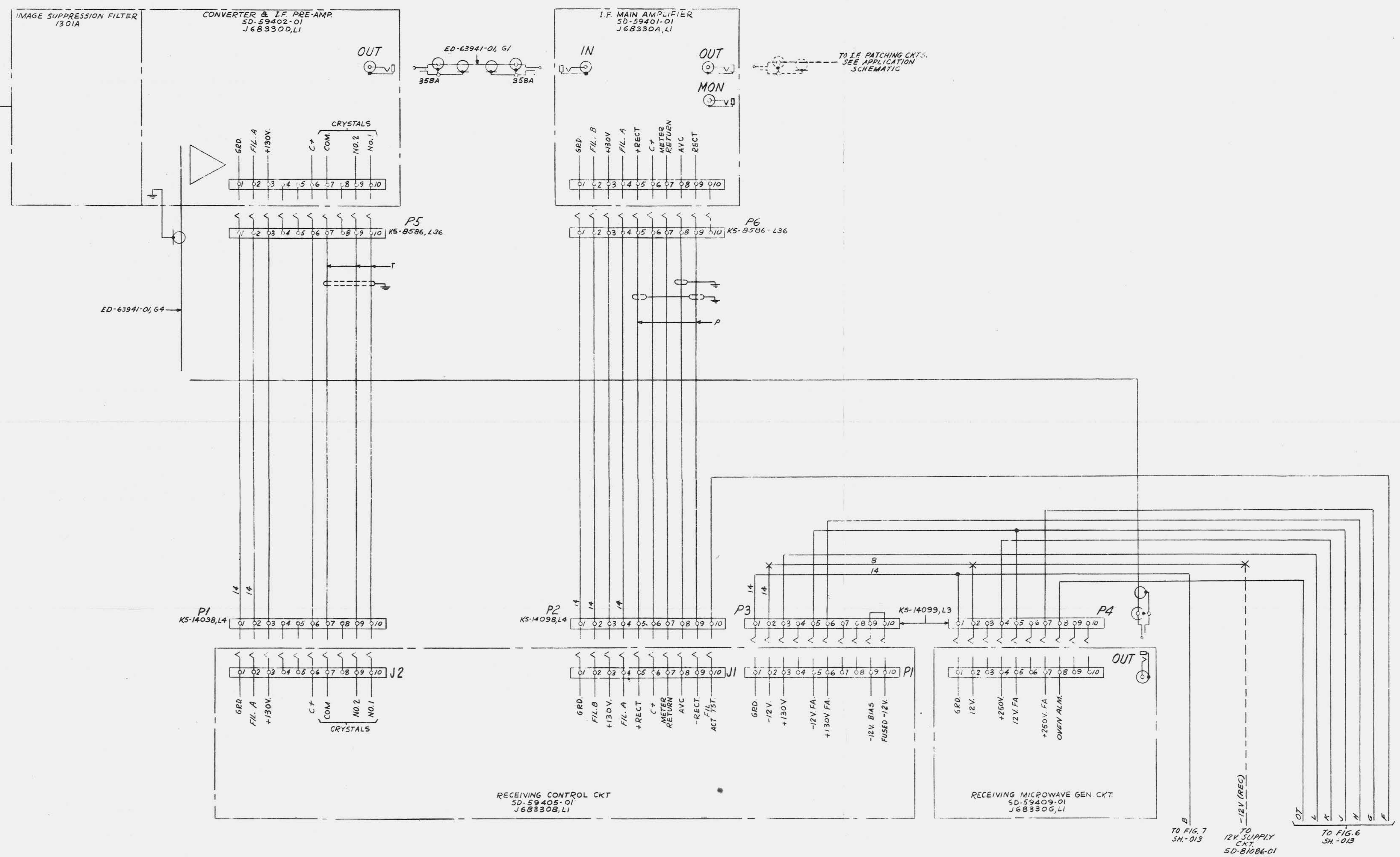


TABLE B

RECEIVER EQUIPPED WITH RECEIVING MICROWAVE GENERATOR (FIG. 2)

| REC. FREQ. | NETWORK | IMAGE SUPP. FILTER | CONV. & I.F. PRE-AMP. J68330D | I.F. MAIN AMP. J68330D | REC. MICROWAVE GEN. | | REC. CONT UNIT J68330B |
|---|---|---|---|---|---|---|---|
| | | | | | UNIT J68330G | CRYSTAL KS-13978, L1 | |
| 3730 | 1400A | 1301A | L1 | L1 | L1 | 17.592592 | L1 |
| 3770 | 1400B | 1301B | L2 | L1 | L1 | 17.777777 | L1 |
| 3810 | 1400C | 1301C | L3 | L1 | L1 | 17.962962 | L1 |
| 3850 | 1400D | 1301D | L4 | L1 | L1 | 18.148148 | L1 |
| 3890 | 1400E | 1301E | L5 | L1 | L1 | 17.685185 | L1 |
| 3930 | 1400F | 1301F | L6 | L1 | L1 | 17.870370 | L1 |
| 3970 | 1400G | 1301G | L7 | L1 | L1 | 18.055555 | L1 |
| 4010 | 1400H | 1301H | L8 | L1 | L1 | 18.240740 | L1 |
| 4050 | 1400J | 1301J | L9 | L1 | L1 | 18.425925 | L1 |
| 4090 | 1400K | 1301K | L10 | L1 | L1 | 18.611111 | L1 |
| 4130 | 1400L | 1301L | L11 | L1 | L1 | 18.796296 | L1 |
| 4170 | 1400M | 1301M | L12 | L1 | L1 | 18.981481 | L1 |

