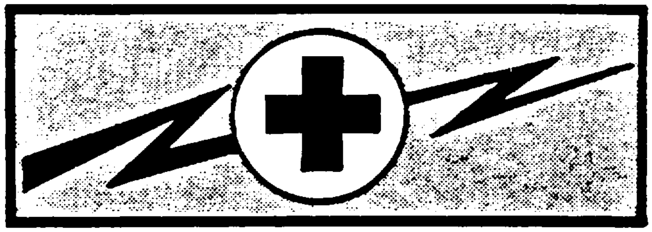
DEPARTMENT OF THE ARMY TECHNICAL MANUAL

DIRECT SUPPORT AND GENERAL SUPPORT MAINTENANCE MANUAL

RADAR CHRONOGRAPH SET M36 W/E (1290-861-7105)

This copy is a reprint which includes current pages for Changes 1 through 3.

HEADQUARTERS, DEPARTMENT OF THE ARMY
JULY 1968



WE 20780

WARNING

HIGH VOLTAGE

is used in the operation of this equipment.

DEATH ON CONTACT

may result if personnel fail to observe safety precautions Learn the areas containing high voltage in each piece of equipment.

Be careful not to contact high-voltage or 115-volt ac input connections when installing or operating this equipment.

Before working inside the equipment, turn power off and ground points of high potential before touching them.

EXTREMELY DANGEROUS POTENTIALS

exist in the following units:

Klystron
Voltage multiplier
Power supply

WARNING
POTENTIAL RADIATION HAZARD
WHEN RADAR IS ENERGIZED, PERSONNEL SHOULD NOT BE WITHIN 6 FEET OF THE RADIATING FEEDHORN (LOCATED IN CENTER OF DISH) IN THE DIRECTION OF THE TRANSMITTED BEAM.

WE 51652

TECHNICAL MANUAL
No. 9-1290-325-34

HEADQUARTERS
DEPARTMENT OF THE ARMY
WASHINGTON, D.C., *18 July 1968*

RADAR CHRONOGRAPH SET: M36 W/E (1290-861-7105)

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***This manual supersedes TM 9-1290-325-34, 8 July 1964.**

CHAPTER 1

INTRODUCTION

Section I. GENERAL

1-1. Scope

a. This manual contains instructions for the information of personnel responsible for direct and general support maintenance of radar chronograph set M36 (fig. 1-1). This manual also provides information for the maintenance of the equipment which is beyond the scope of the tools, equipment, personnel, or supplies normally available to operator's and organizational maintenance.

b. The maintenance allocation chart in TM 9-1290-325-12/1 allocates maintenance responsibilities.

1-2. Forms, Records, and Reports

a. General. DA Forms and procedures used for equipment maintenance will be only those prescribed in TM 38-750, Army Equipment Record Procedures.

b. Recommendations for Maintenance Manual Improvements. Report of errors, omissions, and recommendations for improving this publication by the individual user is encouraged. Reports should be submitted on DA Form 2028 (Recommended Changes to DA Publications) and forwarded to Commanding Officer, Frankford Arsenal, ATTN: AMSWE-MAF-W3100, Philadelphia, Pa. 19137.

c. Field Report of Accidents. Refer to AR 385-40 when injury to personnel or damage to materiel occur.

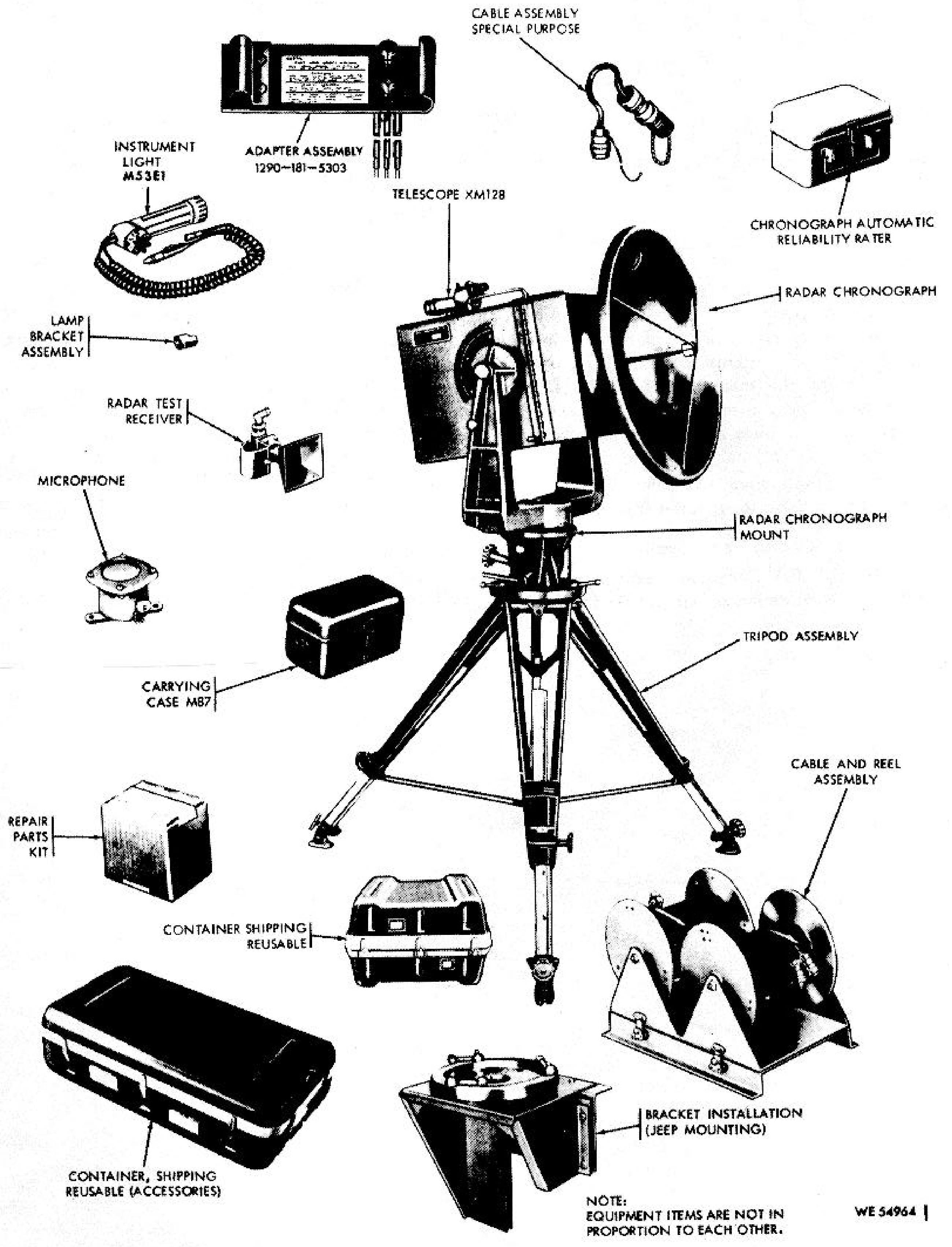


Figure 1-1. Radar chronograph set M36 and associated equipment (1290-861-7105).

Section II. DESCRIPTION AND DATA

1-3. Description

Refer to TM 9-1290-325-12/1.

1-4. Data

Data on capacities, performance characteristics, overall measurements, and weighs are covered in TM 9-1290-325-12/1

CHAPTER 2

THEORY OF OPERATION

Section I. FIRE CONTROL PROBLEM AND SOLUTION

2-1. Purpose of Equipment

For accurate control of weapon aim, it is necessary to know several factors which affect the ballistic curve of a projectile. Primary among these is muzzle velocity. The purpose of radar chronograph set M36 is to provide an accurate and convenient means of obtaining this muzzle velocity figure. The radar chronograph set obtains a velocity measurement by projecting a radar beam to a moving projectile and measuring the change in frequency (Doppler shift) of the signal reflected back. This velocity measurement is made entirely by electronic means, and the result is displayed in a digital form for convenient readout. The resulting velocity figure can readily be converted into actual muzzle velocity.

2-2. Mathematical Discussion of Doppler Shift (fig. 2-1)

a. The characteristic of wave motion called "frequency" is determined by the number of "peaks" or "troughs" passing (and somehow sensed by) the observer in a certain period of time. It may readily be seen that a hypothetical observer on a moving object such as the projectile in figure 2-1 would sense a "zero frequency" if the projectile could be made to move at the same speed and in the same direction as the wave so that it maintained a constant distance away from the wave front. In this case the wave front would never pass the object and thus could not be sensed. This apparent reduction of the wave frequency to zero is only true with respect to the moving object, of course; the actual frequency, which is determined by the source characteristics, remains the same. Reducing the velocity of the moving object would permit a certain number of waves to "catch up" with the object and be counted, giving an indication of some frequency greater than zero, but less than the actual frequency. The formula expressing this effect is:

$$\text{shifted frequency} = \text{original frequency} \times \frac{\text{speed of waves minus speed of object}}{\text{speed of waves}}$$

b. Reducing the velocity further until the object is stationary (A, fig. 2-1) would permit the waves to be received at a normal rate, and the frequency would be the same as that which originates at the source. Carrying this hypothetical case further, it may now be seen that moving the object toward the source would have the apparent effect of increasing the number of waves sensed by the observer in a given time, so the frequency would seem to have increased. (This last example is of no practical interest in this application because the projectile is always moving away from the source.)

c. Let us now reverse the conditions, placing our hypothetical observer in a stationary position and placing the source of waves on the moving object (C, fig. 2-1). Note that the waves which the moving source is emitting are separated by larger intervals than those emitted when it is stationary. This results in an increase in wave length, which may be translated as a reduction in frequency. The effect here is expressed as:

$$\text{shifted frequency} = \text{original frequency} \times \frac{\text{speed of waves}}{\text{speed of waves + speed of projectile}}$$

In the radar chronograph operation, both of these effects occur since the radar signal is shifted upon reaching the projectile and shifted again upon being reflected back from it. In the second case the projectile acts in effect as a moving signal source.

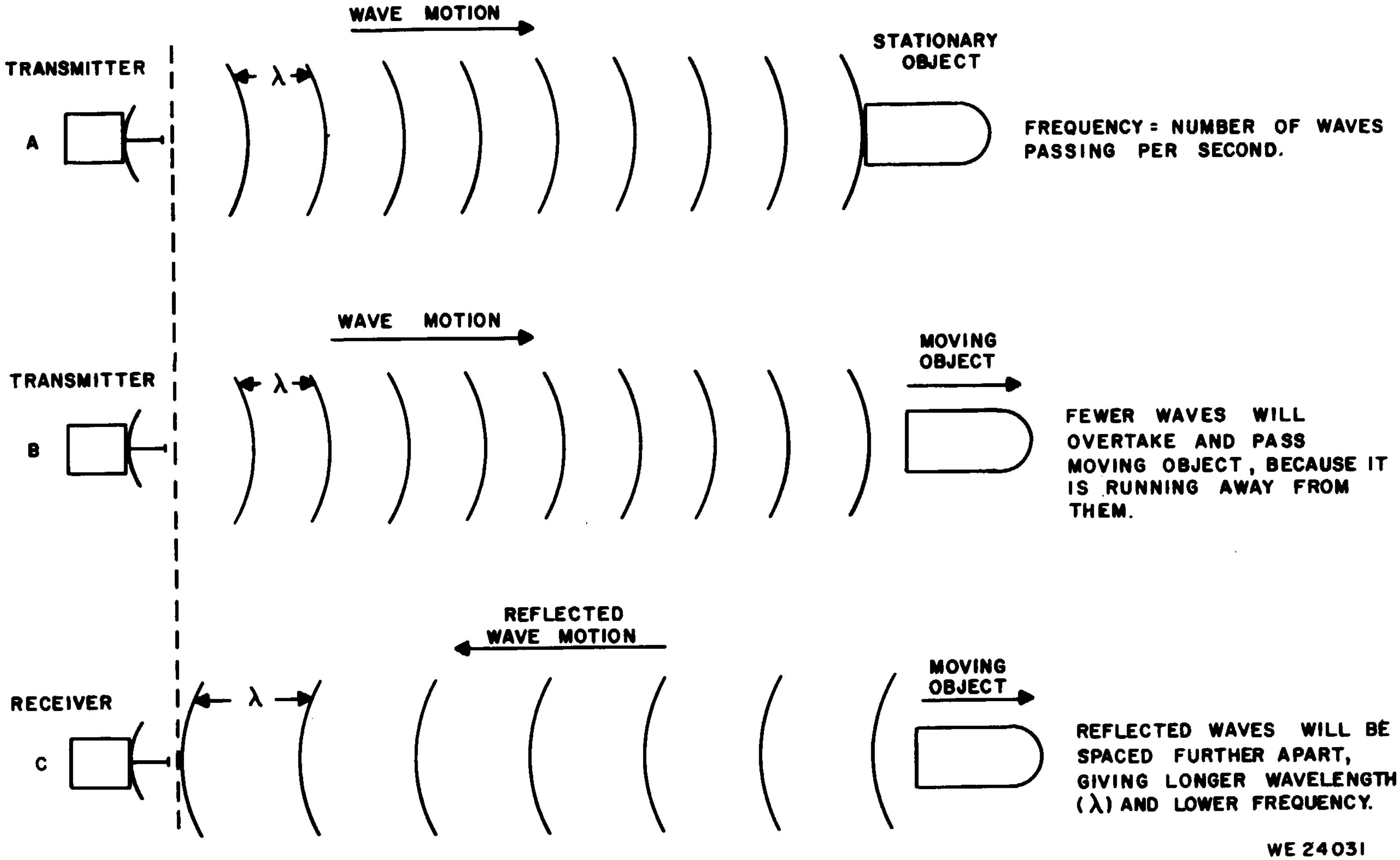


Figure 2-1. Graphic explanation of doppler shift.

d. The apparent shift in the frequency of the transmitted radar signal as it strikes the projectile will be expressed by the equation:

$$f' = f\,\frac{C-S}{C}$$

where f' = shifted frequency
f = original frequency
C = speed of radio waves
S = speed of projectile

Solving for the difference between the original and shifted frequencies, *f-f'*, the result is:

$$f - f' = \frac{fS}{C}$$

The differences $f\text{-}f^1$ will be designated as f_d so that

The additional frequency shift appearing in the signal reflected back from the projectile may be obtained from a similar formula. In this case, however, the projectile is in effect a moving signal source, the basic frequency of which is *f'* (the shifted frequency of the previous formula). Thus the frequency of the signal returned to the receiver, designated as *f"*, is:

$$f'' = f'\,\frac{C}{C+S}$$

Solving for the amount of frequency shift *f'-f"*, which will be designated as f_d,the result is:

$$f'_d = \frac{f''S}{C}$$

For the combined outgoing and returning signals, the two frequency shift figures are added and the result is expressed as:

$$f_d + f'_d = \frac{fS}{C} + \frac{f''S}{C} = \frac{S(f+f'')}{C}$$

The total doppler shift $f+f'_d$ will be designated as *D f*, so that:

$$\Delta f = \frac{S(f+f'')}{C}$$

Solving the above equation for the quantity *S* gives:

$$S = \frac{\Delta f C}{f+f''}$$

By treating *f* and *f"* in the equation as equal (which introduces only a negligible error), the equation is further simplified to:

$$S = \frac{\Delta f C}{2f}$$

Because *C* is a constant and *f* is also held constant, the quantity $\frac{C}{2f}$ may be considered fixed, leaving *D f* as the only independent variable. The constant factor $\frac{C}{2f}$ is resolved into a numerical figure as follows:

$$\frac{C}{2f} = \frac{300{,}000{,}000 \text{ meters per second}}{2\times 10{,}500 \text{ megacycles per second}}$$

$$= \frac{30\times 10^7 \text{ meters per second}}{21\times 10^9 \text{ cycles per second}}$$

=0.01428 meters per cycle

e. The radar chronograph determines the total Doppler shift *D f* in the received echo signal by "beating together" the shifted signal and a sample of the unshifted signal (at an intermediate frequency level) obtaining a new signal which has a frequency equal to *D f*.

f. The *D f* quantity could now be multiplied by the factor 0.01428 simply by limiting the frequency-counting period used by the counter circuits to this part of a second; however, because of other considerations to be explained later, the same effect is achieved by a somewhat less direct method. That is, a counting period is used which is three times as long as that required to give the proper velocity reading, and the resulting 3X velocity figure is subsequently divided by three before application to the digital indicators.

g. The 3X counting period (0.04282 second) is obtained by using a gating frequency of 23.3516 cps (cycles per second). This frequency is obtained by dividing the basic gating signal frequency of 95.648 kc (kilocycles) by 16, getting 5.978 kc, then dividing again by 16, getting 373.6 cps, and again dividing by 16, obtaining the desired 23.3516 cps frequency.

