CHAPTER 13

SINGLE SIDEBAND FOR THE RADIO AMATEUR

1. INTRODUCTION

The whole nature of single-sideband equipment development is one of conserving the radio-frequency spectrum used by the amateur and commercial station so that there can be more channels of communication for a given number of kilocycles. In the amateur, military, and commercial fields of radio communications, there is a continuing demand for more and more channels of communication. With each passing year a larger number of people wish to talk from one point to another by means of radio. Single sideband allows more voice QSO's (contacts) per kilocycle than previous methods. Many amateur transmitters are extremely broad in characteristic, requiring much more bandwidth than is needed to carry on voice communications. An amateur who narrows his transmission and makes sure there are few spurious products from his transmitter will contribute to more efficient use of the crowded amateur bands. There is greater signal density in the sideband portion of the amateur bands than there is in the AM. portion; hence, more QSO's per kilocycle. At the same time SSB produces a much higher percentage of successful contacts than was ever true previously using AM. The use of single sideband has shown that a two-to-one reduction of bandwidth is entirely possible as compared to amplitude modulation.

To secure the desired narrow band transmission low intermodulation products, reduced harmonics, reduced spurious emissions, and the use of minimum bandwidth required for speech must all be considered. Intermodulation distortion in a transmitter results in the generation of new signal components which were not present in the original speech. These components occur both within the normal transmission band and outside. Sometimes these are spread over a wide band and are commonly referred to as splatter. Spurious emissions in a sideband transmitter are mixer products which are not adequately attenuated by tuned circuits. Minimum speech bandwidth refers to the use of narrow band circuits to reproduce a speech signal. Broadcast quality requires 15 kc. AM. stations may use 4 to 6 kc; SSB can reduce the audio bandwidth to 2 kc.

First, consider the generation of single sideband. (For additional discussion of single-sideband exciters, refer to chapter 2.) To secure a desired narrow band single-sideband transmission, start with a good method of sideband generation. This normally implies a balanced modulator plus filter, or a phasing-type generator. If a balanced modulator is used, it must be operated with adequate carrier injection and sufficient carrier balance. This must be followed by a suitable single-sideband separation filter. Either a mechanical, an LC, or a crystal filter can be used for sideband separation. However, the filter must have certain desirable characteristics. It should provide some additional carrier attenuation so that the carrier balance of the balanced modulator is not too critical. It should supply adequate rejection of the unwanted sideband, 40 db or so, and it should also cut off at the high end of the single-sideband spectrum so that only audio frequencies up to two or three kc are permitted on the air. It can be shown that only about two kc is required for intelligible speech communications. Further, this bandwidth permits the speaker's voice to be recognized. Broadcast quality contributes nothing to communication ability, but only produces wide band interfering signals. With the filter separation method of single-sideband generation, there is no need for an audio filter.

With the phasing-type exciter, suitable results can be obtained, but audio filters are required to eliminate both the low audio frequencies and the frequencies above two or three kc. In the phasing-type exciter, it is extremely important that the high audio frequencies be attenuated properly, because normally the audio phase shift networks which are used do not hold a 90-degree relationship above approximately three kc. Thus, if audio frequencies are permitted in the phasing-type exciter above three kc, the undesired sideband will again reappear. This contributes to wide band interfering signals which are completely unnecessary.

The proper carrier level must be fed into the balanced modulator in either filter or phasing exciter. It is also important that the audio level fed into the balanced modulator does not exceed that level which will permit low distortion single-sideband generation. It is possible to drive into a distortion region with excessive audio input. This is much like overmodulation in an AM. transmitter. It is caused by driving the diodes of the balanced modulator past the linear region introducing distortion in the received signal, which detracts rather than enhances intelligibility. It should be obvious to all amateurs now that either in AM. or single sideband, a heavy hand on the gain control does not necessarily let the person on the other end of QSO hear any better. Actually the intelligibility of the channel is reduced because the signal is buried under distortion products.

Assuming that a suitable single-sideband signal has been generated, it is still a long way from this point to the antenna. In the exciter, mixers and amplifiers must be used to transform the single-sideband signal to useful drive voltage for the power amplifier. Many different types of mixers can be used to convert a low-frequency, single-sideband signal to the desired output frequency. In general, the mixers must be operated with low distortion. The injection level must be several times as strong as the highest signal level. Grid current must be avoided on the signal grid. Operating conditions involving the bias voltage and plate voltage must be set so that low distortion operation is possible throughout the life of the equipment. The amplifier should be shielded and filtered to prevent oscillation; however, this is not enough. Even a slight amount of regeneration will contribute to increased distortion products in the exciter. Great care must be taken to ensure that the r-f voltage delivered to the final amplifier grid is an exact replica of the single-sideband signal from the SSB generator. It is possible with a reasonable amount of care to produce an exciter that has distortion products 45 to 50 db down from a two-tone test signal.

Frequency stability is accepted as a necessary part of single-sideband operation. However, frequency stability is not obtained without some design attention. It is important that a double-conversion frequency scheme be used in which a crystal oscillator provides the basic frequency stability for the higher bands. A stable vfo can then be used to secure continuous frequency coverage between the frequencies selected by the high-frequency crystals. It is easy to see that an unstable frequency-generating scheme will result in signals which drift across the band and thereby occupy more frequency spectrum than is required. Improvements in frequency stability and the tendency to use a single radio-frequency channel by both parties in the QSO also greatly increases the number of QSO's per kilocycle. The use of transceiver-type operation in which the transmitter frequency is tuned properly when the receiver is adjusted to the incoming signal ensures that both stations are operating on the same frequency.

In the power amplifier, the rules for proper operation are much like that imposed by the high-fidelity enthusiast in designing an output stage. Adequate tubes must be selected for the power amplifier to operate in the linear region. One can use the class AB_1 characteristics in the tube books. R-f feedback should be used to reduce the intermodulation distortion products. It is necessary to have careful neutralization; regeneration must be avoided, and automatic load control (alc) is recommended to secure a low distortion minimum bandwidth transmitter. To secure adequate neutralization, there must be careful isolation of the grid and plate circuits without common coupling paths and feedback circuits. A wide band bridge neutralization circuit is very useful because this permits a single neutralization setting over the normal range of amateur frequencies. This neutralization is necessary even with power tetrodes, because a small amount of regeneration is possible even with the shielding which is available. Careful adjustment of neutralization and periodic checks following installation of the equipment are necessary parts of the operating procedure. Normally, neutralization requires very little attention.

Regeneration is frequently present in class C stages intended for AM. transmission, but it does not contribute to undesirable characteristics normally. However, for single-sideband operation, regeneration in the power amplifier, as in the exciter, produces increased distortion products which spread the radiated signal over a wider band. Regeneration, as pointed out before, is related to proper neutralization techniques. Shielding of the circuits, particularly between the power amplifer and the exciter, is very necessary, and adequate bypassing of leads must be used to prevent undesired coupling of energy between the power amplifier and the low-level exciter stages.

R-f feedback in a radio-frequency linear amplifier is much like audio feedback in a high-fidelity system. In r-f feedback a sample of r-f voltage is taken from the plate of the power amplifier and fed back either to the cathode of the driver stage or to the control grid of the stage which precedes the driver stage. Thus feedback is taken around either two or three stages again in much the same manner as is done in audio amplifiers. The function of r-f feedback is to reduce undesired signal components.

There are several ways in which the power amplifier and the single-sideband transmitter can be driven into nonlinear operation. In many power amplifiers, the operation is class AB_1; no grid current may be drawn during any portion of the operating cycle. It is also possible to drive the tube into a condition of instantaneous plate current which is beyond its linear capability. To prevent improper operation of the power amplifier, a protective circuit called automatic load control may be used. In automatic load control, a voltage is taken from the plate of the tube, rectified, and fed back to the exciter stages in the form of a negative d-c control voltage. Like avc in a receiver, this control voltage tends to reduce the gain of the system to a level which will maintain constant output. For example, in a transmitter which has a plate voltage of about 2000 volts, a threshold of approximately 1600 volts may be set above which a rectifier in the plate circuit will conduct. Thus above 1600 volts a d-c voltage is generated which serves to control the gain of the exciter as previously mentioned. Above an instantaneous plate voltage of 1600 volts the PA tube begins to become nonlinear, and it is desirable to maintain drive level which does not exceed this point. Another method which can be used is to a-c couple a biased rectifier to the grid return resistor of the power amplifier stage. At the very moment that a minute amount of grid current is drawn an a-c voltage appears across the grid return resistor. This voltage is rectified forming a controlling d-c potential which is applied to the exciter stages to reduce the gain of the exciter. This, as before, prevents overdriving of the power amplifier stage. Operating the power amplifier in a linear region, without automatic load control, could be accomplished by reducing the r-f gain and the audio gain of the single-sideband transmitter to an extent that r-f peaks would never occur to drive the power amplifier beyond a safe level. However, this would result in a rather low level of power output from the transmitter under normal speech conditions. The use of automatic load control with its automatic protective characteristics permits a higher average level of speech; hence, a higher average power output without the danger of wide band distortion products. Automatic load control is a very simple circuit. Utilizing only a rectifier and a handful of resistors and capacitors, it performs a very important function in a single-sideband transmitter. It, in effect, reduces the peak-to-average factor in speech and yet prevents undesired wide band distortion products.

From the standpoint of total spectrum occupancy, it can be seen that transmitter harmonics are capable of interference with other services. Fortunately, the linear single-sideband amplifier has much less harmonic output than the class C amplifier used for AM. The very nature of linear amplification of single-sideband signals greatly reduces harmonic output. This is especially true at the higher harmonics in the vhf bands. For example, it normally is possible to operate a class AB_1 transmitter without the need of a TVI (television interference) low-pass filter, which indicates the low level of harmonic output which falls within the TV bands. Another factor which is important in single-sideband transmission is the intermittent nature of voice in terms of the power which is present at harmonic frequencies. Because there is no steady carrier present, the harmonic voltage fluctuates at the fundamental frequency output of the transmitter. This means that the net interfering effect of single-sideband harmonics is much less than that from an AM. transmitter having equivalent power output.

To summarize, the transmitter should be designed and operated to minimize:

(1) Wide band single-sideband voice components

(2) Intermodulation distortion

(3) Spurious products from exciter mixers and power amplifier

(4) Unwanted sideband

(5) Overloading and overdriving

(6) Regeneration

(7) Harmonics

If this is done, the transmitter will produce a clean, narrow band signal. Proper equipment design and proper equipment operation will produce a narrow band, single-sideband voice transmission.

Equally important in a single-sideband installation is the receiver. To take full advantage of the spectrum-saving features of single sideband, the receiver should embody certain design principles. Among these are (1) stability, (2) selectivity, (3) adequate sensitivity, and (4) calibration. Chapter 3 provides a discussion of the design considerations and circuits employed in Collins single-sideband receivers, including amateur models.

2. 75S-1 RECEIVER

Figure 13-1. 75S-1 Receiver

The 75S-1 Receiver (figure 13-1) provides SSB, CW, and AM. reception on all amateur bands between 3.5 and 29.7 mc. It is capable of coverage of the entire h-f spectrum between 3.5 and 30 mc by selection of the appropriate high-frequency beating crystals.

The standard amateur model includes crystal sockets, crystals, and band switch positions for 3.4-3.6, 3.6-3.8, 3.8-4.0, 7.0-7.2, 7.2-7.4, 14.0-14.2, 14.2-14.4, 21.0-21.2, 21.2-21.4, and 21.4-21.6 mc. Positions and crystal sockets are also provided for three 200-kc bands between 28 and 29.7 mc, with one of the sockets equipped with a crystal for 28.5 to 28.7 mc. A crystal and band switch position is also provided for 14.8 to 15.0 mc for reception of WWV and WWVH for time and frequency calibration data.

Figure 13-2 is a block diagram of 75S-1 Receiver. The 75S-1 is a double-conversion receiver with crystal-controlled, high-frequency oscillator and band-pass i-f. Separate detectors for AM. and SSB are provided. Outputs from the high-frequency oscillator and the vfo are available at jacks on the chassis for controlling frequencies of companion 32S-1 Transmitter when used in transceiver service. When operating the 755-1 with a transmitter, the function switch should be left in STDBY; this allows the receiver mute line to be externally switched; if left in OPR, the receiver mute line is grounded by the switch and the receiver cannot be muted. Figure 13-3 is a schematic diagram of the receiver.

a. R-F CIRCUITS

One set of slug-tuned coils is used to cover the entire tuning range with appropriate capacitance switched in by band switch sections S2, S3, and S4. The r-f amplifier tube, V1, is a type 6DC6. Its output is applied to the grid of the first mixer, V2A. High-frequency injection signal is coupled from the crystal oscillator to the cathode of V2A. On any band selected, the crystal oscillator output frequency is 3.155 mc higher than the lower edge of the desired band. The difference between the crystal oscillator frequency and the desired frequency is between 3.155 mc and 2.955 mc, or the band-pass i-f frequency.

Using a triode first mixer, V2A, reduces cross modulation products. The triode mixer also has a lower noise figure than a pentode mixer. The r-f coils are peaked for the amateur bands. Receiver sensitivity is slightly reduced on the high end of each general coverage band. This can be corrected by repeaking the preselector tuned circuits to the desired frequency range.

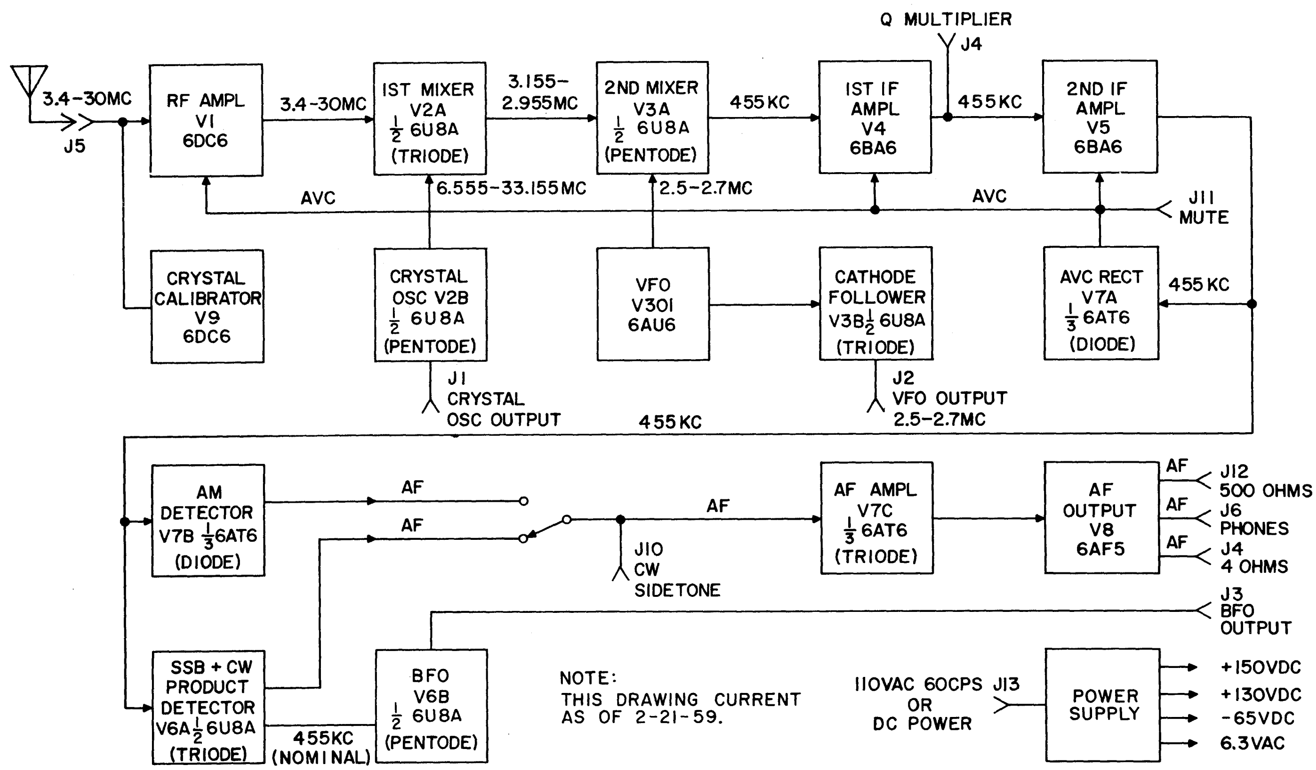


Figure 13-2. 75S-1 Block Diagram

A decided improvement in frequency stability results by using a crystal oscillator in the high-frequency conversion and injecting the tunable oscillator at a lower frequency conversion where good vfo stability is easily attained. The 70K-2 Oscillator used in the 75S-1 is a very stable vfo and essentially determines the frequency stability of the entire receiver as all other oscillators are crystal controlled.

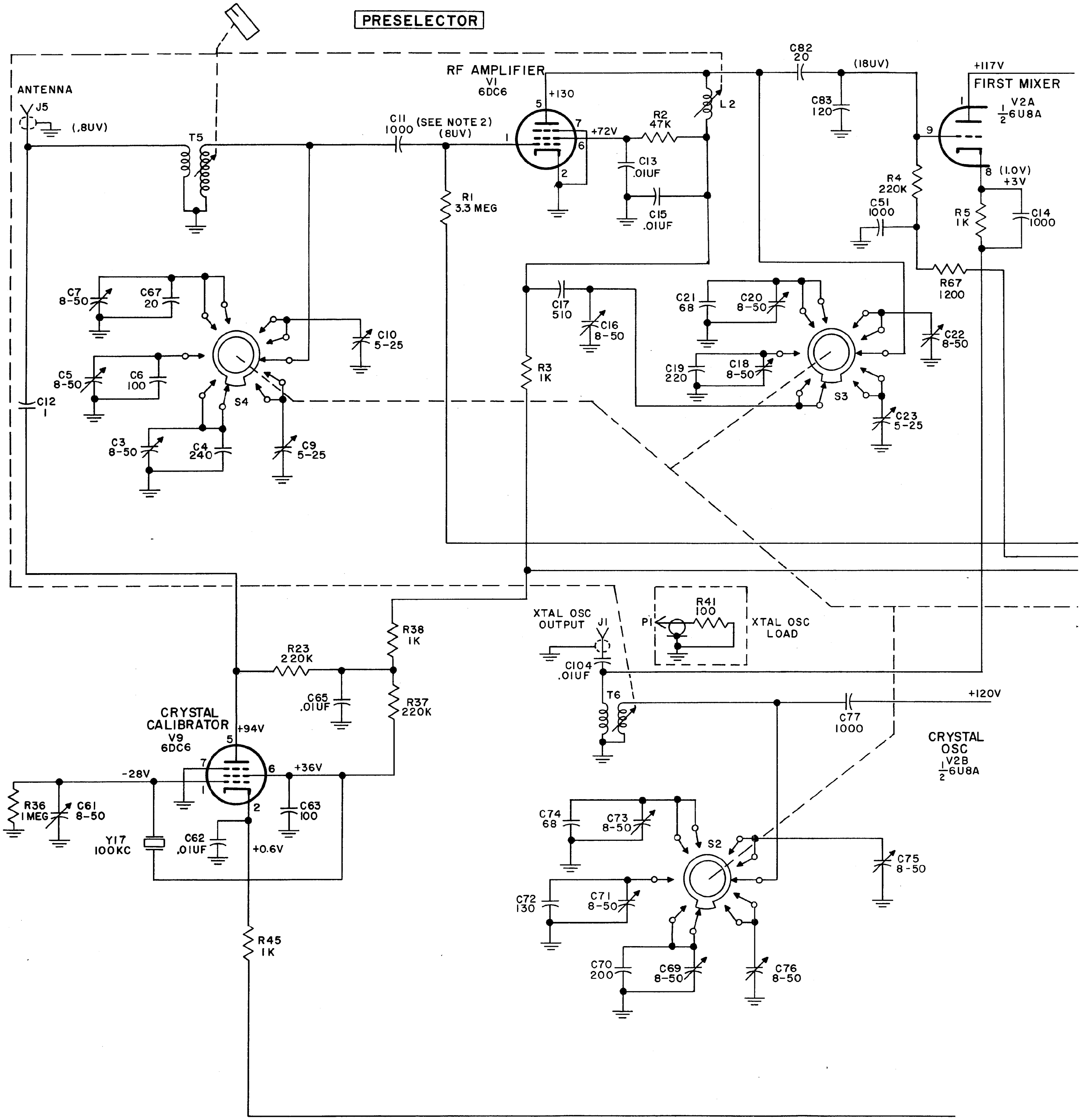
Delayed avc is used in the 75S-1 to allow the incoming signal to build up from the noise to the delay voltage level before avc is applied. The sensitivity is one microvolt for a 15-db signal-plus-noise to noise ratio at avc threshold. The avc is fast attack, slow release for sideband and CW reception. This allows fast avc action before the end of the first syllable and a long enough hold time to prevent gain changes between words.

b. FREQUENCY-CONVERSION DATA

To illustrate the frequency-conversion scheme used with the 75S-1, assume one wishes to listen to a lower sideband signal from a 32S-1 being transmitted at 3.9 mc. The 75S-1 is set at band 3A and the dial reads 100 (3.8 plus 100 on the dial, or 3.9 mc). This means the suppressed carrier frequency of the incoming lower sideband signal is 3.9 mc, with a voice band extending 2.4 kc lower in frequency (3.9000 down to 3.8976 mc). This is because the optimum speech range necessary for communications work is from 300 to 2400 cps (2.1 kc); however, frequencies from 0 to 2400 cps can be transmitted. By placing the carrier 20 db down on the filter skirt of a 2.1-kc mechanical filter the undesired lower 300 cps can be attenuated.

The high-frequency-conversion oscillator V2B is crystal controlled by Y3 at 6.955 mc. Subtractive mixing in V2A inverts the incoming lower sideband signal (6.9550 - 3.9000 = 3.0550 mc; 6.9550 - 3.8976 = 3.0574 mc) so the signal, as far as the remainder of the receiver is concerned, is upper sideband. The 3.055-mc variable i-f carrier frequency is mixed with the 70K-2 Oscillator frequency of 2.601350 mc, which gives a low-frequency i-f suppressed carrier signal of 453.650 kc. This places the suppressed carrier at the -20-db point on the low-frequency skirt of the 455-kc mechanical filter passband, FL2, and centers the desired 300- to 2400-cps portion of the signal in the 2.1-kc filter passband. To detect the audio from this i-f signal in the product detector, V6A, the bfo V6B must inject a carrier (at 453.650 kc, the i-f suppressed carrier frequency) generated by crystal Y15. The bfo signal is filtered out of the product detector output and the audio signal is fed to amplifiers V7 and V8.

To receive a 3.9-mc upper sideband signal, the suppressed carrier remains the same (3.9 mc) with the 2.4-kc speech bandwidth extending from 3.9000 mc to 3.9024 mc. Subtractive mixing in V2A inverts the incoming upper sideband signal (6.9550 - 3.9000 mc = 3.0550 mc; 6.9550 - 3.9024 mc = 3.0526 mc) so that the signal, as far as the remainder of the receiver is concerned, is lower sideband. The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ANTENNA
J5
(.8UV)
T5
C11
1000
(SEE NOTE 2)
(8UV)
R1
3.3 MEG
RF AMPLIFIER
V1
6DC6
+130
+72V
R2
47K
L2
C13
.01UF
C15
.01UF
C82
20
(18UV)
C83
120
+117V
FIRST MIXER
V2A
1/2 6U8A
(1.0V)
+3V
R4
220K
C51
1000
R5
1K
C14
1000
R67
1200
C7
8-50
C67
20
C10
5-25
C5
8-50
C6
100
S4
C12
1
C3
8-50
C4
240
C9
5-25
C17
510
C16
8-50
R3
1K
C21
68
C20
8-50
C22
8-50
C19
220
C18
8-50
S3
C23
5-25
R38
1K
R23
220K
C65
.01UF
R37
220K
CRYSTAL
CALIBRATOR
V9
6DC6
+94V
-28V
+36V
R36
1MEG
C61
8-50
C63
100
Y17
100KC
C62
.01UF
+0.6V
R45
1K
XTAL OSC
OUTPUT
J1
P1
R41
100
XTAL OSC
LOAD
C104
.01UF
T6
C77
1000
+120V
CRYSTAL
OSC
V2B
1/2 6U8A
C74
68
C73
8-50
S2
C75
8-50
C72
130
C71
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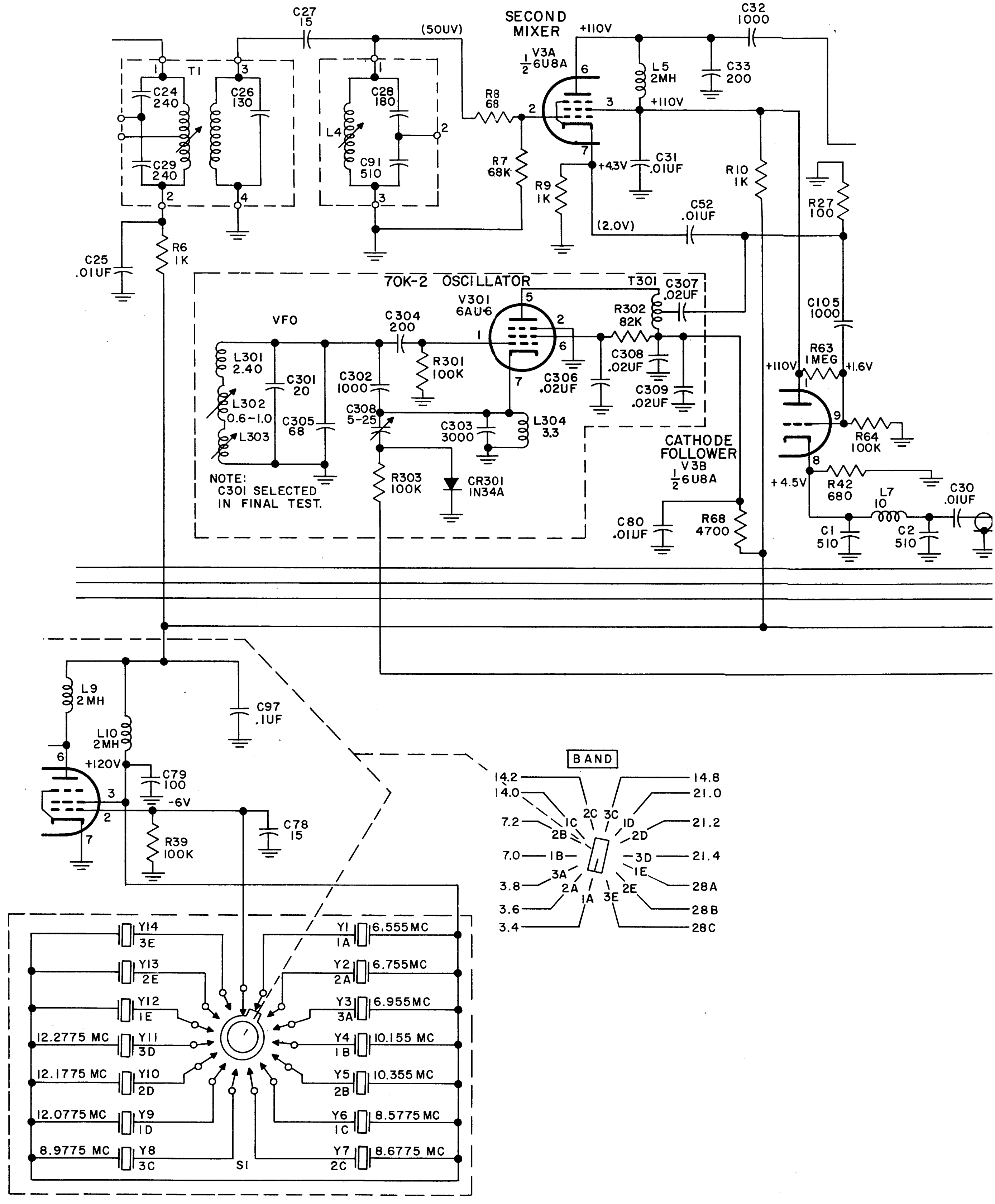
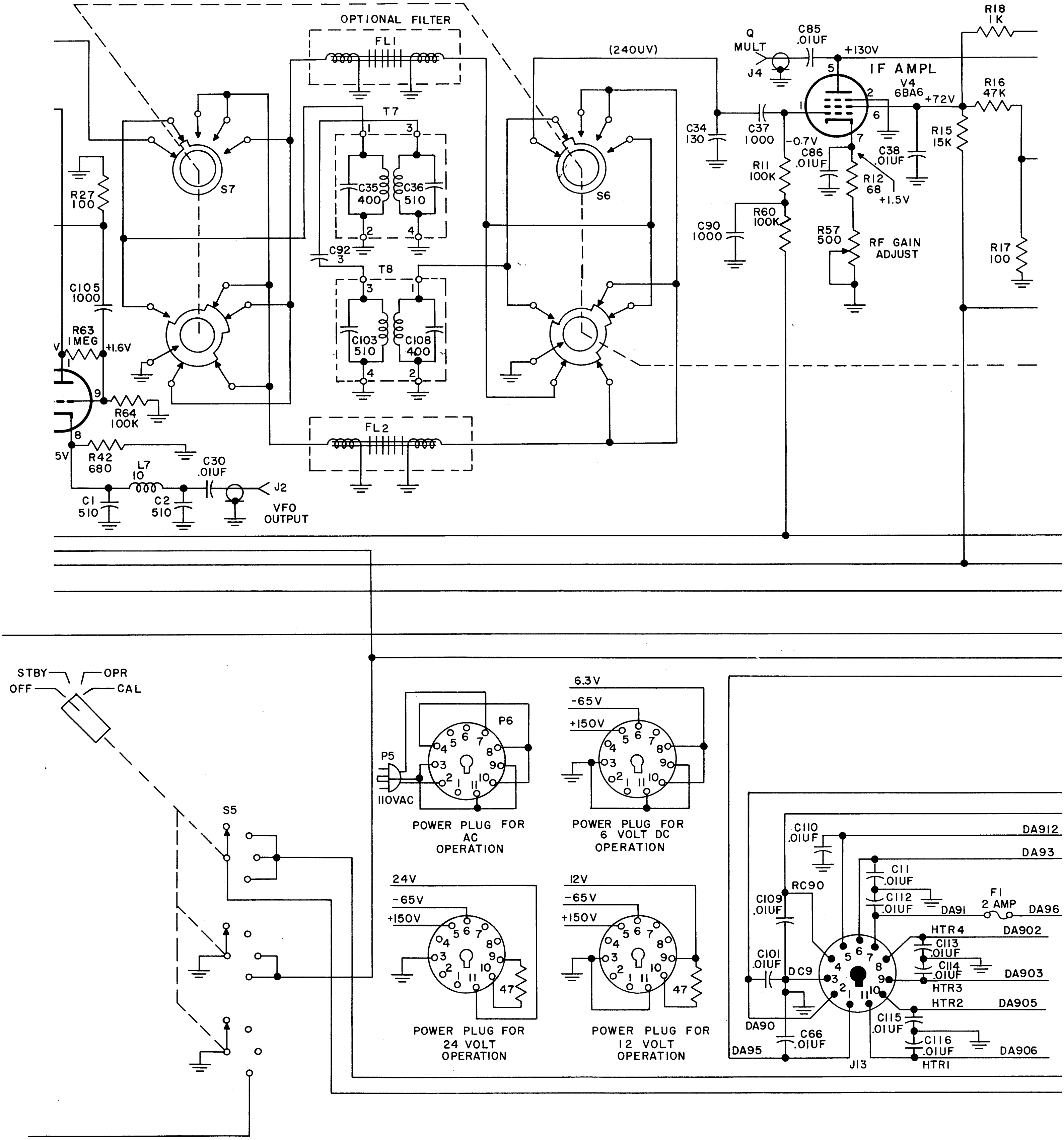
8-50
C76
8-50