DWG. ISS.: 1, 2-A, 3-A, 4-A, 5-A, 6-A

TD-2 RADIO
APPLICATION SCHEMATIC
FOR
TRANSMITTER - RECEIVER BAY

BELL TELEPHONE LABORATORIES, INC

3 SHEETS, SHEET 2

SD-59403-012

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R3

SD-59403-012

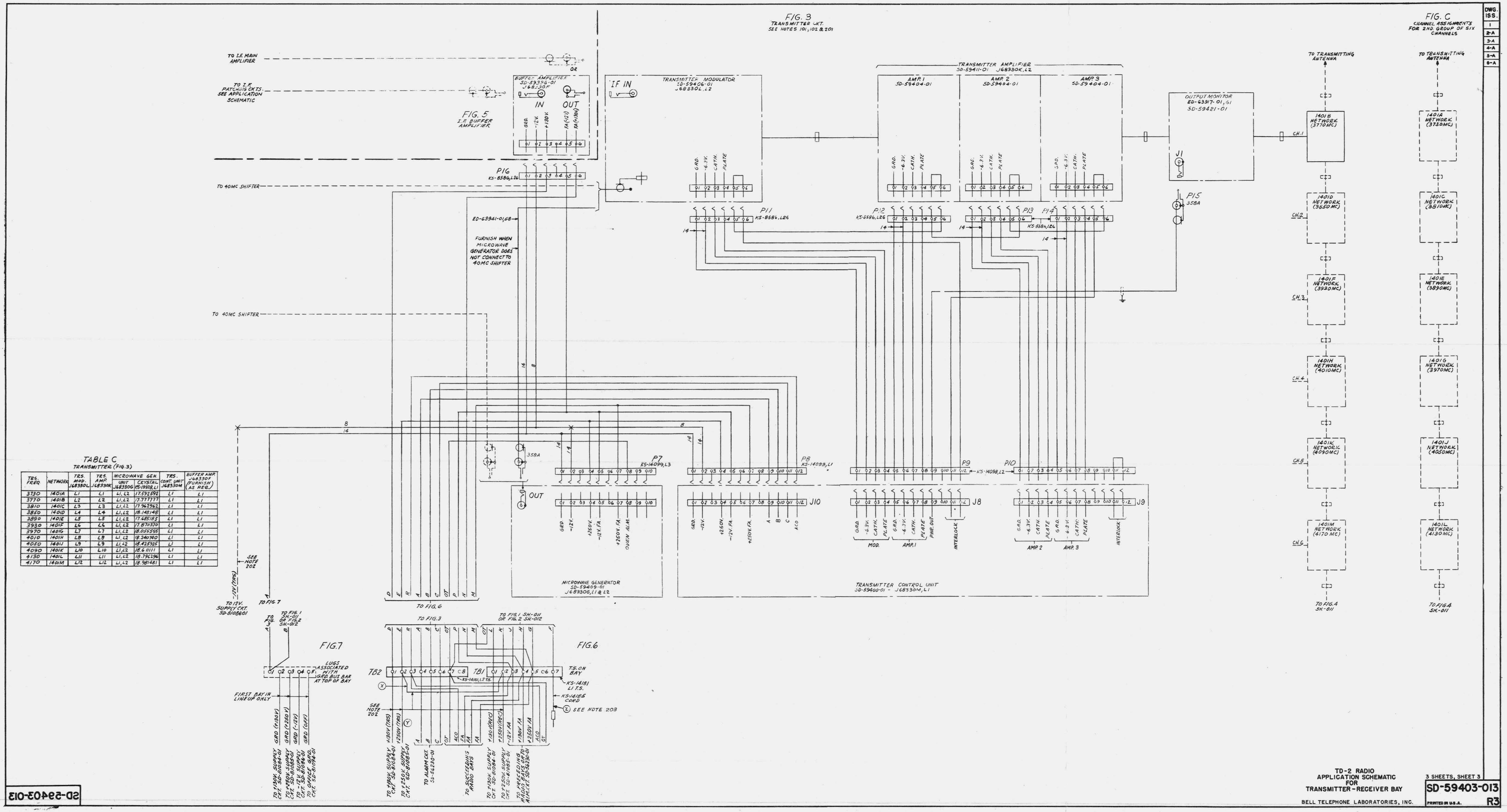



TABLE C
TRANSMITTER (FIG. 3)

| TRS. FREQ. | NETWORK | TRS. MOD. J68330L | TRS. AMP. J68330K | MICROWAVE GEN. UNIT J68330G | MICROWAVE GEN. CRYSTAL KS-13978, L1 | TRS. CONT. UNIT J68330M | BUFFER AMP. J68330F (FURNISH AS REQ.) |
|---|---|---|---|---|---|---|---|
| 3730 | 1401A | L1 | L1 | L1, L2 | 17.592592 | L1 | L1 |
| 3770 | 1401B | L2 | L2 | L1, L2 | 17.777777 | L1 | L1 |
| 3810 | 1401C | L3 | L3 | L1, L2 | 17.962962 | L1 | L1 |
| 3850 | 1401D | L4 | L4 | L1, L2 | 18.148148 | L1 | L1 |
| 3890 | 1401E | L5 | L5 | L1, L2 | 17.685185 | L1 | L1 |
| 3930 | 1401F | L6 | L6 | L1, L2 | 17.870370 | L1 | L1 |
| 3970 | 1401G | L7 | L7 | L1, L2 | 18.055555 | L1 | L1 |
| 4010 | 1401H | L8 | L8 | L1, L2 | 18.240740 | L1 | L1 |
| 4050 | 1401J | L9 | L9 | L1, L2 | 18.425925 | L1 | L1 |
| 4090 | 1401K | L10 | L10 | L1, L2 | 18.611111 | L1 | L1 |
| 4130 | 1401L | L11 | L11 | L1, L2 | 18.796296 | L1 | L1 |
| 4170 | 1401M | L12 | L12 | L1, L2 | 18.981481 | L1 | L1 |

TD-2 RADIO
APPLICATION SCHEMATIC
FOR
TRANSMITTER-RECEIVER BAY

BELL TELEPHONE LABORATORIES, INC.