Section II. GENERAL SYSTEM OPERATION

2-3. Overall System

a. General. The system block diagram (fig. 2-2) shows that the radar chronograph is the main functional part of the set. It consists of a complete radar transmitter and receiver along with special circuitry for comparing outgoing and incoming frequencies, converting the result into velocity terms, and displaying them for readout. The chronograph also has provisions for precisely determining the period of measurement and for delaying the initiation of the measurement period. In addition, it has provisions for calibrating the equipment against an accurate crystal-controlled frequency standard (which is included in the unit), and for monitoring critical voltages and currents. Operating voltages are obtained from a built-in power supply. In figure 2-2 the basic currents are grouped for purposes of theoretical explanation into blocks designated as transmitter, hybrid coupler, receiver comparator, and computer and indicator.

b. Block Diagram Analysis. The radar signal to be used for projectile velocity measurement is generated in the transmitter. This 10,500 me (megacycle) signal is produced by a master klystron oscillator and is passed through a system of waveguides to the antenna. Because this antenna is used for both transmission and reception at the same time, a special coupling device (hybrid coupler) is included in the waveguide system to channel the proper signal in each direction. The signal beamed out by the antenna is reflected back from the projectile to the antenna. This received signal is separated out by the hybrid coupler and channeled into the receiver circuits. The radar receiver is of the superheterodyne type; that is, it "beats" or heterodynes the incoming signal with a local-oscillator signal to produce a lower intermediate frequency signal before final detection and utilization of the signal information. This local-oscillator signal (10.5 kmc + 45 mc) is based on the 10.5 kmc reference signal obtained from the main transmitter oscillator. Using the same signal in both transmitter section and receiver section affords certain advantages. One is that variations in frequency will be the same in both sections, precluding the possibility of error due to a difference between transmitter and reference signals. In the receiver comparator circuits, the resulting intermediate frequency (IF) signal is amplified and the amount of frequency change (Doppler shift) is detected by electronically comparing the shifted frequency with the reference frequency. The resulting difference-frequency signal produced is fed into the computer section where the frequency is determined precisely by counting individual pulses. Factors are also introduced here which result in a

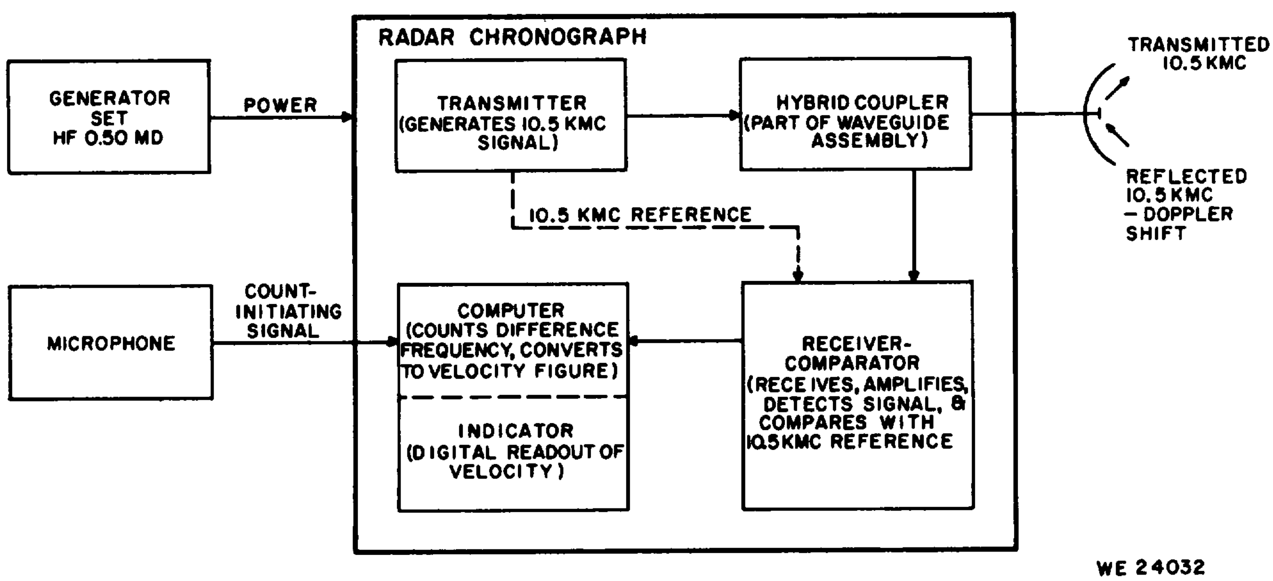


Figure 2-2. Radar chronograph set-functional block diagram..

series of pulses having a number representing the velocity term. This series of pulses is fed to the indicators where the count is displayed in a digital readout form.

2-4. Transmitter Circuits

(fig. 2-3)

a. General. The circuits which function as a radar transmitter are grouped together in the block diagram of figure 2-3. The radar signal is produced by the klystron (master oscillator) which oscillates at a fixed frequency of 10,500 mc. This continuous-wave signal is fed through a section of waveguide to the hybrid coupler which transfers part of the signal to the transmitter output. The hybrid coupler also delivers the 10,500 mc signal to the receiver for use in making a local oscillator signal, while at the same time the transmitter signal is blocked from the receiver signal input. The transmitter signal is passed from the hybrid coupler to the leakage tuner, a tunable section of wave guide which leads to the antenna. This tuner permits adjustment of resonance and signal phase relations in the output waveguide section for maximum transmission efficiency and receiver sensitivity. It also serves to cancel out transmitter signals (reflected both internally and externally) which would otherwise enter the receiver. The transmitter signal is fed through the tuner to the antenna which focuses the radiated signal into a narrow beam covering approximately 3.4 degrees of arc. (A narrow beam permits making the most efficient use of the radiated energy, at the same time limiting the effects of extraneous reflections.)

b. Automatic Frequency Control. The frequency of oscillation of the klystron oscillator is accurately maintained by a special automatic frequency control (AFC) circuit. A sample of the klystron output is taken from the oscillator and applied to an AFC discriminator which senses any deviation from the resonant frequency. By means of two semiconductor diodes, a dc error voltage is obtained from the AFC discriminator. This error voltage, amplified by a differential amplifier, is used to control the output amplitude of a 230 kc AFC oscillator. The 230 kc AFC oscillator output is further amplified by means of a voltage multiplier (sextupler) circuit. The rectified output of this voltage multiplier-rectifier circuit is applied to the klystron electrode as a

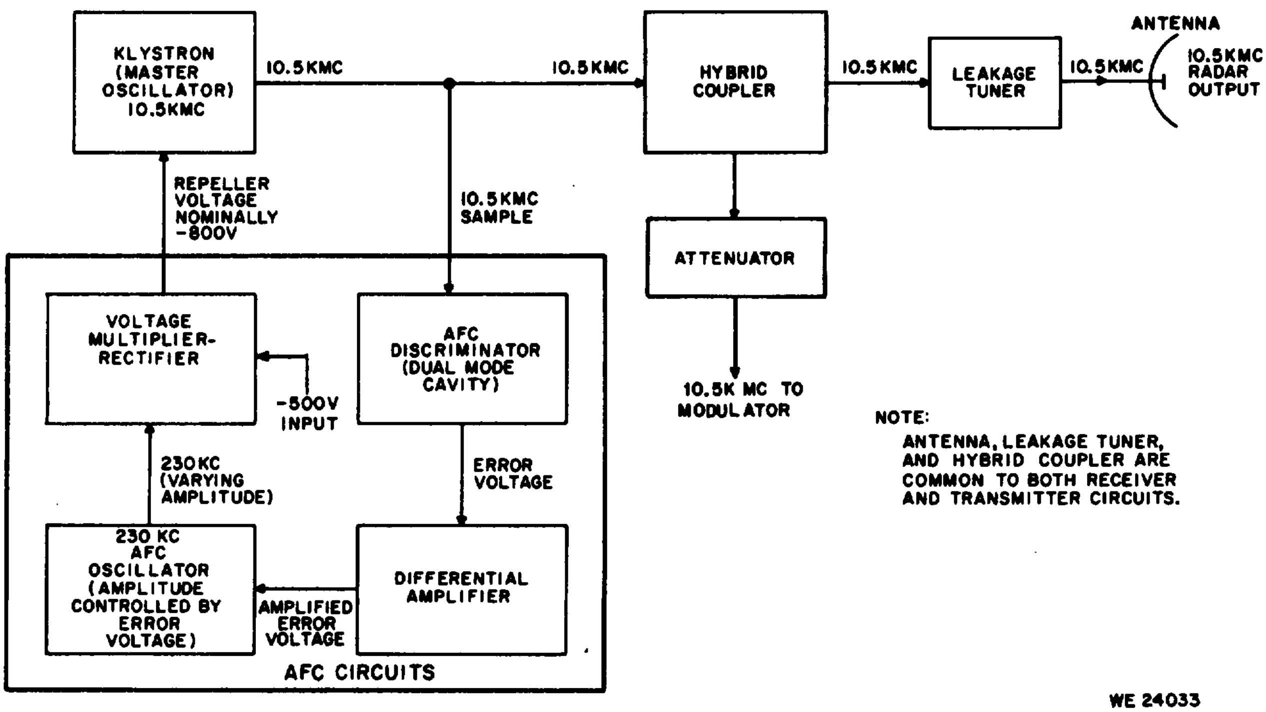


Figure 2-3. Radar chronograph transmitter circuits—functional block diagram.

repeller voltage to control the frequency of the oscillation.

2-5. Receiver Circuits

(fig. 2-4)

The radar signal reflected from a moving projectile is returned to the chronograph antenna with its frequency lowered in proportion to the projectile velocity. This returned signal is conducted by the waveguide from the antenna to the leakage tuner which functions to minimize the leakage of any extraneous signals (either internally produced or externally reflected) into the receiver. These extraneous signals would effectively increase the "noise" level and reduce the usable receiver sensitivity if the tuner were not properly adjusted to cancel them out. This is done by establishing a canceling phase and amplitude relationship between signal components in the leakage tuner. The received signal is passed from the leakage tuner to the hybrid coupler which passes this signal on to the mixer in the receiver circuits. (The transmitter signal is prevented from entering the receiver circuits at this point.) A portion of the 10.5 kmc reference signal from the klystron is passed through the hybrid coupler and applied to the modulator. This signal is heterodyned with a 45 mc signal from a special crystal-controlled oscillator, which effectively shifts it upward 45 mc (45 mc corresponds to the intermediate frequency). The modulator produces outputs having frequencies 45 mc above 10,500 me (sum) and 45 mc below 10,500 mc (difference). Because it is electrically balanced in design, the modulator cancels out the original 10,500 mc component. The lower (difference) frequency signal is suppressed by a subsequent bandpass filter, so that only the 10,545 mc "local-oscillator" signal is applied to the mixer. The mixer then converts the received signal to the 45 mc intermediate frequency by heterodyning the received 10,500 mc signal (reduced by the amount of Doppler shift) with the 10,545 mc "local-oscillator" signal from the balanced modulator. Because the frequency of the received signal will always decrease as the projectile travels away from the signal source, the difference-frequency signal produced by the mixer (and used as the intermediate-frequency signal) will be greater than 45 mc by the amount of the Doppler shift. This signal is fed to the IF amplifier where it is amplified and applied to the detector (a balanced demodulator). In the detector circuit the IF signal is heterodyned with a 45 mc reference signal (from the same oscillator which feeds the modulator) to accomplish the required comparison of the shifted IF signal with the 45 me reference signal. (This 45 me signal is the same as that used in the modulator, so an upward error in the 45 me frequency, which introduces an upward error in the IF signal, also causes a downward error in the detector output, thus, in effect nullifying the error.) Due to the balanced nature of the detector circuit, the 45 me input signal components are canceled out, while the sum and difference-frequency signals appear in the output. The difference-frequency output (which is mainly in the audible range of frequencies and so is referred to as "audio") is applied to the audio amplifier. The amplified audio signal is passed through the bandpass filter selected for the velocity range being used, then through a low-pass filter to further suppress unwanted high frequency components. The audio output of this filter, which is a signal having a frequency equal to the Doppler shift (and thus proportional to the projectile velocity) is fed to the computer for counting and converting into a velocity figure.

2-6. Computer Circuits

a. *General*. The computer circuits of the radar chronograph perform five main functions. The first is the pulse-by-pulse counting of the audio frequency signal resulting from the Doppler shift. The second is the limiting of the counting time to a precisely determined period (by means of electronic gating circuits) which in effect introduces the required multiplying factor for converting the Doppler-shift frequency into velocity terms. (See mathematical discussion, para 2-2.) The third function is providing a pre-selected delay which determined the point on the projectile trajectory at which the measurement will take place. The fourth function is initiating the counting operation by means of gating circuits which are triggered by a microphone and associated amplifier. The fifth function is providing a visible indication of the resulting velocity figure in the form of a digital display. Several secondary functions are also performed by these circuits; a crystal-controlled oscillator provides the basic frequency

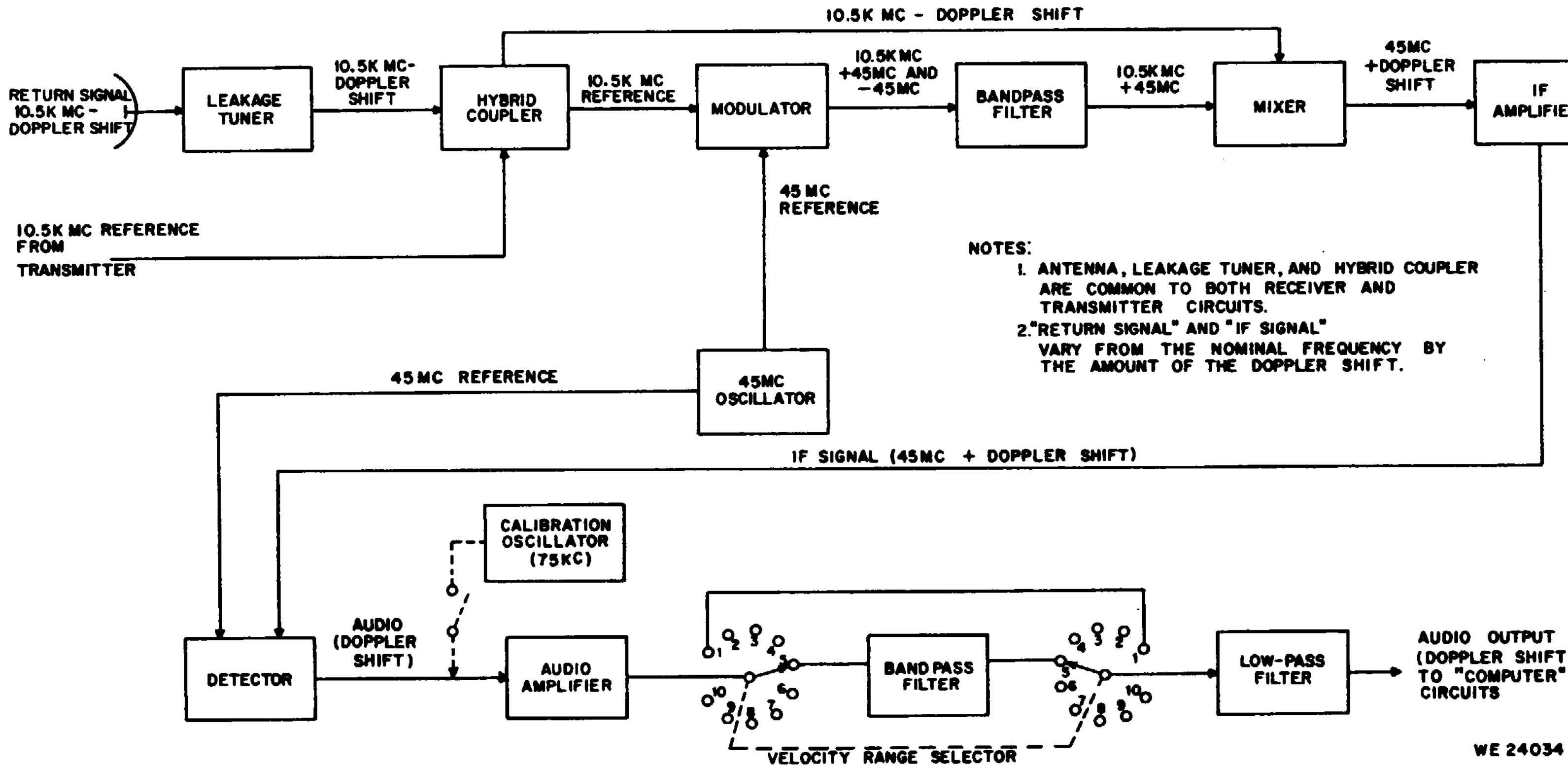


Figure 2-4. Radar chronograph receiver circuits—functional block diagram.