SECOND MIXER
V3A
1/2 6U8A
+110V
C27 15
(50UV)
C32 1000
C33 200
L5 2MH
+110V
T1
C24 240
C26 130
C29 240
C28 180
L4
C91 510
R8 68
R7 68K
R9 1K
+43V
C31 .01UF
R10 1K
R27 100
(2.0V)
C52 .01UF
C25 .01UF
R6 1K
70K-2 OSCILLATOR
T301
C307 .02UF
V301 6AU6
VFO
C304 200
R302 82K
L301 2.40
C301 20
C302 1000
R301 100K
C306 .02UF
C308 .02UF
C309 .02UF
L302 0.6-1.0
C305 68
C308 5-25
C303 3000
L304 3.3
L303
NOTE: C301 SELECTED IN FINAL TEST.
R303 100K
CR301 1N34A
C105 1000
R63 1MEG
+110V
+1.6V
R64 100K
CATHODE FOLLOWER
V3B
1/2 6U8A
+4.5V
R42 680
L7 10
C30 .01UF
C80 .01UF
R68 4700
C1 510
C2 510
L9 2MH
C97 .1UF
L10 2MH
+120V
C79 100
-6V
R39 100K
C78 15
BAND
14.2
14.0
7.2
7.0
3.8
3.6
3.4
14.8
21.0
21.2
21.4
28A
28B
28C
1C 2C 3C 1D 2B 2D 1B 3D 3A 1E 2A 2E 1A 3E
Y14 3E
Y13 2E
Y12 1E
12.2775 MC Y11 3D
12.1775 MC Y10 2D
12.0775 MC Y9 1D
8.9775 MC Y8 3C
Y1 1A 6.555MC
Y2 2A 6.755MC
Y3 3A 6.955MC
Y4 1B 10.155 MC
Y5 2B 10.355 MC
Y6 1C 8.5775 MC
Y7 2C 8.6775 MC
S1



OPTIONAL FILTER
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IF AMPL
V4 6BA6
+72V
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R16 47K
R15 15K
R17 100
C34 130
C37 1000
-0.7V
C86 .01UF
C38 .01UF
R11 100K
R12 68
+1.5V
R60 100K
C90 1000
R57 500
RF GAIN ADJUST
T7
C35 400
C36 510
S7
S6
R27 100
C92 3
T8
C103 510
C108 400
C105 1000
R63 1MEG
+1.6V
R64 100K
FL2
R42 680
5V
L7 10
C30 .01UF
J2
C1 510
C2 510
VFO OUTPUT
STBY
OPR
OFF
CAL
S5
P6
P5
110VAC
POWER PLUG FOR AC OPERATION
6.3V
-65V
+150V
POWER PLUG FOR 6 VOLT DC OPERATION
24V
-65V
+150V
47
POWER PLUG FOR 24 VOLT OPERATION
12V
-65V
+150V
47
POWER PLUG FOR 12 VOLT OPERATION
C110 .01UF
DA912
DA93
C11 .01UF
C112 .01UF
RC90
C109 .01UF
DA91
F1 2 AMP
DA96
HTR4
DA902
C113 .01UF
C114 .01UF
DA903
HTR3
C101 .01UF
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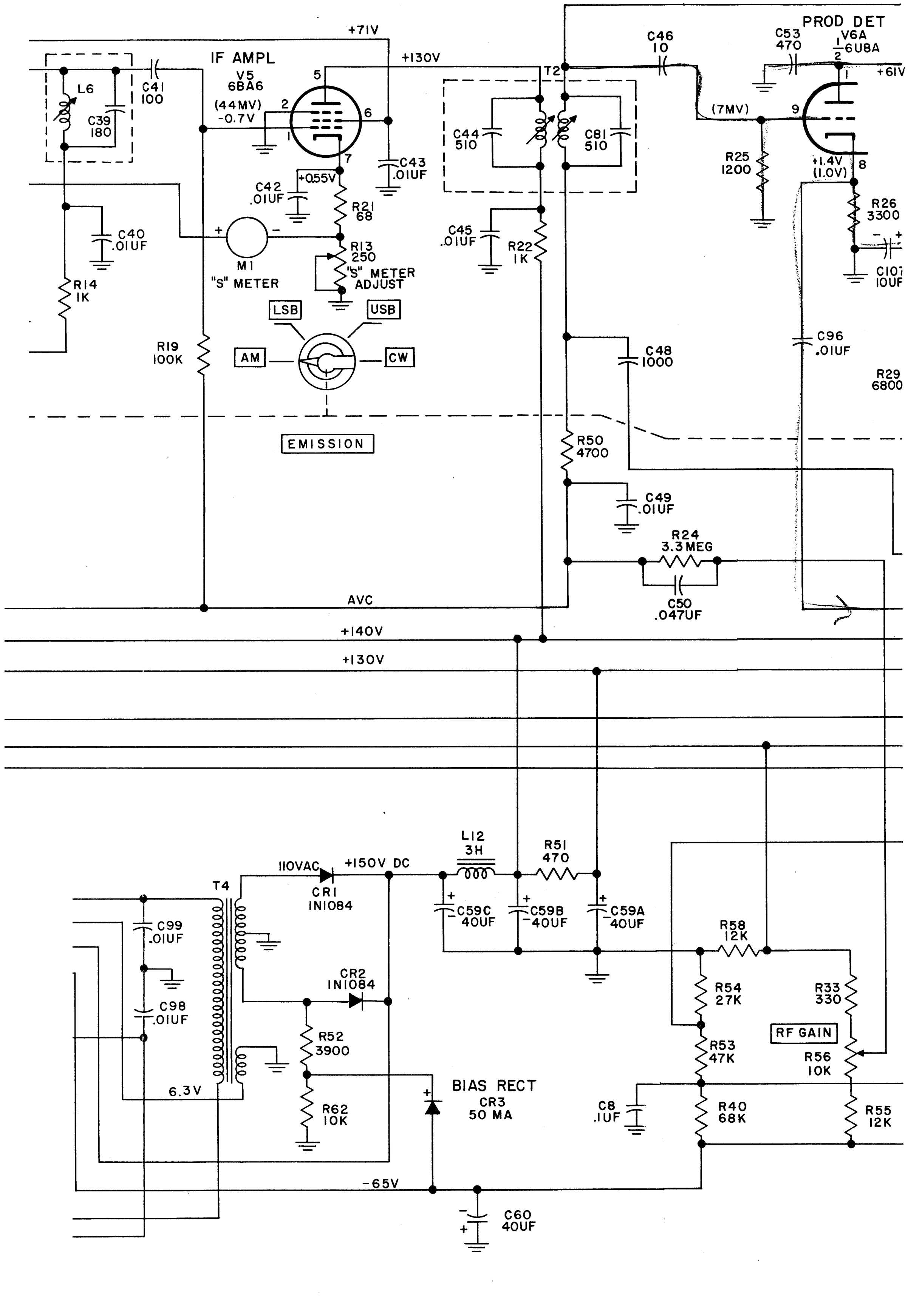
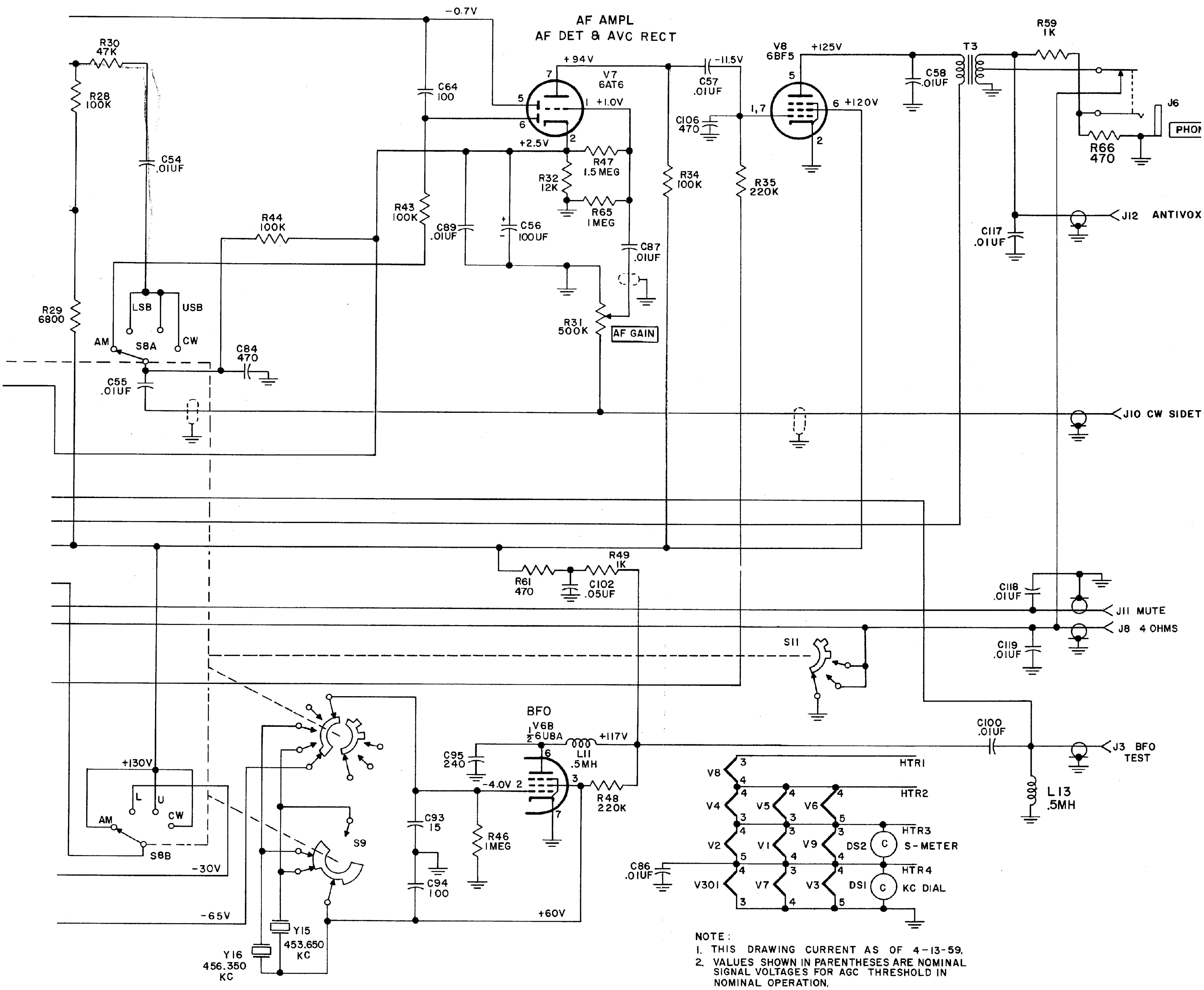
C66 .01UF
DA95
J13



IF AMPL
V5
6BA6
+71V
+130V
(44MV)
-0.7V
L6
C41
100
C39
180
C42
.01UF
+0.55V
R21
68
C43
.01UF
C40
.01UF
M1
"S" METER
R13
250
"S" METER
ADJUST
R14
1K
LSB
USB
AM
CW
R19
100K
EMISSION
T2
C44
510
C81
510
C45
.01UF
R22
1K
C46
10
PROD DET
C53
470
V6A
1/2 6U8A
+61V
(7MV)
R25
1200
+1.4V
(1.0V)
R26
3300
C107
10UF
C96
.01UF
R29
6800
C48
1000
R50
4700
C49
.01UF
R24
3.3 MEG
C50
.047UF
AVC
+140V
+130V
L12
3H
R51
470
T4
110VAC
+150V DC
CR1
1N1084
C59C
40UF
C59B
40UF
C59A
40UF
C99
.01UF
C98
.01UF
CR2
1N1084
R52
3900
R62
10K
6.3V
BIAS RECT
CR3
50 MA
R58
12K
R54
27K
R33
330
RF GAIN
R53
47K
R56
10K
C8
.1UF
R40
68K
R55
12K
-65V
C60
40UF



NOTE:
1. THIS DRAWING CURRENT AS OF 4-13-59.
2. VALUES SHOWN IN PARENTHESES ARE NOMINAL SIGNAL VOLTAGES FOR AGC THRESHOLD IN NOMINAL OPERATION.

Figure 13-3. 75S-1 Schematic Diagram

modulator. In TUNE, LOCK KEY, and CW positions of the EMISSION switch, output from the tone oscillator, V11B, is fed to the grid of the second audio amplifier. Amplified tone oscillator signal is taken from the plate of V1B to the grid of the vox amplifier and the CW sidetone jack, J19. Because of the sharp skirt selectivity on both sides of the 2.1-kc mechanical filter, speech frequencies below 300 cps and above 2400 cps are attenuated, and the desired 300- to 2400-cps speech band is centered in the 2.1-kc filter passband. This emphasizes the optimum communications speech range (300 to 2400 cps).

c. BALANCED MODULATOR AND LOW-FREQUENCY I-F CIRCUITS

Audio output from the cathode of V2A and bfo voltage are fed to the slider of the carrier balance potentiometer, R14. Both upper and lower sideband output from the balanced modulator are coupled through i-f transformer T2 to the grid of the i-f amplifier, V3. Output from the i-f amplifier, V3, is fed to the mechanical filter, FL1. The passband of FL1 is centered at 455 kilocycles.

This passes either upper or lower sideband, depending upon the sideband polarity selected when the EMISSION switch connects bfo crystal Y14 or Y15. The single-sideband output of FL1 is connected to the grids of the first balanced mixer in push-pull.

d. BALANCED MIXERS

The 455-kc single-sideband signal is fed to the first balanced mixer grids in push-pull, the plates are connected in push-pull, and the vfo signal is fed to the grids in parallel. The mixer cancels the vfo signal energy and translates the 455-kc single-sideband signal to a 2.955- to 3.155-mc single-sideband carrier signal. This signal is the band-pass i-f frequency. The coupling network between the plate of the first mixer and the grid of the second balanced mixer is broadbanded to provide a uniform response to the band-pass i-f frequency. The band-pass i-f signal is fed to one of the grids of the second balanced mixer, and the high-frequency injection signal from the crystal oscillator V12 is fed to the signal input cathode and to the other grid. This arrangement cancels the high-frequency injection signal energy within the mixer and translates the band-pass i-f signal to the desired operating band. The use of triode balanced mixers reduces cross-modulation products and lowers the distortion level, although the primary purpose is to reduce oscillator feedthrough.

e. R-F CIRCUITS

The slug-tuned circuits coupling V5 to V6, V6 to V7, and V7 to the power amplifier are ganged to the EXCITER TUNING control. The signal is amplified by the r-f amplifier, V6, and the driver, V7, to drive the power amplifier, V8 and V9. Output from the parallel power amplifiers is tuned by a pi network and applied to the antenna through contacts of transmit-receive relay K2. The pi network matches a 50-ohm load provided the load has vswr not exceeding 2:1. Negative r-f feedback from the PA plate circuit to the driver cathode circuit permits a high degree of linearity at the high power level of the PA tubes. Both the driver and PA stages are neutralized to ensure their stability.

f. CONTROL CIRCUITS

(1) ALC CIRCUIT

Detected audio from the power amplifier grid circuit is rectified by V13, and the negative d-c output is fed to the alc bus. A fast-attack, slow-release, dual time constant is used to prevent over-driving on initial syllables and to hold gain constant between words. The fast time constant alc is applied to V6, and the slow time constant alc is applied to V3. If the companion 30S-1 Power Amplifier is used with the 32S-1, alc output from the 30S-1 is fed back to the alc bus. The minute amount of grid current drawn before alc acts does not degrade linearity. Rather, these few microvolts actually improve the linearity curve; only after appreciable grid current is drawn is linearity affected.

(2) VOX ANTIVOX CIRCUITS

Output from the second audio amplifier, V1B, is fed to the grid of the vox amplifier, V14A, through the VOX GAIN control, R74. This audio input is amplified by V14A and rectified by vox rectifier V10B. When the positive output of V10B is high enough to overcome the negative bias on V11A grid, the vox relay is actuated to turn the transmitter on. Receiver output is fed from J13 through the ANTI-VOX GAIN control, R85, to the grid of antivox amplifier V14B. Output from V14B is rectified by antivox rectifier V10A to provide the negative bias necessary to keep the transmitter disabled during receive periods. The antivox circuit provides a threshold voltage to prevent loudspeaker output (picked up by the microphone circuits) from tripping the vox circuits into transmit. ANTI-VOX GAIN control R85 adjusts the value of the antivox threshold so that loudspeaker output will not produce enough positive d-c output from the vox rectifier to exceed the negative d-c output from the antivox rectifier and cause V11A to actuate vox relay K1. Speech energy into the microphone will cause the positive vox voltage to overcome the negative antivox voltage and produce the desired action of K1. Contacts of relay K1 control relay K2, the key line, PA and driver screens, receiver muting circuits, oscillator plate-voltages, and the high-voltage relay in the d-c supply.

g. OSCILLATORS

(1) TONE OSCILLATOR

The tone oscillator is used for tuneup and CW operation and consists of an RC phase-shift oscillator operating at approximately 1350 cps. Its output is fed to the audio amplifier and is switched by the bfo signal in the balanced modulator to provide continuous wave r-f at the grids of the first mixer. The oscillator is turned on when EMISSION switch section S8C is in TUNE, LOCK KEY, or CW position. TUNE reduces PA screen voltage to keep the PA plate dissipation within ratings during tuneup. LOCK KEY allows final tuning with full carrier.

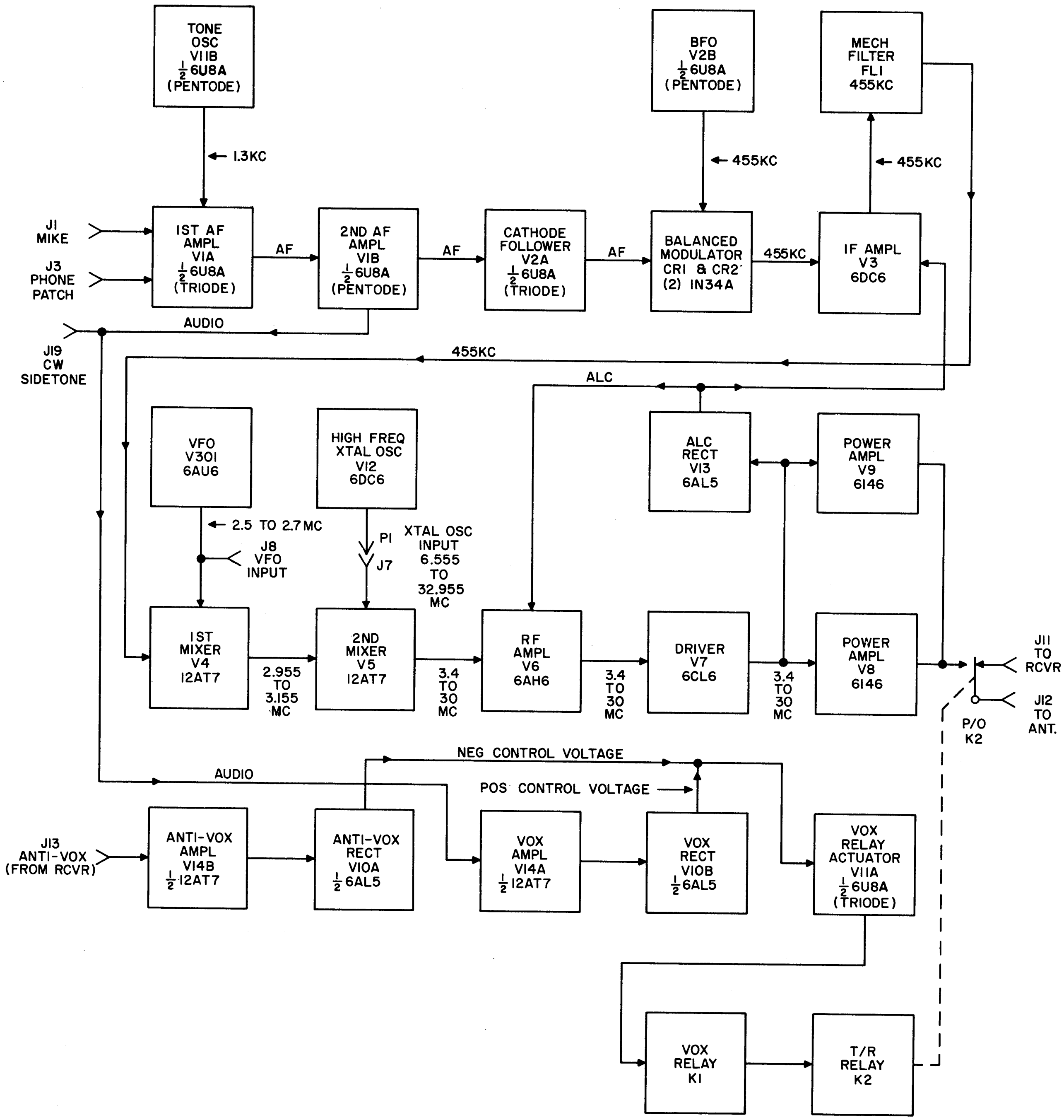


Figure 13-5. 32S-1 Block Diagram

Figure 13-4. 32S-1 Transmitter

Receiver, can be used for an additional 200-kc band in the 9.5- to 15.0-mc range.

Refer to figure 13-5, block diagram of the 32S-1. The 32S-1 Transmitter uses heterodyne exciter principles with crystal-controlled bfo, high-frequency oscillator, and highly stable vfo. The low-frequency i-f is 455 kc, and the high-frequency i-f is a 200-kc wide band-pass circuit. The 32S-1 may be connected in transceiver service with the companion 75S-1 Receiver. Figure 13-6 is a schematic diagram of the transmitter, and figure 13-32 is a schematic diagram of the 516F-2 A-C Power Supply. For additional discussion of single-sideband exciter circuits, refer to chapter 2.

a. FREQUENCY-CONVERSION DATA.

To illustrate the frequency-conversion scheme used in the 32S-1, assume one wishes to transmit a lower sideband signal at 3.9 mc. The 32S-1 is set at band 3A and the dial reads 100 (3.8 plus 100 on the dial, or 3.9 mc). This means the suppressed carrier frequency of the transmitted lower sideband signal is 3.9 mc, with a speech band extending 2.4 kc lower in frequency (3.9000 mc down to 3.8976 mc). This is because the optimum speech range necessary for communications work is from 300 to 2400 cps (2.1 kc); however, frequencies from 0 to 2400 cps can be transmitted. By placing the carrier 20 db down on the filter skirt of a 2.1-kc mechanical filter, the undesired 300 cps can be attenuated.

For lower sideband output, the bfo V2B generates a carrier at 453.650 kc and injects it, along with audio from V2A, into the balanced modulator. The output of the balanced modulator is a double-sideband signal with a 453.650-kc suppressed carrier. This is fed into the 455-kc mechanical filter, FL1. The 453.650-kc suppressed carrier from the balanced modulator is placed 20 db down on the low-frequency skirt of the 2.1-kc filter, which centers the desired 300- to 2400-cps portion of the signal in the filter passband. Filter output consists of a 453.650-kc carrier suppressed approximately 50 db from the accompanying upper sideband (which is later inverted to lower sideband by V5). This upper sideband signal is fed into the first mixer, V4A, along with a 2.601350-mc signal from the 70K-2 Oscillator. Additive mixing gives a suppressed variable i-f carrier frequency of 3.0550 mc with the upper sideband extending to 3.0574 mc (as the speech band extends to 2400 cps). The variable i-f is mixed with the output of the high-frequency crystal oscillator, V12, at 6.955 mc (using crystal Y3) in the second mixer, V5. Subtractive mixing in V5 inverts the signal to the desired lower sideband output (6.9550 - 3.0550 = 3.9000 mc; 6.9550 - 3.0574 = 3.8976 mc). This is the lower sideband r-f output that is fed into the r-f amplifiers.

To transmit an upper sideband signal at 3.9 mc, the suppressed carrier, remains the same with the 2.4-kc speech bandwidth extending up to 3.9024 mc. For upper sideband output, the bfo V2B generates a carrier at 456.350 kc and injects it, along with audio from V2A, into the balanced modulator. The output of the balanced modulator is a double-sideband signal with a 456.350-kc suppressed carrier. This is fed into the 455-kc mechanical filter, FL1. The 456.350-kc suppressed carrier from the balanced modulator is placed 20 db down on the high-frequency skirt of the 2.1-kc filter, which centers the desired 300- to 2400-cps portion of the signal in the filter passband. Filter output consists of a 456.350-kc carrier suppressed approximately 50 db from the accompanying lower sideband (which is later inverted to upper sideband by V5). This lower sideband signal is fed into the first mixer, V4A, along with a 2.598650-mc signal from the 70K-2 Oscillator. Additive mixing gives a suppressed variable i-f carrier frequency of 3.0550 mc with the lower sideband extending down to 3.0526 mc (as the speech band extends 2400 cps). The variable i-f is mixed with the output of the high-frequency crystal oscillator V12 at 6.955 mc (using crystal Y3) in the second mixer, V5. Subtractive mixing inverts the signal to the desired upper sideband output (6.9550 - 3.0550 = 3.9000 mc; 6.9550 - 3.0526 = 3.9024 mc). This is the upper sideband that is fed into the r-f amplifiers.

To keep the vfo dial frequency reading the same (100), the vfo frequency must be shifted 2.7 kc lower in frequency when transmitting upper sideband. This vfo switching is done by applying a positive or negative bias to diode CR301. When the diode bias is positive, the diode impedance is lowered, C308 is effectively in parallel with L304, and the oscillator frequency for transmitting upper sideband, in this example, is 2.598650 mc. When the bias is negative diode impedance is high, C308 is effectively switched out of the circuit, and the oscillator frequency for transmitting lower sideband, in this example, is 2.601350 mc.

b. A-F CIRCUITS

Microphone or phone patch input is connected to the grid of first audio amplifier V1A, amplified, and coupled to the grid of the second audio amplifier, V1B. Output from V1B is coupled to the grid of cathode follower V2A across MIC GAIN control. Output from the cathode follower is fed to the resistive balance

3.055-mc variable i-f carrier frequency is mixed with the 70K-2 Oscillator frequency of 2.598650 mc which gives a low-frequency, i-f suppressed carrier signal of 456.350 kc. This places the suppressed carrier at the -20-db point on the high-frequency skirt of the 455-kc mechanical filter passband, FL2, and centers the desired 300- to 2400-cps portion of the signal in the 2.1-kc filter passband. To detect the audio from this i-f signal in the product detector, V6A, the bfo V6B must inject a carrier (at 456.350 kc, the i-f suppressed carrier frequency) generated by crystal Y16. All mixing products but the desired audio are filtered out of the product detector output, and the audio signal is amplified by V7 and V8.

To keep the vfo dial frequency reading the same (100), the vfo frequency must be shifted 2.7 kc lower in frequency when receiving upper sideband. This vfo switching is done by applying a positive or negative bias to diode CR301. When the diode bias is positive, the diode impedance is lowered, C308 is effectively in parallel with L304, and the oscillator frequency for receiving upper sideband, in this example, is 2.598650 mc. When the bias is negative, diode impedance is high, C308 is effectively switched out of the circuit, and the oscillator frequency for receiving lower sideband, in this example, is 2.601350 mc.

c. I-F CIRCUITS

The 3.155- to 2.955-mc variable i-f frequency is coupled through a band-pass network, consisting of T1 and L4, to the grid of the second mixer, V3A. This mixer is the pentode section of a type 6U8A with vfo injection signal at its cathode. Depending on the setting of EMISSION switch S2, the 455-kc second mixer output is coupled through CW filter FL1 (not supplied with receiver), AM i-f transformers T8 and T7, or SSB filter FL2 to the first i-f amplifier, V4. The i-f amplifiers, V4 and V5, are conventionally coupled. The second i-f amplifier, V5, also operates the S-meter.

The S-meter is calibrated in S-units and db. The S-unit scale is standard up to midscale (S-9). The db scale reads relative signal strength above the avc threshold which is approximately one microvolt. Thus 40 db on the meter is 100 microvolts of signal (which also corresponds to S-9 on the S-unit scale). To read db over S-9 on the S-unit scale, subtract 40 from the corresponding db reading. For instance, a 60-db reading would be 20 db over S-9 (100 uv) or 10,000 uv of signal at the antenna. This reading then is 60 db over the db scale reference of one microvolt and 20 db over the S-9 reference of 100 uv.

d. A-F CIRCUITS

Output from the second i-f amplifier, V5, is coupled from transformer T2 to the grid of CW/SSB product detector, V6A, and to the diodes of V7. Beat-frequency oscillator injection signal is coupled to the cathode of the product detector. Product detector output is filtered and connected to EMISSION switch section S8 where it is selected and fed to the grid of the triode section of V7. The AM. audio signal from one of the V7 diode plates is also connected to S8.

Output from the triode amplifier section of V7 is coupled to the audio output tube, V8, from which it may be fed to phones, speaker, or phone patch by plugging into J6, J8, or J12 respectively.

e. OSCILLATOR CIRCUITS

The receiver contains four oscillators. They are crystal calibrator, crystal oscillator, vfo, and bfo. The 100-kc crystal calibrator, V9, is a type 6DC6 tube. Its output is coupled to the antenna coil, T5. The high-frequency crystal oscillator, V2B, is the pentode section of 6U8A. For high-frequency injection up to 14.955 mc, the oscillator operates on crystal fundamental frequencies. For injection frequencies higher than 14.955 mc, the oscillator doubles the crystal frequency in its plate circuit. Oscillator output is available at J1 for frequency control of companion transmitter such as the 32S-1. Unless this jack is connected to external equipment, the load resistor and plug, P1, is left plugged into J1 to provide proper oscillator plate circuit impedance. The vfo is a 70K-2 Oscillator installed as an integral unit. Its frequency range is 2.5 to 2.7 mc. Oscillator output is fed to the cathode of the second mixer and to the grid of a cathode follower, V3B. The cathode follower (triode section of a 6U8A) isolates the vfo from load variations when a companion transmitter, such as the 32S-1, is connected to it in transceiver service. The bfo is crystal controlled by one of two crystals for CW and SSB signals. If the accessory 0.5-kc CW filter is used, a matched crystal may be installed to produce an 800-cps CW note instead of the 1330-cps note obtained with Y16. EMISSION switch section S9 selects Y16 for CW and USB positions and Y15 for LSB position. Output from the bfo is connected to the product detector and to the BFO TEST jack, J3.