3 SHEETS, SHEET 3

SD-59403-013

R3

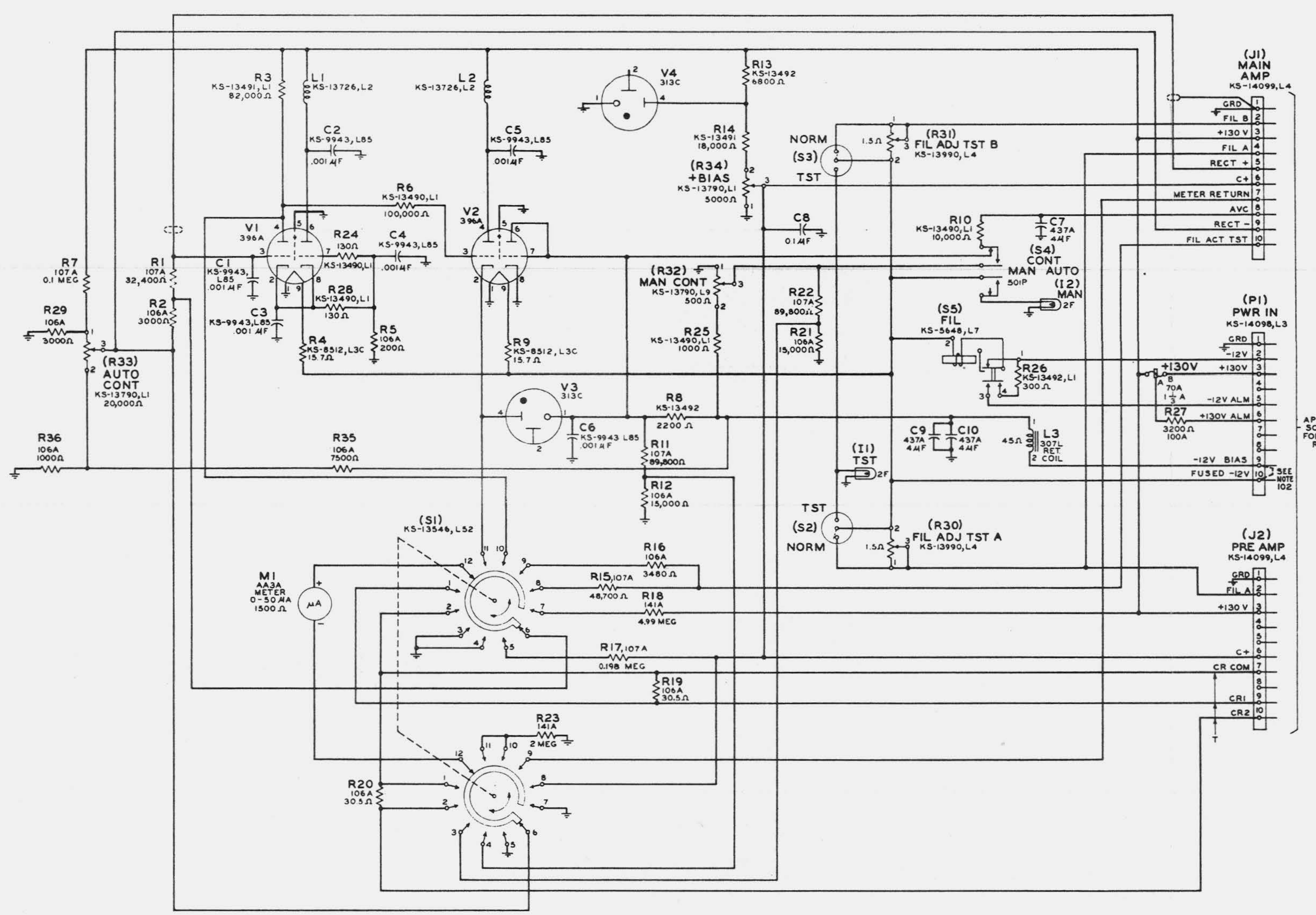
PRINTED IN U.S.A.

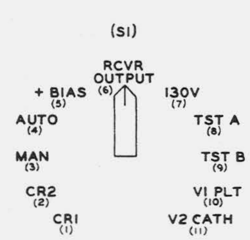
SD-59403-013

| | | | |
|---|---|---|---|
| 1 | 1 | 1-5-49 | G.N.T. |
| 2-A | 2-A | 1-27-49 | G.N.T. |
| 3-A | 2-A APP1-A | 4-6-49 | G.N.T. |
| 4-A | 3-A | 5-20-49 | G.N.T. |

CIRCUIT NOTES:
101. REMOVING (V4) WHEN +130V. SUPPLY IS CONNECTED TO THIS CKT. WILL CAUSE +9V. BIAS TO INCREASE AND MAY DAMAGE ASSOCIATED EQUIPMENT.
102. PROVIDE EXTERNAL STRAP FROM TERM.10 TO TERM. 9 OF (PWR IN) PLUG OR PROVIDE EXTERNAL -12V. BIAS ON TERM.9.

FIG. 1




CHASSIS GRD.

| LAST RES. AND COND. USED ON THIS DWG. | |
|---|---|
| R36 | C10 |

ED-63931-01 EQUIPMENT INFO.

SD-59405-01

TOLL SYSTEMS
TD RADIO
RECEIVER CONTROL UNIT CKT.

(RCVR CONT)

AT&TCO STANDARD

R1

SD-59405-01

BELL TELEPHONE LABORATORIES, INC.

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SD-59405-01

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|---|---|---|---|
| 1 | 1 | 1-13-49 | G.N.T. K. |
| 2-A | 2-A | 3-4-49 | G.N.T. K. |
| 3-A | 2-A APP. 1-A | 3-30-49 | G.N.T. K. |

CIRCUIT NOTES:
101. THIS COIL IS A WIRE APPROXIMATELY $\frac{1}{4}$ WAVELENGTH LONG.