for establishing the measurement period and at the same time the basic delay increment. Associated with this oscillator are several circuits for dividing down the oscillator frequency to the proper frequency for delay and measurement periods. In addition, another crystal-controlled oscillator produces a 75 kc signal which is used to simulate a Doppler-shift signal for calibration purposes. A delay reset, circuit resets the counter 86 millisec after the initiation of the microphone signal. This tends to reduce the effects of shock.

b. Counting circuit. (fig. 2-5). The output signal from the audio amplifier is first fed into another AF/RF amplifier (audio) stage then applied to an oscillator Doppler gate (audio) circuit which passes the gating signal only during the measurement period. After passing through the oscillator Doppler gate (audio) circuit, the signal is applied sequentially to a series of five frequency divider or decade counters, the outputs of which register on associated electron tube digital indicators. The first of these decade counters also divides the count by three to obtain the proper one-to-one reading.

c. Gating and Delay Circuits (fig. 2-6). The basic gating frequency is produced by a 95.648 kc radio frequency oscillator. This signal is fed through an oscillator Doppler gate A5A1 which passes the signal only during the period between actuation of the microphone and the end of the measurement period. The gating signal passed through the oscillator Doppler gate (still at a frequency of 95.648 kc) is applied to a series of three electronic digital counters, divide-by-sixteen subassemblies, each of which is made up of four divide-by-two multivibrator circuits The output of the third electronic digital counter is at a frequency is 23.3516 cps. This frequency has a period three times longer than that required for a one-to-one count; however, this period is suitable for use as the basic delay increment by the delay multivibrator subassembly which follows. The delay multivibrator subassembly passes a pulse only after the elapse of a predetermined period of time. Five takeoffs are used to provide pulses of different lengths and polarities. These pulse outputs are connected to the delay switch A5S1 which selects appropriate combinations for application to the delay gate. The delay gate, after the selected delay, passes a gating signal (having three times the length required for a one-to-one count) to the audio gate circuits. At the end of the measurement period a stop signal is sent back to gate generator A5A3 which applies a gating signal to the oscillator Doppler gate, stopping the flow of the 95.648 kc signal, to the electronic digital counters, and thus stopping the counting process.

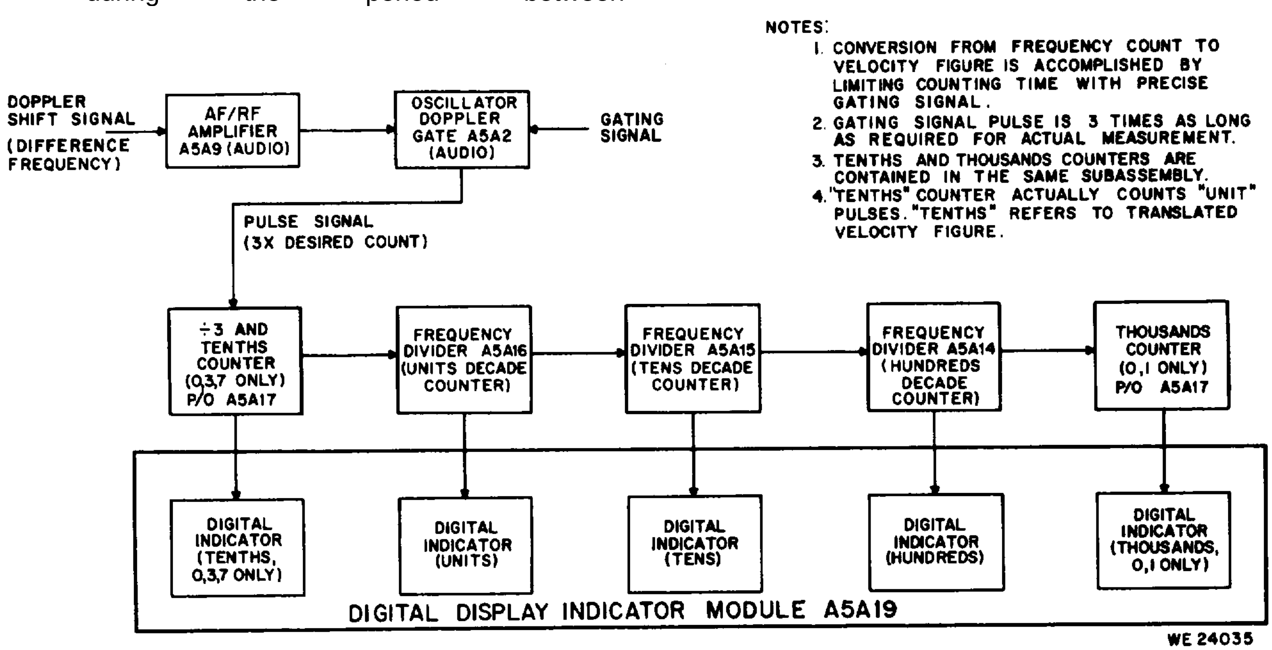


Figure 2-5. Radar chronograph counter and indicator circuits--functional block; diagram.

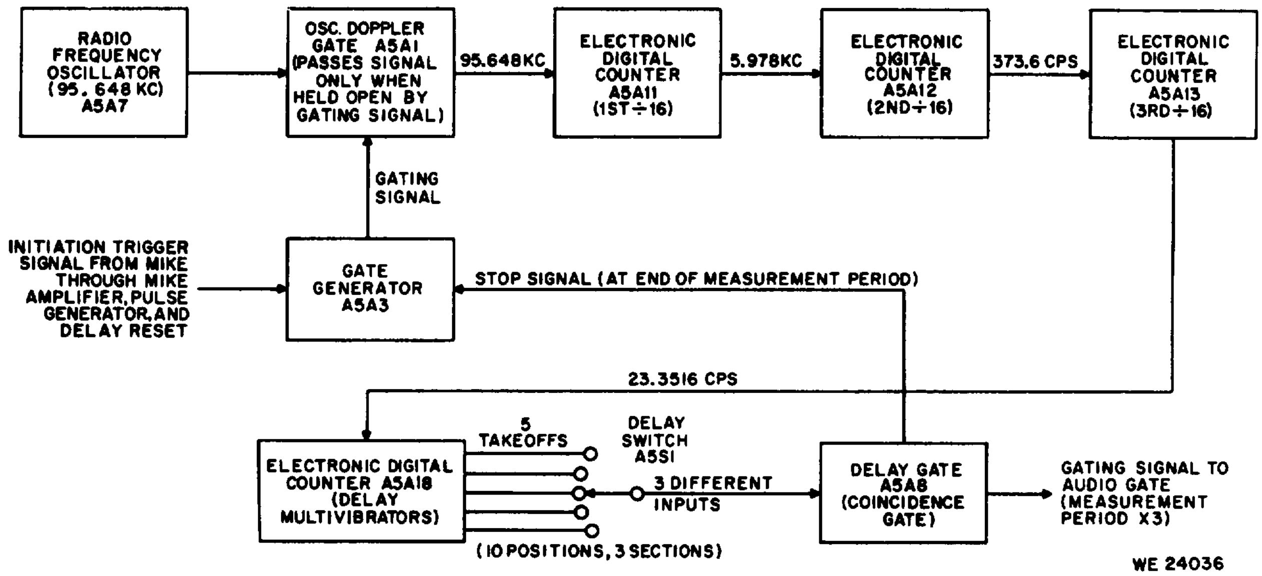


Figure 2-6. Radar chronograph gating and delay circuits--functional block diagram.

d. Count-Initiating Circuits (fig. 2-7). The count-initiating signal is originated by the microphone when it is actuated by the weapon blast. The signal is fed through a microphone amplifier, pulse generator, and delay reset, to the gate generator. The gate generator puts out a pulse which is applied to the oscillator Doppler gate and is maintained until the stop signal is fed to the gate generator.

e. Indicators. The visible display of the velocity figure is presented in meters per second on a set of five electron-tube-digital indicators (fig. 2-5). These indicators have a range from 0000.0 to 1999.7. The "thousands" indicator is connected so as to display only 0 and 1 while the "tenths" indicator is connected for 0, 3, and 7. With the exception of these two indicators, which share the same decade counter module, each of the indicators is fed by a separate decade frequency divider or counter. Each electrode of the indicator tubes, with the exception of those electrodes not in use, is switched on by a separate transistor.

2-7. Calibration Circuits

(fig. 2-8)

The counter circuits are checked out by means of special integral calibration circuits. A precise frequency for calibration purposes is supplied by a radio frequency 75 kc. oscillator. This 75 kc signal may be applied to the audio amplifiers, simulating a Doppler-shift signal. The resulting velocity readout should be 1070.3, 1070.7 or 1071.0 meters per second. When the CAL 1-OPER-CAL 2 switch is in the CAL 2 position, the signal from the 95.648 kc radio frequency oscillator is used to simulate a microphone signal for initiating the counting sequence. When the CAL 1-OPER-CAL 2 switch is in the CAL 2 position a dc voltage is used to simulate a

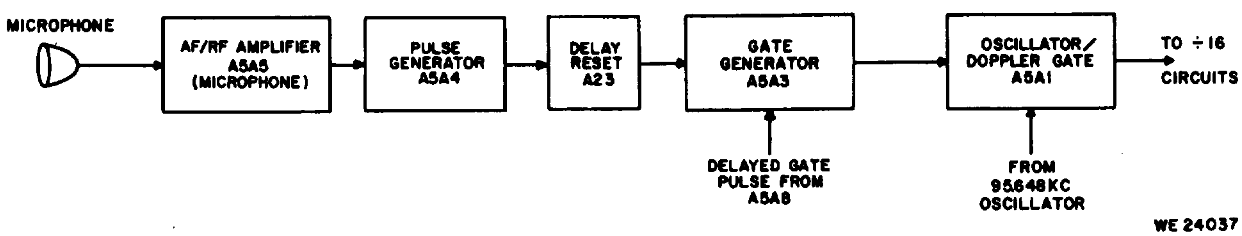


Figure 2-7. Count-initiating circuits—functional block diagram.

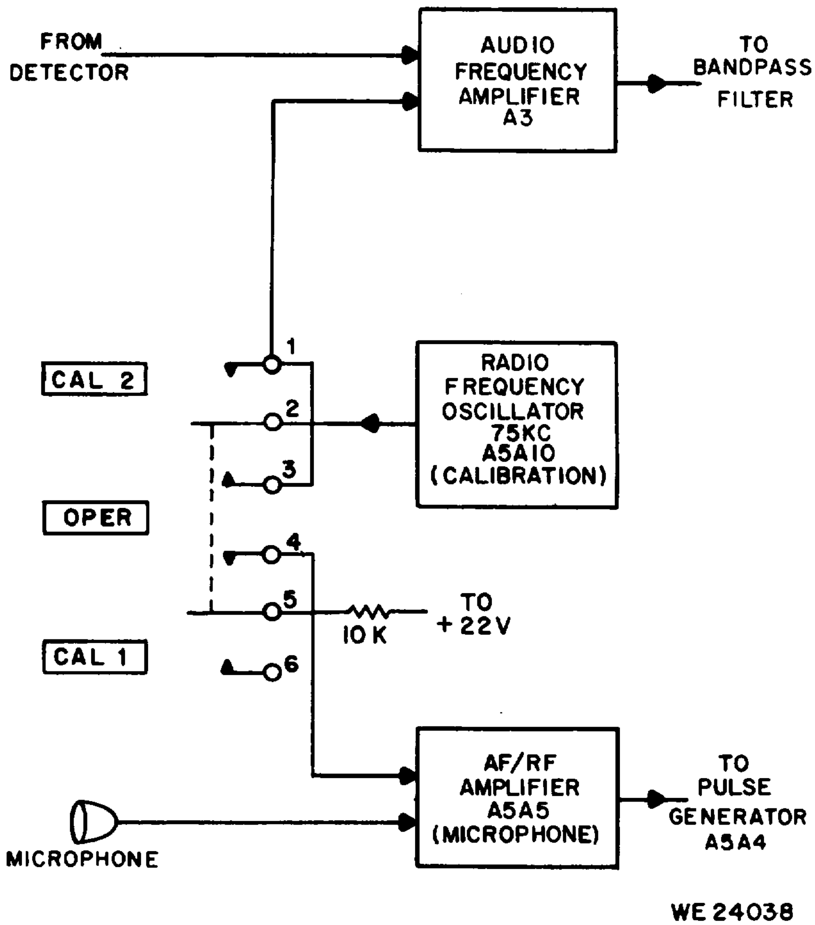


Figure 2-8. Calibration circuit--functional block diagram.

used to simulate a microphone signal for initiating the counting sequence.

2-8. Monitoring Circuits

a. General. Two separate monitoring meters, each with a selector switch and associated circuitry, are provided to permit easy and rapid checking of critical voltages and currents. The external monitor meter, located on the chronograph rear panel is used during setup and operation to check the line voltage, the power supply outputs, the AGC voltage in the audio amplifiers, the amount of leakage signal present in the receiver circuits, and the amount of normal signal present. The internal monitor meter is used to check the klystron AFC discriminator output, the 45 me injection into the modulator, and the crystal (semiconductor diode) currents in both the modulator circuit and the mixer circuit.

b. External Monitoring (fig. 2-9).

(1) Line voltage. With the S1 external monitor switch in the LINE position, the M1 external monitor meter checks that the 115-volt ac line voltage is within tolerance limits. The check is actually made after the line voltage is stepped down to 6.3 volts for use by the tube heaters. The heater voltage is rectified and converted to dc for the meter, then dropped to a value giving the proper meter reading. Clockwise movement of the meter needle indicates an increase in the amplitude of the voltage.

(2) B+ voltages. With the external monitor switch in the B+ position, the monitor meter checks the three ds power supply voltages simultaneously. The --500, + 170. and +22-volt outputs are combined and the resulting voltage dropped through a dividing network to the value giving a

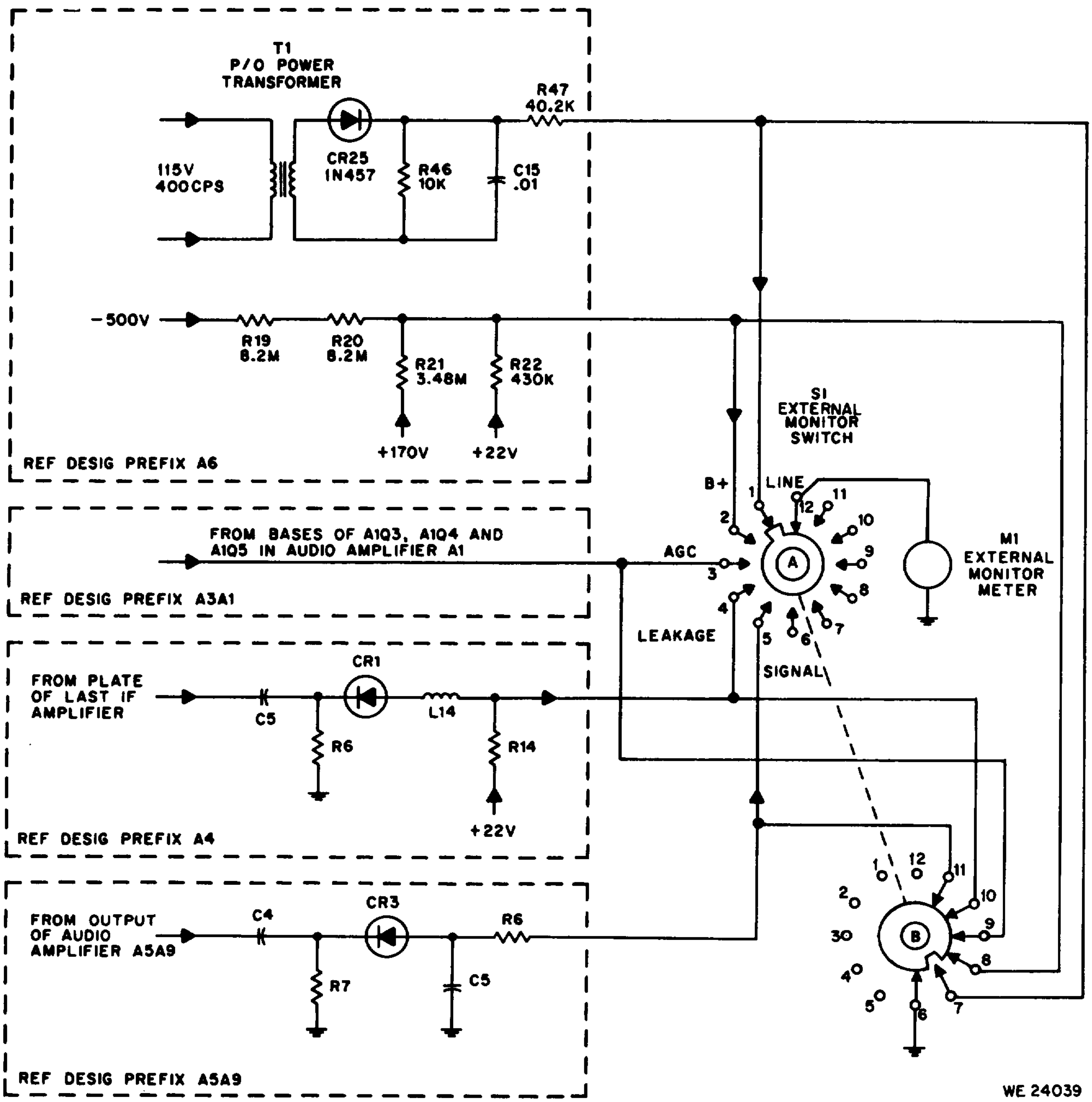


Figure 2-9. External monitoring meter connections-partial schematic diagram.

meter reading in the center of the green band. Clockwise movement of the meter needle may indicate a decrease in the -500-volt potential or a rise in the + 170-volt or + 22-volt potential.