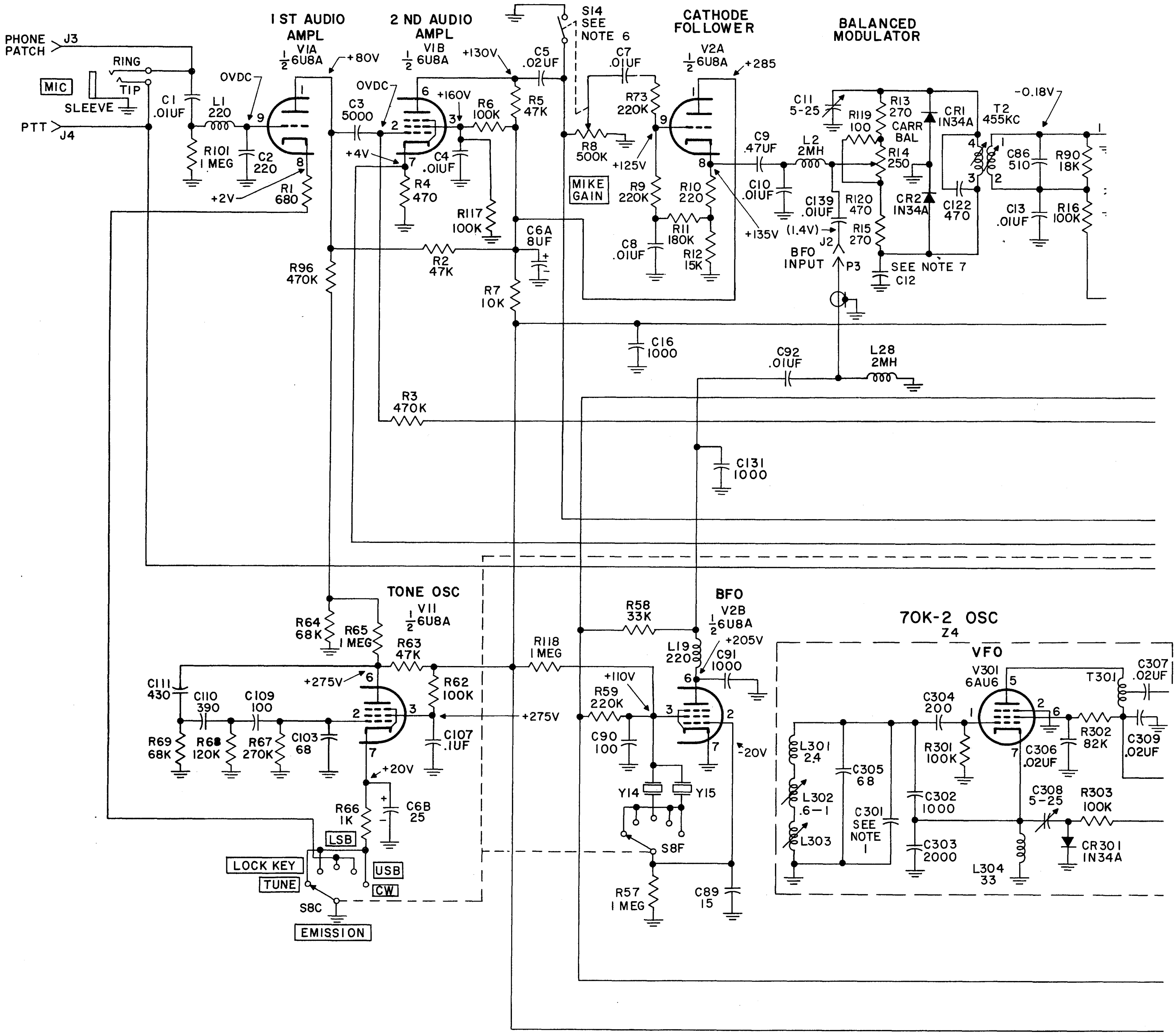
f. POWER SUPPLY

The 75S-1 power supply is self-contained in the receiver and utilizes silicon diodes as rectifiers for lower voltage drop, longer life, and reduced heat. Vacuum tubes are operated at a plate voltage of 150 volts for cooler operation and longer tube life.

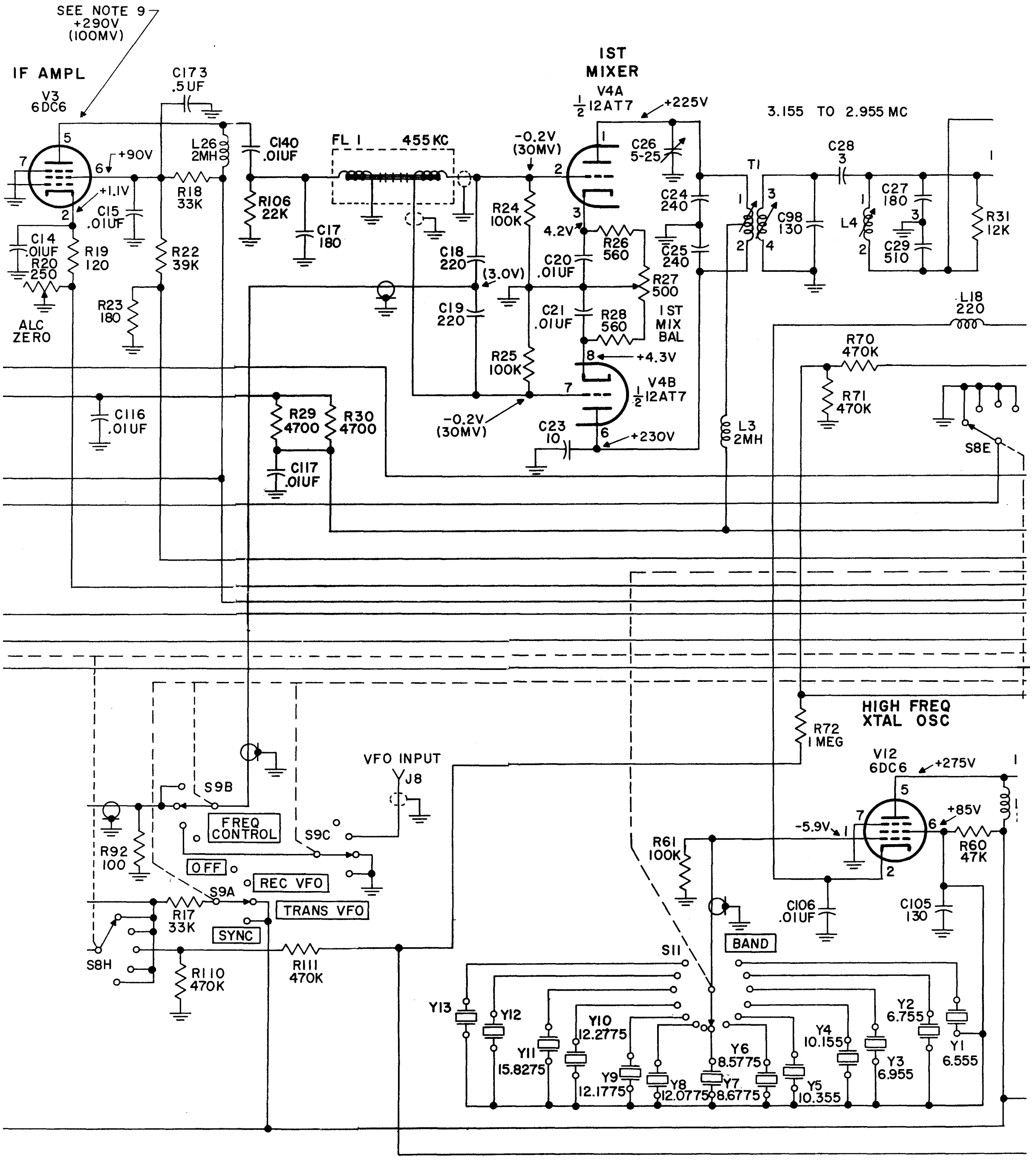
3. 32S-1 TRANSMITTER

The 32S-1 (figure 13-4) is an SSB or CW transmitter with a nominal output of 100 watts for operation on all amateur bands between 3.5 and 29.7 mc. Input power is 175 watts PEP on SSB or 160 watts on CW.

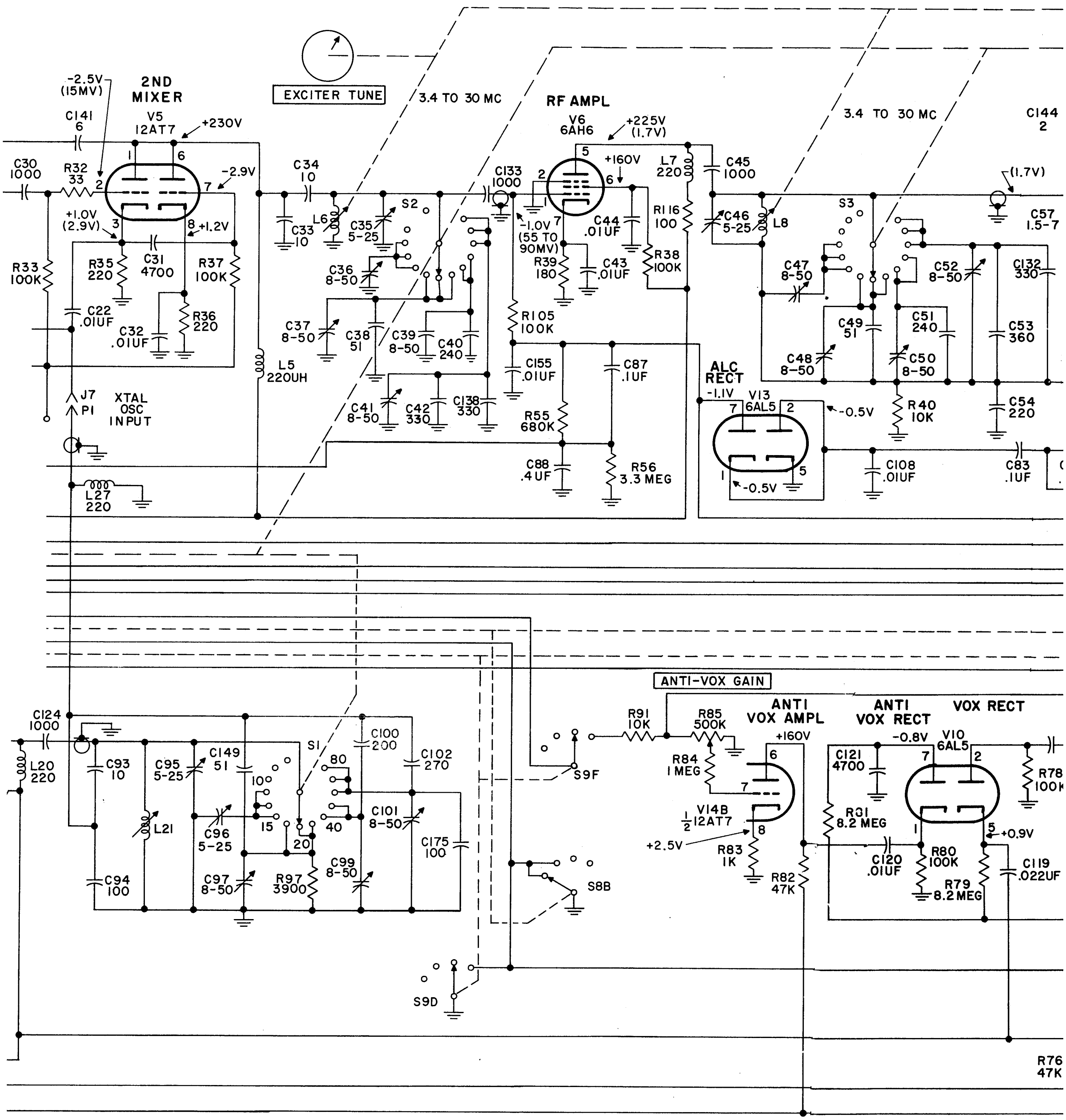
The transmitter can cover 3.5 to 30 mc except for 5.0 to 6.5 mc (the range of the second harmonic of the variable i-f). Crystal sockets, crystals, and band switch positions are provided for ten 200-kc bands, with the standard amateur model equipped as follows: 3.4-3.6, 3.6-3.8, 3.8-4.0, 7.0-7.2, 14.0-14.2, 14.2-14.4, 21.0-21.2, 21.2-21.4, and 21.4-21.6 mc. Crystal sockets and band-switch positions are also provided for three 200-kc bands between 28 and 29.7 mc. The 32S-1 is delivered with one crystal in this range (28.5 to 28.7 mc). A fourteenth position, corresponding to the WWV position on the 75S-1



PHONE PATCH J3
MIC
RING
TIP
SLEEVE
PTT J4
1 ST AUDIO AMPL
V1A 1/2 6U8A
+80V
C1 .01UF
L1 220
OVDC
R101 1 MEG
C2 220
R1 680
+2V
2 ND AUDIO AMPL
V1B 1/2 6U8A
C3 5000
OVDC
+160V
R6 100K
+4V
C4 .01UF
R4 470
R117 100K
+130V
R5 47K
C5 .02UF
S14 SEE NOTE 6
R8 500K
MIKE GAIN
C6A 8UF
R2 47K
R96 470K
R7 10K
C16 1000
R3 470K
CATHODE FOLLOWER
V2A 1/2 6U8A
+285
C7 .01UF
R73 220K
+125V
R9 220K
R10 220
R11 180K
C8 .01UF
R12 15K
+135V
BALANCED MODULATOR
C9 .47UF
L2 2MH
C10 .01UF
C11 5-25
R119 100
R13 270
CARR BAL
R14 250
CR1 IN34A
CR2 IN34A
C139 .01UF
(1.4V)
J2
BFO INPUT
P3
R120 470
R15 270
SEE NOTE 7
C12
C122 470
T2 455KC
-0.18V
C86 510
R90 18K
C13 .01UF
R16 100K
C92 .01UF
L28 2MH
C131 1000
TONE OSC
V11 1/2 6U8A
R64 68K
R65 1 MEG
R63 47K
R62 100K
+275V
C111 430
C110 390
C109 100
R69 68K
R68 120K
R67 270K
C103 68
C107 .1UF
+20V
R66 1K
C6B 25
LSB
USB
LOCK KEY
TUNE
CW
S8C
EMISSION
R118 1 MEG
BFO
V2B 1/2 6U8A
R58 33K
L19 220
+205V
C91 1000
+110V
R59 220K
C90 100
-20V
Y14
Y15
S8F
R57 1 MEG
C89 15
70K-2 OSC
Z4
VFO
V301 6AU6
T301
C307 .02UF
C304 200
L301 2.4
C305 68
R301 100K
C306 .02UF
R302 82K
C309 .02UF
L302 .6-1
L303
C301 SEE NOTE 1
C302 1000
C303 2000
C308 5-25
R303 100K
CR301 IN34A
L304 33

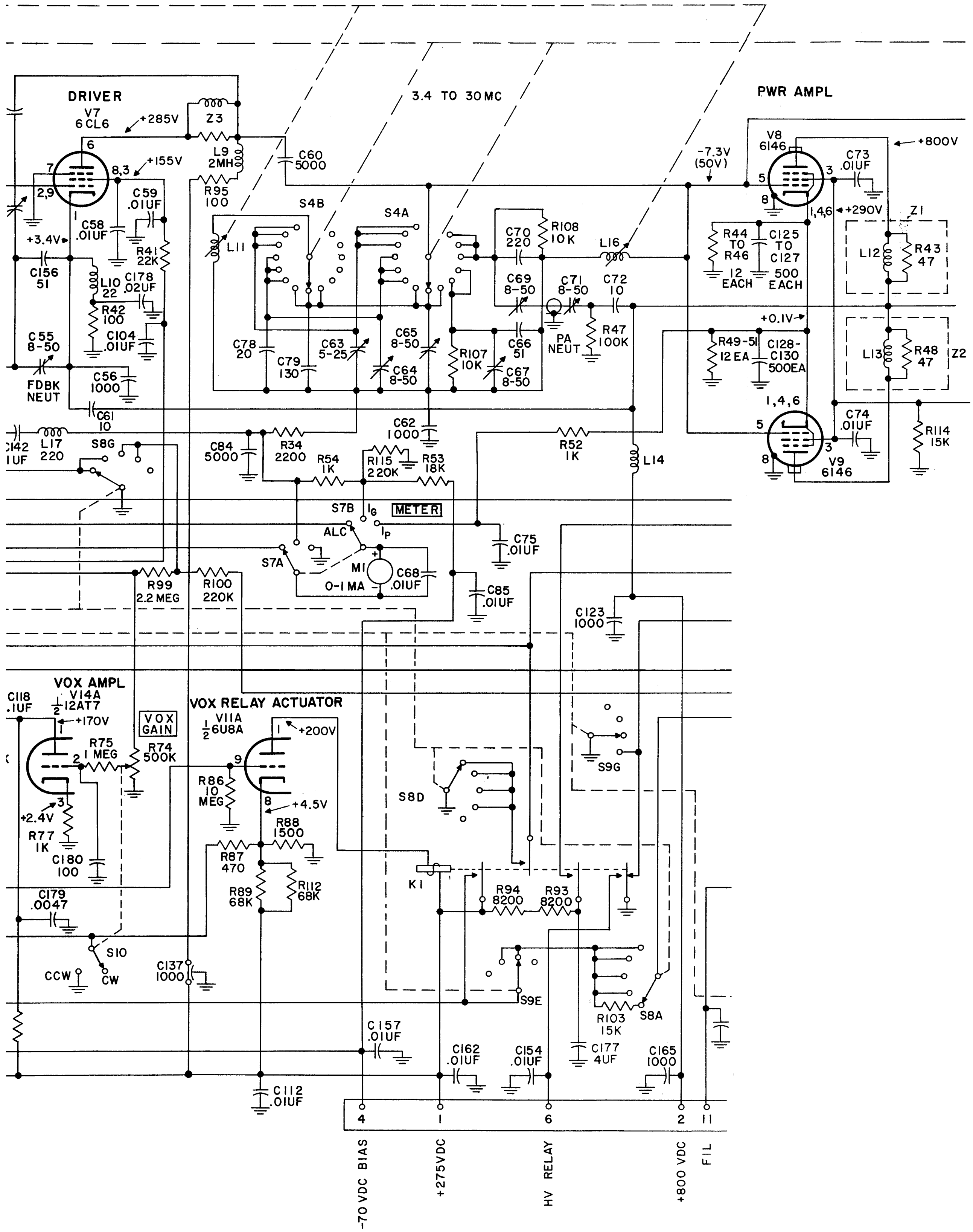


SEE NOTE 9
+290V
(100MV)
IF AMPL
V3
6DC6
C173
.5UF
L26
2MH
C140
.01UF
+90V
+1.1V
R18
33K
C15
.01UF
R106
22K
C14
.01UF
R19
120
R20
250
R22
39K
R23
180
ALC
ZERO
FL 1
455KC
C17
180
C18
220
(3.0V)
C19
220
R24
100K
R25
100K
-0.2V
(30MV)
1ST
MIXER
V4A
1/2 12AT7
+225V
C26
5-25
4.2V
R26
560
C20
.01UF
R27
500
C21
.01UF
R28
560
1ST
MIX
BAL
+4.3V
V4B
1/2 12AT7
C23
10
+230V
C24
240
C25
240
T1
3.155 TO 2.955 MC
C98
130
C28
3
L4
C27
180
C29
510
R31
12K
L3
2MH
L18
220
R70
470K
R71
470K
S8E
C116
.01UF
R29
4700
R30
4700
C117
.01UF
HIGH FREQ
XTAL OSC
R72
1 MEG
V12
6DC6
+275V
+85V
-5.9V
R60
47K
R61
100K
C106
.01UF
C105
130
BAND
S11
VFO INPUT
J8
S9B
FREQ
CONTROL
S9C
OFF
REC VFO
S9A
TRANS VFO
SYNC
R92
100
R17
33K
S8H
R110
470K
R111
470K
Y13
Y12
Y11
15.8275
Y10
12.2775
Y9
12.1775
Y8
12.0775
Y6
8.5775
Y7
8.6775
Y5
10.355
Y4
10.155
Y3
6.955
Y2
6.755
Y1
6.555



NOTES:

1. VALUE OF C301 SELECTED IN FINAL TEST.
2. FREQUENCIES OF CRYSTALS Y12 AND Y13 CHOSEN BY CUSTOMER NOT FURNISHED WITH EQUIPMENT.
3. SWITCH OPEN ONLY IN OFF POSITION.
4. ALL SWITCHES ARE VIEWED FROM KNOB OR DRIVEN END.
5. UNLESS OTHERWISE INDICATED ALL RESISTANCE VALUES ARE IN OHMS, ALL CAPACITANCE VALUES ARE IN UUF, AND ALL INDUCTANCE VALUES ARE IN UH.
6. S14 IS CLOSED WHEN R8 IS IN MAXIMUM COUNTERCLOCKWISE POSITION.
7. SELECTED IN PRODUCTION.
8. THIS DRAWING, CURRENT AS OF 2-19-59.
9. VALUES IN PARENTHESES ARE NOMINAL RF VOLTAGES FOR NORMAL OPERATION.



DRIVER
V7
6CL6
+285V
+155V
Z3
L9
2MH
R95
100
C60
5000
3.4 TO 30MC
S4B
S4A
L11
C59
.01UF
C58
.01UF
+3.4V
R41
22K
C156
51
L10
22
C178
.02UF
R42
100
C104
.01UF
C55
8-50
FDBK
NEUT
C56
1000
C61
10
C78
20
C79
130
C63
5-25
C65
8-50
C64
8-50
C62
1000
C70
220
R108
10K
L16
C69
8-50
C71
8-50
C72
10
PA
NEUT
R47
100K
R107
10K
C66
51
C67
8-50
PWR AMPL
V8
6146
-7.3V
(50V)
C73
.01UF
+800V
+290V
Z1
R44
TO
R46
12
EACH
C125
TO
C127
500
EACH
L12
R43
47
+0.1V
R49-51
12 EA
C128-
C130
500EA
L13
R48
47
Z2
C74
.01UF
R114
15K
V9
6146
L17
220
C142
1UF
S8G
C84
5000
R34
2200
R54
1K
R115
220K
R53
18K
R52
1K
L14
S7B
I_G
METER
ALC
I_P
C75
.01UF
S7A
M1
0-1 MA
C68
.01UF
C85
.01UF
R99
2.2 MEG
R100
220K
C123
1000
VOX AMPL
V14A
½ 12AT7
C118
.1UF
+170V
VOX
GAIN
R75
1 MEG
R74
500K
VOX RELAY ACTUATOR
V11A
½ 6U8A
+200V
R86
10
MEG
+4.5V
R88
1500
R87
470
R89
68K
R112
68K
+2.4V
R77
1K
C180
100
C179
.0047
S10
CCW
CW
C137
1000
S8D
K1
R94
8200
R93
8200
S9G
S9E
R103
15K
S8A
C157
.01UF
C162
.01UF
C154
.01UF
C177
4UF
C165
1000
C112
.01UF
-70 VDC BIAS
+275VDC
HV RELAY
+800 VDC
FIL

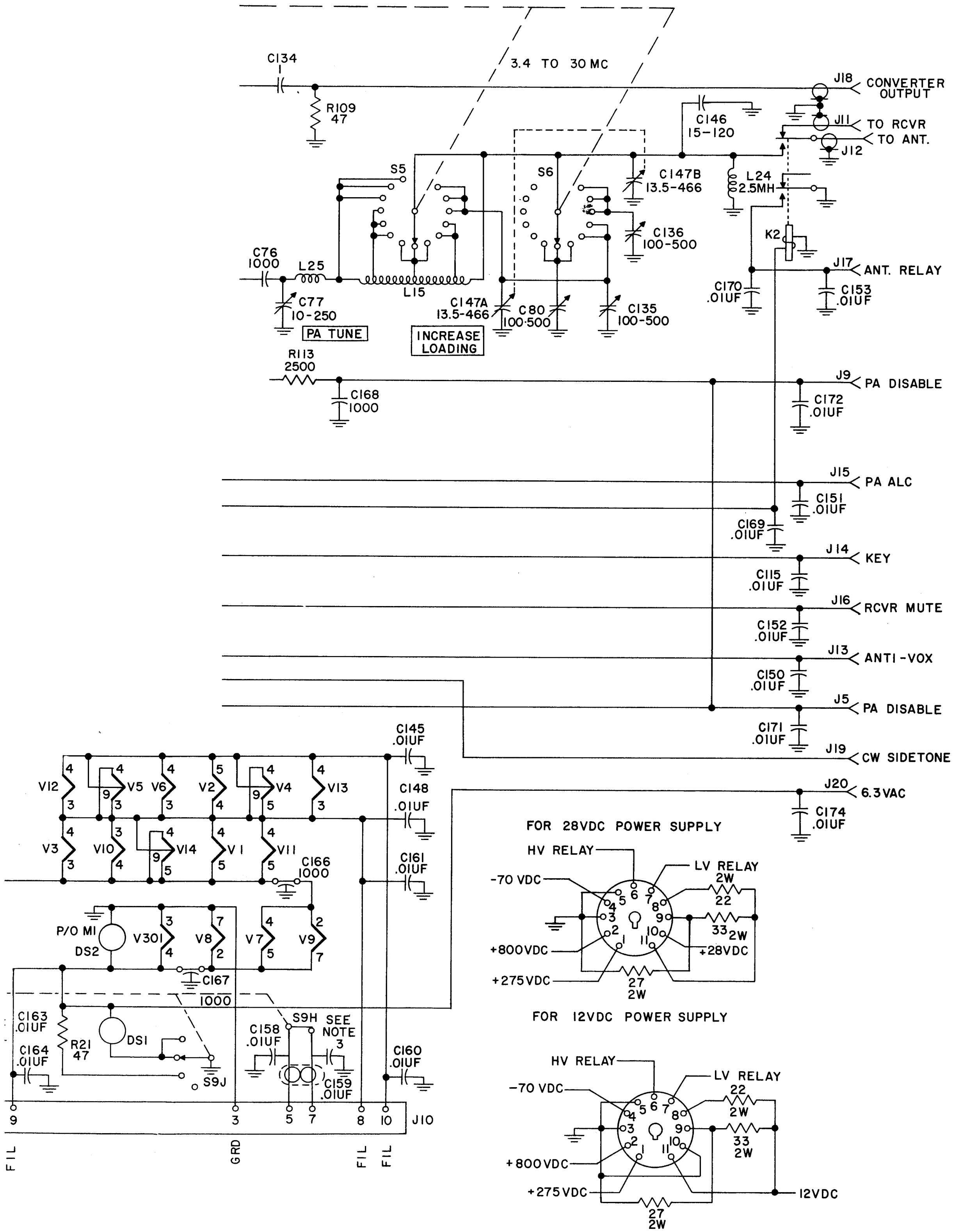


Figure 13-6. 32S-1 Schematic Diagram

The tone oscillator is set at 1350 cps to center the tone in the mechanical filter passband and to place the second harmonic of the tone (2700 cps) out of the filter passband eliminating the possibility of tone modulation. Tone keying also permits two transceivers to work each other on the same CW frequency without leapfrogging across the band (retuning), which would be the case if the carrier were reinserted and keyed. This is because the carrier is ordinarily placed 20 db down on the 2.1-kc mechanical filter skirt, so when the receiving station tunes the CW carrier to center it in the filter passband the transceiver frequency will shift the same amount. The second station would then have to retune to center the incoming signal in the filter passband and, in doing so, would shift frequency when transmitting. Tone keying eliminates this problem.

(2) BEAT-FREQUENCY OSCILLATOR

The bfo is crystal controlled at either 453.650 kc or 456.350 kc, depending upon whether Y14 or Y15 is selected by EMISSION switch section S8F. These crystal frequencies are matched to the passband of the mechanical filter, FL1, so the carrier frequency is placed approximately 20 db down on the skirts of the filter response. This 20-db carrier suppression is in addition to the 30-db suppression provided by the balanced modulator.

(3) VARIABLE-FREQUENCY OSCILLATOR

The vfo is a Colpitts oscillator operating in the range of 2.5 to 2.7 mc. The value of the cathode choke is selected so switching a small trimmer across it shifts the oscillator frequency. This compensates for switching bfo frequency and keeps dial calibration accurate no matter which sideband is selected. Refer to paragraph 3a for additional information on why this is necessary. This vfo switching is done by applying a positive or negative bias to diode CR301. When the diode bias is positive, the diode impedance is lowered, and C308 is effectively in parallel with L304. When the bias is negative, diode impedance is high, and C308 is effectively switched out of the circuit.

(4) HIGH-FREQUENCY CRYSTAL OSCILLATOR

The high-frequency crystal oscillator, V12, is crystal controlled by one of 13 crystals selected by BAND switch S11. Output from the high-frequency crystal oscillator is fed to the second mixer. This frequency is always 3.155 mc higher than the lower edge of the desired transmit band. This high-frequency injection signal is crystal fundamental frequency for all desired output signals below 12 megacycles, but for operating frequencies higher than 12 megacycles, the crystal frequency is doubled in the plate circuit of the oscillator.

h. SYNC OPERATION

To zero the 32S-1 to the same frequency as the 75S-1 receiver, set both the transmitter and receiver to the same sideband, and set the receiver to STDBY (so the transmitter controls receiver muting). Slowly tune the transmitter vfo until the beat note sounds like a canary chirping. When the frequency of chirps is two or three per second, the transmitter is zero beat with the receiver within two or three cycles per second. This operation involves a closed-circuit feedback loop in which the transmitter output signal is fed into the receiver. Receiver output is fed back into the transmitter speech amplifier. The feedback tone will begin to chirp as the transmitter vfo frequency approaches the receiver frequency with the number of chirps indicating the number of cycles from zero beat. At exact zero beat there would be no beat note feedback. This feedback method of frequency spotting is much more accurate than ordinary zero beating.

i. TRANSCEIVER OPERATION WITH THE 75S-1 RECEIVER

Since both the 32S-1 and 75S-1 use the same frequency-generating scheme it is possible to use the receiver high-frequency crystal oscillator and vfo to control the transmitter in transceiver operation. Whe the 32S-1 and 75S-1 are connected together in transceiver service and the FREQ CONTROL switch is in REC VFO position, the transmitter frequency is controlled by the receiver vfo. Both receiver and transmitter must have band switches set to the same position for proper r-f coil selection. Both units must be set to the same sideband, otherwise bfo injection frequencies would be incorrect. If the transmitter FREQ CONTROL switch is set to the TRANS VFO position, the two units may operate on different frequencies within the same 200 kc band. Again, both units must be set to the same band as the receiver high-frequency crystal oscillator is still controlling the transmitter.

4. KWM-1 TRANSCEIVER

The KWM-1 (figure 13-7) receives or transmits (on the same frequency) SSB or CW signals in the 14- to 30-mc range. The KWM-1 transmits on upper sideband with an input of 175 watts PEP. The bands are covered in 100-kc segments with a total of ten segments available. A box that plugs into the front panel contains the ten injector oscillator crystals. For other selections than the amateur bands, extra

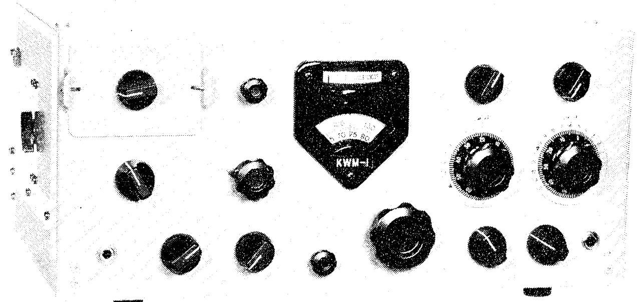


Figure 13-7. KWM-1 Transceiver

crystal boxes with the proper crystal complement are used. The front panel meter acts as an S-meter on receive and as the tuning meter on transmit. A 100-kc crystal calibrator is included for frequency reference.

Figure 13-8 is a block diagram of the KWM-1. Transmit signal paths are shown in heavy solid lines, receive signal paths in heavy dashed lines, and control circuits in light dashed lines. Figure 13-12 is the schematic diagram of KWM-1. The 516E-1 and 516E-2 D-C Power Supplies and the 516F-1 A-C Power Supply (refer to paragraph 10, power supplies) are used with the KWM-1.

a. RECEIVE-TRANSMIT COMMON CIRCUITS

Circuits common to both receive and transmit functions are receive-transmit amplifier V4 and its tunable grid and plate circuits. (These are gang tuned with other circuits tuned by EXCITER TUNE control on front panel.)

(1) The 3.9- to 4.0-mc band-pass i-f transformer, T1.

(2) Mechanical filter FL1.

(3) High-frequency oscillator V11.

(4) Beat-frequency oscillator V9.

(5) Variable-frequency oscillator V22.

(6) Control circuits.

b. RECEIVE CIRCUITS

(1) R-F CIRCUITS

Signals from the antenna are connected from J5-A1 through contacts of relays K1 and K2 to the grid of r-f amplifier V4. Grid circuit (L1, C13, and C15) and plate circuit (L3, C10, and C21) are tracked and ganged to the EXCITER TUNE control on front panel. Output from V4 and high-frequency oscillator signal from V11 are fed to the first receiver mixer, V7.

(2) I-F CIRCUITS

Difference frequency (3.9 to 4.0 mc) is coupled through i-f transformer T1 to the receiver second mixer, V8. The 3.9- to 4.0-mc signal is mixed with the 3.445- to 3.545-mc vfo signal in V8 to produce the 455-kc i-f signal. This i-f signal is coupled through the mechanical filter, FL1, to the grid of the receiver i-f amplifier, V13. A two-stage i-f strip, consisting of V13 and V14, amplifies the 455-kc signal and applies it to the agc rectifier, V12A, and the product detector, V15.