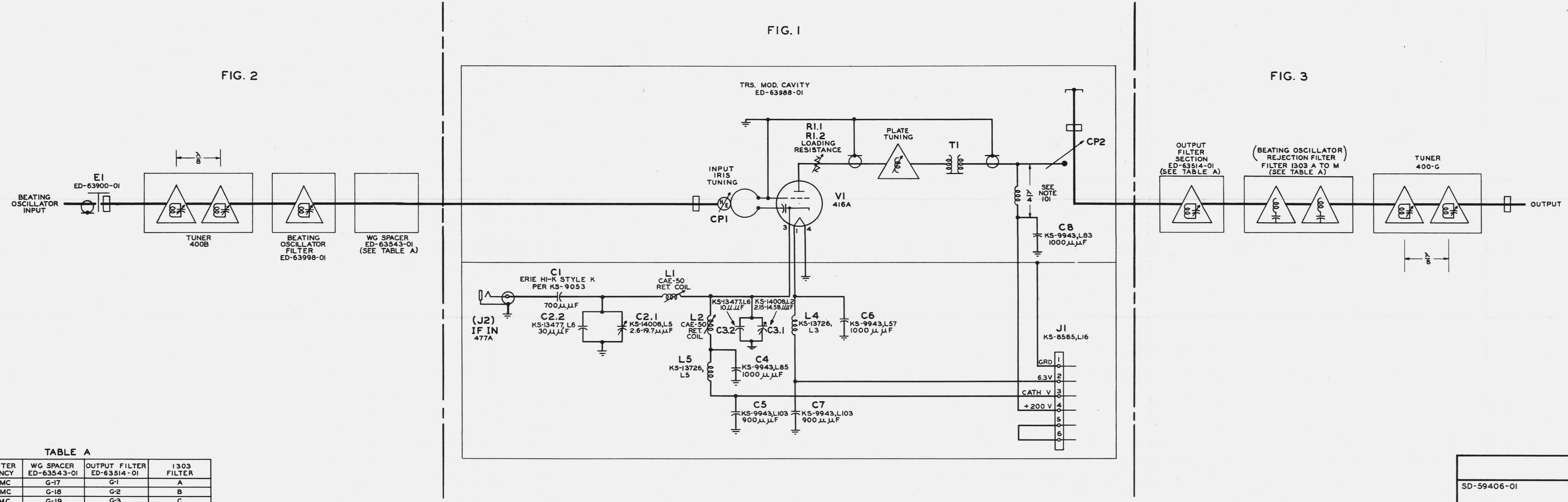


TABLE A

| LIST | TRANSMITTER FREQUENCY | WG SPACER ED-63543-01 | OUTPUT FILTER ED-63514-01 | 1303 FILTER |
|---|---|---|---|---|
| 1 | 3730 MC | G-17 | G-1 | A |
| 2 | 3770 MC | G-18 | G-2 | B |
| 3 | 3810 MC | G-19 | G-3 | C |
| 4 | 3850 MC | G-20 | G-4 | D |
| 5 | 3890 MC | G-21 | G-5 | E |
| 6 | 3930 MC | G-22 | G-6 | F |
| 7 | 3970 MC | G-23 | G-7 | G |
| 8 | 4010 MC | G-24 | G-8 | H |
| 9 | 4050 MC | G-25 | G-9 | J |
| 10 | 4090 MC | G-26 | G-10 | K |
| 11 | 4130 MC | G-27 | G-11 | L |
| 12 | 4170 MC | G-28 | G-12 | M |

SD-59406-01

ED-63979-01 EQUIPMENT INFO.

SD-59406-01

TOLL SYSTEMS
TD RADIO
TRANSMITTER MODULATOR CKT.

(TRS MOD)

AT&TCO STANDARD

01

SD-59406-01

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|---|---|---|---|
| 1 | 1 | 12-20-48 | G.H.T. |

FIG. 1
40MC SHIFTER CONVERTER
ED-63905-01, G1

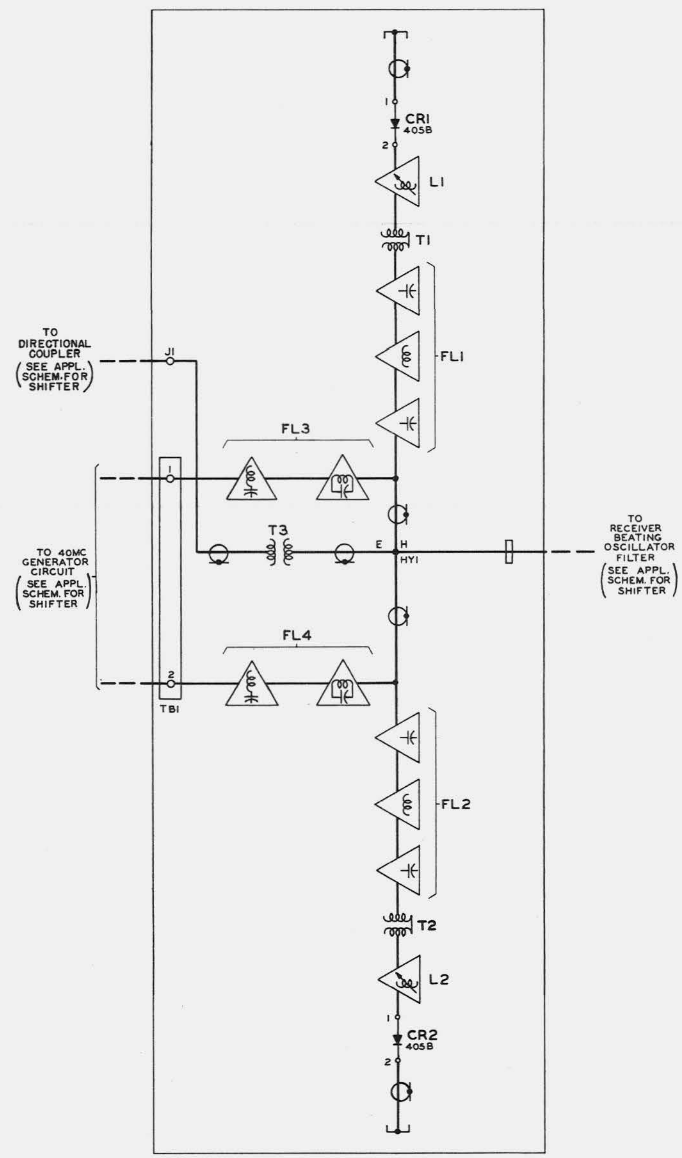
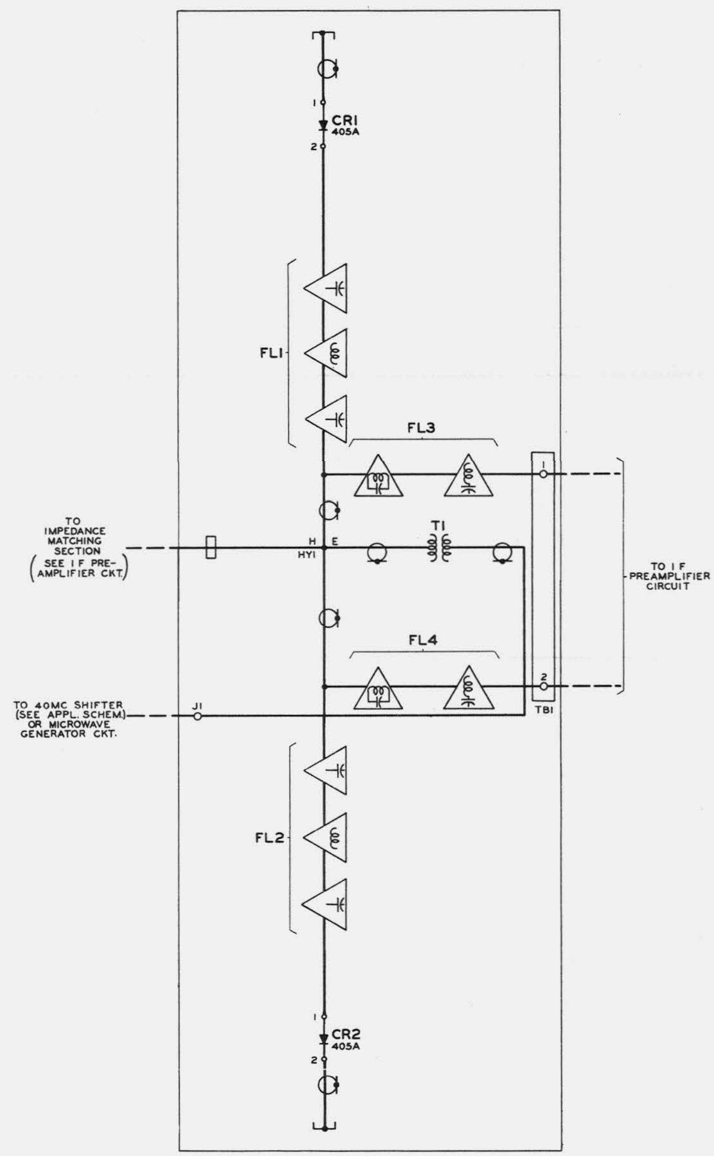