(3) AGC voltage. With the external monitor selector switch in the AGC V position, the monitor meter checks the audio amplifier AGC voltage. This is done by measuring the positive voltage taken from a voltage divider between the AGC line and ground. Counterclockwise meter needle movement

indicates an increase in the positive bias resulting from an increase in signal input. (This increase in bias is used to reduce the amplifier gain.)

(4) Leakage. With the external monitor selector switch in the LEAKAGE position, the monitor meter checks the leakage signal by measuring the signal at the plate of the last IF amplifier. This IF signal is rectified and the resulting negative voltage is combined with 22 volts to give a proper meter reading. Clockwise needle *movement indicates a lowered IF signal amplitude.*

(5) Signal voltage. With the S1 external monitor switch in the SIGNAL position, the M1 external monitor meter normally reads less than 20. With a rectified signal output from the audio amplifier A5A9, the meter pointer swings clockwise into the green band.

c. Internal Monitoring (fig. 2-10).

(1) AFC discriminator. With the S1 internal monitor selector switch in the AFC DISC position, the M1 internal monitor meter checks the error signal output from the AFC discriminator. The normal operating indication should be at the zero point (±2 microamperes) which occurs between the two symmetrical positive and negative peaks produced by varying the AFC control.

(2) Modulator drive. With the internal monitor selector switch in the MOD I)RIVE position, the internal monitor meter checks the 45 mc

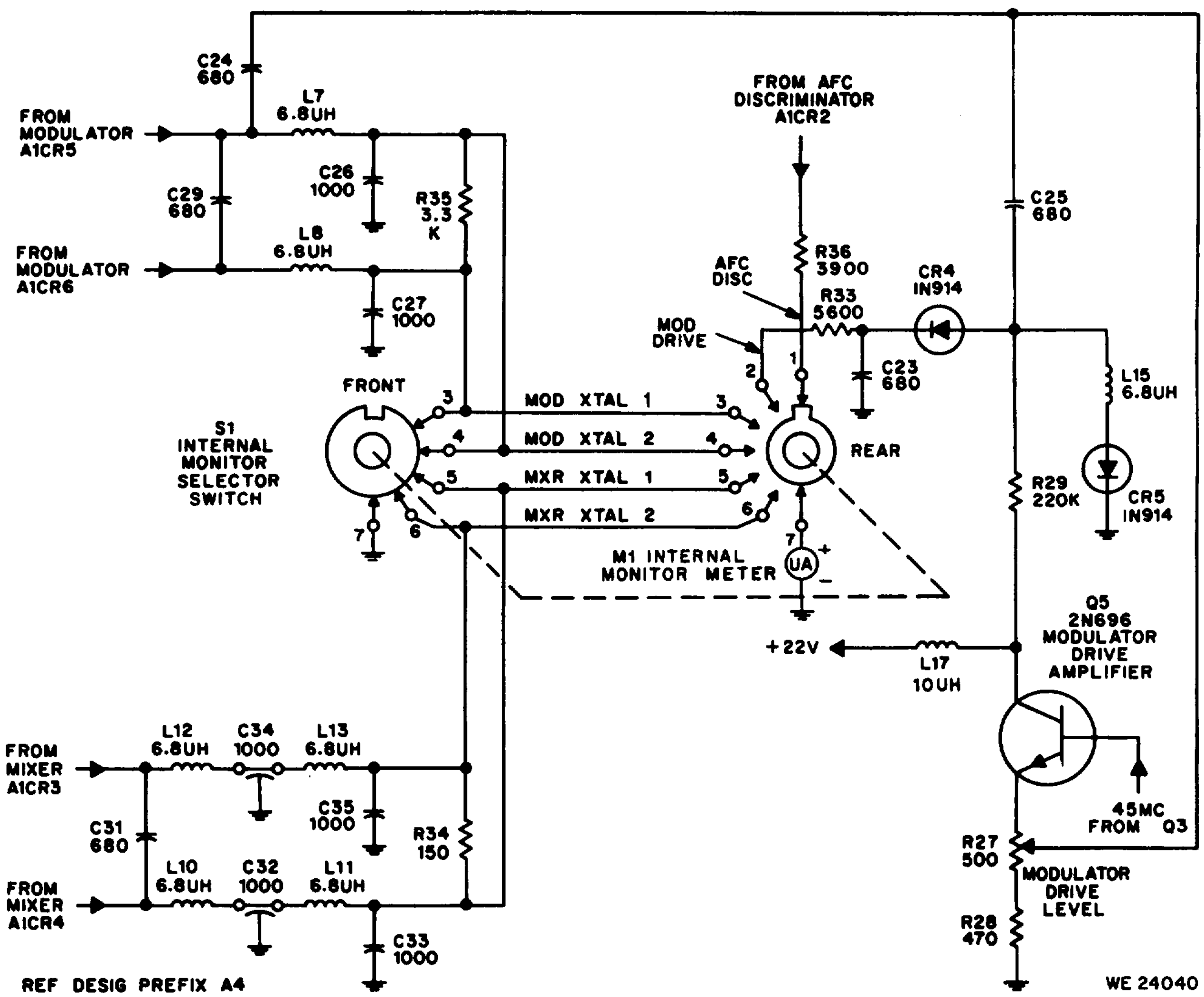


Figure 2-10. Internal monitoring meter connections-partial schematic diagram.

injection signal being fed to the modulator. The sample of signal is taken from the drive amplifier, rectified, and the resulting direct current applied to the monitor meter. The normal operating modulator drive reading should be between +40 and +70 microamperes.

(3) Modulator crystal checks.

(a) With the internal monitor selector switch in the MOD XTAL 1 position, the internal monitor meter checks the current through A1CR6 in the modulator circuit. The normal reading is between +45 and +90 microamperes.

(b) With the internal monitor selector switch in the MOD XTAL 2 position, the internal monitor meter checks the current through A1CR5 in the modulator circuit. The normal reading is -45 to 90 microamperes or greater.

(4) Mixer crystal checks.

(a) With the internal monitor selector switch in the MXR XTAL 1 position, the internal monitor meter checks the current through A1CR4 in the mixer circuit. The normal reading is -20 to 80 microamperes.

(b) With the internal monitor selector switch in the MXR XTAL 2 position, the internal monitor meter checks the current through A1CR3 in the mixer circuit. The normal reading is + 20 to 4-80 microamperes.

2-9. Power Supply Circuits

(fig. 2-11)

a. General. All dc operating voltages for the radar chronograph (and the ac voltage for IF tube heaters) are produced by power supply assembly A6, which is comprised of three different dc supplies fed from a common power transformer A6T1. Two of these supplies (-500-volt and + 170-volt) include power sources for their regulator transistors. The third supply produces 22 volts for use by transistors throughout the system. Each of the de supplies has its own dynamic regulation provisions using transistor circuits. A sampling of the de output voltages is combined in a resistive network for application to the monitor meter so that. all three supplies are checked out at the same time. (Current for the klystron tube heater is supplied by a separate heater transformer not located in the power supply assembly.)

b. -500-Volt Supply. This supply uses a four-diode bridge rectifier. The rectified current is filtered, then passed through a series-regulator transistor. The conduction of the series-regulator transistor is controlled by a transistor control amplifier which in turn is controlled by an error amplifier that "senses" variations in the output voltage. Operating de voltages for the three transistors are produced by an integral supply using a pair of diodes in a full-wave rectifier configuration, fed by a separate secondary winding on the main power transformer. The series-regulator transistor is protected against over-voltage damage by a shunt breakdown (Zener) diode. The effects of thermal variations are compensated for by a thermistor (thermally varying resistance) shunting a part of the output voltage divider. The application of -500 volts to the klystron is delayed until after warm-up by a time-delay relay.

c. 170-Volt Supply. The circuitry of the 170-volt supply is basically the same as that of the 500-volt supply. The 170-volt output is obtained from the emitter of its series-regulator transistor, instead of from the base as in the 500-volt supply. The 170-volt supply also has a second output at 130 volts for use in the IF amplifier circuits.

d. 22-Volt Supply. This supply uses a two-diode full-wave rectifier, fed by a separate secondary winding on the main power transformer. The rectifier output is filtered, then passed through a series-regulator transistor. The conduction of the series-regulator transistor is controlled by a two-step control amplifier which in turn is controlled by an error amplifier and current amplifier that "senses" variations in the output voltage. The series-regulator transistor is protected from heavy current by a separate transistor current limiter amplifier which limits the current flow through the series regulator.

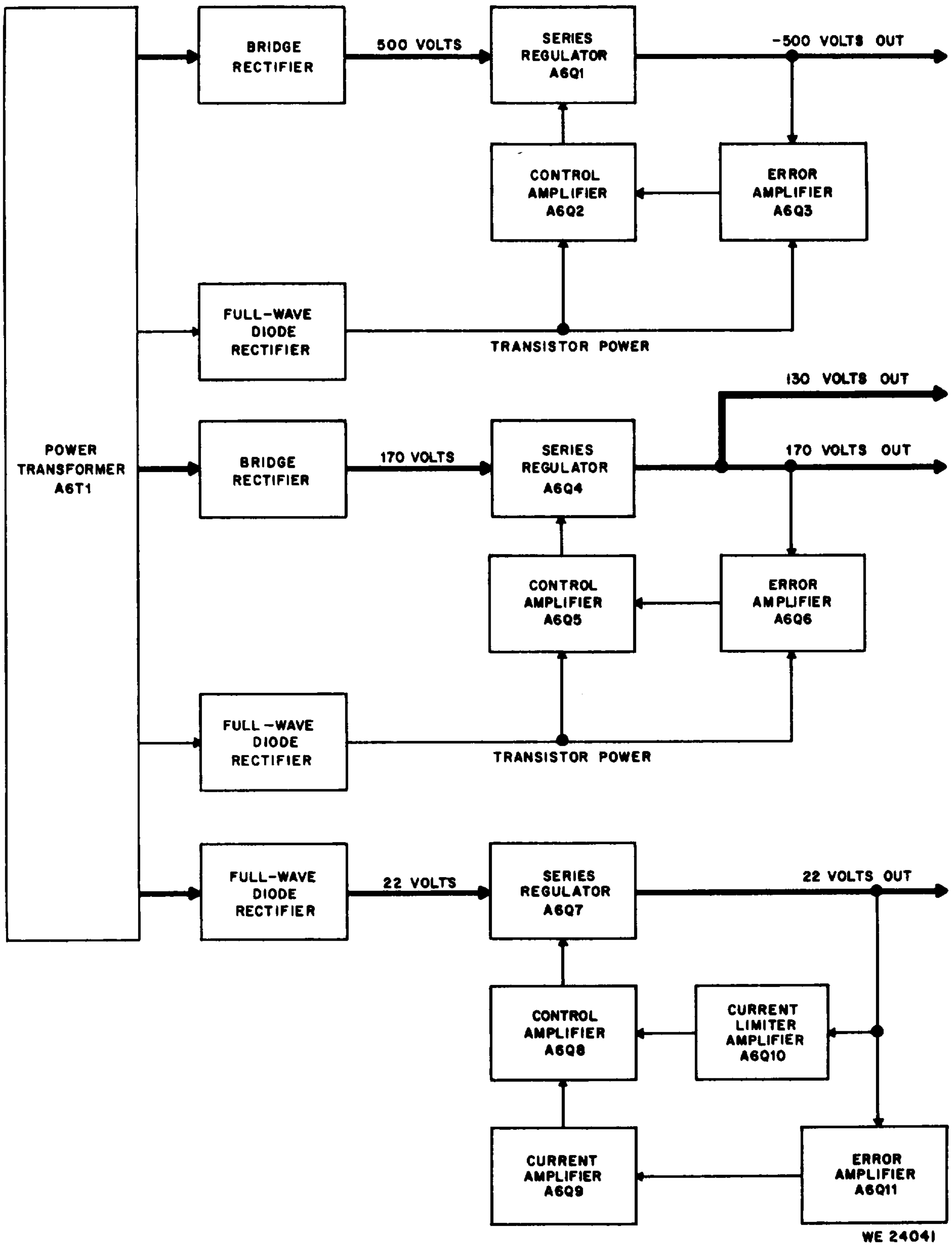


Figure 2-11. Power supply assembly A6—simplified block diagram.

Section III. FUNCTIONAL DESCRIPTION OF RADAR CHRONOGRAPH

2-10. Waveguide Assembly A1 (fig. 2-12).

a. General. In the radar chronograph, all circuits handling the microwave signal in transmission or reception are grouped into the waveguide assembly Al, located in the front section of the chronograph cabinet directly behind and connected to the antenna assembly. This assembly includes the klystron oscillator, AFC discriminator, hybrid coupler, attenuator, modulator, bandpass filter, mixer, and leakage tuner, as shown in figure 2-12.

b. Master Oscillator (fig. 2-13). The radar signal to be transmitted is produced by a master oscillator circuit which consists essentially of reflex klystron tube A1V1. This tube is mounted directly to the waveguide section which serves as its output line. Electrical connections are made through terminal board 1TB2 which is mounted on the inner surface of the front wall of the chronograph cabinet. Air cooling is provided by a blower mounted on a bracket located near the terminal board. The reflex klystron "velocity-modulates" the stream of electrons emitted from its cathode by means of a set of grids associated with a resonant cavity which performs the functions of both "bunching" and "catching". A repeller plate held at a negative potential forces the electrons to return through the cavity grids toward the cathode, setting up an oscillatory action. The output of the oscillator is in the form of a continuous wave signal at a frequency of 10,500 mc. The output power level of the klystron oscillator is approximately 500 milliwatts; however, the power reaching the antenna is reduced to approximately 250 milliwatts. The klystron is designed for fixed-frequency operation, but can be readily adjusted to an exact frequency within the range of 10.45 kmc to 10.55 kmc by means of the trimming nut which applies pressure to the metal wall of the tube, changing the size of the cavity and thus the frequency of oscillation. The cavity may be thought of as a parallel resonant circuit in which the cavity walls constitute the inductance and the two grids the parallel capacitance. The electrons emitted by the heated cathode are accelerated toward the wire mesh grids which are maintained at 500 volts (ground potential) with respect to the cathode. The electrostatic field which exists between the grids and the

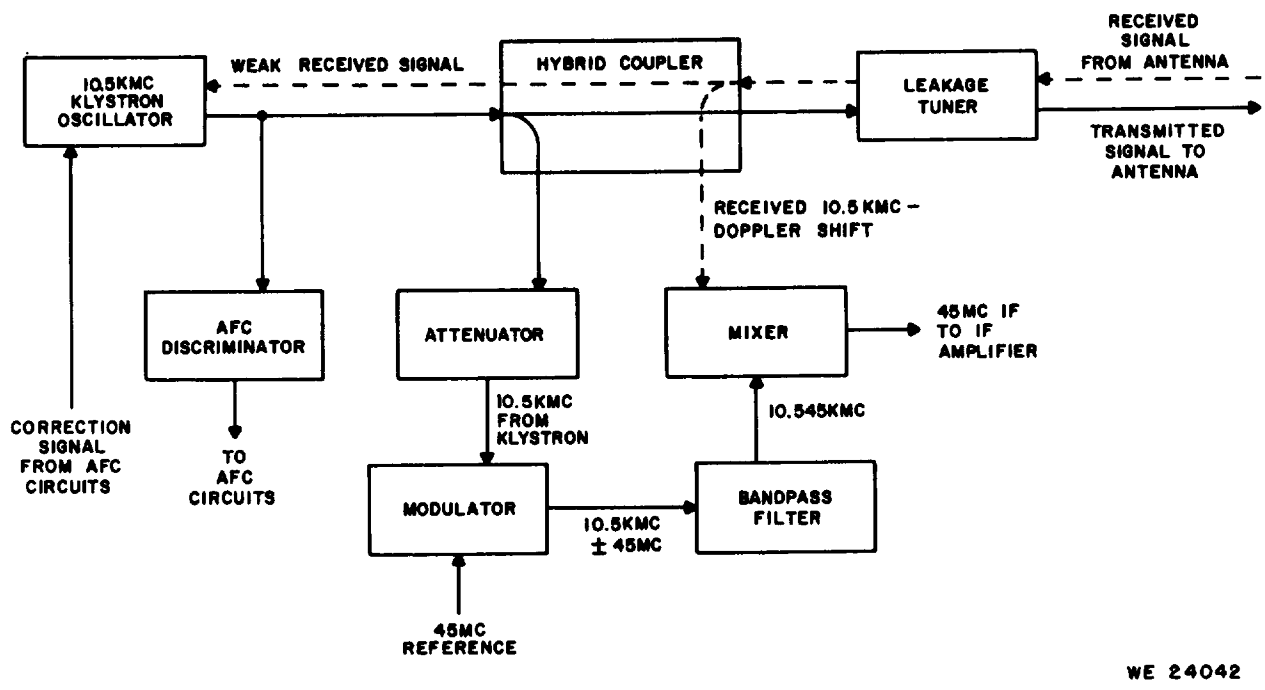


Figure 2-12. Waveguide assembly A1—functional block diagram.