(3) A-F CIRCUITS

Beat-frequency oscillator signal is applied to the product detector which mixes the two signals to produce a demodulated audio signal. The audio signal is filtered by L17, C86, C89, C88, and C77 and amplified by V16A and V17 for application to phone patch, speaker, and headphone circuits. Negative voltage, developed by V12A, provides automatic gain control to receiver amplifier circuits. The R.F. GAIN control, R116, is used to set the level of operating gain for all receiver r-f and i-f amplifier stages. Audio output level is controlled by A.F. GAIN control R79.

c. TRANSMIT CIRCUITS

(1) A-F CIRCUITS AND SSB GENERATION

Microphone signal is amplified by V19A and V19B and applied to cathode follower V18A. Signal level applied to the cathode follower is controlled by MIC. GAIN control R92. Output from the cathode follower is filtered (by L18, C96, and C98) and applied to the diode-ring balanced modulator (CR1 through CR4) consisting of four matched 1N67 diodes. Carrier energy is supplied from the bfo through an isolation stage, V18B, to the balanced modulator. Output of the balanced modulator (with carrier balanced out) is applied to mechanical filter FL1 which passes only the lower sideband energy to the first transmit mixer, V6.

(2) R-F CIRCUITS

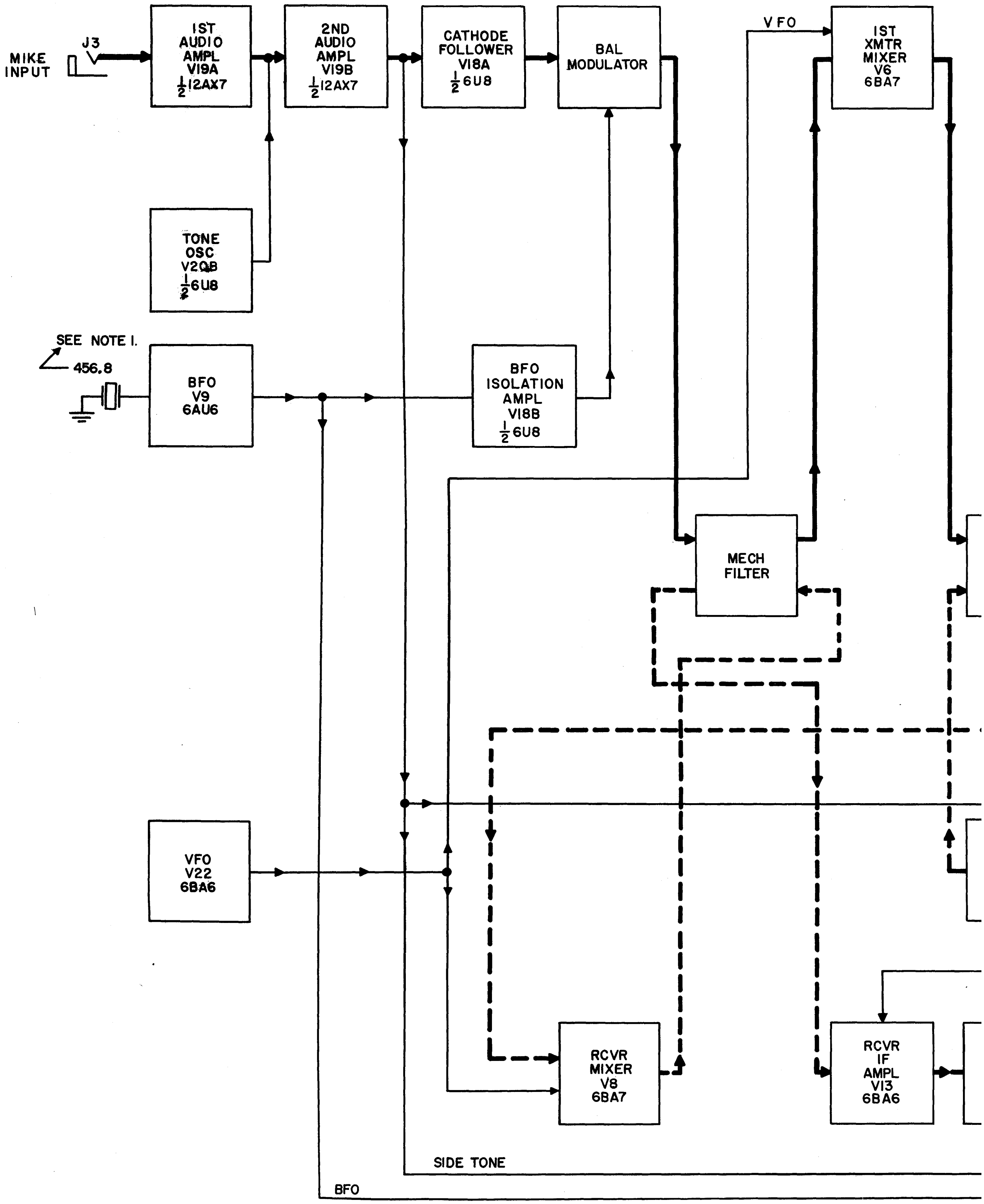
Mixer V6 combines the 455-kc sideband signal and the 3.455- to 3.545-mc vfo signal to produce a 3.9- to 4.0-mc output. The 3.9- to 4.0-mc signal is amplified by V3 and applied to second transmit mixer V5. Tuned circuits T1 and T2 are band-pass transformers. Mixer V5 combines the 3.9- to 4.0-mc signal with the high-frequency oscillator signal and inverts the sideband to produce the desired upper sideband output frequency. This output signal is amplified by V4 and V2 and applied to the final amplifier. Both driver, V2, and final amplifier, V23 and V24, stages are neutralized by the capacity-bridge method, and negative feedback is coupled to the cathode of the driver to improve linearity. The pi-L power-output circuit consists of C42, L10, L11, C43 and C44, and L12. The pi-L network matches 50-ohm load provided the load has a vswr not exceeding 2:1. Output power is connected from L12 through contacts of K1 and connector J5-A1 to the antenna.

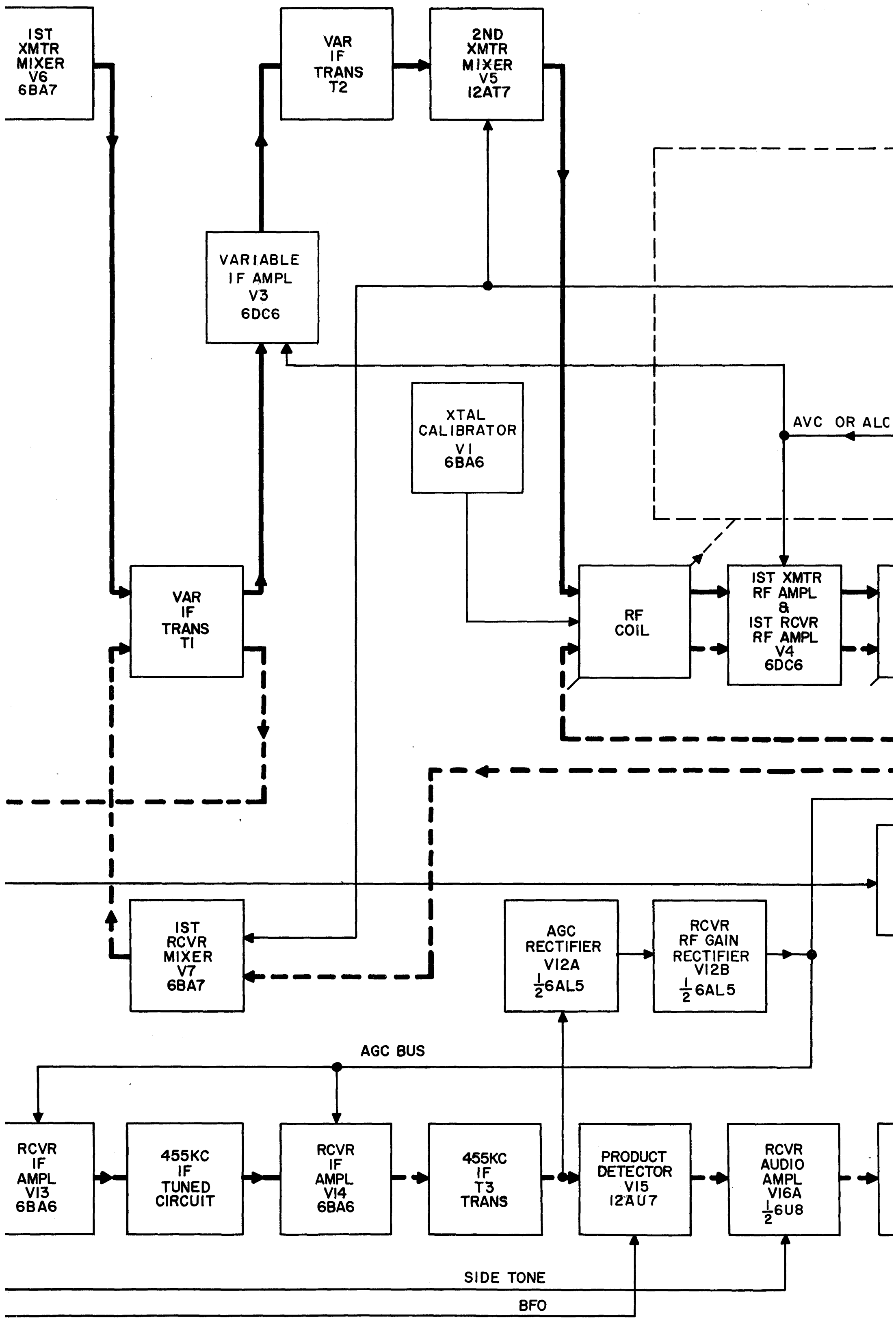
d. CONTROL CIRCUITS

Figure 13-9 shows vacuum-tube control circuits, and figure 13-10 shows relay and switching circuits.

(1) VOX AND ANTITRIP CIRCUITS

Vox and antitrip circuits operate as follows: A portion of the audio voltage developed across R93 (in output of V19B) is amplified by V20A and rectified by V21A. The positive d-c output of V21A is applied to the grid of V16B causing V16B to conduct current and actuate vox relay K2. Contacts of K2 switch the high-voltage plate power supply into operation (on d-c supply only; these contacts are jumpered in the a-c supply), disconnect the antenna from V4 grid, and energize relays K1 and K3. Relay K1 switches meter M1 from receiver S-meter circuits to transmitter multimeter circuits and switches antenna connections


MIKE INPUT
J3
1ST AUDIO AMPL V19A ½12AX7
2ND AUDIO AMPL V19B ½12AX7
CATHODE FOLLOWER V18A ½6U8
BAL MODULATOR
VFO
1ST XMTR MIXER V6 6BA7
TONE OSC V20B ½6U8
SEE NOTE I.
456.8
BFO V9 6AU6
BFO ISOLATION AMPL V18B ½6U8
MECH FILTER
VFO V22 6BA6
RCVR MIXER V8 6BA7
RCVR IF AMPL V13 6BA6
SIDE TONE
BFO


IST XMTR MIXER V6 6BA7
VAR IF TRANS T2
2ND XMTR MIXER V5 12AT7
VARIABLE IF AMPL V3 6DC6
XTAL CALIBRATOR V1 6BA6
AVC OR ALC
VAR IF TRANS T1
RF COIL
IST XMTR RF AMPL & IST RCVR RF AMPL V4 6DC6
IST RCVR MIXER V7 6BA7
AGC RECTIFIER V12A 1/2 6AL5
RCVR RF GAIN RECTIFIER V12B 1/2 6AL5
AGC BUS
RCVR IF AMPL V13 6BA6
455KC IF TUNED CIRCUIT
RCVR IF AMPL V14 6BA6
455KC IF T3 TRANS
PRODUCT DETECTOR V15 12AU7
RCVR AUDIO AMPL V16A 1/2 6U8
SIDE TONE
BFO

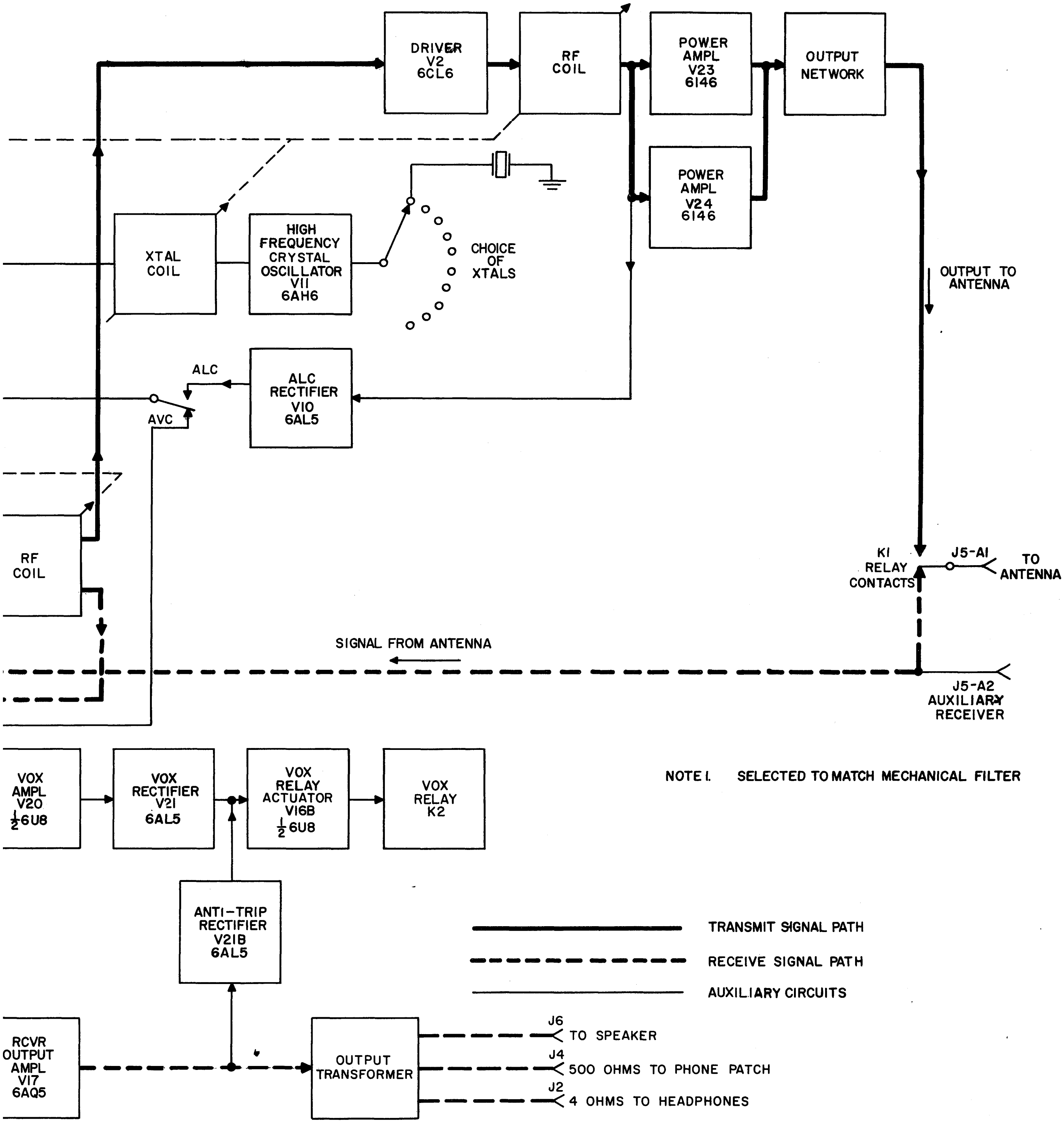


Figure 13-8. KWM-1 Block Diagram

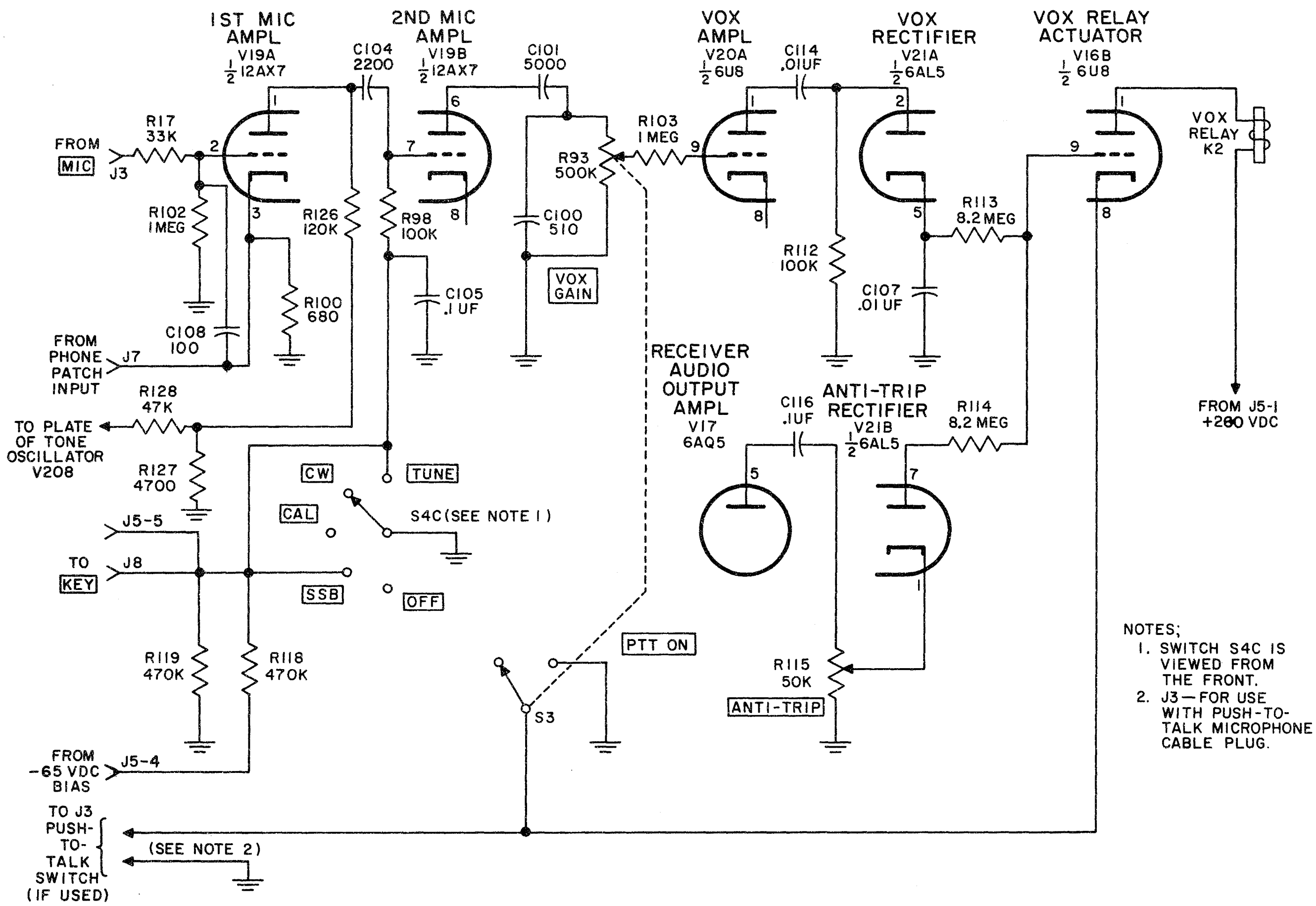


Figure 13-9. KWM-1 Vacuum-Tube Control Circuits

so that receiver input is grounded and transmitter output is connected from L12 to the antenna through J1. Relay K3 applies screen voltage to the power amplifier, and plate voltage to V18A turns on transmitter tubes (V2, V5, V6, and V18B) and turns off receiver tubes (V7, V8, V12, V13, V14, and V15).

The antitrip circuit provides a threshold voltage to prevent loud-speaker output (picked up by the microphone circuits) from tripping the KWM-1 into transmit function. Some of the receiver audio output voltage is connected through C116 and R115 to the antitrip rectifier (21). Negative d-c output voltage from V21B, connected to the grid of V16B, provides the necessary antitrip threshold. ANTITRIP control R115 adjusts the value of the antitrip threshold so that loudspeaker will not produce enough positive d-c output from the vox rectifier to exceed the negative d-c output from V21B and cause V16B to actuate K2. However, speech energy into the microphone will cause the positive vox voltage to overcome the negative antitrip voltage and produce the desired action of K2.

(2) MANUALLY OPERATED SWITCHES

VOX GAIN control R93 is ganged mechanically to switch S3 which may be used for transmit-standby manual control if desired. When R93 is turned down through minimum, S3 closes and shorts the cathode of V16B to ground, causing the tube to conduct and actuate the switching relays. (Refer to figure 13-9.) As the EXCITER TUNE control is adjusted near 14.0 mc, 21.0 mc, or 30.0 mc, S5 connects pins 15, 16, or 17 (respectively) of J5 to ground to operate any desired combination of antenna selecting relays (see figure 13-11). Crystal selector switch S1 selects the proper crystal for high-frequency oscillator V11 to put the KWM-1 in the desired 100-kc portion of its operating range. Switch S2 selects metering function for M1 when the EMISSION SWITCH S4 is in SSB, CW, or TUNE position.

EMISSION SWITCH section S4A applies PA screen voltage through PA SCREEN switch S6 in all positions except OFF. In TUNE position, the screen voltage is reduced through a voltage divider R154 and R155. Section S4B turns on crystal calibrator V1 in

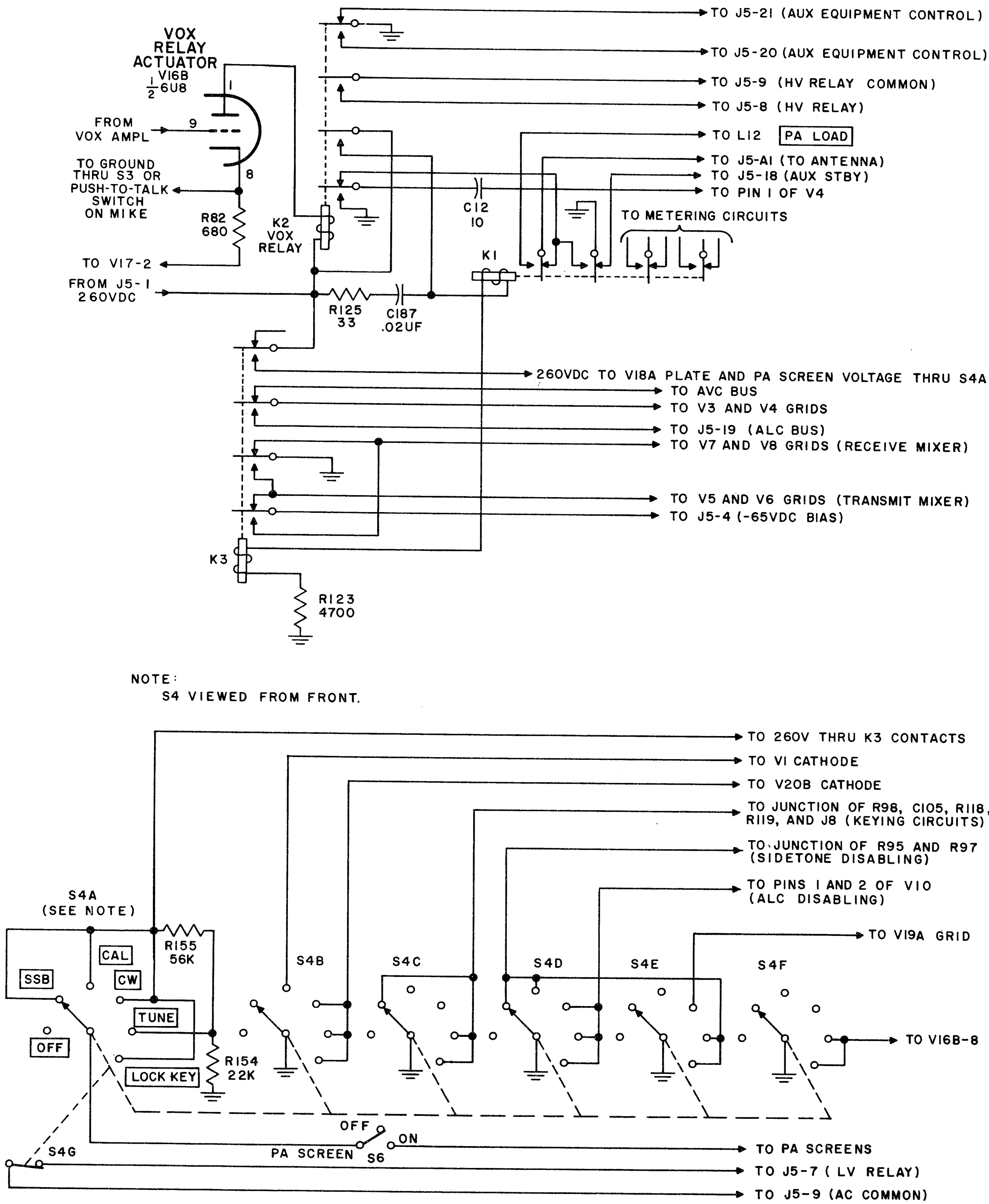


Figure 13-10. KWM-1 Relay and Switch Control Circuits

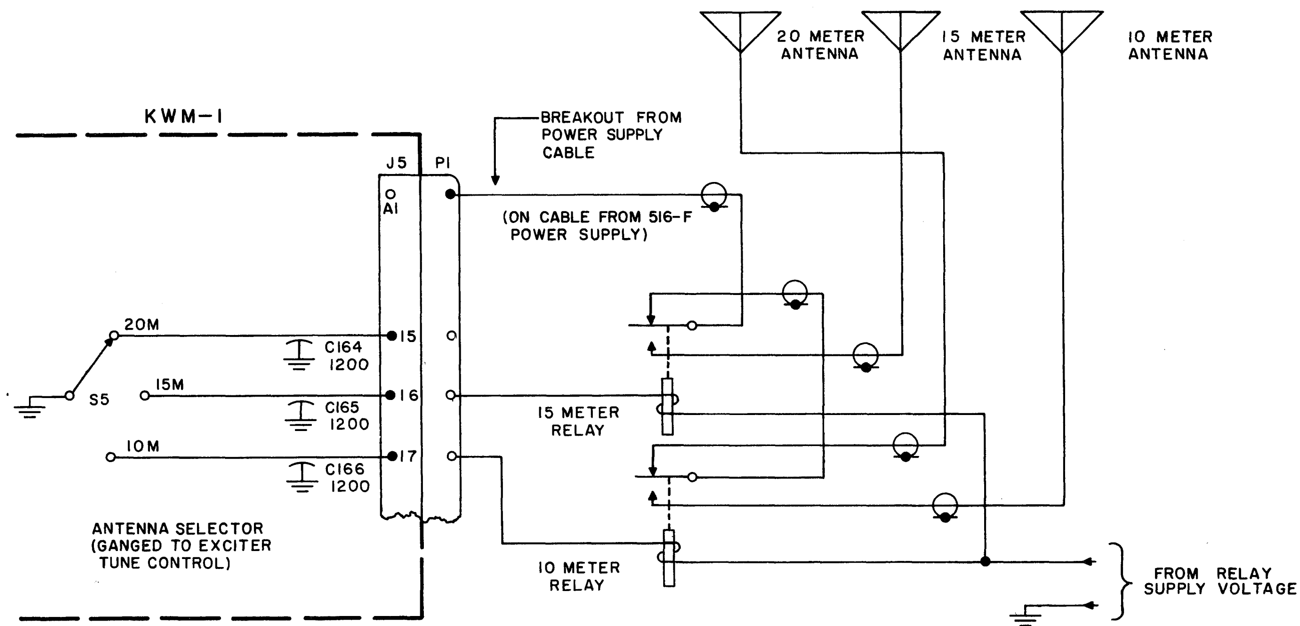


Figure 13-11. KWM-1 Antenna Switching Circuit

CAL position and turns on tone oscillator V20B in CW and TUNE positions. Section S4C removes cutoff bias from V19B when in SSB, TUNE, and LOCK KEY positions. Section S4D reduces input of V18A and V16A when in SSB and CAL positions and grounds alc voltage in CW, TUNE, and LOCK KEY positions. Switch S4G, mounted on rear of S4, turns on all low-voltage supplies in all positions except OFF.

e. OSCILLATOR CIRCUITS

The crystal-controlled bfo provides 455-kc (nominal frequency) carrier to the balanced modulator and bfo injection to the frequency product detector. Its crystal is selected to fall at the -20-db point on the high-frequency skirt of the mechanical filter band pass. The vfo is a series-tuned type circuit. Its operating frequency of 3.445 to 3.545 mc is controlled by a permeability-tuned coil. The high-frequency oscillator, V11, is crystal controlled by one of ten crystals selected by the crystal selector switch on the front panel. These crystals may be selected to operate at any frequency in the operating range. The tone oscillator, V20B, is an RC phase shift type which supplied a 1-kc tone for tuneup and CW operation. The 100-kc crystal calibrator, V1, supplies calibration check points for calibrating the receiver dial.

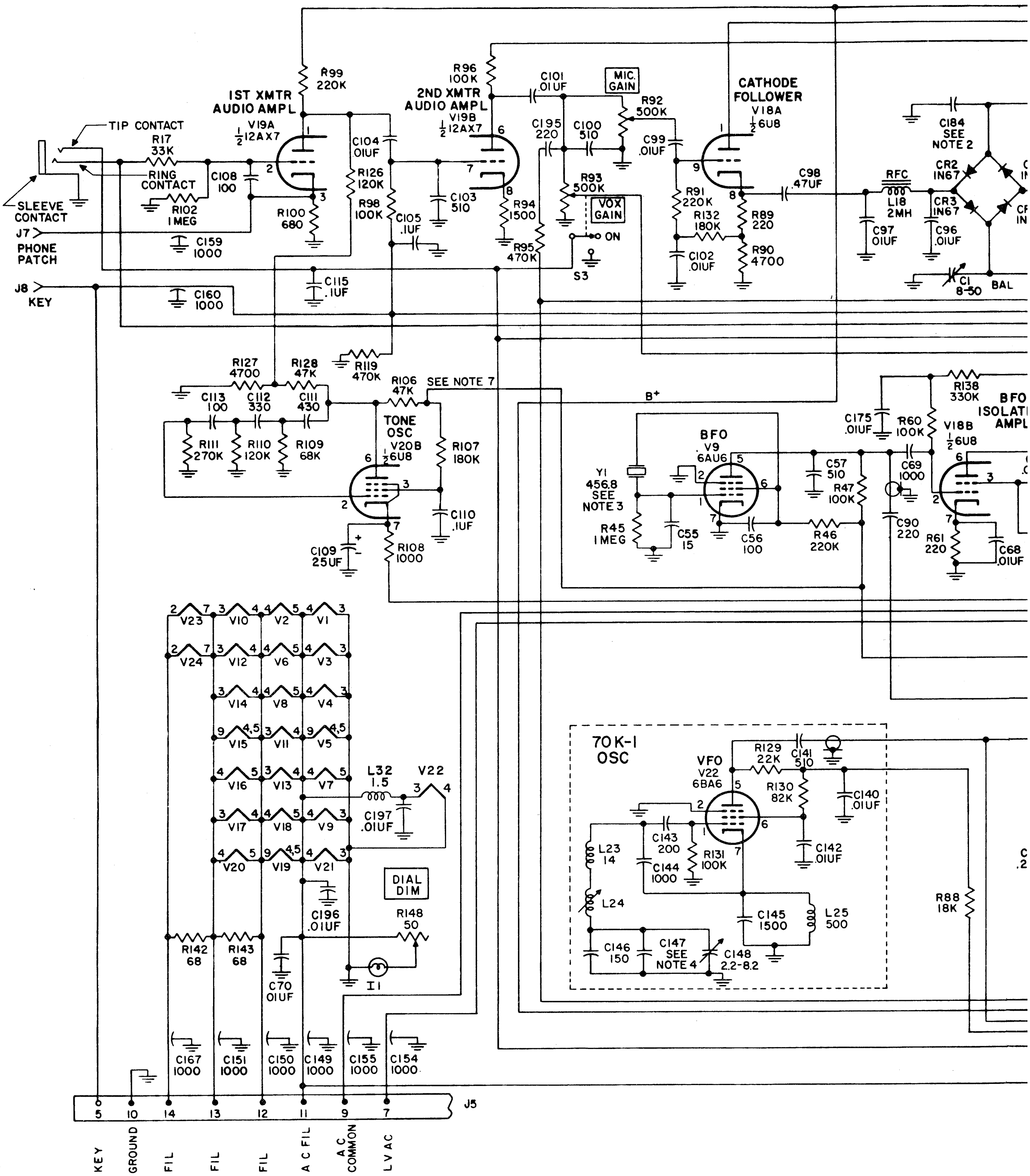
5. KWM-2 TRANSCEIVER

Refer to figure 13-14, block diagram of the KWM-2. The KWM-2 (figure 13-13) is an SSB or CW transceiver operating in the range between 3.4 and 29.7 mc. It consists of a double-conversion receiver and a double-conversion exciter-transmitter, with an input of 175 watts PEP. The transmitter and receiver circuits use common oscillators, common mechanical filter, and common r-f amplifier. The transmitter low-frequency i-f and the receiver low-frequency i-f is 455 kc. The high-frequency i-f for both is 2.955 to 3.155 mc. This is a band-pass i-f which accommodates the full 200-kc bandwidth. Figure 13-15 is a schematic diagram of the KWM-2. Figure 13-32 is a schematic diagram of the 516F-2 A-C Power Supply. The 516E-1 and 516E-2 D-C Power Supplies also can be used with the KWM-2. Refer to paragraph 10 for additional information on these power supplies.