FIG. 2
RECEIVER CONVERTER
ED-63905-01, G2




ED-63905-01
EQUIPMENT INFO.

SD-59407-01

TOLL SYSTEMS
TD RADIO
CONVERTER CKT.

AT&TCO
STANDARD

SD-59407-01

R

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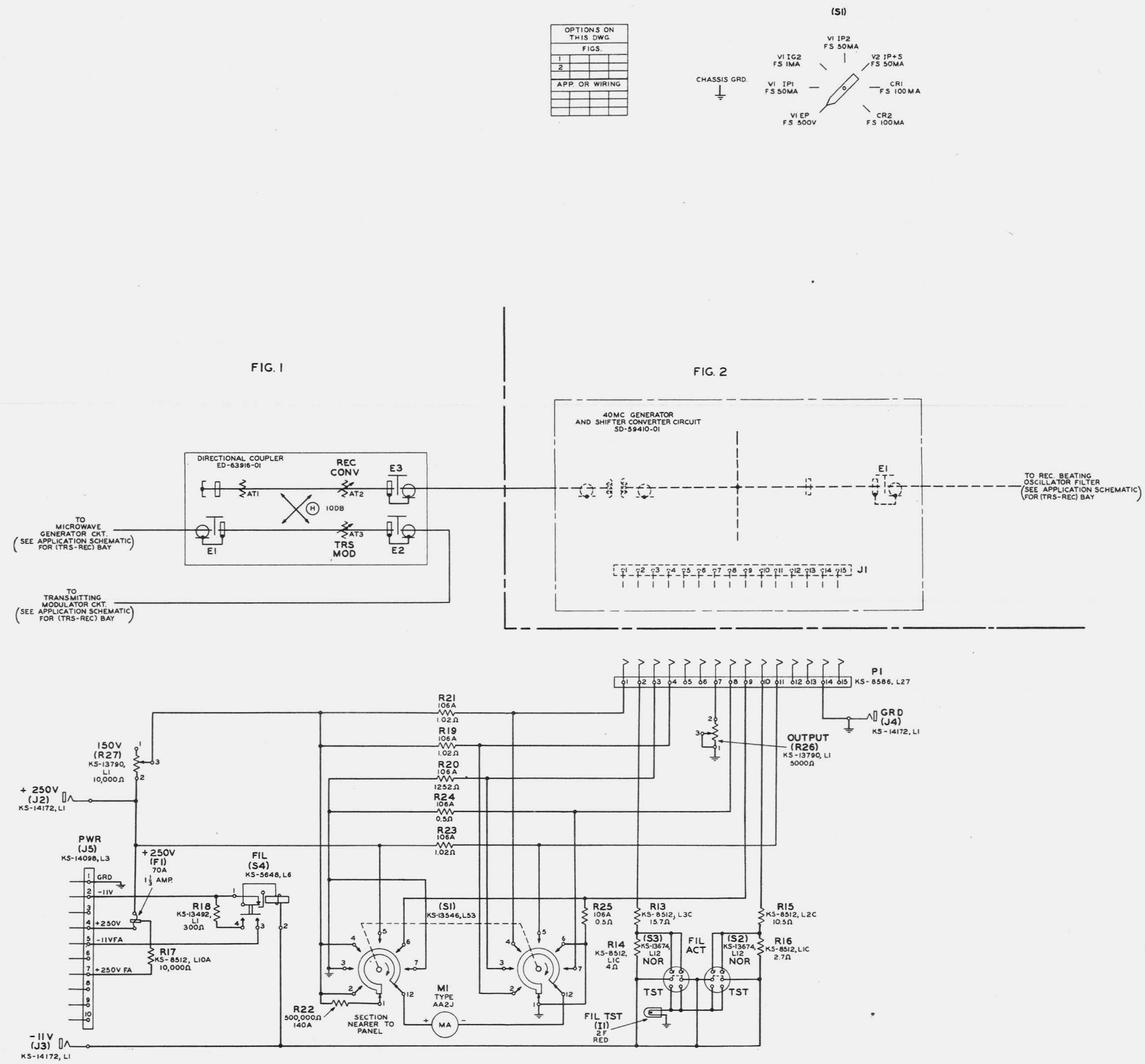
| DWG. ISS. | C.D. ISSUE | DATE ISSUED | DWG. ISS. | C.D. ISSUE | DATE ISSUED |
|---|---|---|---|---|---|
| 1 | 1 | 12-15-48 | | | |

| DWG. ISS. | C.D. ISSUE | DATE ISSUED | APPROVED |
|---|---|---|---|
| 2-A | 2-A | 2-21-49 | G.N.T. |
| 3-A | 2-A APP 1-A | 5-13-49 | G.N.T. |




J68330H-90
ED-63934-01
EQUIPMENT INFO.