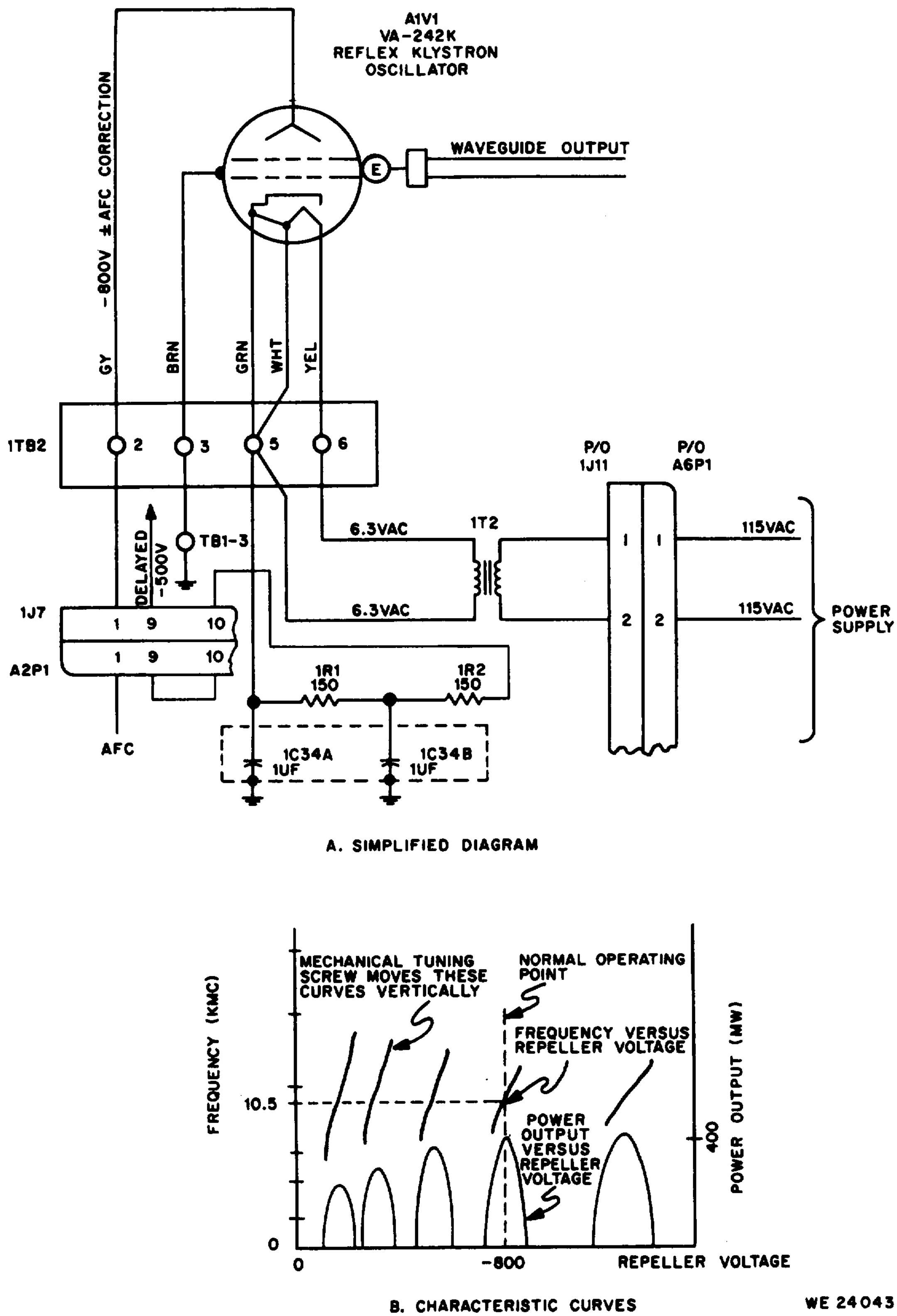


Figure 2-13. Reflex klystrom oscillator circuit—simplified schematic diagram.

cathode confines the electrons to a concentrated beam. The widely spaced mesh of the grids allows most of the accelerated electrons to pass through them toward the repeller plate. This plate is at a potential of approximately -800 volts with respect to the grids, and, therefore, repels the electrons, forcing them to make a return trip through the grids. The electrons not intercepted by the wires of one of the grids on the return trip are attracted to the cavity walls. The first electrons to approach the grids induce a charge on the resonator grid nearest the cathode. The electrons then pass to the second resonator grid, inducing an equal charge at a later time. The time involved is dependent upon the spacing of the grids and the resonant frequency of the cavity. The alternate charges induced on the grids tend to accelerate some electrons and decelerate others, causing the electrons to travel through the grids in "bunches". When the "bunched" electrons approach the repeller, they are turned back to pass through the grids again. In doing so, they deliver some of their energy to the field between the electrodes. The repeller is at the proper distance and its potential is of the correct value to cause the "bunched" electrons to return toward the grids when the resonator grid potential has just passed its maximum value. The returning cloud of electrons contributes to the charge on the resonator grid in such a phase as to reinforce the resonator grid signal. Since the energy extracted from the electron "bunch" on the return trip exceeds that lost in the cavity during the "bunching" process, the excess energy is available as useful output power, and the tube functions as an oscillator. Even with the proper spacing of cavity, grids, and repeller, however, the tube will not oscillate at the correct frequency and at the proper amplitude unless the proper voltage relationships exist between the cathode, grids, and repeller plate. The characteristic curves for the VA-242K reflex klystron (B, fig. 2-13) show that the tube will oscillate in a number of different voltage modes (not to be confused with cavity resonant modes) having different output powers. Also, the curves show that the frequency of oscillation will vary for different repeller voltages. The range of electrical frequency variation is approximately ±40 mc.

c. AFC Discriminator (fig. 2-14). The 10.5 within close tolerance by means of a special automatic frequency control (AFC) circuit. This circuit uses a frequency-sensitive discriminator consisting essentially of a waveguide cavity having two modes of resonance (indicated by the two sets of waves at right angles in B, fig. 2-14), one of which is 6 mc above, and the other 6 mc below the 10.5 kmc center frequency, and two rectifying diodes (CR1 and CR2), the outputs of which will change as the oscillator frequency varies around the center frequency. The center frequency of the dual-mode cavity (10.5 kmc), may be adjusted by means of the screw on the rear face of the cavity box, while the separation of the two resonance peaks may be adjusted by means of the screw on the lower left side. This cavity box is constructed of invar to minimize the effects of temperature changes, and sealed at its ports by means of ceramic windows to prevent the accumulation of moisture which would affect the resonance characteristic.. The discriminator produces a dc error signal proportional to the amount of frequency deviation and of a polarity indicating the direction of deviation. An increase in the frequency of the klystron oscillator results in a greater positive voltage from CR2, while a decrease in frequency results in a greater negative voltage from CR1 .The diode output terminals are tied directly together by means of a short length of coaxial cable. From this point, a coaxial cable is connected to the input of frequency control A2 (AFC), and another cable is connected through a switch to the internal monitoring circuit. Since this error signal is at a low level, it is amplified before it is used to correct the frequency of the klystron oscillator.

d. Hybrid Coupler (fig. 2-15).

(1) The hybrid coupler permits the use of a single antenna for simultaneous transmission and reception. The high-level transmitter signal on the antenna is prevented from entering the sensitive receiver circuits, and at the same time the weak radar return signals are permitted to enter the receiver. The hybrid coupler (which is one of a class called "directional couplers") is a special waveguide junction consisting of two sections of waveguide coupled together so that four entries are obtained. Because of the physical relationships of the waveguide and the two coupling apertures, it is possible to apply two signals to two different entries, each signal being divided between two of

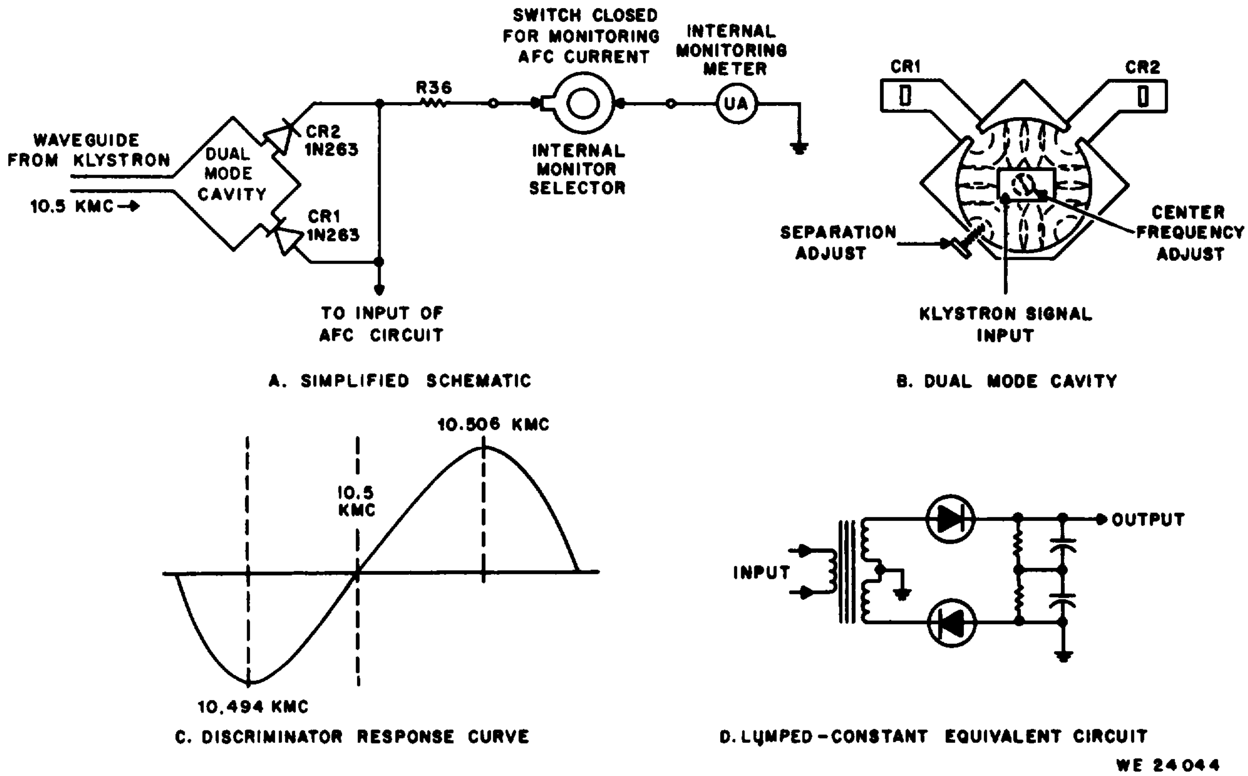


Figure 2-14. AFC discriminator—partial schematic diagram.

the three remaining entries but causing practically 110o output at the third. In this application, the klystron oscillator output is applied to entry 1 of the hybrid coupler. This signal is divided into two parts, one of which goes to the antenna entry 4 while the other goes to the modulator circuit entry 3 for the production of a local-oscillator signal for the mixer. Although the receiver mixer is also connected directly to another entry 2 of the hybrid coupler, none of the transmitter signal is permitted to enter here. However, the radar return signals which are picked up by the antenna enter the hybrid coupler where they are divided into two parts. These parts are applied to both the klystron oscillator and the receiver mixer. The weak return signals have no effect upon the klystron oscillator, but are still of sufficient strength for the receiver mixer circuits.

(2) The principle of the two-aperture directional-coupler used here is illustrated in figure 2-15. The waveguide sections are joined along their narrow walls and coupled together by means of two apertures spaced one-quarter wave length apart.

(3) Because the apertures are located at points of zero electric field in the main wave pattern, coupling between the guides is due almost entirely to the magnetic field component of the main wave. Thus each coupling aperture gives rise to two waves (one in each direction) in the auxiliary guide. The directional property of the coupler results from the cancellation of the component waves propagating in one direction and reinforcement of the component waves propagating in the opposite direction.

e. Modulator (fig. 2-16). The function of this circuit is to provide a local-oscillator signal to be injected into the mixer for conversion of the received signal from a nominal 10.5 kmc to a lower (IF) frequency range. The frequency of this injection signal must be precisely maintained with respect to that of the original transmitted signal to avoid the introduction of error. This precise frequency control is accomplished by using a sample

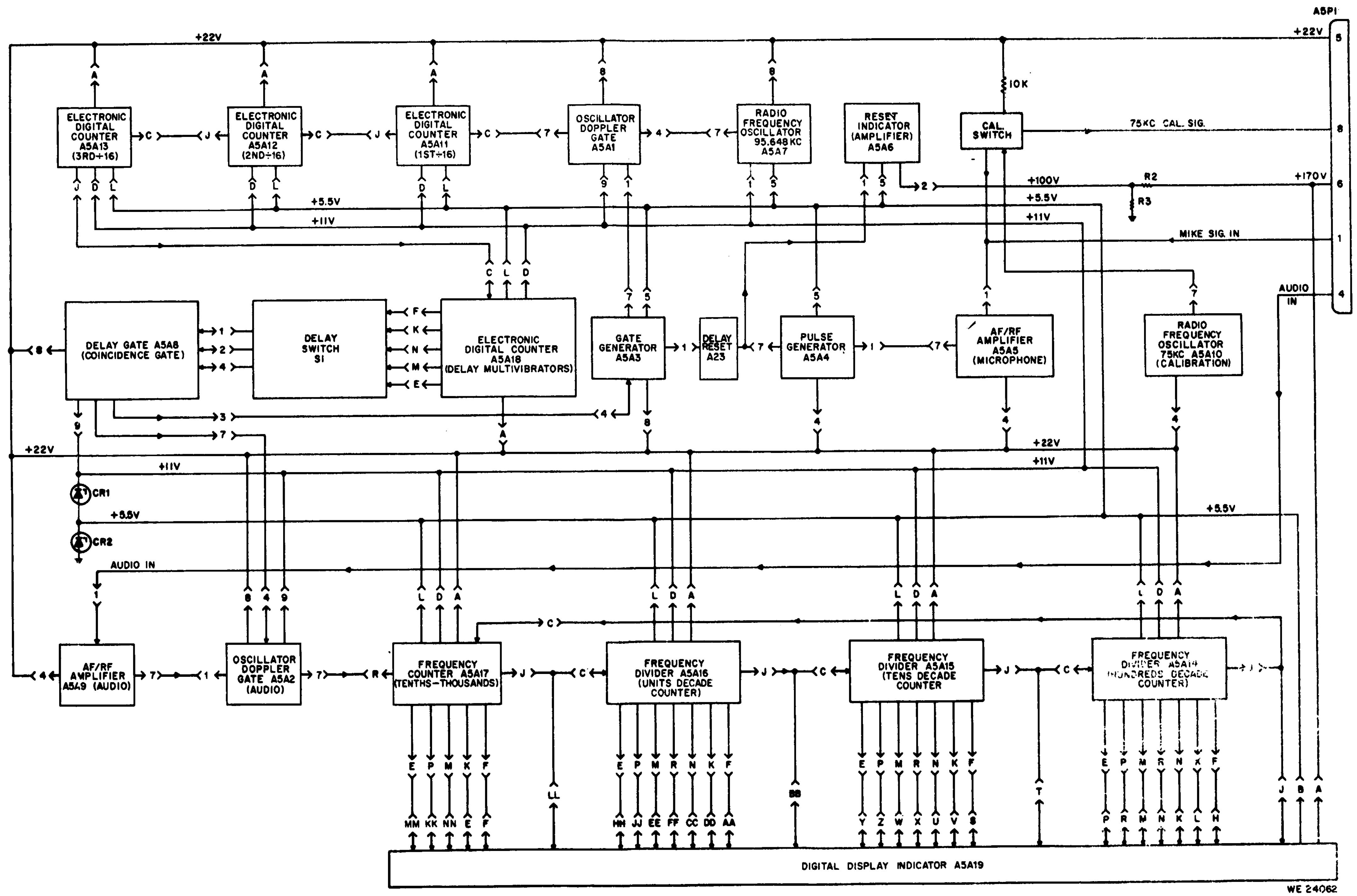


Figure 2-32. Digital display indicator A5 counter assembly—interconnection block diagram.