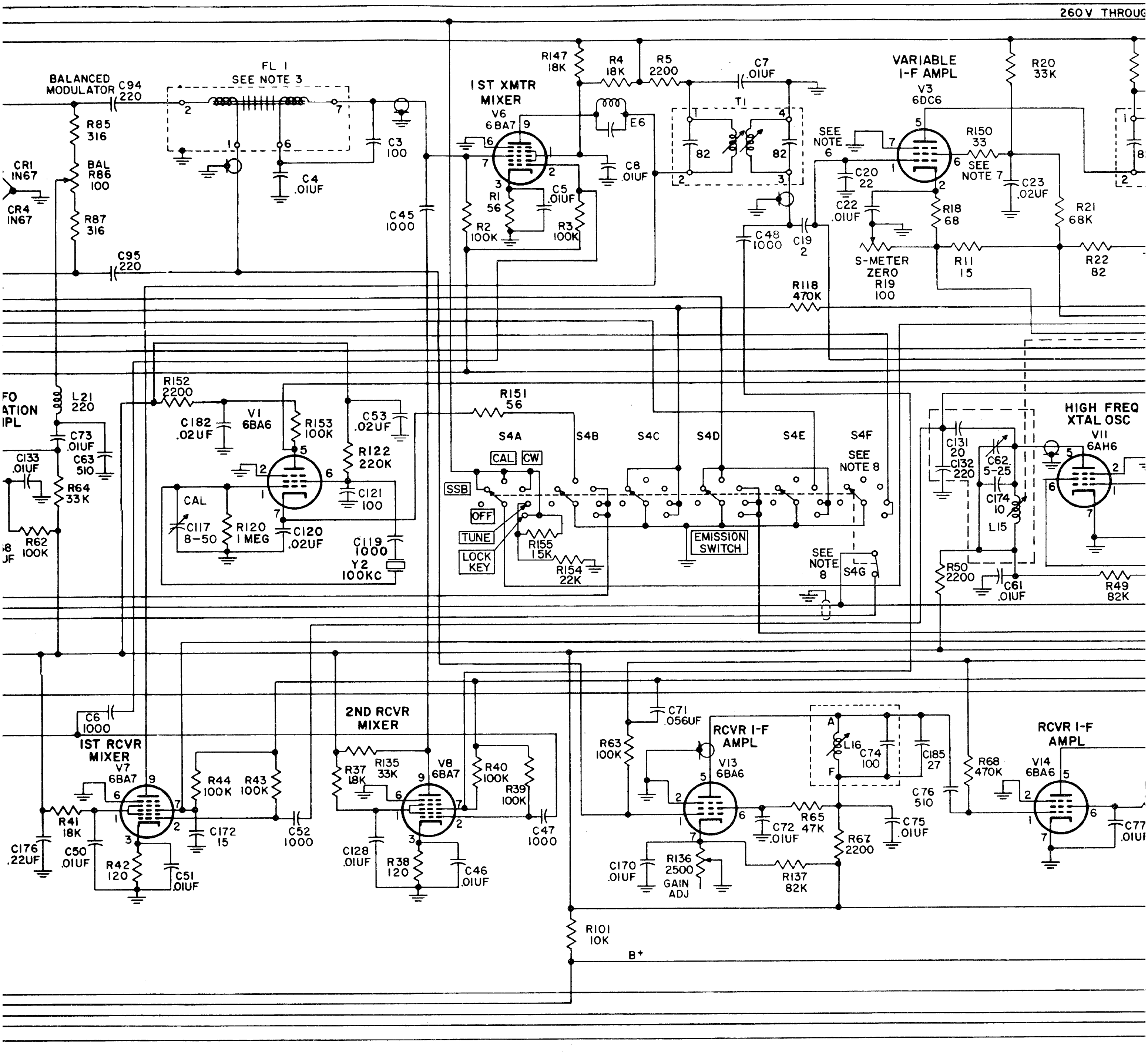
a. FREQUENCY-CONVERSION DATA

(1) RECEIVE

To illustrate the frequency-conversion scheme used with the KWM-2, during the receive condition, assume one wishes to listen to a lower sideband signal being transmitted at 3.9 mc. The KWM-1 band switch is set at 3.8 (band 3A) and the dial reads 100 (3.8 plus 100 on the dial, or 3.9 mc). This means the suppressed carrier frequency of the incoming lower sideband signal is 3.9 mc, with a voice band extending 2.4 kc lower in frequency (3.9000 down to 3.8976 mc). This is because the optimum speech range necessary for communications work is from 300 to 2400 cps (2.1 kc); however, frequencies from 0 to 2400 cps can be transmitted. By placing the carrier 20 db down on the filter skirt of a 2.1-kc mechanical filter, the undesired lower 300 cps can be attenuated. Higher speech frequencies above 2400 cps will also be attenuated by the opposite filter skirt so that the optimum speech range (300 to 2400 cps) is passed by the filter.

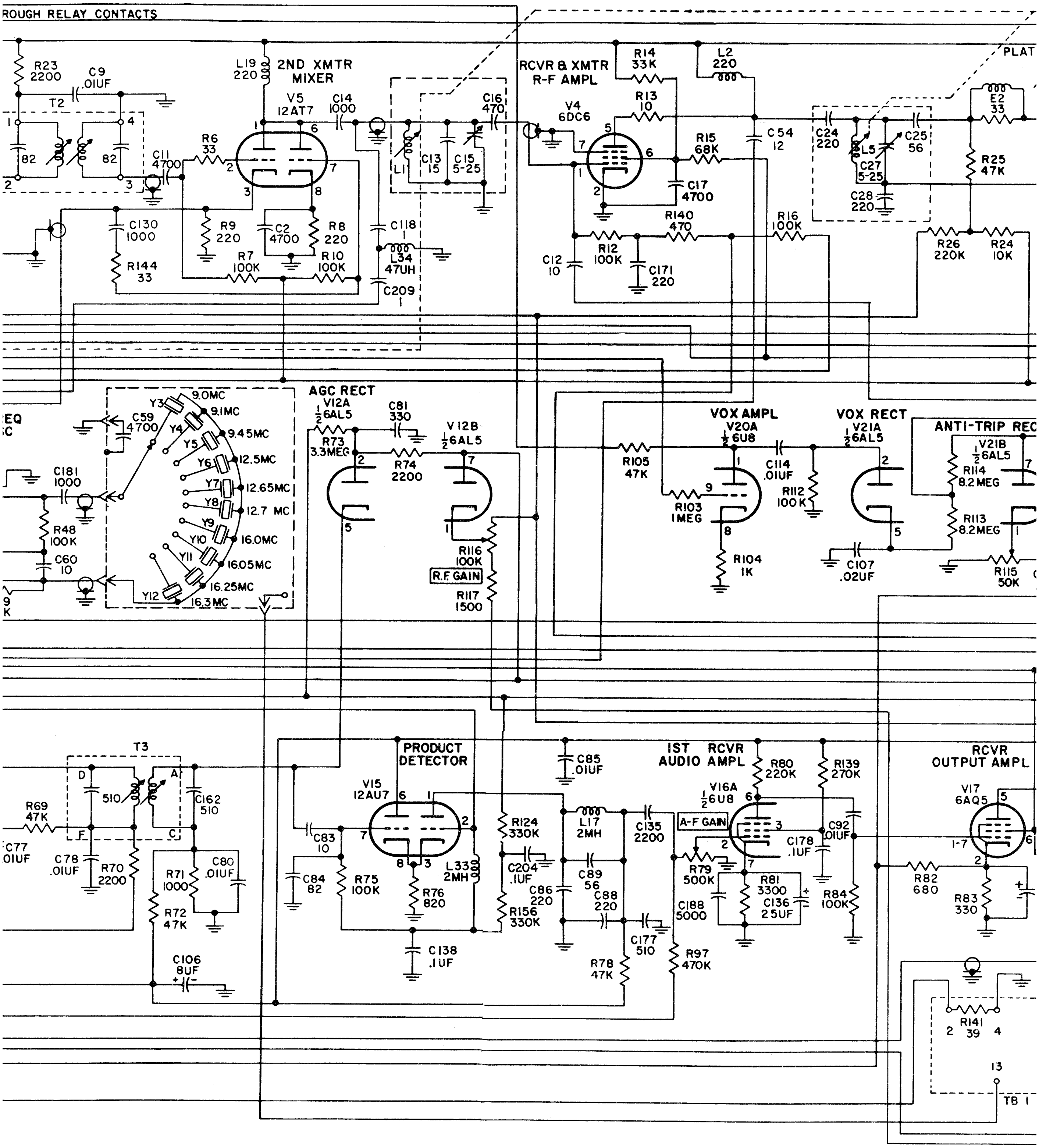


1ST XMTR AUDIO AMPL
V19A ½ 12AX7
2ND XMTR AUDIO AMPL
V19B ½ 12AX7
CATHODE FOLLOWER
V18A ½ 6U8
TIP CONTACT
RING CONTACT
SLEEVE CONTACT
J7 PHONE PATCH
J8 KEY
R17 33K
R99 220K
R96 100K
C101 .01UF
MIC. GAIN
R92 500K
C195 220
C100 510
C99 .01UF
C104 .01UF
C108 100
R102 1MEG
R126 120K
R98 100K
R100 680
C103 510
R94 1500
R93 500K
VOX GAIN
ON
S3
C105 .1UF
R95 470K
C159 1000
C115 .1UF
C160 1000
R91 220K
R132 180K
R89 220
R90 4700
C102 .01UF
C98 .47UF
RFC L18 2MH
C97 .01UF
CR3 1N67
C96 .01UF
C184 SEE NOTE 2
CR2 1N67
C1 8-50
BAL
R119 470K
R127 4700
R128 47K
R106 47K
SEE NOTE 7
C113 100
C112 330
C111 430
TONE OSC
V20B ½ 6U8
R111 270K
R110 120K
R109 68K
R107 180K
C110 .1UF
C109 25UF
R108 1000
B+
BFO V9 6AU6
Y1 456.8 SEE NOTE 3
R45 1MEG
C55 15
C56 100
C57 510
R47 100K
R46 220K
C175 .01UF
R60 100K
C69 1000
C90 220
R138 330K
V18B ½ 6U8
BFO ISOLATI AMPL
R61 220
C68 .01UF
V23 V10 V2 V1
V24 V12 V6 V3
V14 V8 V4
V15 V11 V5
V16 V13 V7
L32 1.5
V22
C197 .01UF
V17 V18 V9
V20 V19 V21
DIAL DIM
C196 .01UF
R148 50
I1
R142 68
R143 68
C70 .01UF
70K-1 OSC
VFO V22 6BA6
R129 22K
C141 510
R130 82K
C140 .01UF
C143 200
C144 1000
R131 100K
C142 .01UF
L23 14
L24
C145 1500
L25 500
C146 150
C147 SEE NOTE 4
C148 2.2-8.2
R88 18K
C167 1000
C151 1000
C150 1000
C149 1000
C155 1000
C154 1000
J5
5 10 14 13 12 11 9 7
KEY
GROUND
FIL
FIL
FIL
AC FIL
AC COMMON
LV AC



NOTES:

1. 6-12 OHM RESISTORS IN PARALLEL, 6-.0047UF CAP, 1 ACROSS EACH 12 OHM RESISTOR.
2. C184 SELECTED IN MANUFACTURE. DO NOT CHANGE VALUE UNLESS FILTER FL-1 IS CHANGED.
3. IF FILTER FL-1 NEEDS REPLACEMENT, REPLACE FL-1 AND CRYSTAL Y1 AS A MATCHED SET.
4. SELECTED FOR FREQ. COMPENSATION AT FACTORY.



5. UNLESS OTHERWISE INDICATED ALL RESISTANCE VALUES ARE IN OHMS, ALL CAPACITANCE VALUES ARE IN MICROMICROFARADS, AND ALL INDUCTANCE VALUES ARE IN MICROHENRIES.
6. C20 IS SELECTED IN MANUFACTURE.
7. IN SOME EARLY MODELS; R107 IS 100K AND R106 IS CONNECTED TO 100 V B+ BUS, R150 IS NOT USED.
8. NOT INCLUDED IN SOME EARLY MODELS. S4G CLOSED IN ALL POSITIONS OF EMISSION SWITCH, EXCEPT OFF.
9. TERM. 21 & 22 OF J5 ARE JUMPERED IN CONNECTING PLUG.

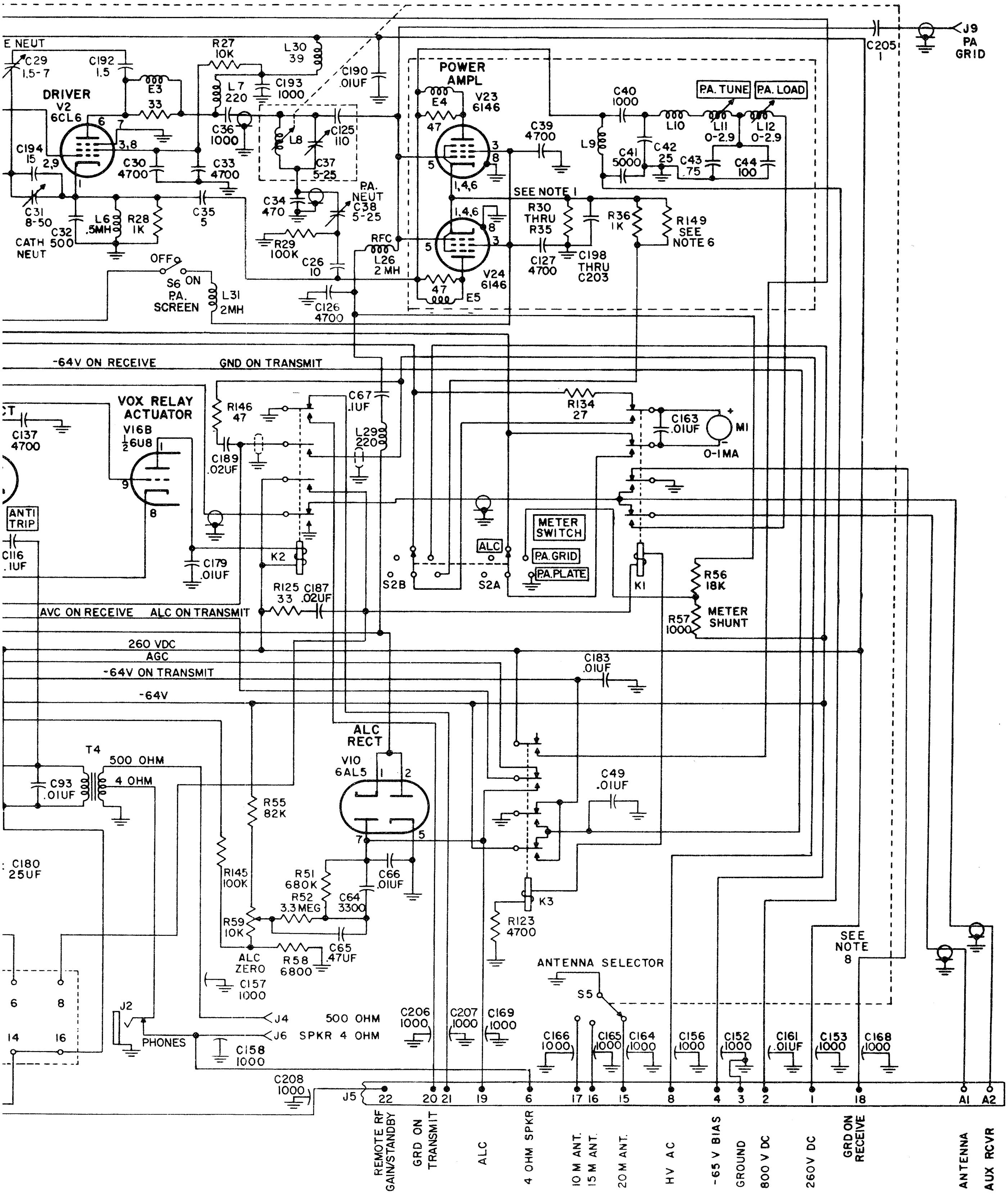


Figure 13-12. KWM-1 Schematic Diagram

Figure 13-13. KWM-2 Transceiver

The high-frequency-conversion oscillator, V13A, is crystal controlled by Y3 at 6.955 mc. Subtractive mixing in V13B inverts the incoming lower sideband signal (6.9550 - 3.9000 = 3.0550 mc; 6.9550 - 3.8976 = 3.0574 mc) so the signal, as far as the remainder of the transceiver is concerned, is upper sideband. The 3.055-mc variable i-f carrier frequency is mixed with the 70K-2 Oscillator frequency of 2.601350 mc, which gives a low-frequency i-f suppressed carrier signal of 453.650 kc. This places the suppressed carrier at the -20-db point on the low-frequency skirt of the 455-kc mechanical filter passband, FL1, and centers the desired 300- to 2400-cps portion of the signal in the 2.1-kc filter passband. To detect the audio from this i-f signal in the product detector V15B, the bfo V11A must inject a carrier (at 453.650 kc, the i-f suppressed carrier frequency) generated by crystal Y16. The bfo signal is filtered out of the product detector output and the audio signal is fed to amplifiers V16A and V16B.

To receive a 3.9-mc upper sideband signal, the suppressed carrier remains the same (3.9 mc) with the 2.4-kc speech bandwidth extending from 3.9000 mc to 3.9024 mc. Subtractive mixing in V13B inverts the incoming upper sideband signal (6.9550-3.9000 mc = 3.0550 mc; 6.9550-3.9024 mc = 3.0526 mc) so that the signal, as far as the remainder of the transceiver is concerned, is lower sideband. The 3.055-mc variable i-f carrier frequency is mixed with the 70K-2 Oscillator frequency of 2.598650 mc which gives a low-frequency i-f suppressed carrier signal of 456.350 kc. This places the suppressed carrier at the 20-db point on the high-frequency skirt of the 455-kc mechanical filter passband, FL1, and centers the desired 300- to 2400-cps portion of the signal in the 2.1-kc filter passband. To detect the audio from this i-f signal in the product detector, V15B, the bfo V11A must inject a carrier (at 456.350 kc, the i-f suppressed carrier frequency) generated by crystal Y17. The bfo signal is filtered out of the product detector output and the audio signal is amplified by V16A and V16B.

(2) TRANSMIT

Assume one wishes to transmit a lower sideband signal at 3.9 mc. The KWM-2 dial is set at 3.8 (band 3A) and the dial still reads 100 (3.8 plus 100 on the dial, or 3.9 mc). This means the suppressed carrier frequency of the transmitted lower sideband signal is 3.9 mc, with a speech band extending 2.4 kc lower in frequency (3.9000 mc down to 3.8976 mc). This is because the optimum speech range necessary for communications work is from 300 to 2400 cps (2.1 kc); however, frequencies from 0 to 2400 cps can be transmitted. By placing the carrier 20 db down on the filter skirt of a 2.1-kc mechanical filter, the undesired 300 cps can be attenuated. Higher speech frequencies above 2400 cps are also attenuated by the opposite filter skirt.

For lower sideband output, the bfo V11A generates a carrier at 453.650 kc and injects it, along with audio from V3A, into the balanced modulator. The output of the balanced modulator is a double-sideband signal with a 453.650-kc suppressed carrier. This is fed into the 455-kc mechanical filter FL1. The 453.650-kc suppressed carrier from the balanced modulator is placed 20 db down on the low-frequency skirt of the 2.1-kc filter, which centers the desired 300- to 2400-cps portion of the signal in the filter passband. Filter output consists of a 453.650-kc carrier suppressed approximately 50 db from the accompanying upper sideband (which is later inverted to lower sideband by V6). This upper sideband signal is fed into the first transmitter mixer, V5, along with a 2.601350-mc signal from the 70K-2 Oscillator. Additive mixing gives a suppressed variable i-f carrier frequency of 3.0550 mc with the upper sideband extending to 3.0574 mc (as the speech band extends to 2400 cps). The variable i-f is mixed with the output of the high-frequency crystal oscillator V13A at 6.955 mc (using crystal Y3) in the second transmitter mixer, V6. Subtractive mixing in V6 inverts the signal to the desired lower sideband output (6.9550-3.0550 mc = 3.9000 mc; 6.9550-3.0574 mc = 3.8976 mc). This is the desired lower sideband r-f output that is fed into the r-f amplifiers.

To transmit an upper sideband signal at 3.9 mc, the suppressed carrier remains 3.9 mc with the 2.4-kc speech bandwidth extending up to 3.9024 mc. For upper sideband output, the bfo V11A generates a carrier at 456.350 kc and injects it, along with audio from V3A, into the balanced modulator. The output of the balanced modulator is a double-sideband signal with a 456.350-kc suppressed carrier. This is fed into the 455-kc mechanical filter, FL1. The 456.350-kc suppressed carrier from the balanced modulator is placed 20 db down on the high-frequency skirt of the 2.1-kc filter, which centers the desired 300- to 2400-cps portion of the signal in the filter passband. Filter output consists of a 456.350-kc carrier suppressed approximately 50 db from the accompanying lower sideband (which is later inverted to upper sideband by V6). This lower sideband signal is fed into the first transmitter mixer, V5, along with a 2.598650-mc signal from the 70K-2 Oscillator. Additive mixing gives a suppressed variable i-f carrier frequency of 3.0550 mc with the lower sideband extending down to 3.0526 mc (as the speech band extends 2400 cps). The variable i-f is mixed with the output of the high-frequency crystal oscillator V13A at 6.955 mc (using crystal Y3) in the second transmitter mixer, V6. Subtractive mixing inverts the signal to the desired upper sideband output (6.9550-3.0550 mc = 3.9000 mc; 6.9550-3.0526 mc = 3.9024 mc). This is the upper sideband that is fed into the r-f amplifiers.

(3) VFO DIAL READING

To keep the vfo dial frequency reading the same (100), the vfo frequency must be shifted 2.7 kc lower in frequency when transmitting or receiving upper sideband. This vfo switching is done by applying a positive or negative bias to diode CR301. When the diode bias is positive, the diode impedance is lowered, C308 is effectively in parallel with L304, and the oscillator frequency for upper sideband, in this example, is lowered to 2.598650 mc. When the bias is negative diode impedance is high, C308 is effectively switched out of the circuit, and the oscillator frequency for lower sideband, in this example, is 2.601350 mc.

b. TRANSMITTER CIRCUITS

(1) A-F CIRCUITS

Microphone or phone-patch input is connected to the grid of first audio amplifier V1A, amplified, and coupled to the grid of second audio amplifier V11B. Output from V11B is coupled to the grid of cathode follower V3A through MIC GAIN control R8. Output from the cathode follower is fed to the resistive balance point of the balanced modulator. In TUNE, LOCK, and CW positions of the EMISSION switch, output from the tone oscillator, V2B, is fed to the grid of the second audio amplifier. Amplified tone oscillator signal is taken from the plate of V11B to the grid of the vox amplifier to activate the vox circuits in CW operation. This signal also is fed to the grid of the first receiver a-f amplifier V16A for CW monitoring. Because of the sharp skirt selectivity on both sides of the 2.1-kc mechanical filter, speech frequencies below 300 cps and above 2400 cps are attenuated, and the desired 300- to 2400-cps speech band is centered in the 2.1-kc filter passband. This emphasizes the optimum communications speech range (300 to 2400 cps).

(2) BALANCED MODULATOR AND LOW FREQUENCY I-F CIRCUITS

Audio output from the cathode of V3A and the bfo voltage are fed to the slider of the carrier balance potentiometer, R15. Both upper and lower sideband output from the balanced modulator are coupled through i-f transformer T1 to the grid of the i-f amplifier, V4A. Output from the i-f amplifier is fed to the mechanical filter, FL1. The passband of FL1 is centered at 455 kc. This passes either upper or lower sideband, depending upon the sideband polarity selected when the EMISSION switch connects the bfo crystal Y16 or Y17. The single-sideband output of FL1 is connected to the grids of the first transmitter mixer in push-pull.

(3) BALANCED MIXERS

The 455-kc single-sideband signal is fed to the first balanced mixer grids in push-pull. The plates of the mixer are connected in push-pull, and vfo signal is fed to the two grids in parallel. The mixer cancels the vfo signal energy and translates the 455-kc single-sideband signal to a 2.955- to 3.155-mc single-sideband signal. The coupling network between the plates of the first mixer and the grid of the second balanced mixer is broadbanded to provide a uniform response to the band-pass i-f frequency. The transmit frequency is determined within the passband by the vfo frequency. The band-pass i-f signal is fed to one of the grids of the second balanced mixer, and the high-frequency injection signal energy from the crystal oscillator V13A is fed to the signal input cathode and to the other grid. This arrangement cancels the high-frequency injection signal energy within the mixer and translates the band-pass i-f signal to the desired operating band. Balanced triode mixers are used in the KWM-2 for lower noise and less cross modulation, as well as reduced oscillator feedthrough.

(4) R-F CIRCUITS

The slug-tuned circuits coupling V6 to V7, V7 to V8, and V8 to the power amplifier are ganged to the EXCITER TUNING control. The signal is amplified by the r-f amplifier, V7, and the driver, V8, to drive the power amplifier, V9 and V10 in class AB_1. Output from the parallel power amplifiers is tuned by a pi network and fed to the antenna through contacts of transmit-receive relay K3. The pi network is designed to work into a 50-ohm load provided the load presents a vswr not exceeding 2:1. Negative r-f feedback from the PA plate circuit to the driver cathode circuit permits a high degree of linearity at the high power level of the PA tubes. Both the driver and PA stages are neutralized to ensure stability. On signal peaks, the detected envelope from the PA grids is rectified by the alc rectifier V17A. D-c output from V17A is filtered and used to control the gain of V4A and V7. This prevents overdriving the power amplifier. The minute amount of grid current drawn before alc acts does not degrade linearity. Rather, these few microvolts actually improve the linearity curve; only after appreciable grid current is drawn is linearity affected.

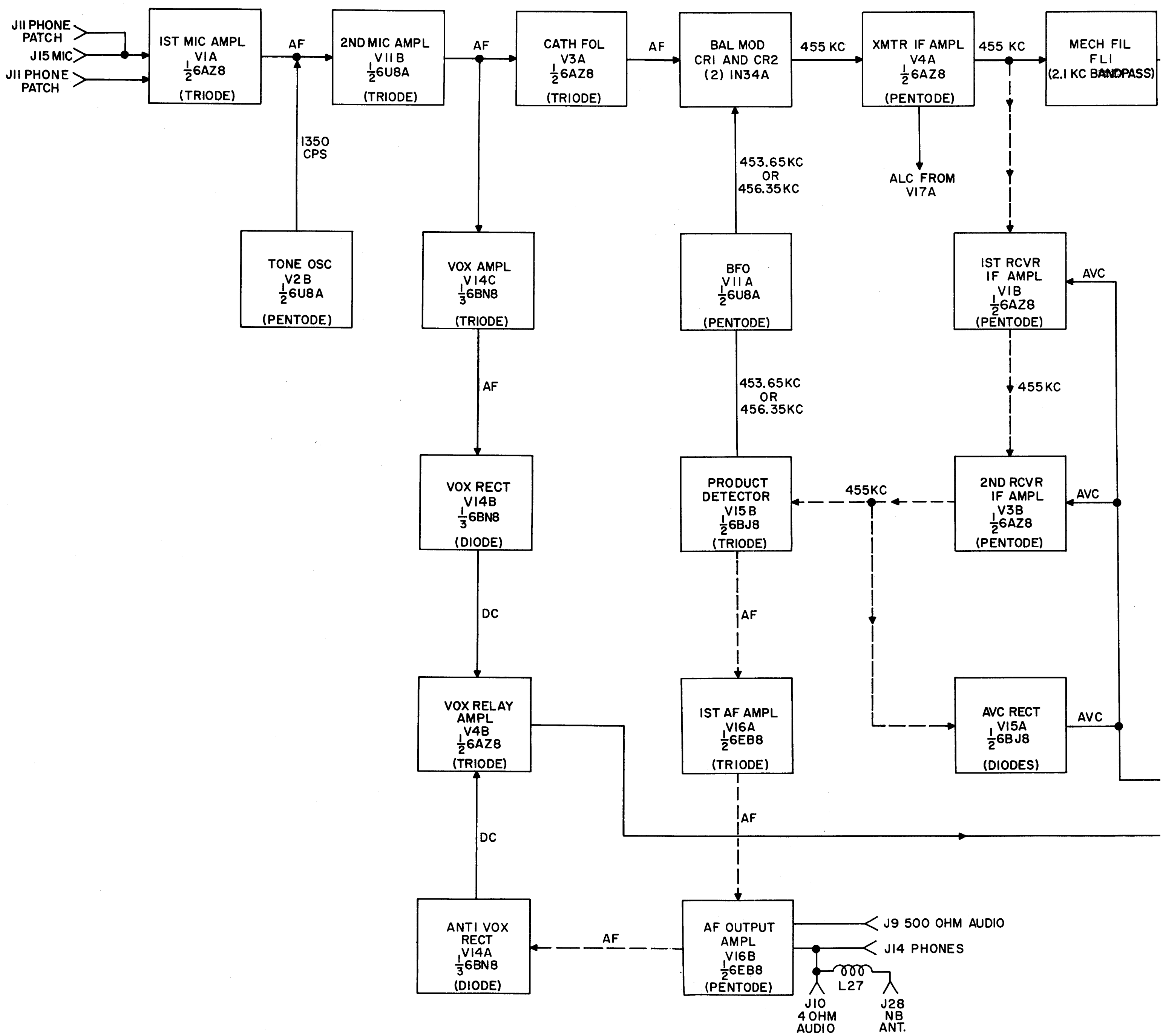
c. RECEIVER CIRCUITS

(1) R-F CIRCUITS

Signal input from the antenna is connected through relay contacts to the tuned input circuit, T3. The signal is applied from T3 to the grid of the receiver-transmitter r-f amplifier, V7. Amplified signal from V7 is applied from the tuned circuit consisting of L10 and band switch-selected capacitors to the grid of the receiver first mixer, V13B.