SD-59408-01

TOLL SYSTEMS
TD RADIO
APPLICATION SCHEMATIC
FOR 40 MC SHIFTER CKT.

AT&TCO STANDARD

R1

SD-59408-01

BELL TELEPHONE LABORATORIES, INC.

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SD-59408-01

CIRCUIT NOTES:

101. ALL WIRING EXCEPT PIGTAIL LEADS SHOWN ABOVE THE GROUND BUS IS D1 UNLESS OTHERWISE INDICATED.

102. WHEN FIG 2 IS OMITTED THE COAXIAL CABLE OF (V5) ASSEMBLY IS CONNECTED TO (V7) ASSEMBLY.

103. THIS CAPACITY IS FORMED BY THE ASSEMBLY OF P-255365, P-255363, AND P-255369 ASSEMBLIES.

| DWG. ISS. | C.D. ISSUE | DATE ISSUED | APPROVED |
|---|---|---|---|
| 1 | 1 | 12-27-48 | G.N.T. K |
| 2-A | APP. 1-A | 1-27-49 | G.N.T. K. |
| 3-A | APP. 2-A | 2-21-49 | G.N.T. K. |
| 4-A | APP. 3-A | 3-31-49 | G.N.T. K |
| 5-A | APP. 4-A | 5-5-49 | G.N.T. K. |
| 6-A | APP. 5-A | 5-25-49 | G.N.T. K |

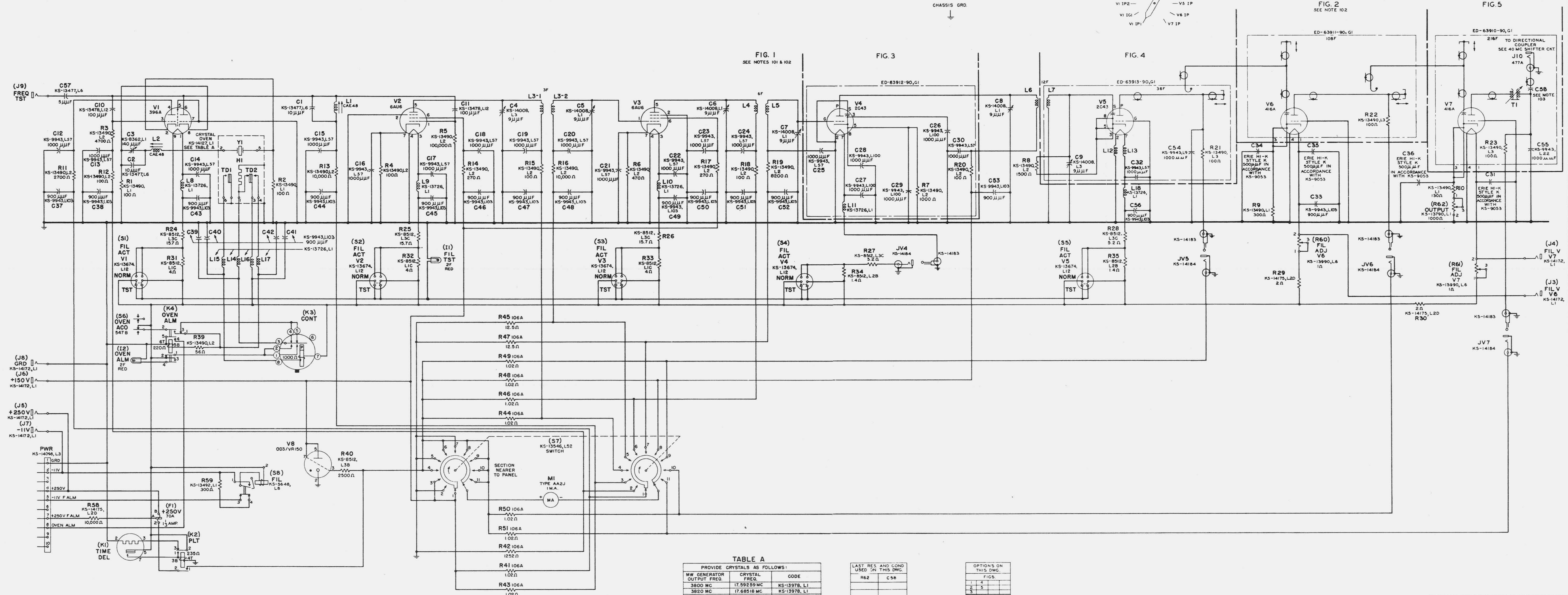


TABLE A

| PROVIDE CRYSTALS AS FOLLOWS: | | |
|---|---|---|
| MW GENERATOR OUTPUT FREQ. | CRYSTAL FREQ. | CODE |
| 3800 MC | 17.59259MC | KS-13978, L1 |
| 3820 MC | 17.68518MC | KS-13978, L1 |
| 3840 MC | 17.77778MC | KS-13978, L1 |
| 3860 MC | 17.87037MC | KS-13978, L1 |
| 3880 MC | 17.96296MC | KS-13978, L1 |
| 3900 MC | 18.05556MC | KS-13978, L1 |
| 3920 MC | 18.14815MC | KS-13978, L1 |
| 3940 MC | 18.24074MC | KS-13978, L1 |
| 3980 MC | 18.42592MC | KS-13978, L1 |
| 4020 MC | 18.61111MC | KS-13978, L1 |
| 4060 MC | 18.79630MC | KS-13978, L1 |
| 4100 MC | 18.98148MC | KS-13978, L1 |

| LAST RES. AND COND USED ON THIS DWG. | |
|---|---|
| R62 | C58 |
| | |
| | |
| | |
| NOT USED | |
| R12 | |
| R36-38 | |
| R52-57 | |
| | |
| | |

| OPTIONS ON THIS DWG. | | | |
|---|---|---|---|
| FIGS. | | | |
| 1 | 4 | | |
| 2 | 5 | | |
| 3 | | | |
| APP. OR WIRING | | | |
| | | | |
| | | | |
| | | | |

ED-63937-01 EQUIPMENT INFO.

SD-59409-01 2 SHEETS

TOLL SYSTEMS
TD RADIO
MICROWAVE GENERATOR CKT.