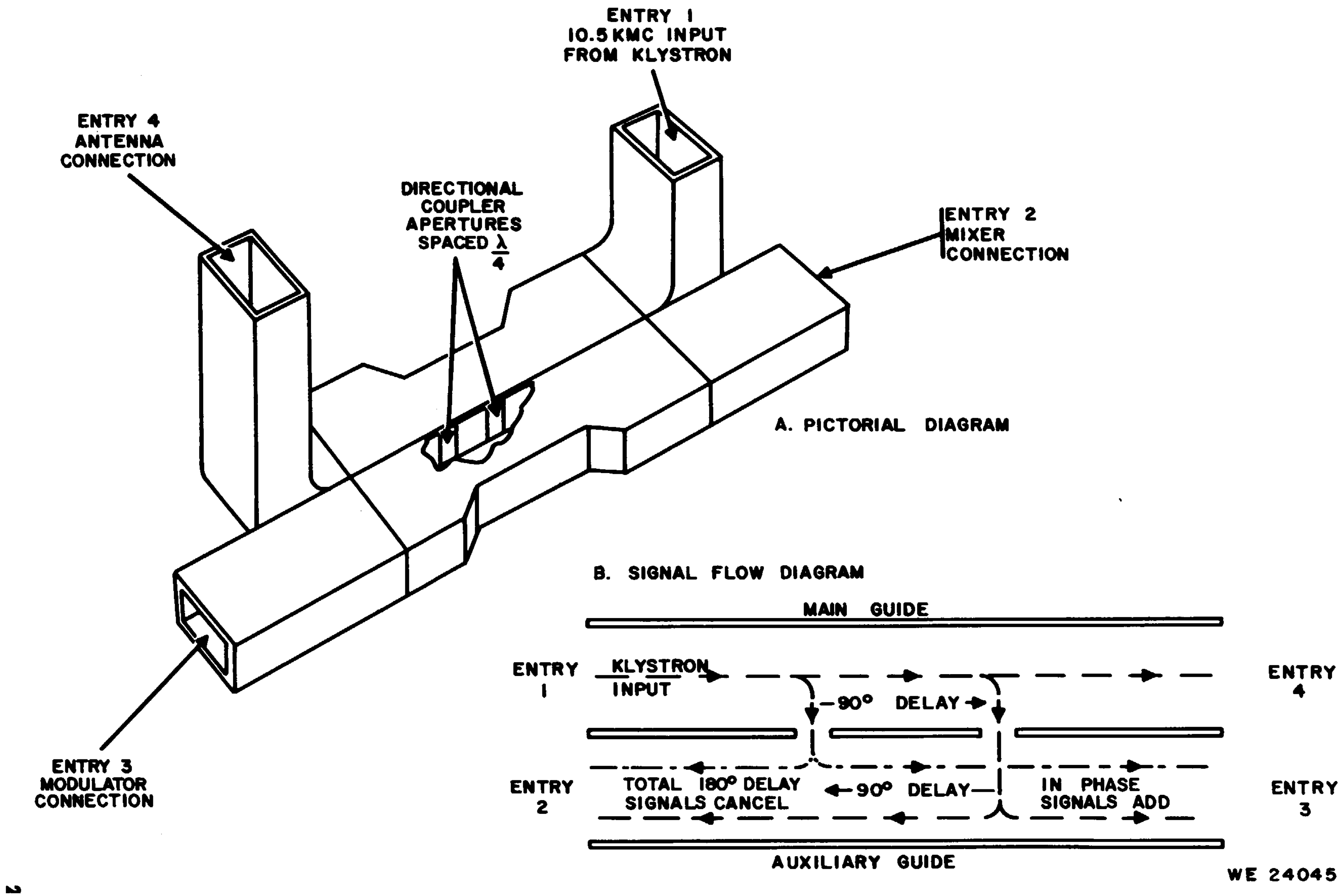
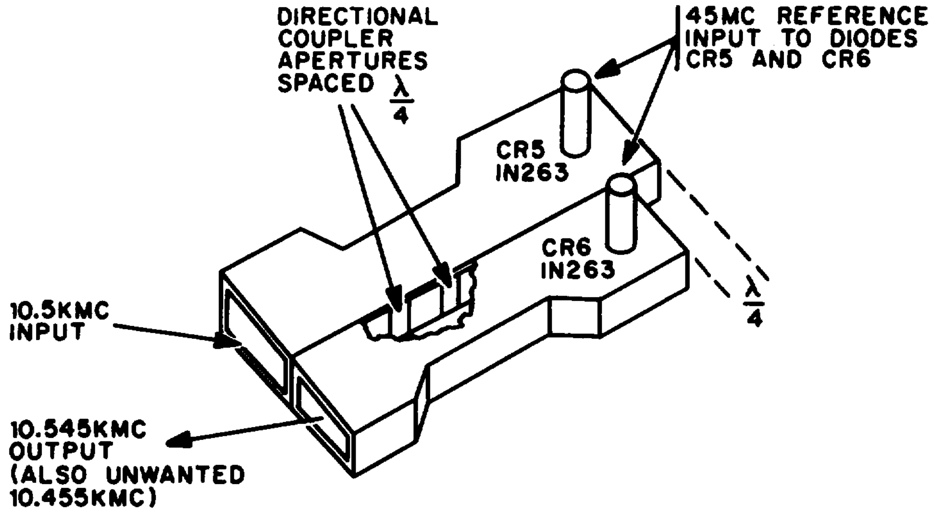
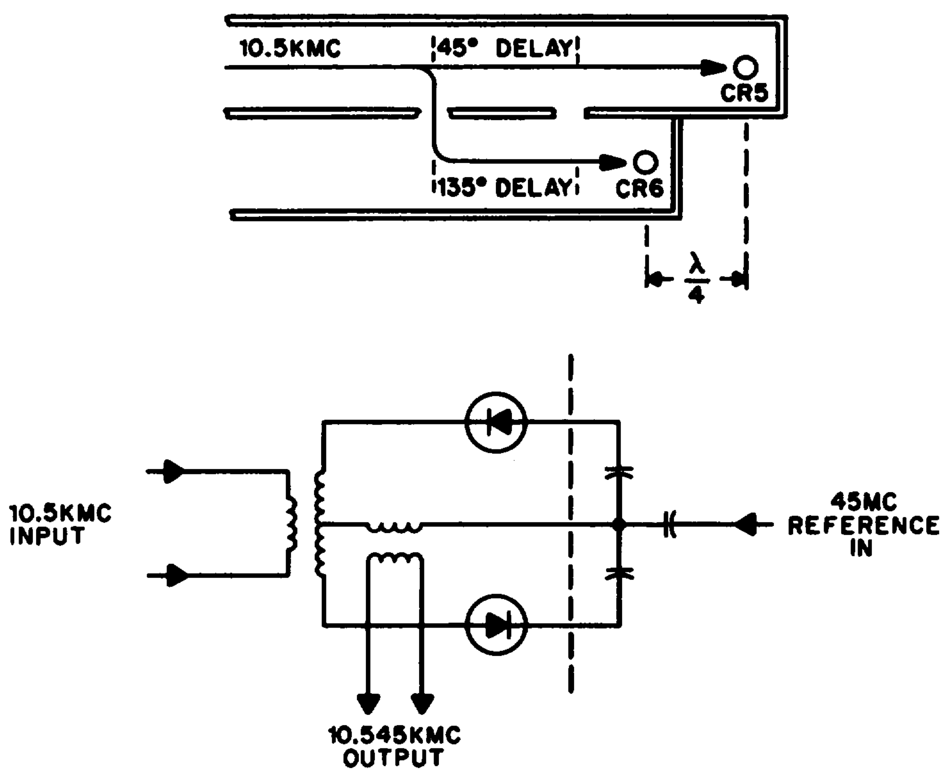


Figure 2-15. Hybrid coupler - simplified diagram



A. SIMPLIFIED PICTORIAL DIAGRAM



B. EQUIVALENT CIRCUIT WE 24046

Figure 2-16. Modulator circuit - simplified diagram.

of the actual klystron output as the basis for development of the injection signal. The klystron signal (at a frequency of 10.5 kmc) is first shifted to a frequency 45 me higher (corresponding to a 45 me IF) by means of the modulator circuit. This is done by feeding into the modulator both the 10.5 kmc signal and a 45 me signal from a special crystal-controlled oscillator. These signals are heterodyned in the two modular diodes, producing sum and difference-frequency signals. The unwanted difference-frequency components appearing in the output are eliminated by subsequent filtering before the sum-frequency signal is applied to the mixer. The balanced modulator is constructed of two coupled sections of waveguide (like those of the hybrid coupler) arranged to act as a directional coupler. The 10.5 kmc signal passing through the modulator is divided between the two waveguide sections, and in each section is modulated by the 45 me signal applied to the other side of the diode. The 10.5 kmc input signal components reaching the output section are canceled by directional-coupler action, while the two input components reflected back from the waveguide ends are canceled because they are out of phase with the inputs. The sum and difference-frequency components resulting from heterodyning in the diodes, however, are not canceled, but appear in the output where they are passed to the band-pass filter. One of the two arms containing diodes is one-quarter wavelength longer than the other. This is necessary to get the proper phase relation-ship between the two 10.5 kmc signals applied to the two diodes and between the sideband components (produced by the diodes) which comprise the output signal. The sketch in figure 2-16 shows that in addition to the phase shifts which give directional-coupler action (shown in fig. 215), certain other shifts are present which must be considered when combining and re-combining two or more signals in the balanced modulator. First, the 10.5 kmc input signal (which must reach the diodes in phase) is delayed 45° by the effect of the coupling apertures in its passage through the input section to CR5. In addition, the 10.5 kmc signal is given a 135° delay in passing through the coupling apertures into the output section and on to CR6. The sum effect is a 90° difference in phase between these two signals. This is compensated for by elongating one waveguide section and moving CR5 back one-quarter wavelength to get the 90° phase lag required to make the signal reaching CR5 agree in phase with that reaching CR6. The sideband components originating in CR5 start with a phase lag of 1800 with respect to those originating in CR6 since the two diodes are driven out of phase (the diodes are of opposite polarity). These components are next delayed an additional 90° by the extra quarter wave-length of guide and finally delayed 183.5 in passing through the apertures and into the second waveguide section. This adds up to a total delay of 405°. The components originating in CR6, on the other hand, are delayed only 45° in passing the apertures on the way to the output point. The difference in phase shift between the two amounts to 360°, which means the side-band components are in the proper phase for reinforcement rather than cancellation.

f. Bandpass Filter (fig. 2-17). The bandpass filter consists of a double waveguide cavity, the tuning of which may be adjusted by means of a screw in each section. The highly selective cavities, which are constructed of invar to minimize the effects of temperature changes, are coupled together through an aperture and are tuned to pass the upper sideband products from the balanced modulator (10,545 me) while attenuating the lower sideband products (10,455 mc) and any remaining 10,500 me component. The output of the bandpass filter is passed on to the mixer circuit for use as the local-oscillator signal.

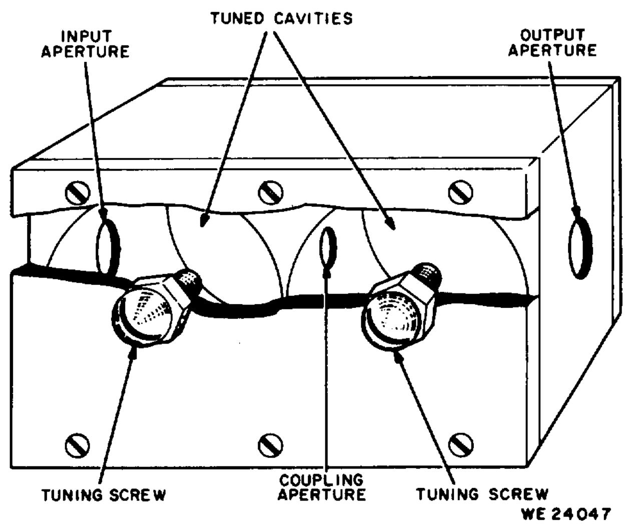


Figure 2-17. Bandpass filter - simplified diagram.

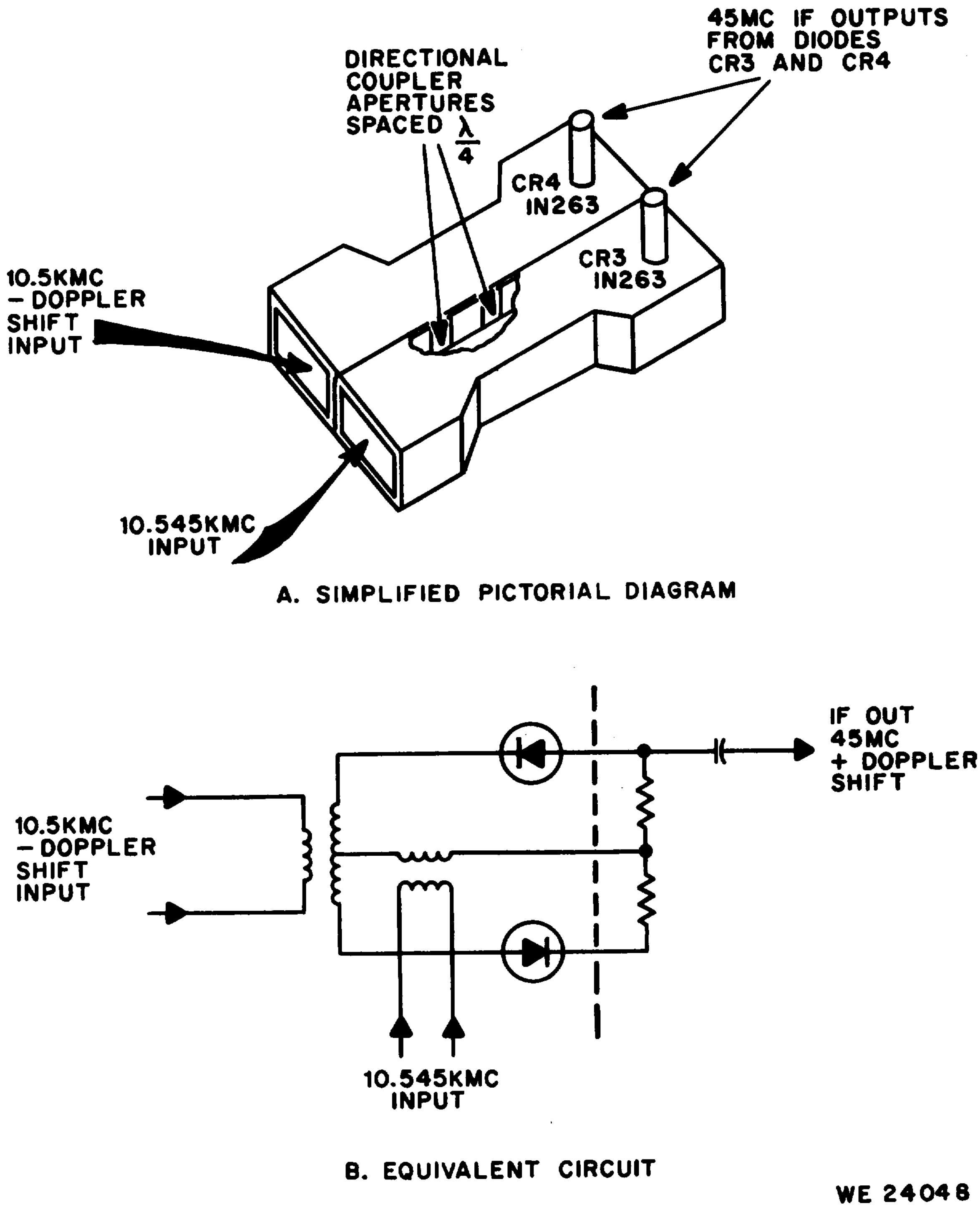


Figure 2-18. Mixer circuit - simplified diagram.

g. Miser (fig. 2-18). The function of the mixer is to convert the received signal (which is at a nominal frequency of 10,500 me) down to the 45 mc intermediate frequency, permitting amplification and detection by "lumped-constant' circuitry. The balanced mixer is of the directional-coupler.

type and is similar in design and operation to the balanced modulator described in e above. The mixer also has two sections of waveguide which are joined along their narrow walls and coupled by means of two apertures. Diodes are located in two of the entry arms, the 10.545 kmc local-oscillator signal from the modulator is introduced into a third entry, and the 10.5 kmc klystron signal (from the hybrid coupler) is injected into the remaining entry. The signals fed into the two wave-guide sections are heterodyned in the two diodes (CR3 and CR4), producing sum (21.045 kmc) and difference (45 me) frequencies. The undesired sum frequency is far above the selective range of the subsequent tuned circuits, and is greatly attenuated. The difference frequency signal (45 mc + the Doppler shift) is passed on to the intermediate-frequency amplifier circuits.