(2) RECEIVER MIXERS

The input r-f signal is fed to the grid of V13B, and the high-frequency oscillator injection signal is fed to the cathode of V13B. The difference product of the first mixer is applied from the plate of the tube to the variable i-f transformer, T2. Output of T2 in the range of 2.955 to 3.155 megacycles is applied to the grid of the second receiver mixer,



JII PHONE PATCH
JI5 MIC
JII PHONE PATCH
IST MIC AMPL V1A 1/2 6AZ8 (TRIODE)
AF
1350 CPS
2ND MIC AMPL V11B 1/2 6U8A (TRIODE)
AF
CATH FOL V3A 1/2 6AZ8 (TRIODE)
AF
BAL MOD CR1 AND CR2 (2) IN34A
455 KC
XMTR IF AMPL V4A 1/2 6AZ8 (PENTODE)
455 KC
MECH FIL FL1 (2.1 KC BANDPASS)
453.65KC OR 456.35KC
ALC FROM V17A
TONE OSC V2B 1/2 6U8A (PENTODE)
VOX AMPL V14C 1/3 6BN8 (TRIODE)
BFO V11A 1/2 6U8A (PENTODE)
IST RCVR IF AMPL V1B 1/2 6AZ8 (PENTODE)
AVC
AF
453.65KC OR 456.35KC
455KC
VOX RECT V14B 1/3 6BN8 (DIODE)
PRODUCT DETECTOR V15B 1/2 6BJ8 (TRIODE)
455KC
2ND RCVR IF AMPL V3B 1/2 6AZ8 (PENTODE)
AVC
DC
AF
VOX RELAY AMPL V4B 1/2 6AZ8 (TRIODE)
IST AF AMPL V16A 1/2 6EB8 (TRIODE)
AVC RECT V15A 1/2 6BJ8 (DIODES)
AVC
AF
DC
ANTI VOX RECT V14A 1/3 6BN8 (DIODE)
AF
AF OUTPUT AMPL V16B 1/2 6EB8 (PENTODE)
J9 500 OHM AUDIO
J14 PHONES
L27
J10 4 OHM AUDIO
J28 NB ANT.

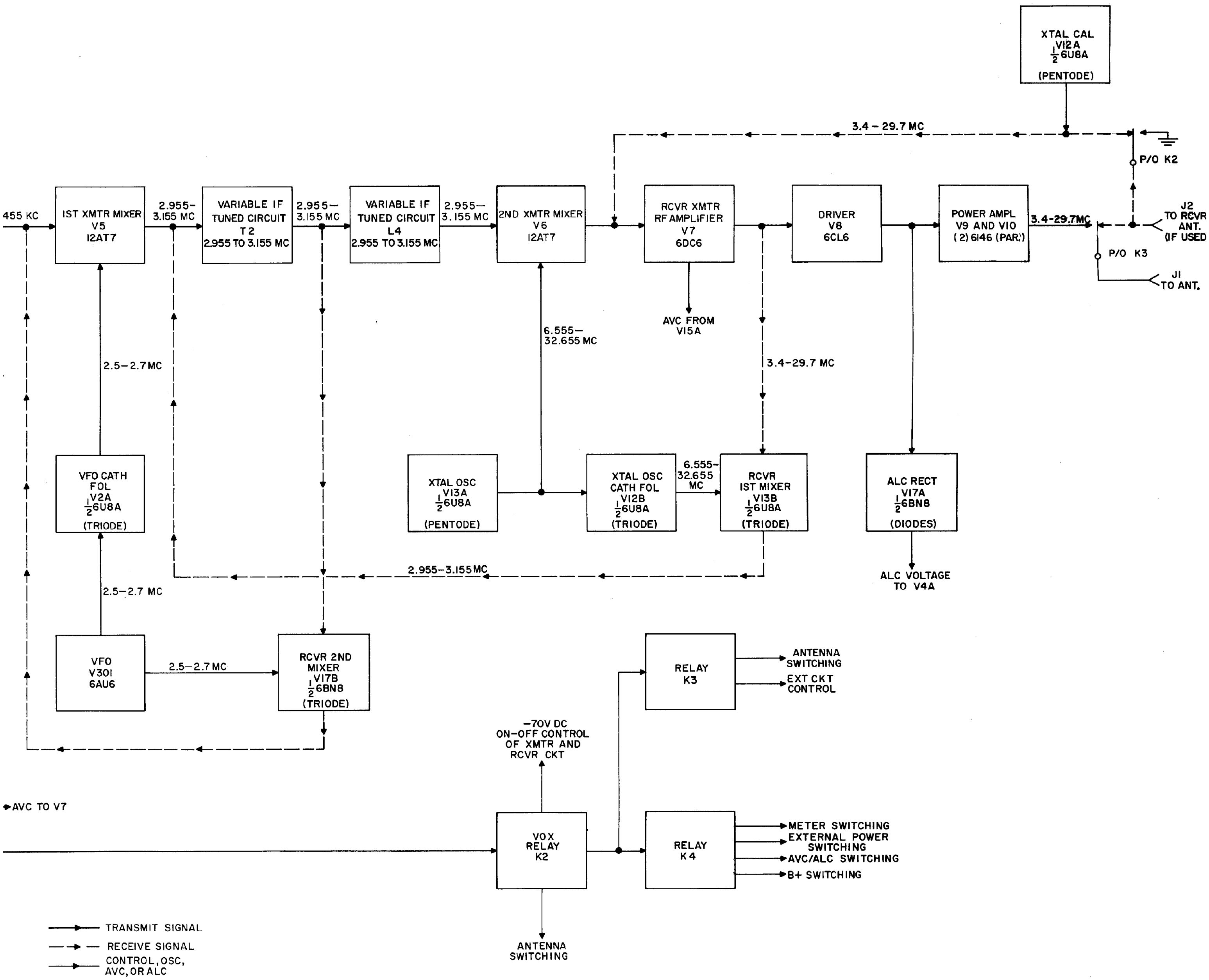
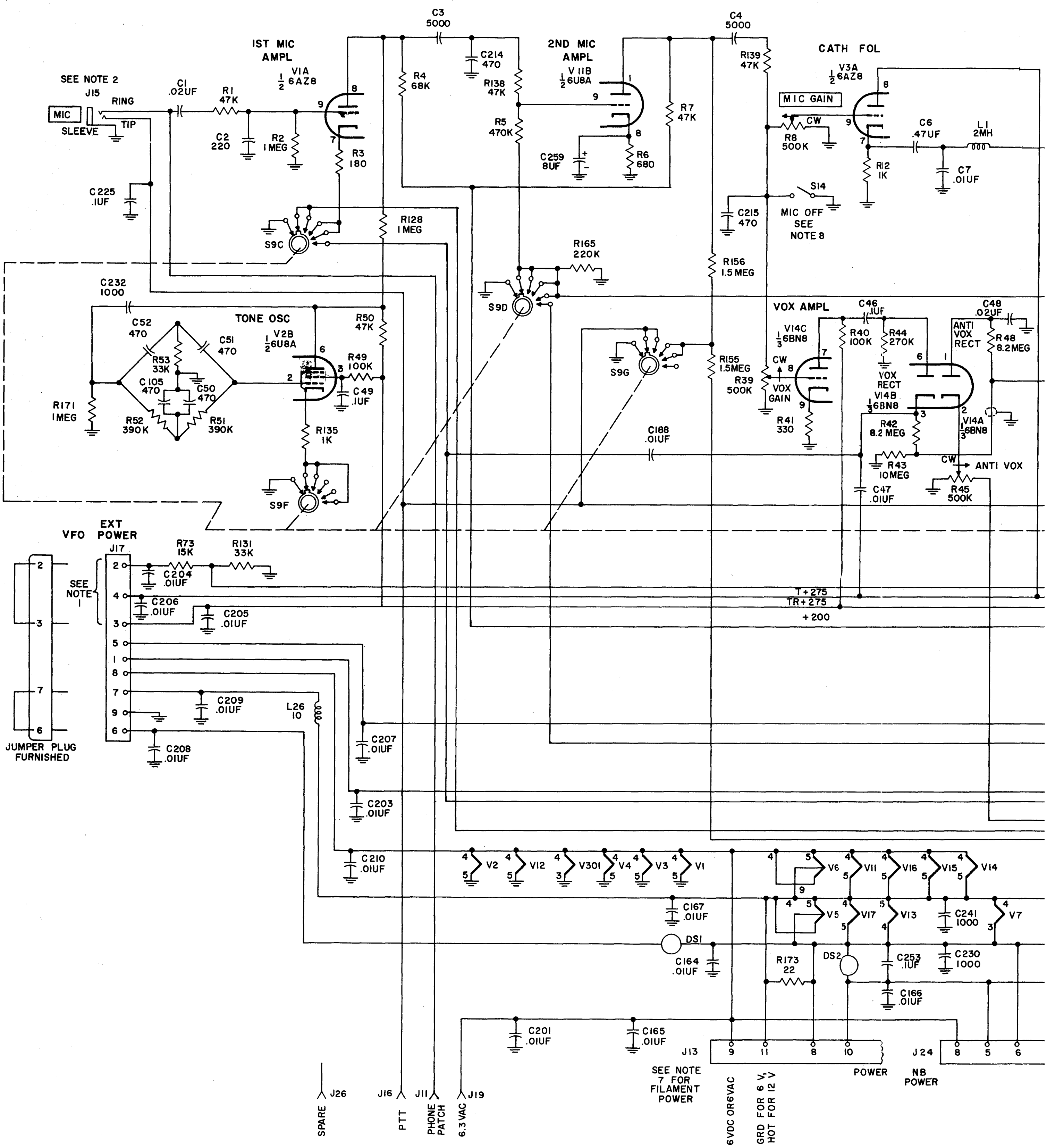
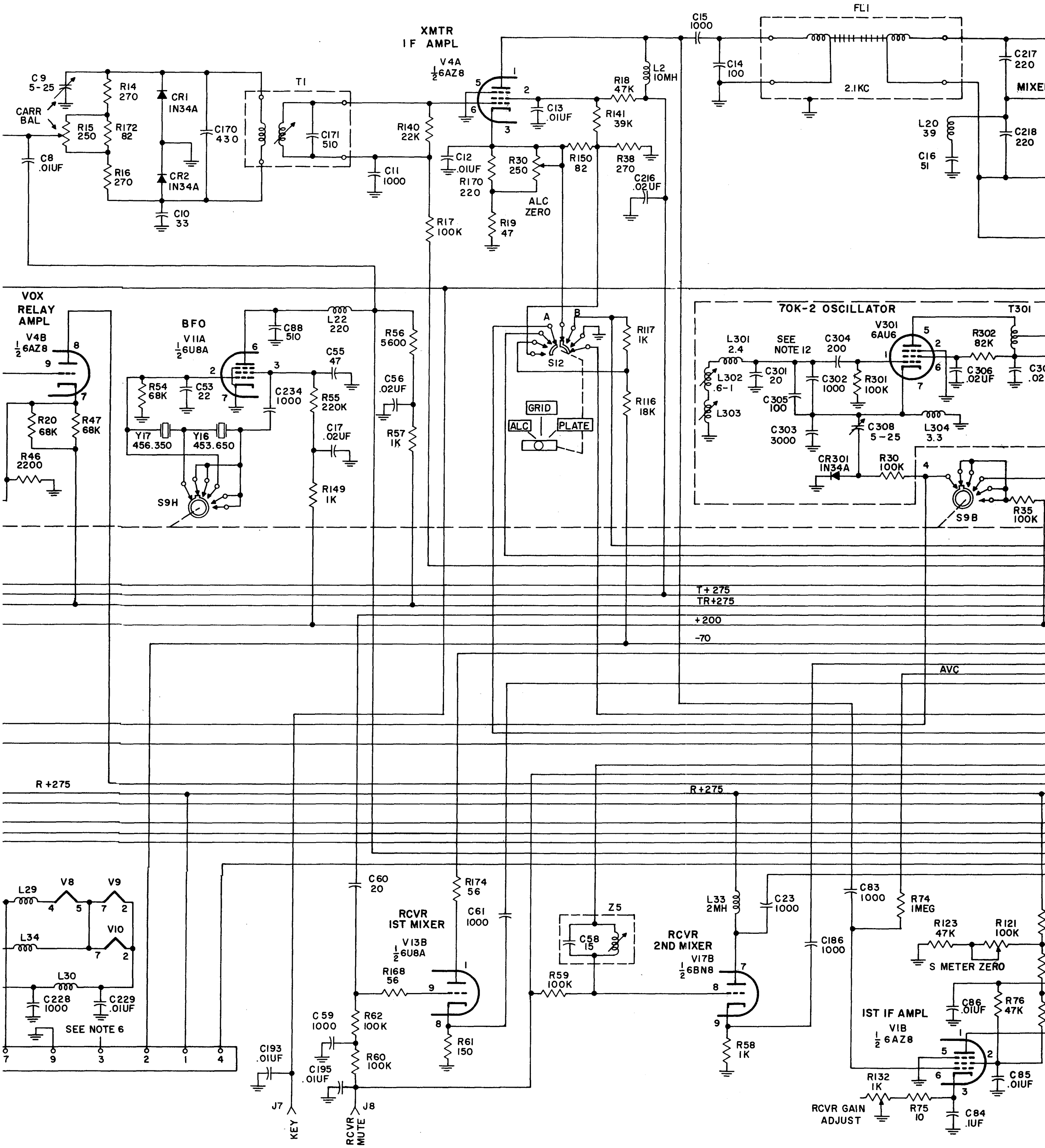
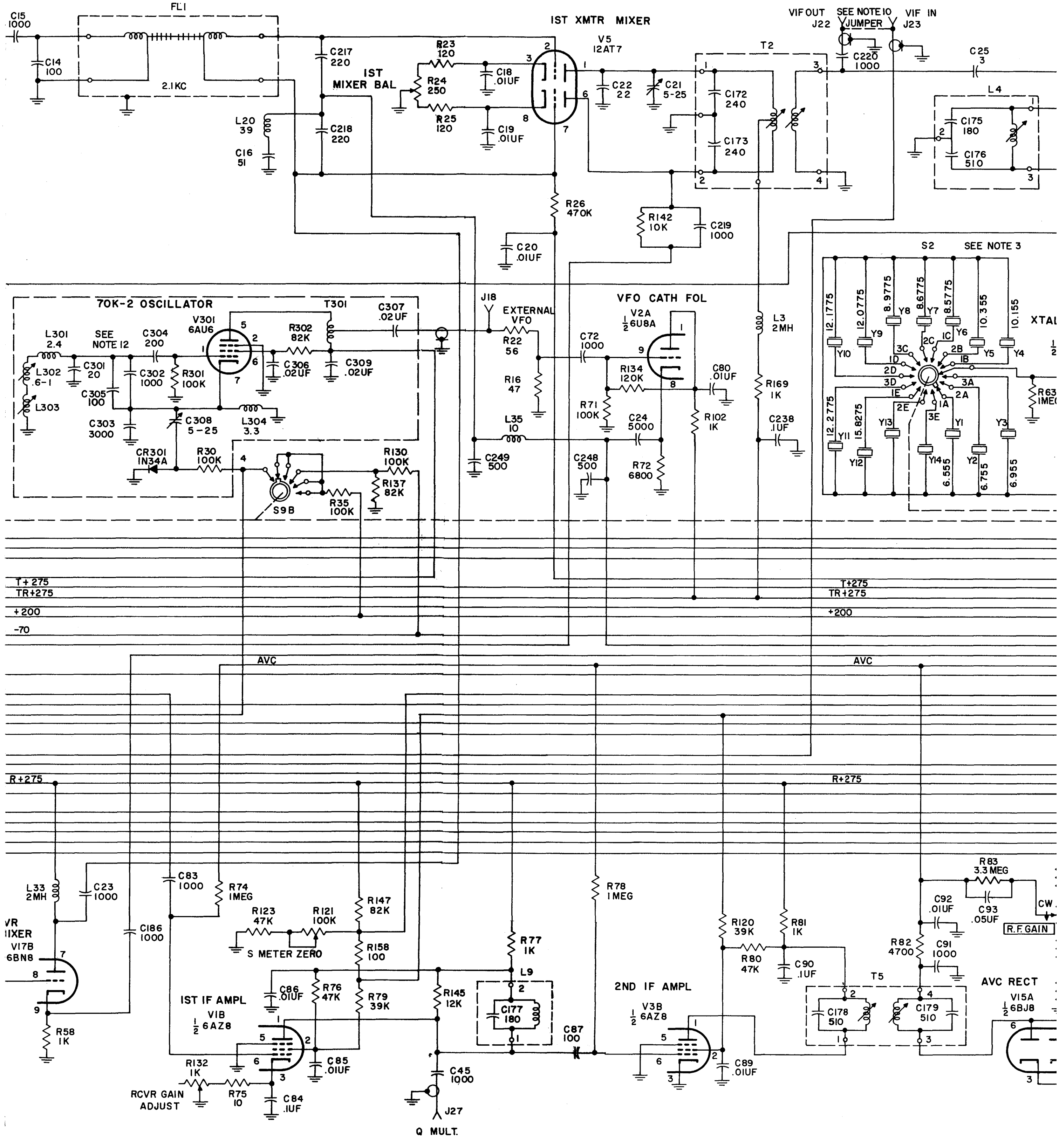


Figure 13-14. KWM-2 Block Diagram

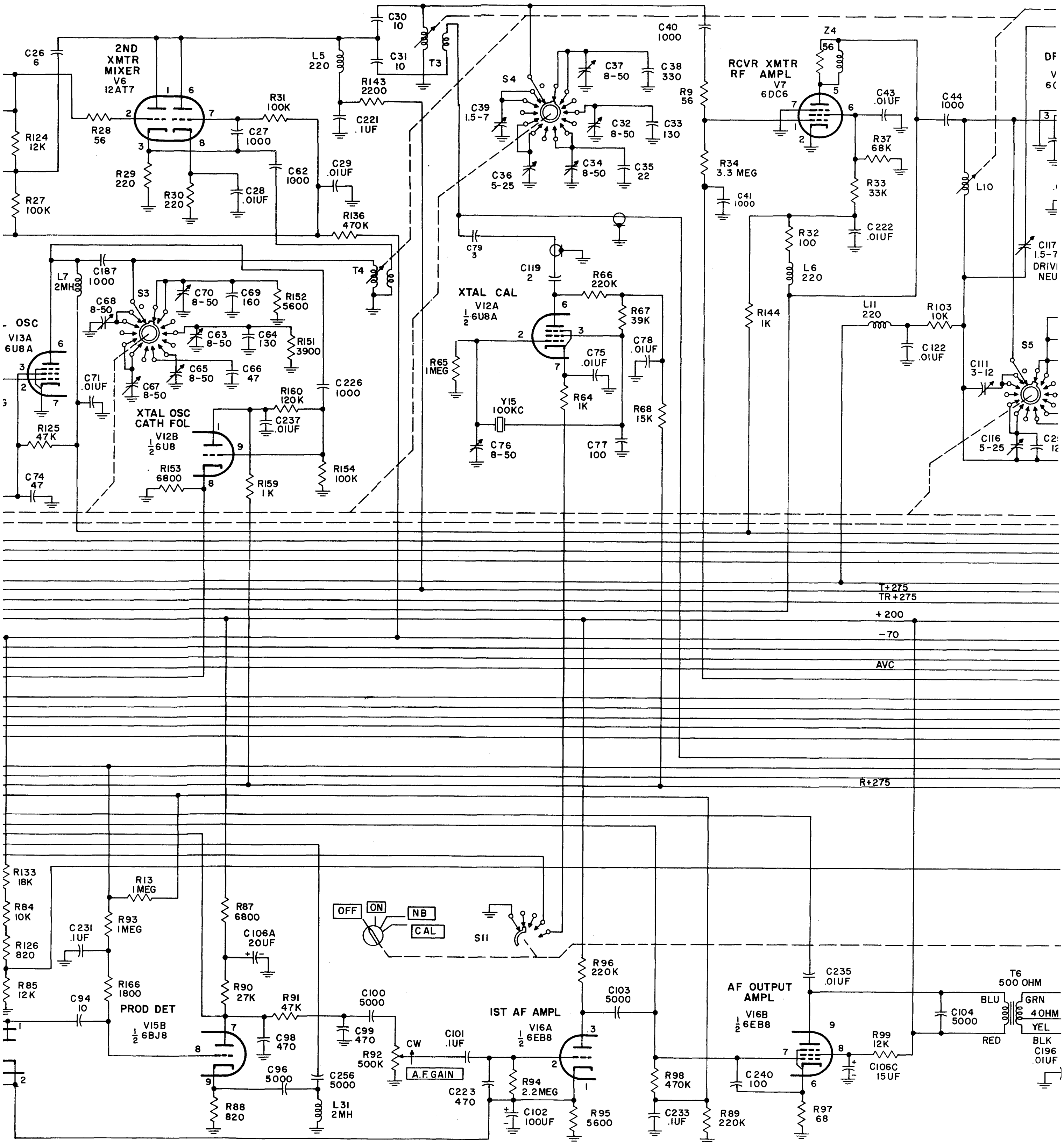


SEE NOTE 2
J15
RING
TIP
SLEEVE
MIC
C1 .02UF
R1 47K
C2 220
R2 1MEG
C225 .1UF
IST MIC AMPL
V1A 1/2 6AZ8
R3 180
S9C
C3 5000
C214 470
R4 68K
R138 47K
R5 470K
R128 1MEG
2ND MIC AMPL
V 11B 1/2 6U8A
C259 8UF
R6 680
R7 47K
C4 5000
R139 47K
CATH FOL
V3A 1/2 6AZ8
MIC GAIN
CW
R8 500K
C6 .47UF
L1 2MH
R12 1K
C7 .01UF
S14
MIC OFF SEE NOTE 8
C215 470
R165 220K
S9D
R156 1.5 MEG
R155 1.5MEG
S9G
C232 1000
C52 470
C51 470
TONE OSC
V2B 1/2 6U8A
R53 33K
C105 470
C50 470
R52 390K
R51 390K
R171 1MEG
R50 47K
R49 100K
C49 .1UF
R135 1K
S9F
VOX AMPL
C46 .1UF
V14C 1/3 6BN8
R40 100K
R44 270K
VOX RECT
V14B 1/3 6BN8
ANTI VOX RECT
C48 .02UF
R48 8.2MEG
R39 500K
VOX GAIN
R41 330
R42 8.2 MEG
V14A 1/3 6BN8
R43 10MEG
ANTI VOX
R45 500K
C47 .01UF
C188 .01UF
VFO
EXT POWER
J17
R73 15K
R131 33K
C204 .01UF
SEE NOTE 1
C206 .01UF
C205 .01UF
T+275
TR+275
+200
C209 .01UF
L26 10
C208 .01UF
C207 .01UF
C203 .01UF
C210 .01UF
JUMPER PLUG FURNISHED
V2 V12 V301 V4 V3 V1
V6 V11 V16 V15 V14
V5 V17 V13 V7
C167 .01UF
C241 1000
DS1
C164 .01UF
R173 22
DS2
C253 .1UF
C230 1000
C166 .01UF
C201 .01UF
C165 .01UF
J13
POWER
J24
NB POWER
SEE NOTE 7 FOR FILAMENT POWER
J26 SPARE
J16 PTT
J11 PHONE PATCH
J19 6.3 VAC
6VDC OR6VAC
GRD FOR 6 V, HOT FOR 12 V

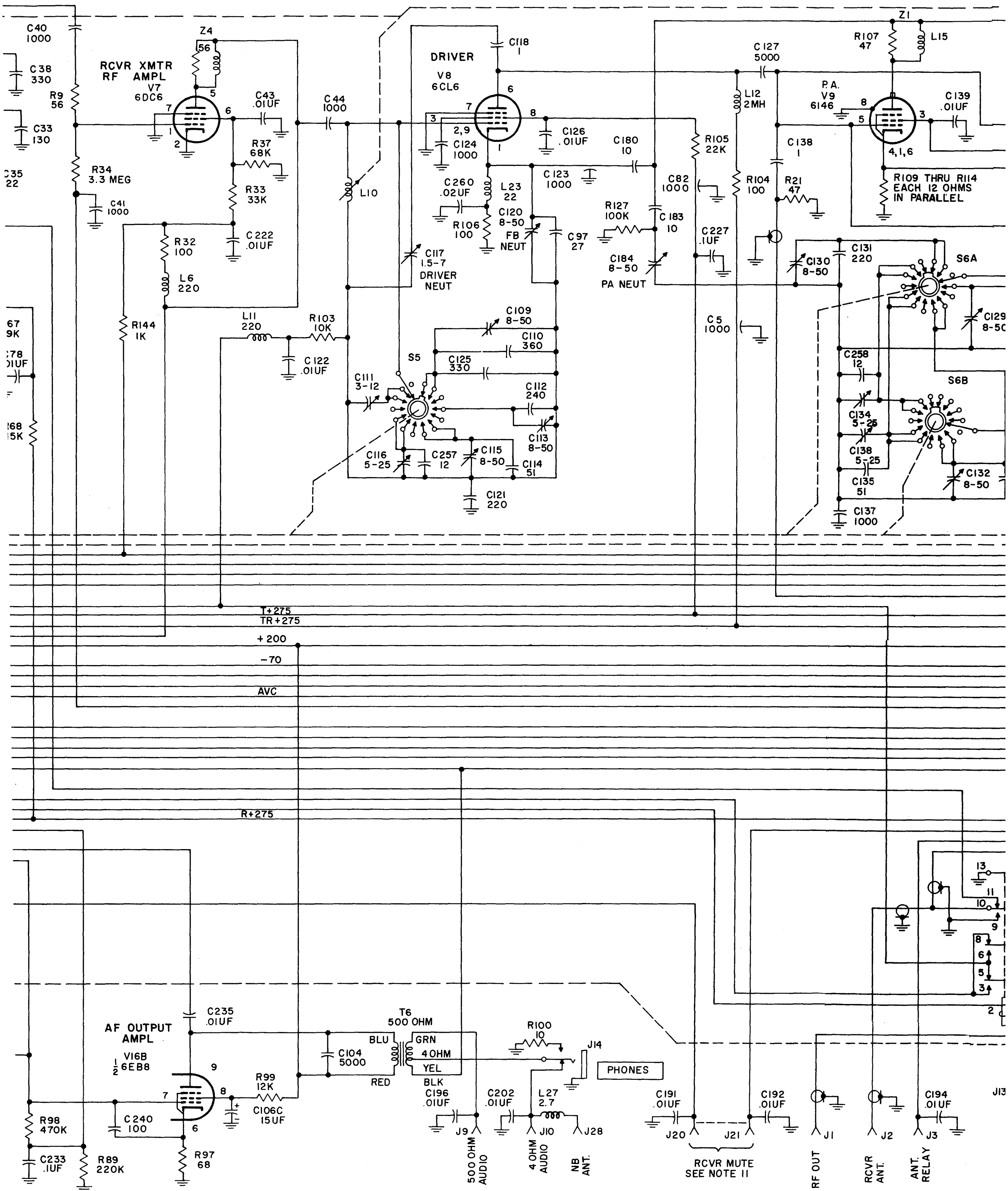

XMTR
IF AMPL
V4A
½ 6AZ8
C15
1000
FL1
2.1KC
C217
220
MIXER
C218
220
L20
39
C16
51
C14
100
L2
10MH
R18
47K
R141
39K
C13
.01UF
R150
82
R38
270
C216
.02UF
R30
250
ALC
ZERO
R170
220
R19
47
C12
.01UF
R140
22K
R17
100K
C11
1000
T1
C171
510
C170
430
CR1
IN34A
CR2
IN34A
C10
33
R14
270
R172
82
R16
270
R15
250
CARR
BAL
C9
5-25
C8
.01UF
VOX
RELAY
AMPL
V4B
½ 6AZ8
R20
68K
R47
68K
R46
2200
BFO
V11A
½ 6U8A
C88
510
L22
220
R54
68K
C53
22
C234
1000
Y17
456.350
Y16
453.650
S9H
C55
47
R55
220K
C17
.02UF
R149
1K
R56
5600
C56
.02UF
R57
1K
S12
A
B
GRID
ALC
PLATE
R117
1K
R116
18K
70K-2 OSCILLATOR
L301
2.4
SEE
NOTE 12
C304
200
V301
6AU6
R302
82K
T301
L302
.6-1
C301
20
C302
1000
R301
100K
C306
.02UF
C30
.02U
L303
C305
100
C303
3000
C308
5-25
L304
3.3
CR301
IN34A
R30
100K
S9B
R35
100K
T+275
TR+275
+200
-70
AVC
R+275
R+275
L29
V8
V9
L34
V10
L30
C228
1000
C229
.01UF
SEE NOTE 6
C60
20
RCVR
1ST MIXER
V13B
½ 6U8A
R174
56
C61
1000
R168
56
C59
1000
R62
100K
R61
150
R60
100K
C193
.01UF
C195
.01UF
J7
KEY
J8
RCVR
MUTE
Z5
C58
15
R59
100K
L33
2MH
C23
1000
RCVR
2ND MIXER
V17B
½ 6BN8
R58
1K
C186
1000
C83
1000
R74
1MEG
R123
47K
R121
100K
S METER ZERO
1ST IF AMPL
V1B
½ 6AZ8
C86
.01UF
R76
47K
C85
.01UF
R132
1K
RCVR GAIN
ADJUST
R75
10
C84
.1UF



C15 1000
C14 100
FL1
2.1KC
L20 39
C16 51
C217 220
C218 220
IST MIXER BAL
R23 120
R24 250
R25 120
C18 .01UF
C19 .01UF
IST XMTR MIXER
V5 12AT7
C22 22
C21 5-25
T2
C172 240
C173 240
VIF OUT J22
SEE NOTE 10 JUMPER
VIF IN J23
C220 1000
C25 3
L4
C175 180
C176 510
R26 470K
C20 .01UF
R142 10K
C219 1000
S2 SEE NOTE 3
70K-2 OSCILLATOR
V301 6AU6
T301
C307 .02UF
L301 2.4
SEE NOTE 12
C304 200
R302 82K
L302 .6-1
C301 20
C302 1000
R301 100K
C306 .02UF
C309 .02UF
L303
C305 100
C303 3000
C308 5-25
L304 3.3
CR301 1N34A
R30 100K
R130 100K
R137 82K
R35 100K
S9B
J18
EXTERNAL VFO
R22 56
R16 47
L35 10
C249 500
VFO CATH FOL
V2A 1/2 6U8A
C72 1000
R134 120K
R71 100K
C80 .01UF
C24 5000
R102 1K
C248 500
R72 6800
L3 2MH
R169 1K
C238 .1UF
12.1775
12.0775
8.9775
8.6775
8.5775
10.355
10.155
Y10 Y9 Y8 Y7 Y6 Y5 Y4
XTAL
R63 1MEG
12.2775
15.8275
Y11 Y12 Y13 Y14 Y1 Y2 Y3
6.555
6.755
6.955
T+275
TR+275
+200
-70
AVC
R+275
L33 2MH
C23 1000
C83 1000
R74 1MEG
C186 1000
VR MIXER V17B 6BN8
R58 1K
R123 47K
R121 100K
S METER ZERO
R147 82K
R158 100
R77 1K
L9
C177 180
R78 1MEG
C86 .01UF
R76 47K
R79 39K
R145 12K
IST IF AMPL
V1B 1/2 6AZ8
C85 .01UF
R132 1K
R75 10
RCVR GAIN ADJUST
C84 .1UF
C45 1000
J27
Q MULT.
C87 100
2ND IF AMPL
V3B 1/2 6AZ8
C89 .01UF
R120 39K
R81 1K
R80 47K
C90 .1UF
T5
C178 510
C179 510
R83 3.3MEG
C92 .01UF
C93 .05UF
CW
R.F. GAIN
R82 4700
C91 1000
AVC RECT
V15A 1/2 6BJ8