(MW GEN)

AT&TCO STANDARD

SD-59409-01I

BELL TELEPHONE LABORATORIES, INC.

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R4

| DWG. ISS. | C.D. ISSUE | DATE ISSUED | DWG. ISS. | C.D. ISSUE | DATE ISSUED |
|---|---|---|---|---|---|
| 1 | 1 | 12-30-48 | 2-A | 1 APP. 1-A | 1-27-49 |

| DWG. ISS. | C.D. ISSUE | DATE ISSUED | APPROVED |
|---|---|---|---|
| 3-A | 2-A | 2-21-49 | G.N.T. K. |
| 4-D | 3-D | 12-22-49 | G.N.T. K. |
| | | | |
| | | | |

CIRCUIT NOTES:

101 ALL WIRING IN FIG. 1 EXCEPT PIGTAIL LEADS IS D1 UNLESS OTHERWISE INDICATED.

EQUIPMENT NOTES:

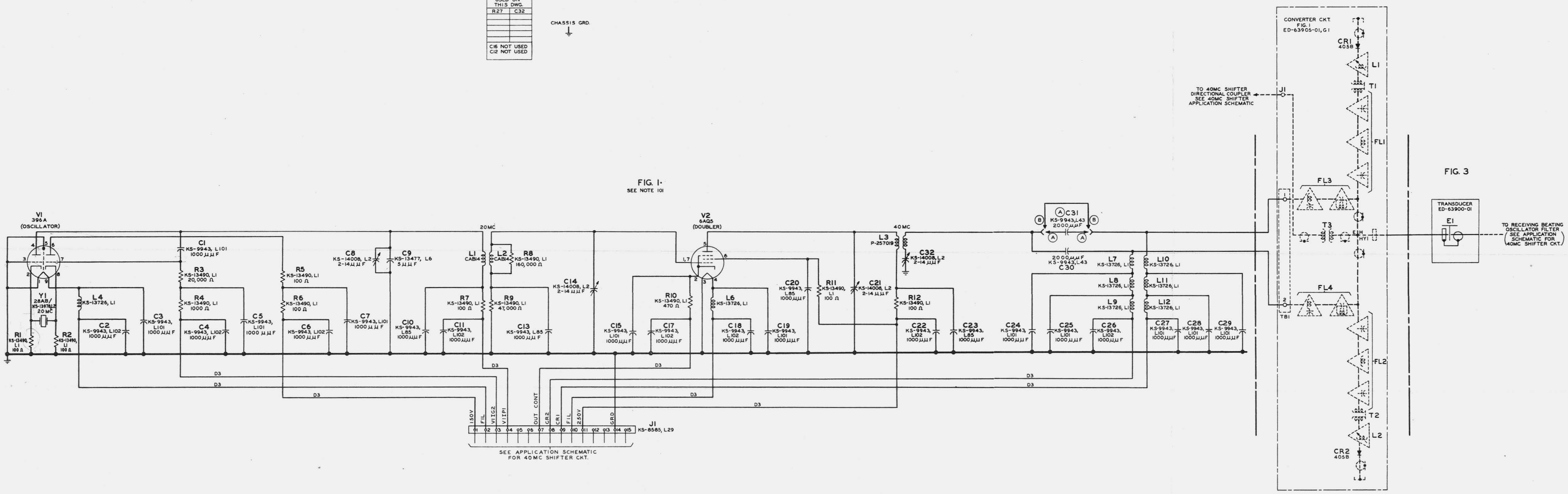
201. THE PLACEMENT OF APPARATUS AND ARRANGEMENT OF CRITICAL WIRING MUST BE IN ACCORDANCE WITH EQUIPMENT REQUIREMENTS.

| OPTIONS ON THIS DWG. | | | |
|---|---|---|---|
| FIGS. | | | |
| 1 | | | |
| 2 | | | |
| 3 | | | |
| APP OR WIRING | | | |
| | | | |
| | | | |
| | | | |

| RECORD OF FIGURES, WIRING, AND APPARATUS CHANGES | | | | | | | |
|---|---|---|---|---|---|---|---|
| CHANGED ON ISS. | IF JOB RECORDS DO NOT SPECIFY | THIS OPTION WAS FURN. | SEE NOTE | USE IN CIRCUIT | | | |
| | | | | STD. | A & M | M.D. | |
| 4-D | A & B | A | | B | | A | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |

| LAST RES. AND COND USED ON THIS DWG. | |
|---|---|
| R27 | C32 |
| | |
| | |
| | |
| | |
| C16 NOT USED C12 NOT USED | |

CHASSIS GRD.




ED-63934-01
ED-63905-01
EQUIPMENT INFO.

SD-59410-01

TOLL SYSTEMS
TD RADIO
40 MC GENERATOR
AND SHIFTER CONVERTER CKT.

(40MC GENERATOR & SHIFTER CONVERTER)

AT&TCO
STANDARD

R3

SD-59410-01

BELL TELEPHONE LABORATORIES, INC.



SD-59410-01

| DWG ISS | FE OR CD ISSUE | DATE ISSUED | APPROVED |
|---|---|---|---|
| 1 | 1 | 12-30-48 | G.N.T. K. |
| 2-A | 1 APP. 1-A | 1-27-49 | G.N.T. K. |
| 3-A | 2-A | 3-4-49 | G.N.T. K. |

CIRCUIT NOTES:

101. THIS COIL IS ACTUALLY A WIRE ABOUT $\frac{\lambda}{4}$ LONG (APPROX. 1").

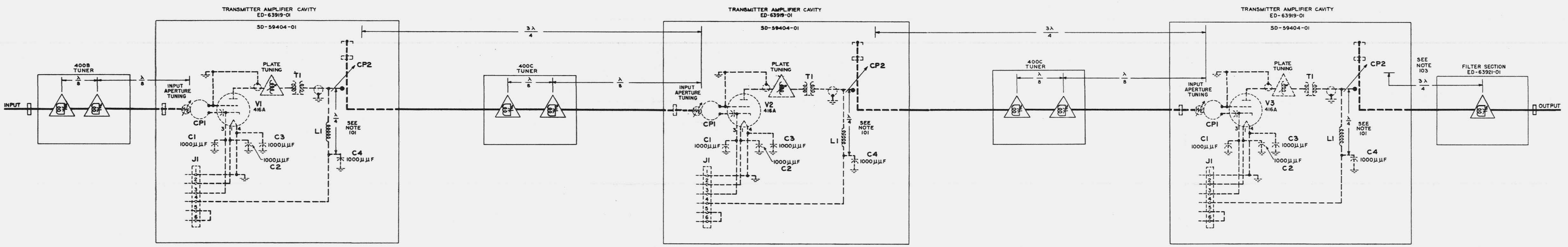
102. $\lambda$ IS THE WAVELENGTH IN WAVEGUIDE AT 3950 MC EXCEPT AS NOTED IN NOTE 103.