2-11. Antenna Assembly

The antenna assembly used for both transmission and reception of the radar signals in the radar chronograph consists of a parabolic "dish" reflector which is fed by a dipole radiator and wave-guide section. A telescope sighting port is located in the upper part of the reflector. The parabolic shape permits focusing the radar beam to an angle of approximately 3.4 degrees (at the half-power points). The type of feed used is "rear feed"; that is, the feed waveguide projects from the rear through the front of the reflector, and a device is used at the outer end of the waveguide to direct energy back toward the reflectors This feed element is located at the focus of the para-bola. The half-wave dipole in the feed system is the main radiating element. It is supported in position in the feed waveguide by means of plastic (epoxy) dielectric material. The openings in the feed waveguide on each side of the dipole are also sealed by plugs of the same material. The dipole radiates energy in both forward and backward directions, but a small disc reflector element one-quarter wavelength forward of the dipole re-directs the forward radiation back to-ward the parabolic reflector. An adjustment screw protruding into the end of the feed wave-guide permits some adjustment of standing wave ratio (VSWR) in the feed system. This screw is cemented after factory setting and normally requires no attention. The feed dipole is protected by a sleeve of teflon plastic cemented around it.

***Note*. Two decals are affixed on the rear of the antenna assembly, one on each side of the telescope sighting port (fig. 3-4.1) citing the following radiation hazard.**

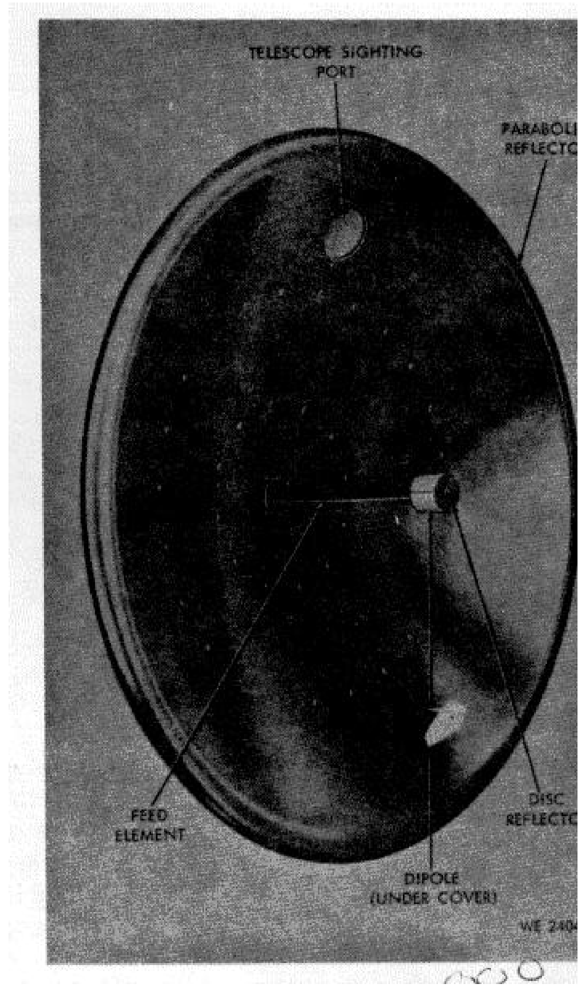


Figure 2-19. Antenna assembly.

WARNING
POTENTIAL RADIATION HAZARD
When radar is energized, personnel should not be within 6-feet of the radiating feedhorn (located in the center of dish) in the direction of the transmitted beam.

2-12. Frequency Control A2 (AFC)

a. General. The AFC assembly consists of a differential amplifier, a 230 kc AFC oscillator, and a voltage-multiplier rectifier. The positive or negative voltages from the AFC discriminator are applied to the AFC assembly, which puts out a proportional voltage of suitable amplitude for application to the klystron repeller element to control the frequency of oscillation. When the kystron oscillator frequency starts to drop below 10.5 kmc, the AFC assembly supplies a more negative voltage to the klystron repeller plate,

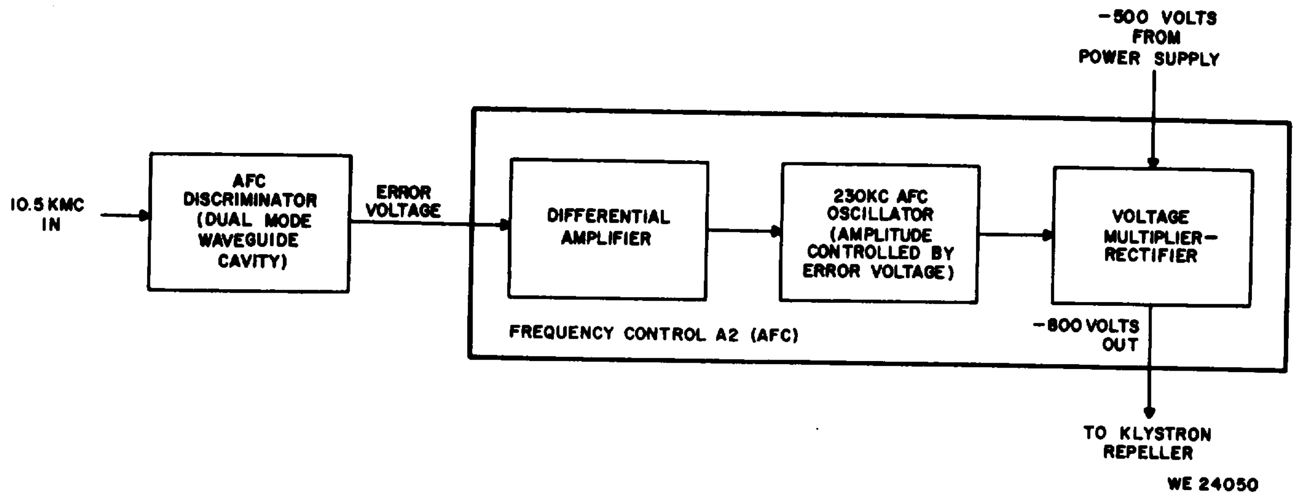


Figure 2-20. Frequency control A2 (AFC) - functional block diagram.

raising the frequency accordingly. If the klystron frequency rises, the AFC assembly sup-plies a less negative voltage to the repeller plate, correcting the condition.

b. Differential Amplifier (fig. 2-21). The function of the differential simplifier is to amplify the error signal produced by the AFC discriminator circuit. The differential type of amplifier is used because of its ability to balance out variations in component characteristics caused by heat and aging, as well as variations in supply voltages. This circuit consists of two stages of differential amplification, each using two transistors, and a final transistor amplifier which applies the signal to the 230 kc oscillator. The input signal is applied to the base of transistor Q1, changing the emitter current flowing through R5 and through the load resistor R9 which is common to both Q1 and Q2. The voltage developed across R9 is applied to the emitter of Q2. This results in a change in the current drawn by Q2 through R4. The voltages produced across collector load resistors R3 and R4 are applied to the bases of Q3 and Q4 in the next stage, so that conduction in one transistor (either Q3 or Q4) is increased while the other is decreased for a change in input voltage. When the currents are unequal due to an imbalance caused by an error voltage at Q1, the difference between the two will develop a voltage across R13, from which the input for Q5 is taken. Q5 amplifies this error signal voltage and applies it to the 230 kc oscillator for control of oscillator output amplitude. When the error signal fed into the differential amplifier is of a negative potential (indicating a decrease in klystron frequency), the output of Q5 is a positive error signal. The reverse is true when the input error signal is positive.

c. 230 KC Oscillator (fig. 2-22). This oscillator is employed in the AFC circuitry to permit converting ("chopping") the low level "varying dc" error signal to an ac form suitable for amplification. The oscillator circuit is basically of the Colpitts type, having the tuned circuit capacitance divided into two parts (C4 and C5) to provide a tap point for the feedback path to the emitter of Q6. The tuned circuit inductance is provided by L1. The collector voltage is applied as 170 volts through choke coil L3 and resistor R15 which drops it to 100 volts. Capacitor C2 provides a ground for ac at the end of tank coil L1. Break-down (Zener) diode CR1, in conjunction with R15, regulates the dc potential at 100 volts. Inductor L3 and capacitor C15 form a tuned circuit which filters out the 230 kc signal, blocking it from the power source. Bypass capacitor C1 provides additional signal decoupling from the power source. Potentiometer R16 provides for adjustment of the nominal oscillator output voltage (appearing across R18). This output voltage is controlled by varying the application of the output of emitter follower A2Q5 (differential amplifier) to the base of oscillator Q6. When the output of A2Q5 becomes less positive, the amplitude of the oscillator output is decreased. The output of A2Q5 will vary in accordance with any error signal which indicates a deviation in the klystron.

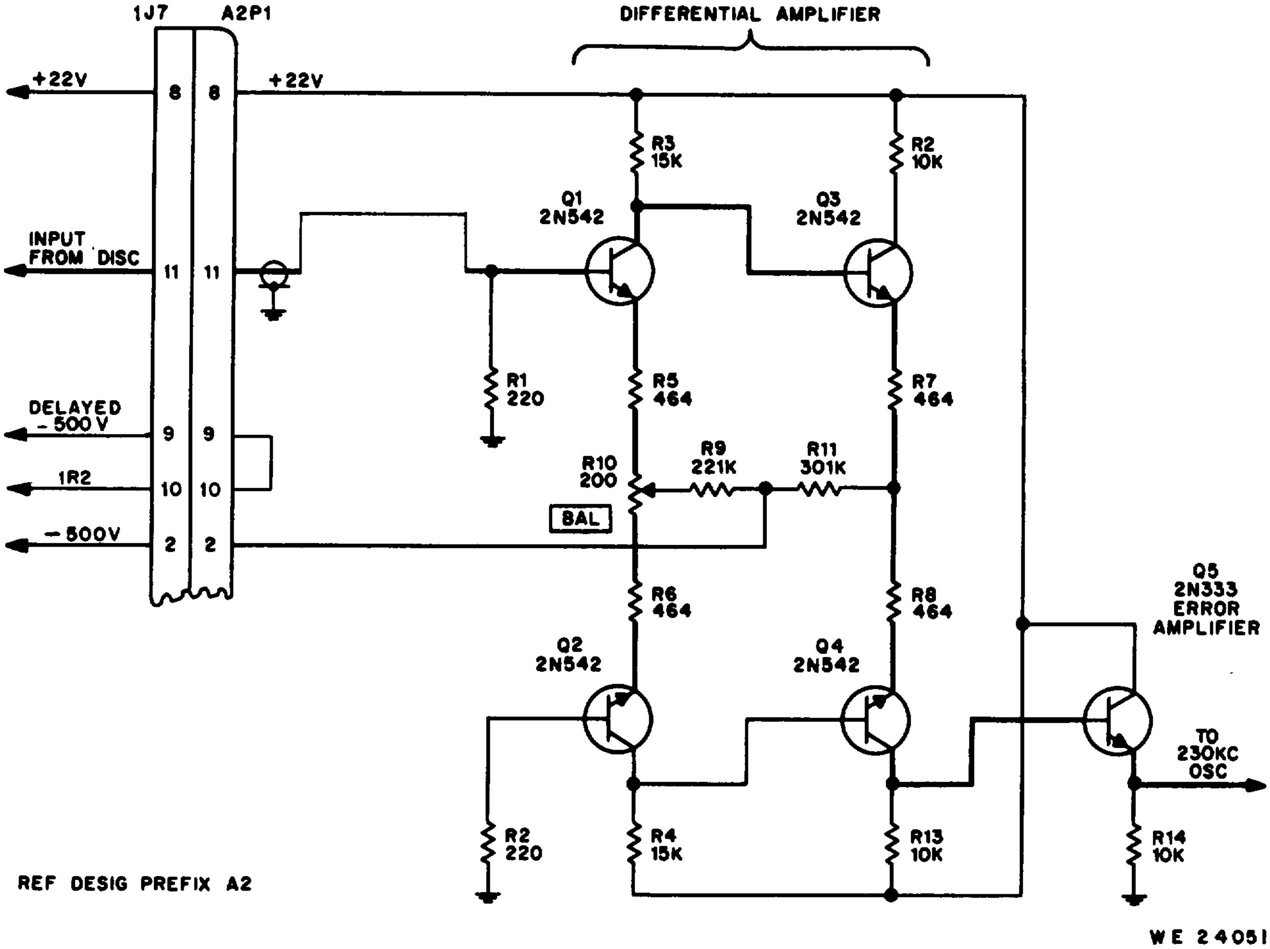


Figure 2-21. Differential amplifier - partial schematic diagram.

frequency. As a result the output of Q6 is an ac voltage which varies in amplitude with changes in error signal amplitude. When the control signal supplied by A2Q5 to the oscillator is positive, indicating a decrease in klystron frequency, the amplitude of the 230 kc oscillation will be increased. The reverse is true for a negative A2Q5 output.

d. Voltage Multiplier-Rectifier (fig. 2-23). The output of the 230 kc oscillator is not at a level high enough for application directly to the klystron repeller (after rectification) and the slowly varying error signal component riding on it (appearing as a variation in oscillator output amplitude) is not of the amplitude required to control the klystron frequency. To raise the dc level and at the same time amplify the error signal, a voltage multiplier-rectifier circuit is used. The circuit consists essentially of three stacked half-wave voltage doublers. The first doubler consists of C7, CR2, and C12. The first positive half wave of the input ac passes through diode CR2, charging capacitor C7 to approximately the peak ac value (50 volts). The succeeding negative half wave passes through CR3 to charge C12, and since this voltage is added to that on C7, the charge on C12 reaches a potential approximately twice the peak ac voltage. The second doubler functions in a similar manner during the next ac cycle (applied through C7 and C8) charging capacitor C11 also to twice the peak voltage. Capacitor C10 is then charged to twice the peak value by the third doubler, so that the total potential across the three series-connected capacitors (and across paralleled capacitor C14) is approximately six times the peak ac voltage, or nominally 300 volts. This group of capacitors is connected in series with capacitor C13 which is charged to the.