2ND XMTR MIXER V6 12AT7
C26 6
R124 12K
R27 100K
R28 56
R29 220
R30 220
C27 1000
C28 .01UF
R31 100K
C62 1000
C29 .01UF
R136 470K
L5 220
C30 10
C31 10
T3
R143 2200
C221 .1UF
T4
S4
C37 8-50
C38 330
C39 1.5-7
C32 8-50
C33 130
C36 5-25
C34 8-50
C35 22
C40 1000
R9 56
R34 3.3 MEG
C41 1000
RCVR XMTR RF AMPL V7 6DC6
Z4
C43 .01UF
R37 68K
R33 33K
C222 .01UF
R32 100
L6 220
C44 1000
L10
C117 1.5-7
DRIV
NEU
R144 1K
L11 220
C122 .01UF
R103 10K
S5
C111 3-12
C116 5-25
OSC V13A 6U8A
L7 2MH
C187 1000
S3
C68 8-50
C70 8-50
C69 160
R152 5600
C63 8-50
C64 130
R151 3900
C67 8-50
C65 8-50
C66 47
C71 .01UF
C226 1000
R160 120K
C237 .01UF
XTAL OSC CATH FOL V12B 1/2 6U8
R154 100K
R125 47K
C74 47
R153 6800
R159 1K
C79 3
C119 2
XTAL CAL V12A 1/2 6U8A
R66 220K
R67 39K
R65 1MEG
C75 .01UF
C78 .01UF
R64 1K
Y15 100KC
R68 15K
C76 8-50
C77 100
T+275
TR+275
+200
-70
AVC
R+275
R133 18K
R84 10K
R126 820
R85 12K
C231 .1UF
R13 1MEG
R93 1MEG
R166 1800
C94 10
PROD DET V15B 1/2 6BJ8
R87 6800
C106A 20UF
R90 27K
R91 47K
C98 470
C96 5000
R88 820
C256 5000
L31 2MH
C100 5000
C99 470
R92 500K
CW
A.F. GAIN
OFF
ON
NB
CAL
S11
C101 .1UF
C223 470
R94 2.2MEG
C102 100UF
IST AF AMPL V16A 1/2 6EB8
R96 220K
C103 5000
R95 5600
R98 470K
C233 .1UF
R89 220K
AF OUTPUT AMPL V16B 1/2 6EB8
C235 .01UF
C240 100
R97 68
R99 12K
C106C 15UF
C104 5000
T6 500 OHM
BLU
GRN
4 OHM
YEL
RED
BLK
C196 .01UF



C40 1000
C38 330
C33 130
R9 56
R34 3.3 MEG
C41 1000
RCVR XMTR RF AMPL
V7 6DC6
Z4
56
C43 .01UF
R37 68K
R33 33K
C222 .01UF
R32 100
L6 220
R144 1K
L11 220
R103 10K
C122 .01UF
C44 1000
L10
C117 1.5-7 DRIVER NEUT
DRIVER
V8 6CL6
C118 1
C124 1000
2,9
C126 .01UF
C260 .02UF
R106 100
L23 22
C120 8-50 FB NEUT
C97 27
C123 1000
C180 10
C82 1000
R127 100K
C183 10
C184 8-50 PA NEUT
C227 .1UF
R105 22K
R104 100
L12 2MH
C127 5000
C138 1
R21 47
Z1
R107 47
L15
P.A. V9 6146
4,1,6
C139 .01UF
R109 THRU R114 EACH 12 OHMS IN PARALLEL
C5 1000
C130 8-50
C131 220
S6A
C129 8-50
C258 12
C134 5-25
C138 5-25
C135 51
C137 1000
S6B
C132 8-50
S5
C109 8-50
C110 360
C125 330
C112 240
C111 3-12
C113 8-50
C116 5-25
C257 12
C115 8-50
C114 51
C121 220
T+275
TR+275
+200
-70
AVC
R+275
67 9K
C78 .01UF
R68 15K
C35 22
AF OUTPUT AMPL
V16B 1/2 6EB8
C235 .01UF
R98 470K
C240 100
C233 .1UF
R89 220K
R97 68
R99 12K
C106C 15UF
C104 5000
T6 500 OHM
BLU
RED
GRN
4 OHM
YEL
BLK
C196 .01UF
J9
500 OHM AUDIO
C202 .01UF
J10
4 OHM AUDIO
L27 2.7
J28
NB ANT.
R100 10
J14
PHONES
C191 .01UF
J20
J21
RCVR MUTE SEE NOTE 11
C192 .01UF
J1
RF OUT
J2
RCVR ANT.
C194 .01UF
J3
ANT. RELAY
J13
13
11
10
9
8
6
5
3
2

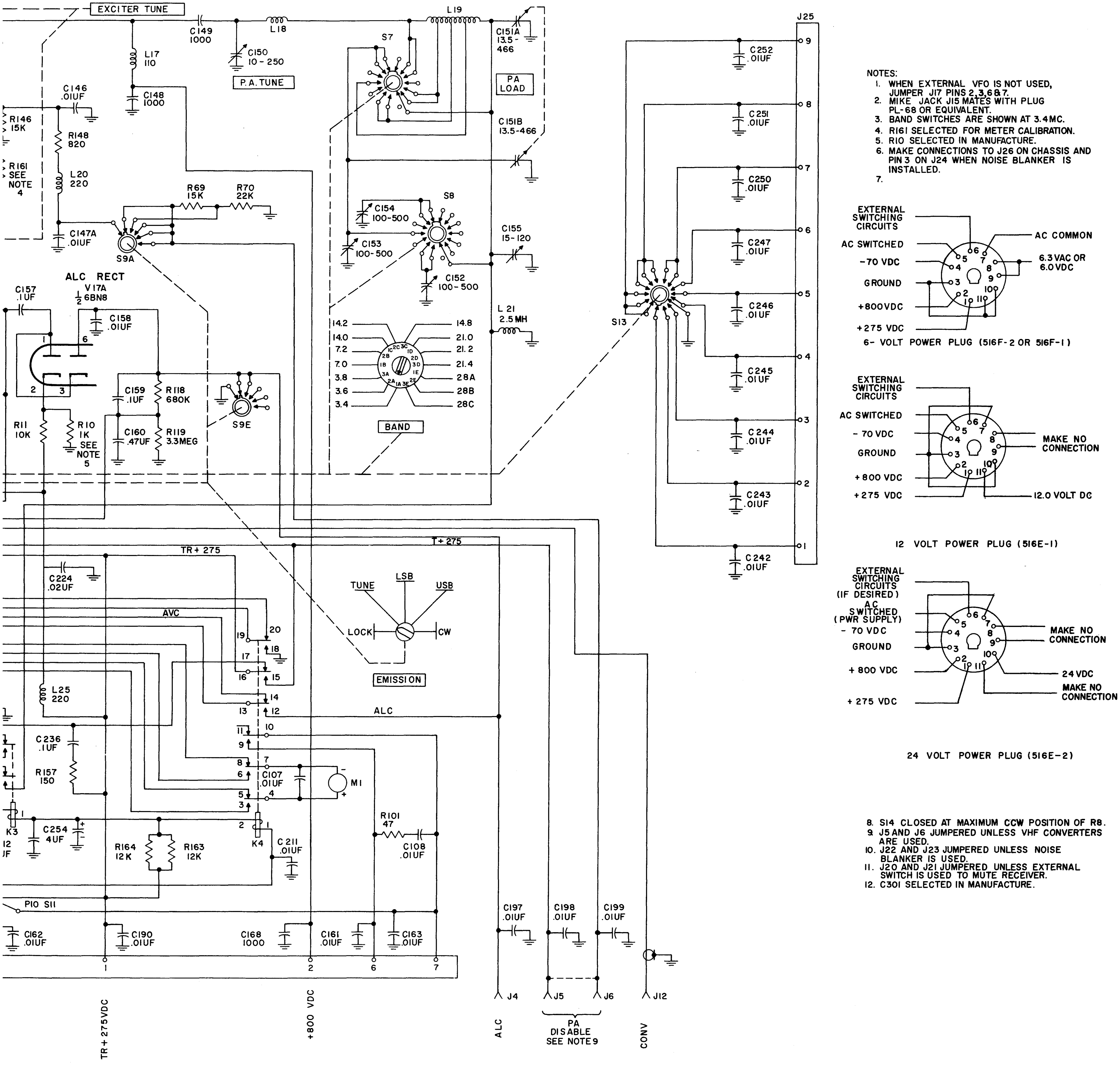


Figure 13-15. KWM-2 Schematic Diagram

V17B, across the parallel-tuned trap circuit, Z5. This trap circuit minimizes a spurious response which would otherwise result from harmonics of the high-frequency crystal oscillator. When signal input is applied to the grid of V17B and vfo injection signal is applied to the cathode of V17B, the 455-kc difference product is fed from V17B plate to the mechanical filter, FL1.

(3) I-F CIRCUITS

The output from FL1 is applied to the grid of the first i-f amplifier, V1B. The i-f signal is amplified by V1B and V3B and applied through T5 to the avc rectifier, V15A, and the grid of the product detector, V15B. Beat-frequency oscillator signal is applied to the cathode of V15B and the product of mixing is the detected audio signal. Output of the avc rectifier circuit is applied to the two receiver i-f amplifiers and through contacts of relay K4 to the receiver-transmitter r-f amplifier. The avc is fast attack, slow release for sideband and CW. This allows fast avc action before the end of the first syllable and a long enough hold time to prevent gain changes between words. This avc voltage controls the gain of the receiver and prevents overloading. Delayed avc is incorporated to allow the signal to build up out of the noise before avc is applied. The avc threshold is approximately one microvolt with 100 microvolts necessary to read S-9 on the S-meter.

(4) A-F CIRCUITS

Output from the product detector is applied through the A. F. GAIN control, R92, to the grid of the first a-f amplifier, V16A. Amplified audio output of V16A is coupled to the grid of the a-f output amplifier, V16B, which produces the power to operate speaker, headphones, or phone patch.

(5) OSCILLATORS

The transceiver contains five oscillators. They are the tone oscillator, the beat-frequency oscillator, the variable-frequency oscillator, the high-frequency crystal oscillator, and the crystal calibrator.

(a) TONE OSCILLATOR

The tone oscillator operates when the EMISSION switch is in LOCK, TUNE, or CW position. It is a phase-shift oscillator operating at approximately 1350 cps. Its output is fed to the transmitter audio circuits for tuneup signal and to the balanced modulator to produce a carrier frequency 1350 cps removed from the dial reading. This signal allows carrier to be applied to the power amplifier grids for CW or tuneup. Some of the output from the tone oscillator is applied to the receiver audio circuits for sidetone monitoring in CW operation. TUNE reduces PA screen voltage to keep the PA plate dissipation within ratings for tuneup. LOCK position allows final tuneup with full carrier.

The tone oscillator is set at 1350 cps to center the tone in the mechanical filter passband and to place the second harmonic of the tone (2700 cps) out of the filter passband eliminating the possibility of tone modulation. Tone keying also permits two transceivers (operating on the same sideband, of course) to work each other on the same frequency without leapfrogging across the band (retuning), which would be the case if the carrier were reinserted and keyed. This is because the carrier is ordinarily placed 20 db down on the 2.1-kc mechanical filter skirt, so when the receiving station tunes the CW carrier to center it in the filter passband the transceiver frequency will shift the same amount. The second station would then have to retune to center the incoming signal in the filter passband and, in doing so, would shift frequency when transmitting. Tone keying eliminates this problem.

(b) BEAT-FREQUENCY OSCILLATOR

The bfo is crystal controlled at either 453.650 or 456.350 kilocycles, depending upon whether Y16 or Y17 is selected by the EMISSION switch section S9H. The unused crystal is shorted out by this switch section. These crystal frequencies are matched to the passband of the mechanical filter, FL1, so that the carrier frequency is placed approximately 20 db down on the skirt of the filter response. This 20-db carrier attenuation is in addition to the 30-db suppression provided by the balanced modulator.

(c) VARIABLE-FREQUENCY OSCILLATOR

The vfo operates in the range of 2.5 to 2.7 mc. The value of the cathode choke is selected so that switching a small trimmer across it shifts the oscillator frequency. This compensates for switching bfo frequency and keeps dial calibration accurate no matter which sideband is selected. Refer to paragraph 5a for additional discussion on why the vfo frequency must be shifted. This bfo switching is done by applying a positive or negative bias to diode CR301. When the diode bias is positive, the diode impedance is lowered, and C308 is effectively in parallel with L304. When the bias is negative, diode impedance is high, and C308 is effectively switched out of the circuit.

(d) HIGH-FREQUENCY CRYSTAL OSCILLATOR

The high-frequency crystal oscillator, V13A, is crystal controlled by one of 14 crystals selected by BAND switch S2. Output from the high-frequency crystal oscillator is fed to the transmitter second mixer and to the crystal oscillator cathode follower. The cathode follower provides isolation and impedance matching between the crystal oscillator and the receiver first mixer cathode. The output frequency of this oscillator is always 3.155 mc higher than the lower edge of the desired band. This high-frequency injection signal is the crystal fundamental frequency for all desired signals below 12 megacycles, but for operating frequencies higher than 12 mc, the crystal frequency is doubled in the plate circuit of the oscillator.

Figure 13-16. 30S-1 Linear Amplifier

(e) CRYSTAL CALIBRATOR

The 100-kc crystal calibrator, V12A, is the pentode section of a type 6U8A tube. Its output is coupled to the antenna coil, T3. The calibrator may be trimmed to zero beat with WWV (or any other desired frequency standard) by adjustment of capacitor C76.

(6) VOX AND ANTIVOX CIRCUITS

Audio output voltage from the second microphone amplifier, V11B, is coupled to the VOX GAIN control, R39. A portion of this voltage is amplified by the vox amplifier, V14B, and fed to the vox rectifier which is one of the diodes of V14. The positive d-c output of the vox rectifier is applied to the grid of vox relay amplifier V4B, causing it to conduct current and actuate the vox relay, K2. Contacts of K2 switch the receiver antenna lead, the other relay coils, and the -70-volt d-c muting and bias voltage. Relays K3 and K4 switch the metering circuits from receiver to transmit, the low plate voltages from receive to transmit tubes, and the avc and alc leads.

The antivox circuit provides a threshold voltage to prevent loudspeaker output (picked up by the microphone circuits) from tripping the KWM-2 into transmit function. Some of the receiver output audio voltage is connected through C235 to the ANTI VOX gain control, R45. Signal from the slider of the potentiometer is rectified by the antivox rectifier, which is the other diode of V14. Negative d-c output voltage from the antivox rectifier, connected to the grid of V4B, provides the necessary antivox threshold. ANTI VOX control R45 adjusts the value of the antivox voltage threshold so that loudspeaker output will not produce enough positive d-c output from the vox rectifier to exceed the negative d-c output from the antivox rectifier and cause V4B to actuate K2. However, speech energy into the microphone will cause the positive vox voltage to overcome the negative antivox voltage and produce the desired action of K2.

6. 30S-1 LINEAR AMPLIFIER

The 30S-1 R-F Linear Amplifier (figure 13-16) consists of a one-stage linear amplifier and the necessary power supplies. It is capable of maximum legal input power in the amateur bands between 3.5 and 29.7 mc. It operates either CW or SSB service with any exciter (such as the KWM-1, KWM-2, or 32S-1) capable of 80 watts PEP output. In addition, the amplifier may be operated outside the amateur bands at any frequency between 3.4 and 30 mc by

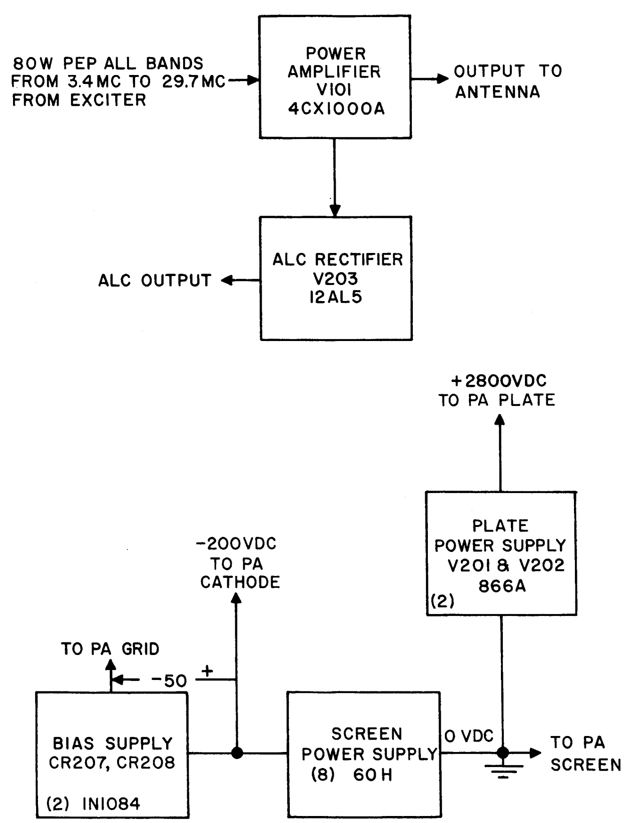
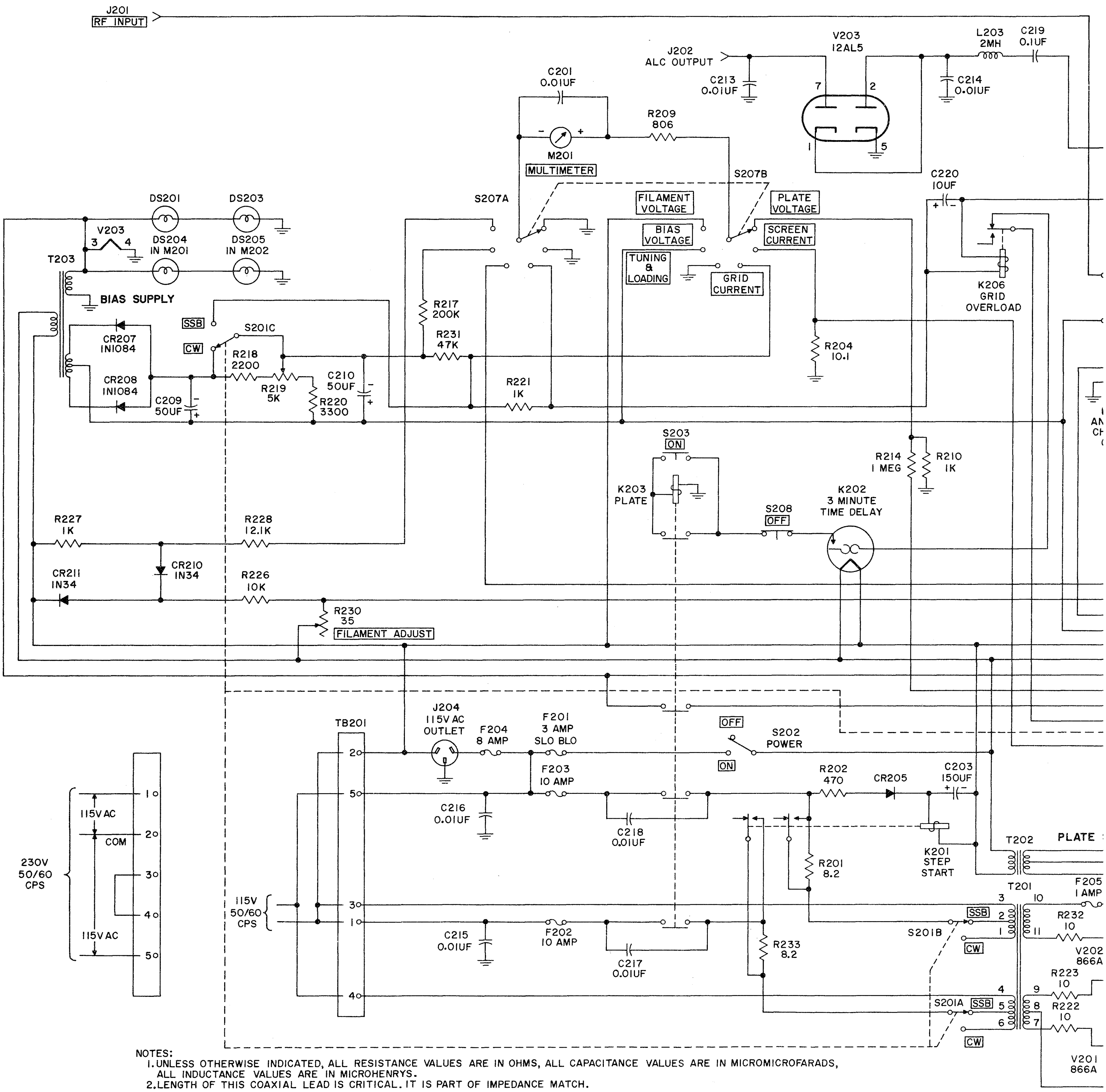
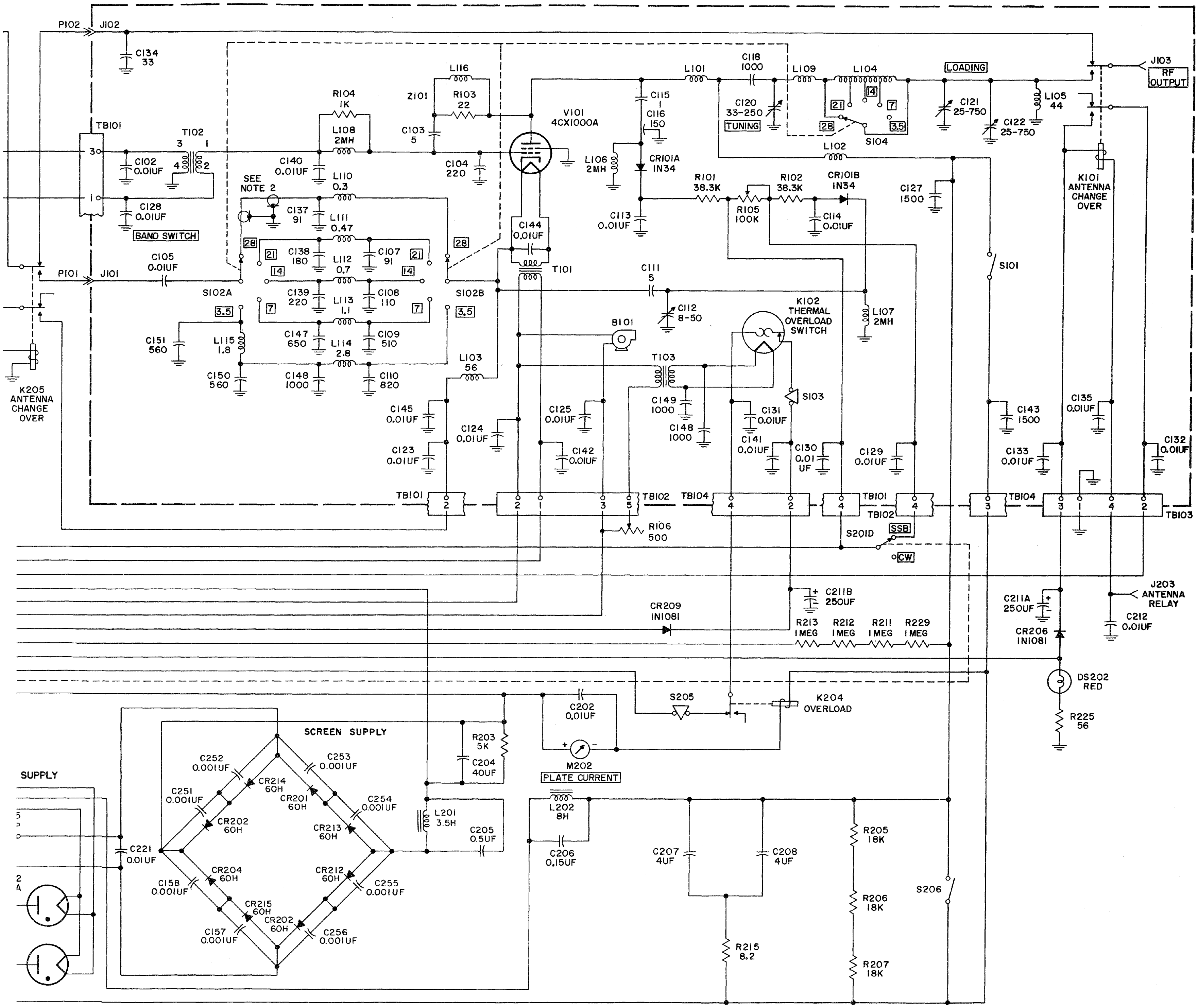


Figure 13-17. 30S-1 Block Diagram



NOTES:
1. UNLESS OTHERWISE INDICATED, ALL RESISTANCE VALUES ARE IN OHMS, ALL CAPACITANCE VALUES ARE IN MICROMICROFARADS, ALL INDUCTANCE VALUES ARE IN MICROHENRYS.
2. LENGTH OF THIS COAXIAL LEAD IS CRITICAL. IT IS PART OF IMPEDANCE MATCH.


P102
J102
C134
33
J103
RF
OUTPUT
LOADING
TB101
T102
C102
0.01UF
C128
0.01UF
BAND SWITCH
R104
1K
L116
R103
22
Z101
L108
2MH
C140
0.01UF
C103
5
C104
220
V101
4CX1000A
L101
C118
1000
L109
L104
C120
33-250
TUNING
C115
1
C116
150
L106
2MH
CR101A
IN34
C113
0.01UF
C121
25-750
C122
25-750
L105
44
S104
L102
R101
38.3K
R102
38.3K
R105
100K
CR101B
IN34
C114
0.01UF
C127
1500
K101
ANTENNA
CHANGE
OVER
SEE
NOTE 2
L110
0.3
C137
91
L111
0.47
C138
180
L112
0.7
C107
91
C144
0.01UF
T101
S101
P101
J101
C105
0.01UF
S102A
S102B
C139
220
L113
1.1
C108
110
C111
5
C112
8-50
L107
2MH
K102
THERMAL
OVERLOAD
SWITCH
C151
560
L115
1.8
C147
650
L114
2.8
C109
510
B101
C150
560
C148
1000
C110
820
L103
56
T103
K205
ANTENNA
CHANGE
OVER
C145
0.01UF
C124
0.01UF
C125
0.01UF
C149
1000
C148
1000
S103
C131
0.01UF
C141
0.01UF
C130
0.01
UF
C129
0.01UF
C143
1500
C135
0.01UF
C133
0.01UF
C132
0.01UF
C123
0.01UF
C142
0.01UF
TB101
TB102
TB104
TB101
TB102
TB104
TB103
R106
500
S201D
SSB
CW
J203
ANTENNA
RELAY
C211B
250UF
C211A
250UF
C212
0.01UF
CR209
IN1081
R213
1MEG
R212
1MEG
R211
1MEG
R229
1MEG
CR206
IN1081
DS202
RED
R225
56
S205
K204
OVERLOAD
C202
0.01UF
SCREEN SUPPLY
R203
5K
C204
40UF
M202
PLATE CURRENT
SUPPLY
C252
0.001UF
C253
0.001UF
CR214
60H
C251
0.001UF
CR201
60H
C254
0.001UF
CR202
60H
CR213
60H
L201
3.5H
C205
0.5UF
L202
8H
C206
0.15UF
C207
4UF
C208
4UF
R205
18K
C221
0.01UF
CR204
60H
CR212
60H
C158
0.001UF
C255
0.001UF
CR215
60H
CR202
60H
C157
0.001UF
C256
0.001UF
R206
18K
S206
R215
8.2
R207
18K

retuning the input circuits. Figure 13-17 is the block diagram of the 30S-1, and figure 13-18 is the schematic diagram. Refer to chapter 7 for design considerations of linear amplifiers.

a. R-F CIRCUIT DESCRIPTION

The 30S-1 uses a 4CX1000A tetrode as the r-f amplifier. The cathode of the amplifier is driven, requiring some 80 watts PEP for proper operation. The screen grid is grounded directly to the chassis for better grid-plate isolation. The biased control grid is bypassed so that it is at r-f ground. A 12AL5 automatic load control rectifier monitors the grid circuit and applies alc to the exciter the moment the r-f amplifier draws any grid current, thus maintaining class AB_1 operation. The minute amount of grid current drawn before alc acts does not degrade linearity. Rather, these few microvolts actually improve the linearity curve; only after appreciable grid current is drawn is linearity affected. A plate overload relay, grid overload relay, and thermal overload relay are included for protection of the 4CX1000A. R-f output is coupled through a pi network into a 50-ohm load (with a maximum permissible swr of 2:1).

b. POWER SUPPLY

Since the power amplifier screen grid is at d-c ground potential, it is necessary to provide the cathode with negative 200 volts in order to supply screen voltage which is 200 volts higher than the cathode potential. Effective plate-cathode voltage is the sum of the screen-plate supply (2800 volts) and the cathode-screen supply (200 volts). Control grid bias is referenced to the cathode. All plate and screen current passes through the 200-volt supply, and only plate current through the 2800-volt supply. All relays are operated from d-c sources except the time-delay relay K202 and thermal overload relay K102. Switching from SSB to CW operation automatically lowers plate voltage and changes grid bias. The amplifier operates with approximately 3000 volts plate-to-cathode in SSB service and approximately 2400 volts plate-to-cathode in CW service. The power supplies may be connected to either 115-volt lines or 230-volt, 3-wire service lines. The 230-volt, 3-wire connection is preferred.

7. 312B-4 STATION CONTROL

The 312B-4 Station Control (figure 13-19) contains a pm (permanent magnet) speaker, a directional wattmeter, and a phone patch. The directional wattmeter indicates 0-200 or 0-2000 watts, forward or reflected. This power indication is useful in tuning and loading to produce minimum vswr. (See paragraph for a detailed discussion of directional wattmeters.) The phone patch is of the hybrid type and can be used for vox phone patch operation. The 312B-4 has a function switch for station control and can be used with any receiver transmitter combination or transceiver having power outputs up to 2000 watts PEP. The unit was designed for operation with the 32S-1, 75S-1, 30S-1 combination; the 32S-1, 75S-1; the KWM-2; or KWM-2, 30S-1 combination. Figure 13-20 is the schematic diagram.

Also available for use with the KWM-2 is the 399C-1 a unit in a case similar to the 312B-4. The 399C-1 contains a 70K-2 Oscillator identical to the one in the KWM-2 enabling the KWM-2 to transmit and receive on separate frequencies. Also included is a pm speaker and a switch for transferring oscillators. The 312B-5 combines the features of both the 312B-4 and 399C-1. It contains a 70K-2 oscillator, directional wattmeter, phone patch, and switching circuits for the KWM-2.

8. NOISE BLANKERS

The Collins noise blankers convert noise to bias pulses for gating the companion receivers. This minimizes receiver output noise when it is a result of radiated noise present on both the blanker and receiver antennas. The 136A-1, 136B-1, 136B-2, and 136C-1 Noise Blankers are designed for the 75S-1, KWM-1, KWM-2, and 75A-4 respectively. All are similar in design but are packaged differently for each unit. The noise blanker receiver operates in the 40.0-mc portion of the spectrum and works on the premise that noise pulses present in the 40.0 mc area occur simultaneously with noise pulses in the high-frequency (3-30 mc) portion, enabling the blanker unit to gate noise in the receiver unit. To do this the noise blanker is provided with a separate 40.0 mc antenna. Figure 13-21 shows a 136A-1 Noise Blanker installed in a 75S-1, and figure 13-22 shows a 136B-1 Noise Blanker installed in a KWM-1.