103. THE AMPLIFIER MAY BE TUNED FROM 3700 TO 4200 MC. FOR FREQUENCIES BELOW 3950 MC THE FILTER SECTION SHOULD BE PLACED WITH THE BLACK DOTS MATCHING. FOR FREQUENCIES ABOVE 3950 MC THE WHITE DOTS SHOULD MATCH. IN THIS CASE, $\lambda$ IS THE WAVELENGTH IN WAVEGUIDE AT 3825 MC FOR FREQUENCIES BELOW 3950 MC AND 4075 MC FOR FREQUENCIES ABOVE 3950 MC.

104. FOR INPUT, OUTPUT AND POWER CONNECTIONS REFER TO THE APPLICATION SCHEMATIC FOR THE TRANSMITTER.

105. EACH AMPLIFIER SHALL BE ADJUSTED AND TESTED FOR A SPECIFIC OPERATING FREQUENCY AND SHALL BE STAMPED ACCORDINGLY.

FIG. 1
SEE NOTES 104 & 105




ED-63923-01
EQUIPMENT INFO.

SD-59411-01

TOLL SYSTEMS
TD RADIO
TRANSMITTER AMPLIFIER CKT.
(THREE STAGE)

(TR AMP)

AT&TCO
STANDARD

SD-59411-01

BELL TELEPHONE LABORATORIES, INC.

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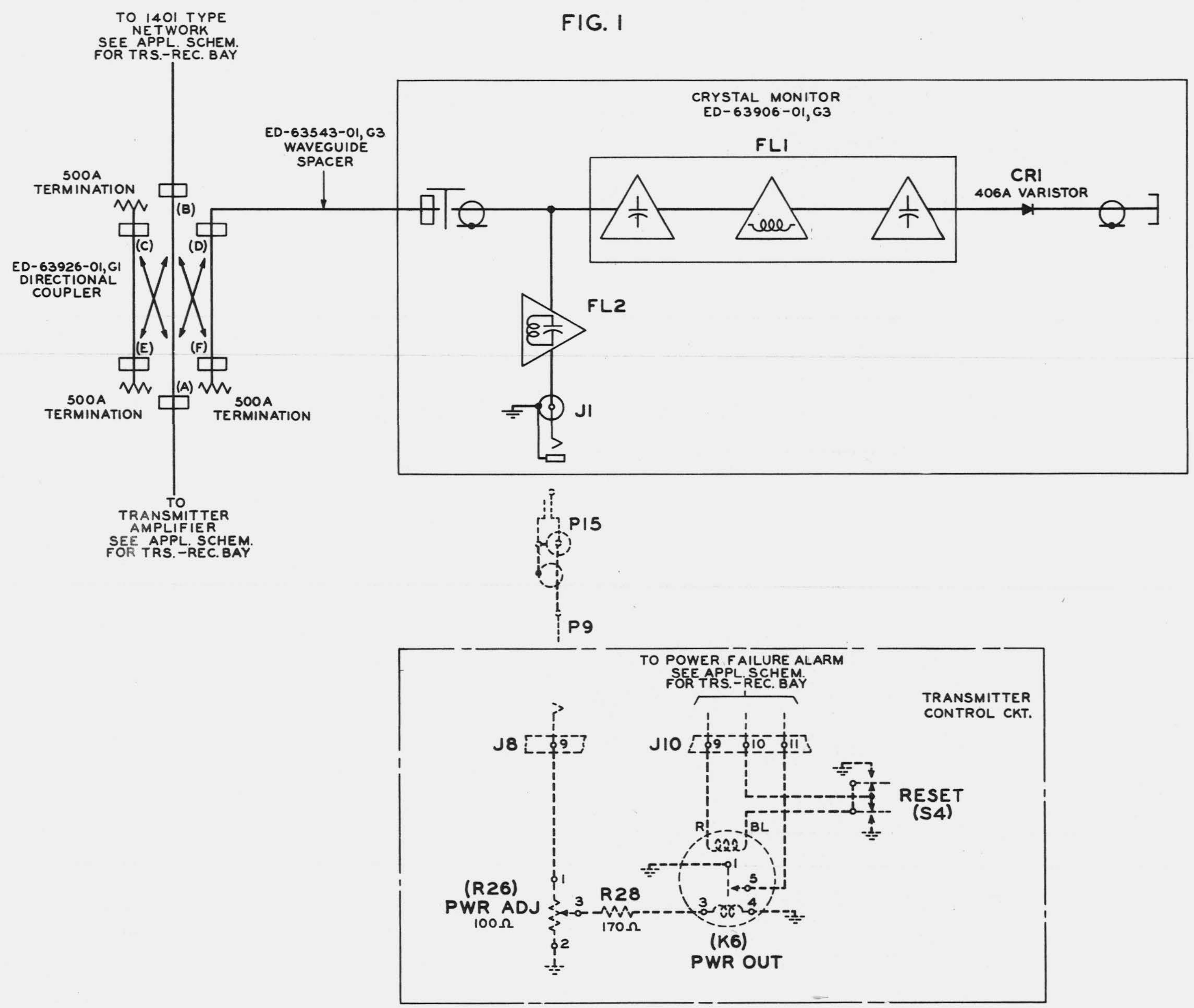
R3

SD-59411-01

| DWG. ISS. | EE OR CD ISSUE | DATE ISSUED | APPROVED |
|---|---|---|---|
| 1 | 1 | 4-28-49 | G.N.T. |

FIG. 1




ED-63917-01 EQUIPMENT INFO.

SD-59421-01

TOLL SYSTEMS
TD RADIO
OUTPUT MONITOR CKT.

(OUTPUT MONITOR)

AT&TCO STANDARD

O

SD-59421-01

**BELL TELEPHONE LABORATORIES, INC.**

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SD-59421-01