Figure 13-23, a block diagram of a noise blanker, illustrates the blanking scheme, along with figure 13-24, schematic diagram of the 136A-1. Tube sections V1A, V2A, and V3A are connected as a three-stage, cascade, 40-mc tuned r-f amplifier. Gain of the trf amplifier is controlled by potentiometer R4 in the cathode circuit of V2A. The output of V3A is limited by the action of diode CR8 and V3A. The positive component of the signal is clamped to the cathode of V3A. The signal is detected by CR1 and filtered by C15. The combination of C15 and R5

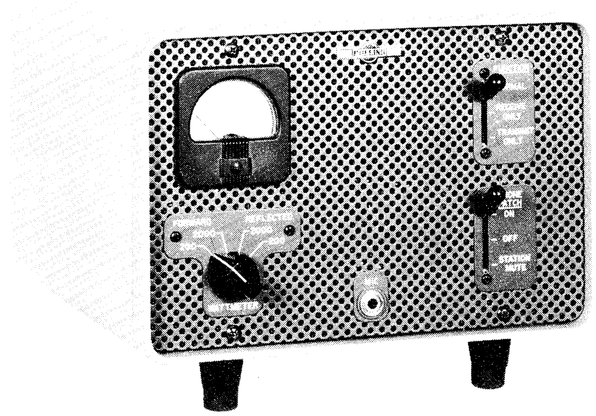


Figure 13-19. 312B-4 Station Control

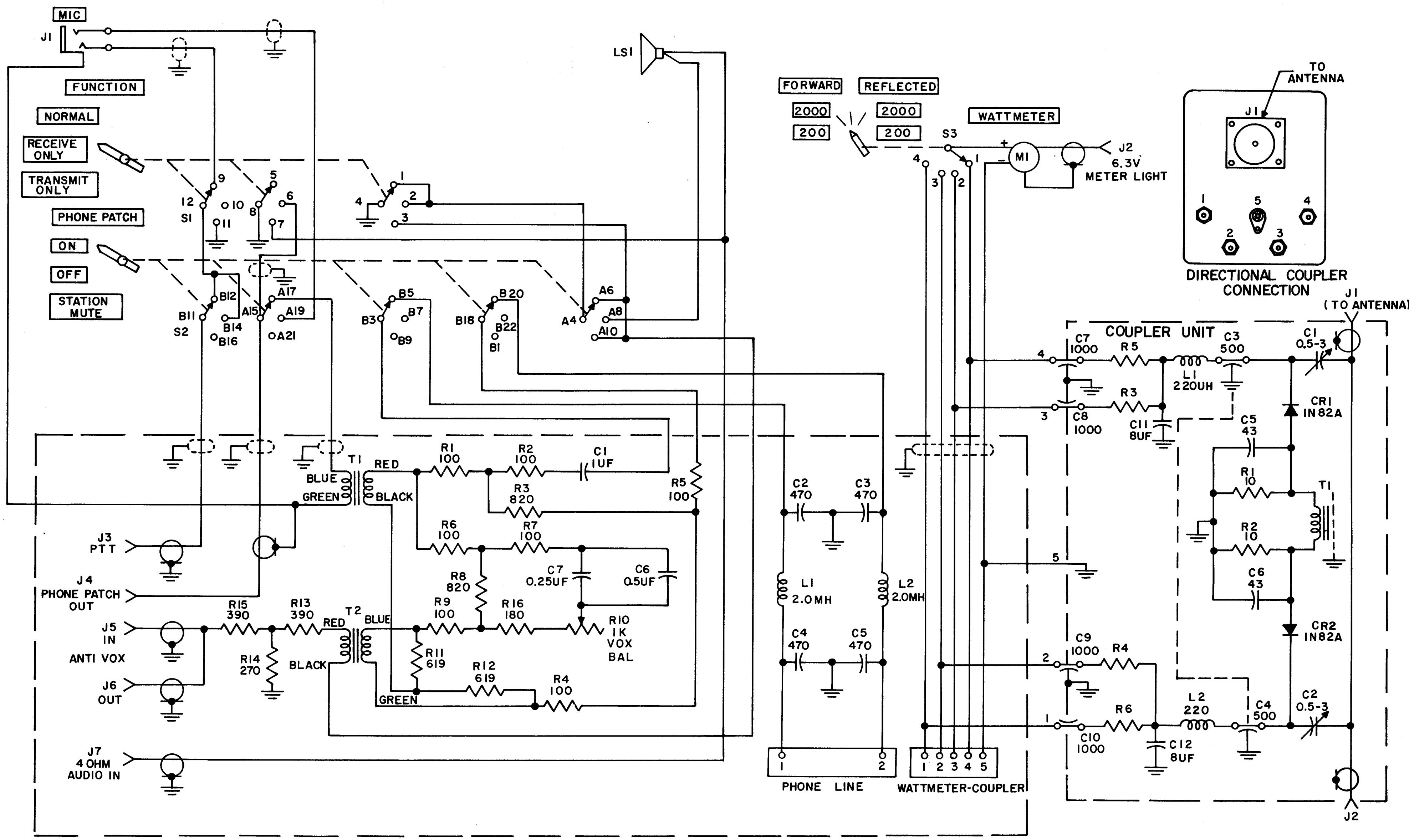


Figure 13-20. 312B-4 Schematic Diagram

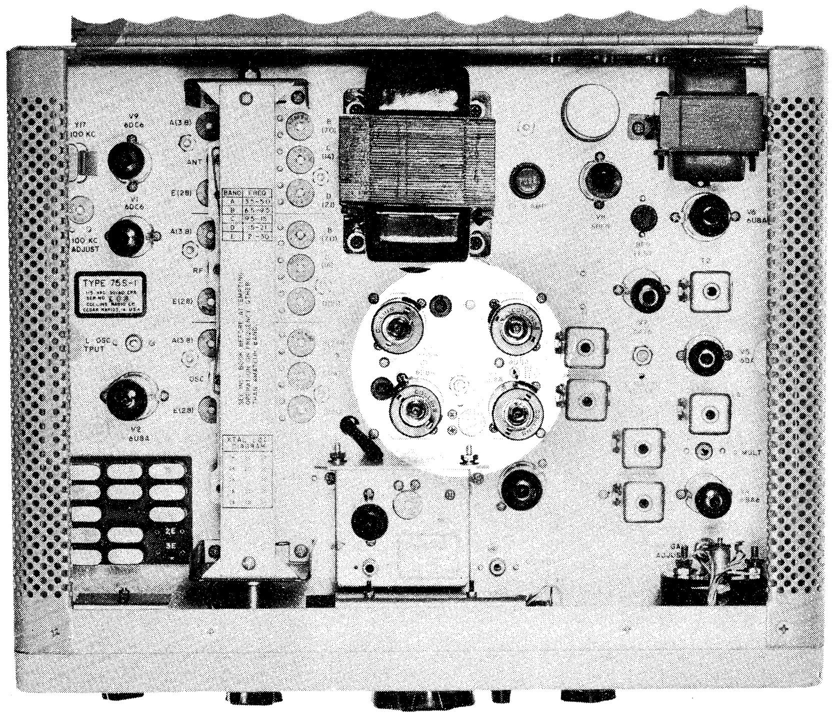


Figure 13-21. 136A-1 Noise Blanker Installed in 75S-1

determines the length of the blanking pulse. The audio component of the noise is limited by CR2 and applied to the grid of the first pulse amplifier, V3B. Positive-going output pulses from V3B are applied to the grid of V2B. Any negative portion of the waveform is clipped by CR4. Positive-going square pulses from V1B plate are applied through CR7 to the center tap of T1. The bias of CR7 keeps it cut off and at a high impedance to the low-level pulses, but high-level pulses overcome the bias and pass into the gate circuit. Gating diodes CR5 and CR6 are biased to conduction for normal, noise-free operation. However, when a high-amplitude noise burst occurs, the positive-going pulse passes through CR7 and cuts off both CR5 and CR6. This effectively disconnects the variable i-f signal for the period of blanking pulse. The length of the blanking pulse varies from a few microseconds to a maximum of 30 microseconds. Blanking pulse length is determined by the magnitude of the noise pulse appearing at the noise blanker antenna. For short-duration noise disturbances in the variable i-f, the blanking pulses are short, while greater noise bursts develop longer blanking pulses. Transformers T1 and T2 and the gating diodes are arranged in a balanced modulator configuration so that any noise which results from the gating action is canceled and prevented from entering the receiver circuits. Any discontinuity of signal resulting from the gating action is compensated by tuned-circuit restoration in the following stages of the receiver. Both sections of V4 serve to isolate the noise operated gate circuit from the receiver circuits. V4A provides only enough gain to compensate for the small

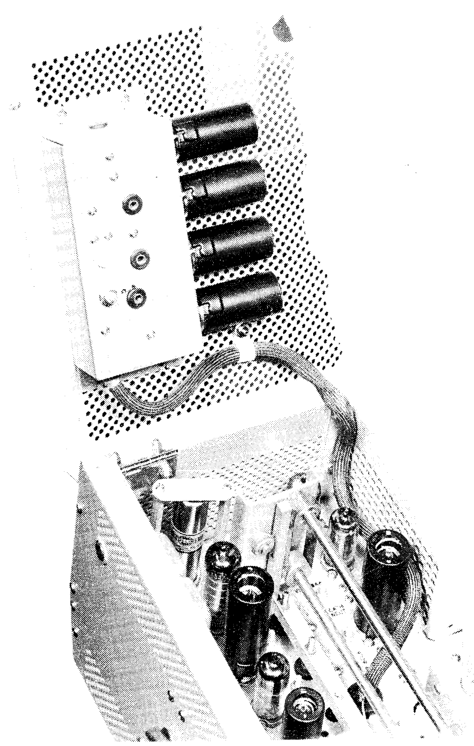


Figure 13-22. 136B-1 Noise Blanker Installed in KWM-1

loss in the gate circuit so that over-all gain through the noise blanker is approximately unity. Filament power, B+ power, and bias voltage are taken from the companion unit power supply, with the exception of the 136C-1 which has its own power supply.

The noise blanking scheme has the following three limitations which decrease blanking efficiency:

(1) Noise pulses which have no energy distribution at 40 mc will occur in the frequency spectrum of the radio receiver range. The noise blanker will not generate a blanking pulse in this case and will permit passage of such noise pulses.

(2) A very strong signal in the passband between the first and second mixers can be modulated by blanking pulses. This modulation process will cause sidebands in the passband which result in decreased blanking efficiency.

(3) Some corona noise and static disturbances have a repetition rate in excess of one hundred thousand pulses per second. The blanking efficiency decreases as the pulse repetition rate exceeds five thousand pulses per second.

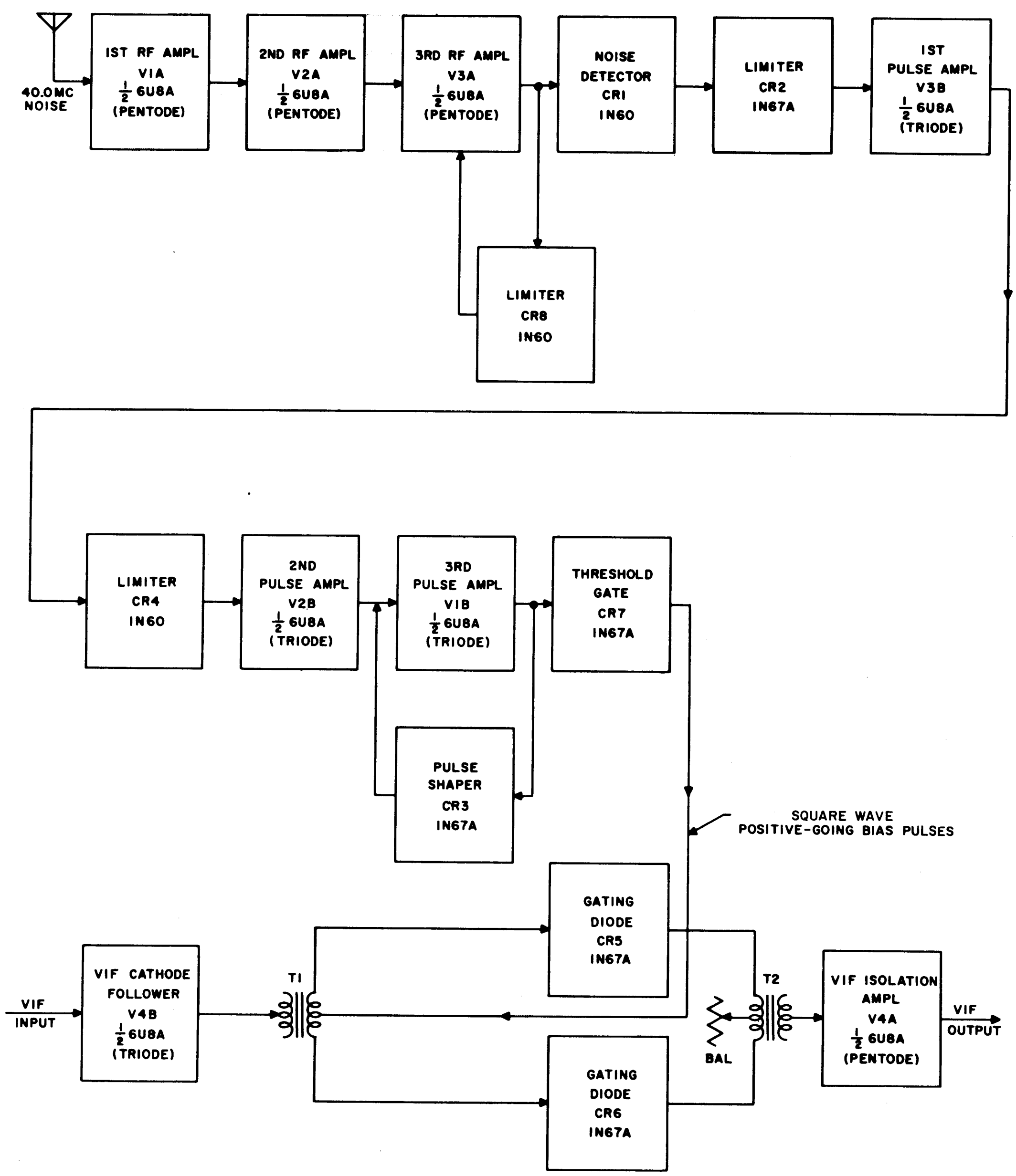


Figure 13-23. 136A-1 Block Diagram

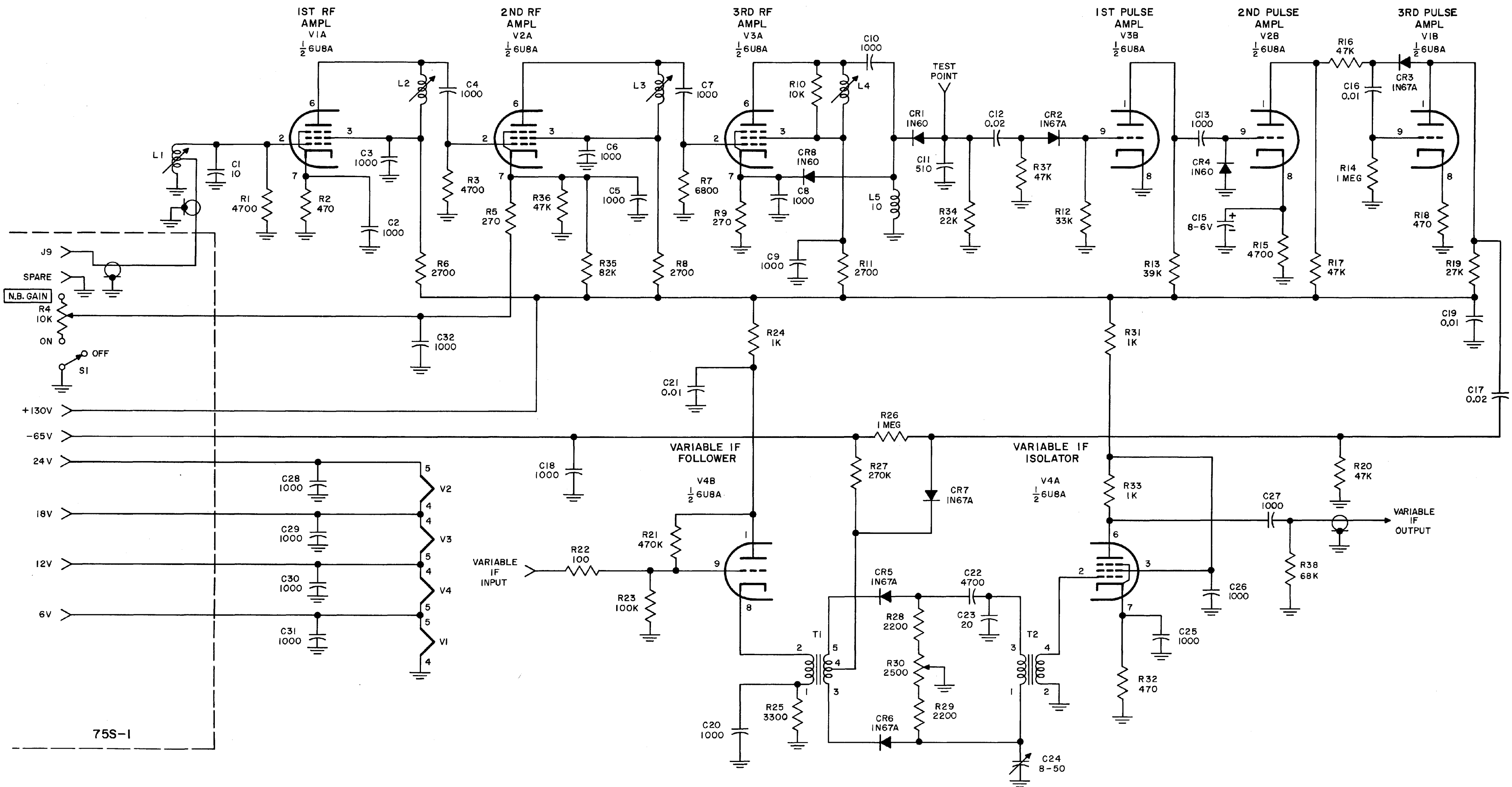


Figure 13-24. 136A-1 Schematic Diagram

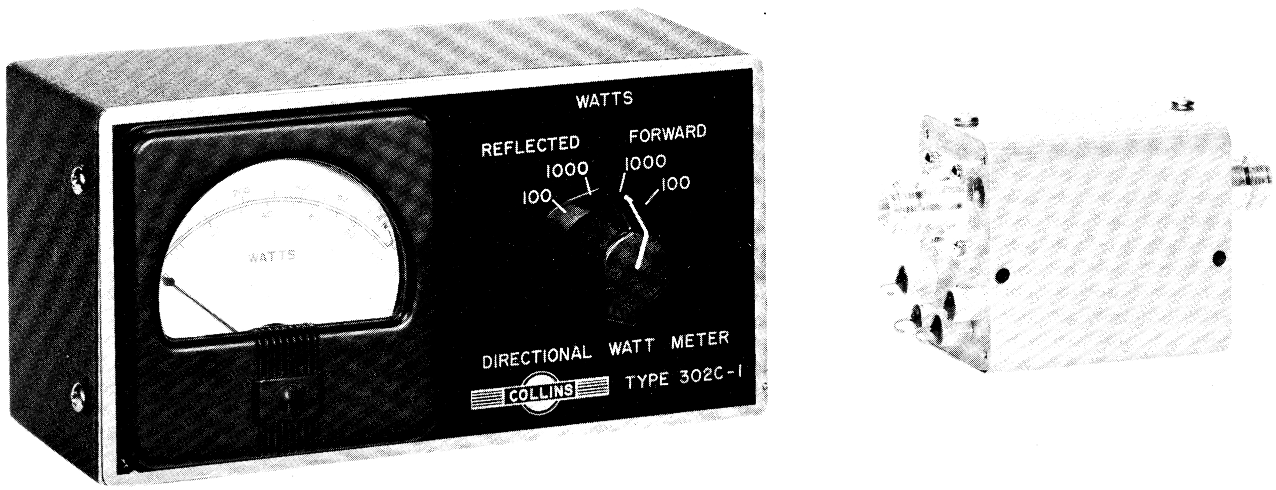


Figure 13-25. 302C-1 Directional Wattmeter

9. DIRECTIONAL WATTMETERS

Collins directional wattmeters measure forward and reflected r-f power on 52-ohm transmission line (RG-8/U or equivalent). The instruments are accurate to ±10 per cent (5 percent nominal) over the 3- to 30-mc frequency range. Power loss and mismatch introduced is negligible. The forward and reflected power readings are primarily used to determine transmission line swr and transmitter power output. In addition, antenna match, antenna bandwidth (match vs frequency), attenuation in transmission lines, and other system performance characteristics can be determined from the forward and reflected power

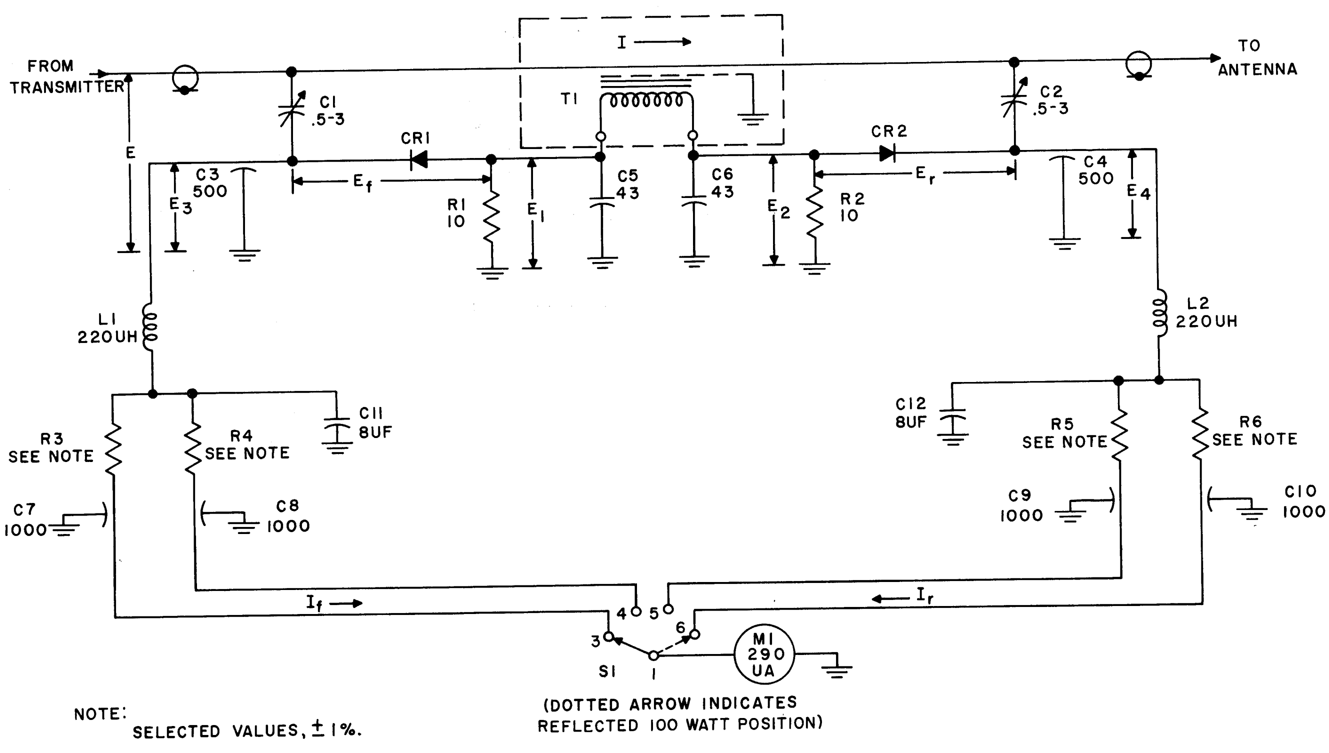


Figure 13-26. 302C-1 Directional Wattmeter, Simplified Schematic Diagram

readings. During transmission the instrument acts as a continuous monitor of transmitter performance and antenna match. Directional wattmeters are included in the 312B-2 Speaker Console for the KWM-1, the 312B-4, and 312B-5 Station Controls. They are also available separately as the 302C-1/2 Directional Wattmeter (figure 13-25) (calibrated for 100- and 1000-watt scales, 52-ohm line).

a. R-F CIRCUIT

Refer to figure 13-26. Transmission line current, I, flows through the line center conductor and through the center of a toroid coil. The conductor forms the primary section and the coil the secondary winding of a toroidal transformer, T1. Induced toroid current produces a voltage that divides equally across series resistors R1 and R2. This results in two equal voltages, E_1 and E_2, across the resistors. Since the junction of R1 and R2 is grounded, E_1 and E_2 are opposite in phase and proportional to line current, I. Line voltage, E, is applied across two capacity dividers, C1-C3 and C2-C4, resulting in two equal voltages of the same phase, E_3 and E_4.

When the transmission line is mismatched (terminated in an impedance other than 52 ohms), E_1 and E_2 represent the vector sum of two components, one proportional to the current of the forward wave, and the other proportional to the current of the reflected wave. Similarly, E_3 and E_4 represent the vector sum of forward- and reflected-wave voltage components. Capacitors C1 and C2 are factory adjusted so that the magnitude of the forward voltage and current components is identical; the reflected components are then equal also. The settings of C1 and C2 are correct for 52-ohm transmission line only.

The phase relationship between the various components is such that the r-f voltage across rectifier CR1 (E_f) is equal to the arithmetic sum of the two equal forward components, while the r-f voltage across rectifier CR2 (E_r) is equal to the arithmetic sum of the two equal reflected components.

When the transmission line is matched perfectly (terminated in a resistive load of 52 ohms), E_1 is equal in magnitude to E_3 and opposite in phase; E_f is the sum of E_1 and E_3, or twice the value of either. E_2 and E_4 are equal in magnitude and of the same phase, and E_r is zero volt. These relationships are used for adjusting C1 and C2 under laboratory conditions.

b. D-C CIRCUIT

R-f voltages E_f and E_r are rectified and filtered by CR1, CR2, C3, and C4 to produce d-c currents, I_f and I_r, through meter M1. The meter scale is calibrated in such a way that I_f produces a scale reading proportional to forward power, while I_r produces a scale reading proportional to reflected power. Capacitors C11 and C12 cause the meter reading to approach the PEP level during SSB voice transmission. Calibrating resistors R3, R4, R5, and R6 are selected so that I_f and I_r give accurate indications of two power levels.

c. FREQUENCY LINEARITY

Accuracy of the r-f wattmeter is maintained over a frequency range of 2 to 30 mc in both the inductively coupled and the capacitively coupled elements. In the inductive element, the increase with frequency of the induced voltage is canceled by the voltage drop in the toroidal coil due to the increase with frequency of the inductive reactance. In the directly coupled capacitive element, the ratio of the capacitive reactances in the voltage divider remains constant even though the reactance varies with frequency. Capacitors C5 and C6 compensate for the residual series inductance of resistors R1 and R2.

d. REAL POWER

Real power is the power output of the transmitter. When a line is perfectly matched, reflected power is zero and real power is equal to forward power. When the line is mismatched, the phase relationship between forward power and reflected-wave components causes the forward power to increase by an amount equal to the magnitude of the reflected power. Since the reflected power cancels a portion of the forward power at the transmitter terminals, the real power in the line is equal to the difference between forward and reflected power, or:

Real power = forward power - reflected power

10. POWER SUPPLIES

a. 516E-1 12-VOLT D-C POWER SUPPLY

Figure 13-30 is the schematic diagram of the 516E-1. The 516E-1 (figure 13-27) includes an 800-volt, 200-ma supply for the power amplifier plates and a 260-volt, 215-ma supply for other circuits. The 260-volt supply is tapped for -65 volts bias. This supply can be used with the KWM-1, KWM-2, or 32S-1. The 516E-1 is used primarily for mobile operation.

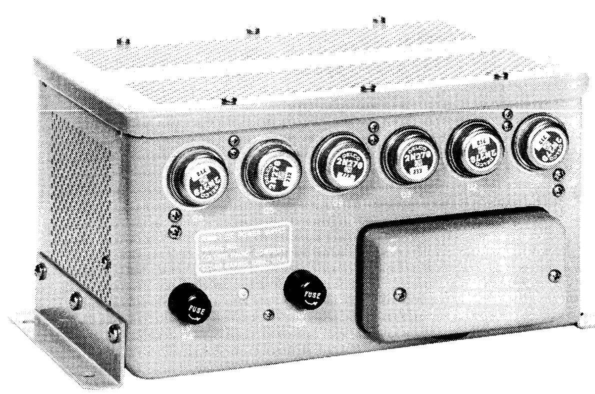


Figure 13-27. 516E-1 12-Volt D-C Power Supply

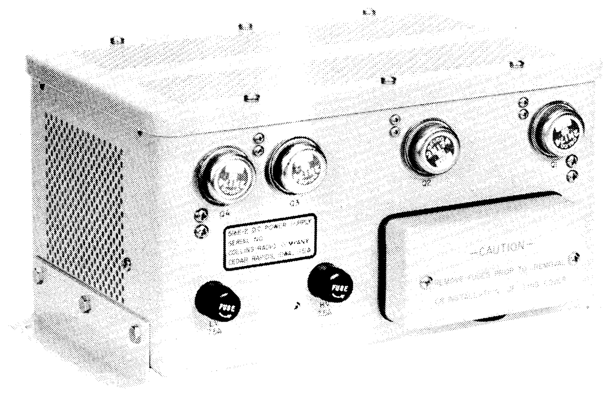


Figure 13-28. 516E-2 28-Volt D-C Power Supply

The transistors for each supply are connected in a grounded-collector multivibrator circuit which switches the d-c input power to a-c power for application to the primary winding of the power transformer. Switching rates of 600 and 800 cps are used in the two power supplies to prevent the transistor multivibrators from locking frequency with each other. Output from the power transformer secondary is rectified in a silicon diode voltage doubler circuit. The voltage from the bias tap of the 260-volt supply is rectified by a half-wave silicon diode rectifier. Input current requirement is 25 amperes (maximum) at 12 to 14 volts d-c.

b. 516E-2 28-VOLT D-C POWER SUPPLY

The 516E-2 D-C Power Supply (figure 13-28) is similar in construction and layout to the 516E-1. Input voltage and current requirements are 24 to 30 volts d-c at 12.5 amperes (maximum). Figure 13-31 is the schematic diagram.

c. 516F-2 A-C POWER SUPPLY

The 516F-2 A-C Power Supply (figure 13-29) can be used with the KWM-2 or 32S-1. Figure 13-32 is the schematic diagram of the unit. The 516F-2 contains an 800-volt, 200-ma power supply for all plate circuits and a 260-volt, 215-ma power supply for all other plate circuits. The 260-volt supply is tapped for -65 volts bias. The input voltage requirement is 115 volts a-c, 60 cps. The 516F-1 A-C Power Supply for the KWM-1 is quite similar to the 516F-2, but uses two separate transformers for the high- and low-voltage supplies rather than a single unit. Voltage outputs are the same.

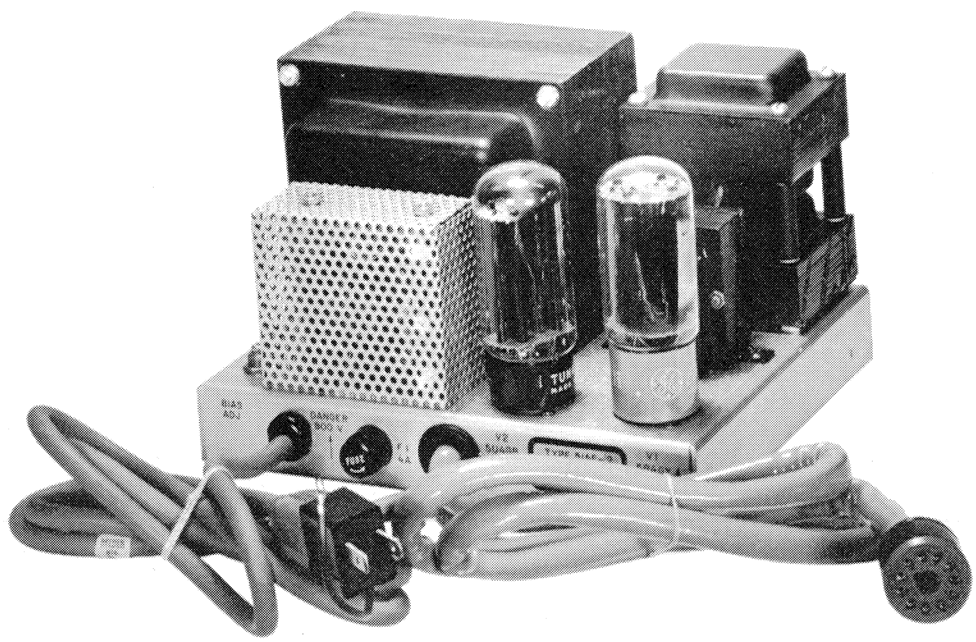


Figure 13-29. 616F-2 A-C Power Supply (Removed from Case)

COLLINS

COLLINS RADIO COMPANY