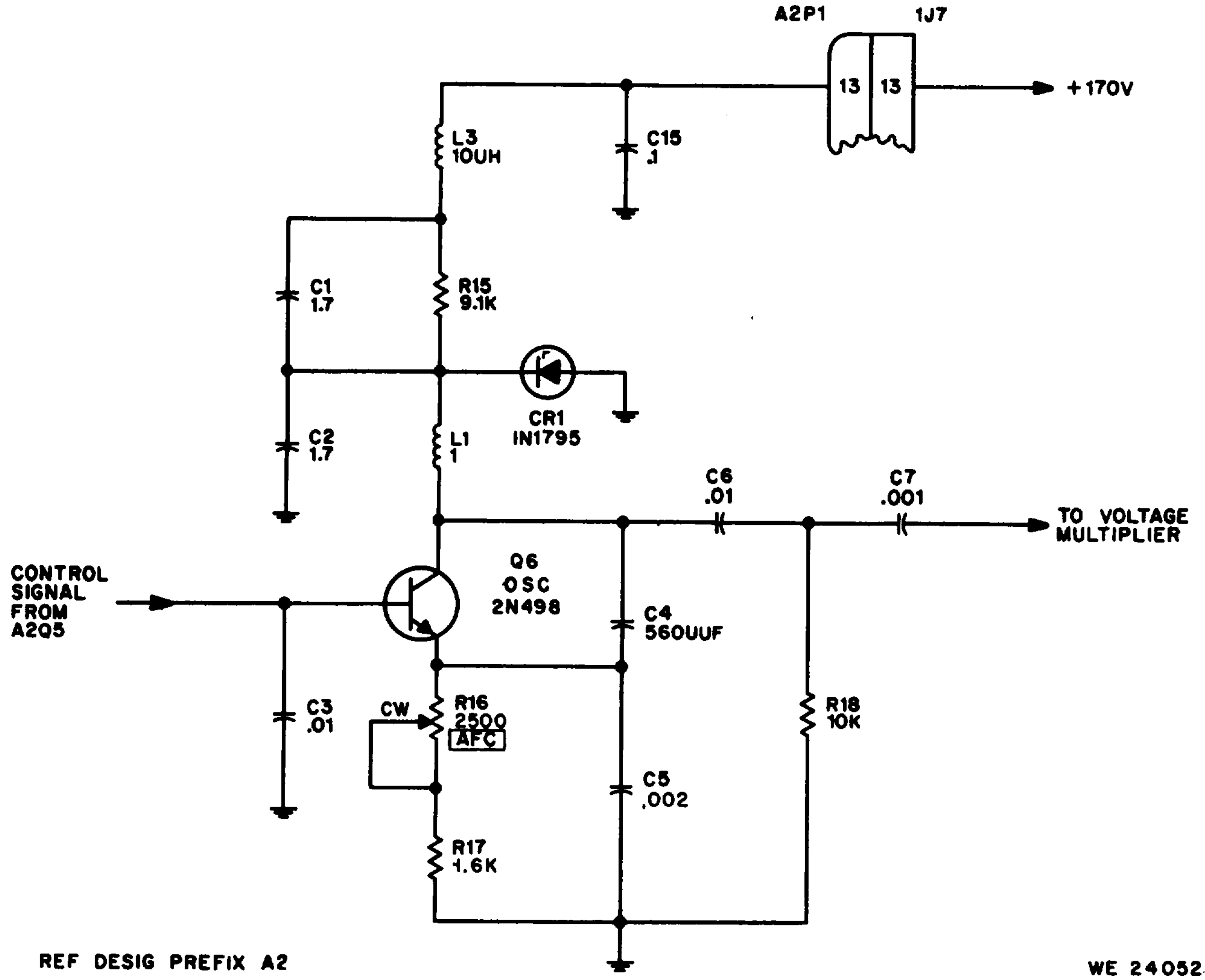


Figure 2-22. 230 kc oscillator - partial schematic diagram.

-500-volt power supply potential, so that the total potential between output and ground is nominally -800 volts. Filtering of the -300 volt section is supplied by L5, C16, and C18. The output voltage will vary from approximately -790 to -830 volts as the error signal varies, going more negative when the 230 kc signal amplitude is in-creased (indicating a lowered klystron frequency) and less negative when the conditions are reversed.

2-13. Detector Amplifier A4 (IF Amplifier-Detector) (Fig. 2-24)

This assembly includes several circuits having different functions: the IF amplifier, the detector, the 45 mc oscillator, and the internal monitor selector with internal monitor meter.

a. IF Amplifier (fig. 2-25).

(1) *General*. The intermediate-frequency amplifier consists of two stages of electron-tube amplification. (The cascade amplifier consisting of two triodes is considered to be one stage.) The electron tubes used are highly rugged ceramic triodes (type 7462). The first two triodes are connected in a "cascode" configuration; that is, the first tube is wired as a conventional grid-fed, grounded-cathode triode, while the second tube, which is capacitance-coupled to the plate of the first, is wired as a cathode-fed grounded-grid triode. The cascade configuration affords a gain comparable to that of

a pentode tube without introducing the noise usually associated with that type of tube. The output of the cascode amplifier is transformer-coupled to the next stage which is a cathode-fed, grounded-grid amplifier. A sampling of the signal at the output of this amplifier stage is rectified and applied to the external monitor meter when the selector switch is in the LEAKAGE position. The output of the last IF stage is transformer-coupled to the detector circuit. The output of the detector is applied to a transistor buffer amplifier connected as an emitter-follower. The output of this stage is applied to the audio frequency amplifier A3.

(2) *Circuit analysis*. The two output lines from J3 and J4 of the waveguide mixer are connected to the IF amplifier circuit (across C31). The output from J4 is coupled (through capacitor C30) to a tap on the tuning coil T1 and then on to the grid of the first IF amplifier V1. The other line from J3 is normally connected to ground by selector switch S1, after passing through a filter consisting of L12, C34 and L13, and C35 (fig. 2-10). In MXR XTAL 2 position of the selector switch, this line is connected to ground through the internal monitor meter MI. The mixer output on the line from J3 and J4 is coupled to the primary of transformer T1 by capacitors C30 and C31. The signal induced across the secondary of T1 is applied to the grid of V1, amplified, and the output developed across the plate load resistor R3 is coupled through C2 to the V2 cathode load inductor L1. The cathode current of V2 flowing through R5 develops the bias voltage for V2. After amplification by V2, the signal developed across the primary of T2 is induced into the secondary and applied to the cathode of V3 through C7 and R7, which develops the cathode bias for V3. After amplification by V3, the signal developed across the tuned circuit consisting of C10 and the primary of T3 is induced into the secondary winding which serves to feed the two semiconductor diodes of the detector circuit. The tuned circuits are peaked to a frequency 75 kc above 45 mc, which is in the center of the band of operating frequencies to be passed. Semiconductor diode CR1 rectifies a portion of the signal and applies the dc voltage developed across load resistor R6 to the external monitor meter through filter choke L14, feed-through capacitor C39, and selector switch S1 in

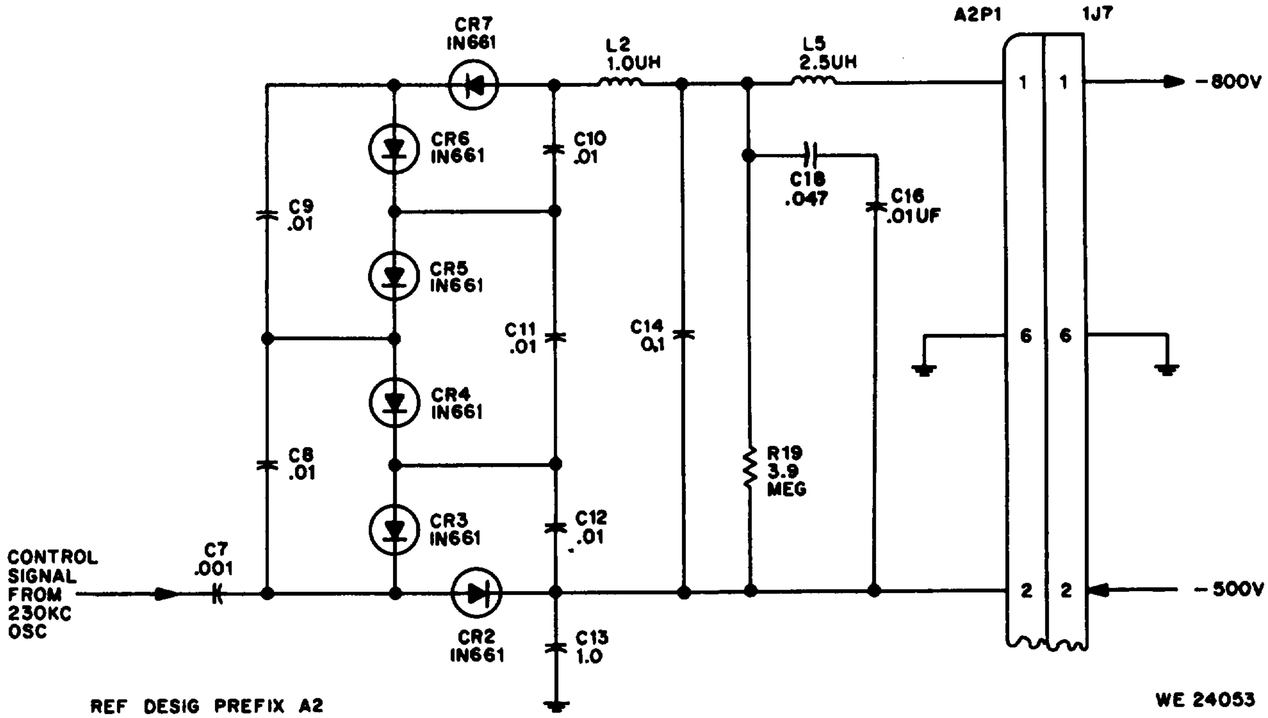


Figure 2-23. Voltage multiplier - rectifier - partial schematic diagram.

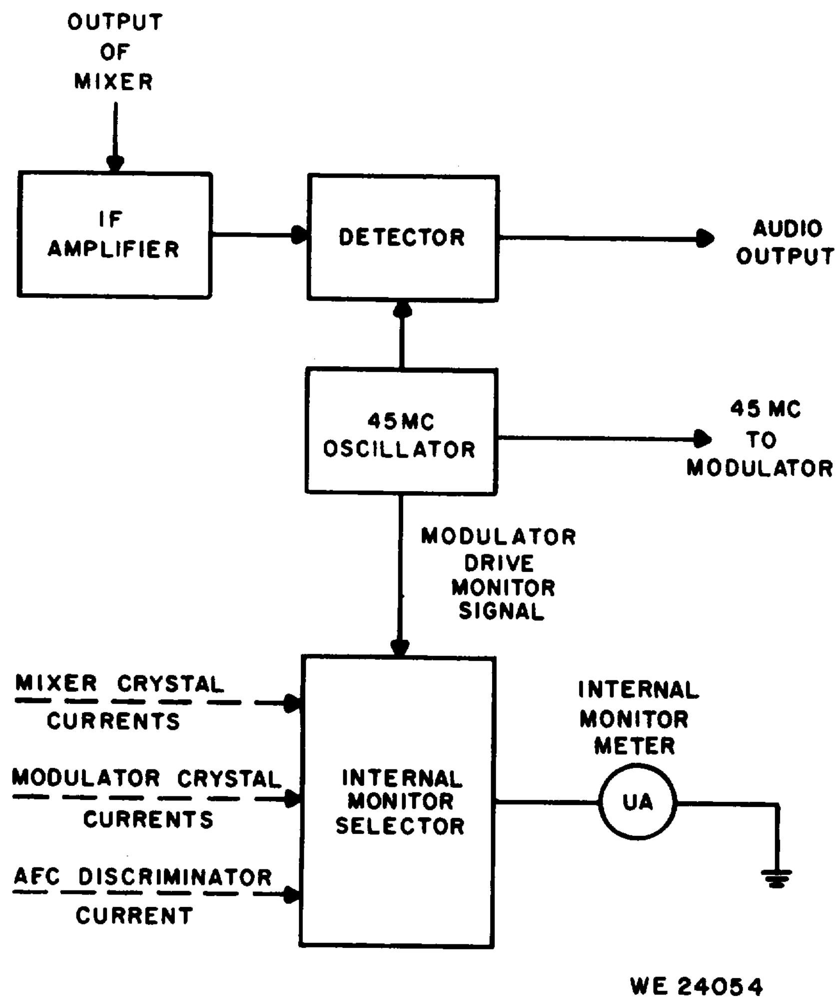


Figure 2-24. Detector amplifier A4 (IF amplifier-detector)

the LEAKAGE position. The meter reading indicates the amount of signal in the IF circuit when no radar return signal is present.

b. Detector (fig. 2-26).

(1) *General.* The IF signal, varying from 45 me to a frequency higher by the amount of the Doppler shift, is compared with the 45 mc reference signal and a result obtained which is a signal having a frequency equal to the difference between the transmitted and received signals. (See para 2-2.) The required comparison function is per-formed by heterodyning the two signals in the two diodes of the detector (balanced demodulator) circuit. Heterodyning results in two new signals whose frequencies are equal to the sum of and the difference between the frequencies of the two input signals. In this case, only the difference-frequency signal is desired; the unwanted frequencies, consisting of the 45 mc reference signal and the sum frequency, along with the various harmonics also produced, are eliminated by subsequent filtering. The 45 me signal is applied to the diodes in such a manner that the resulting currents cancel each other and do not appear in the output. The difference frequencies resulting are mainly within the audio and ultrasonic range and are handled from this point on by conventional audio frequency circuits.

(2) *Circuit analysis*. The IF signal is applied to the primary winding of transformer T3. (It will be assumed for the sake of explanation that no other signal is present.) The transformer primary and secondary windings are tuned to 45 mc by means of C10 and C43. The current induced into

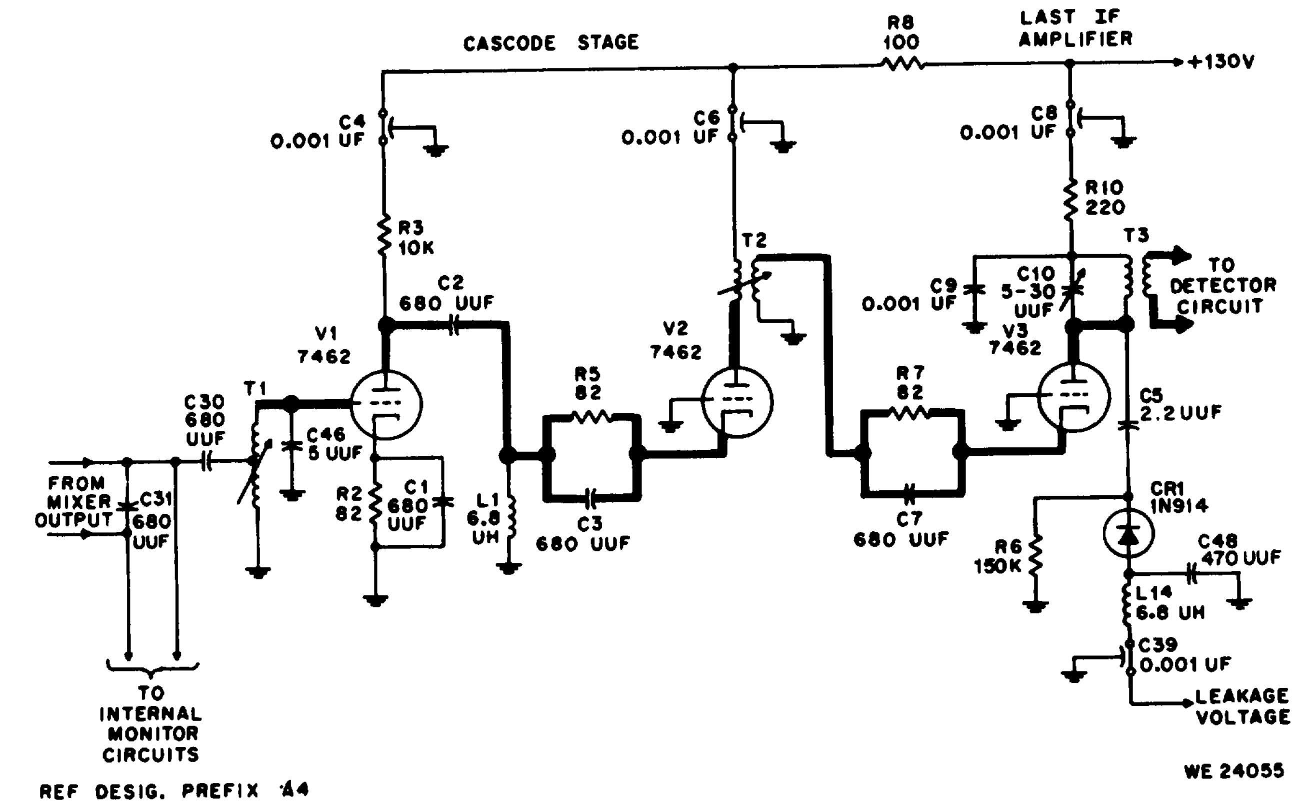


Figure 2-25. IF amplifier - partial schematic diagram.

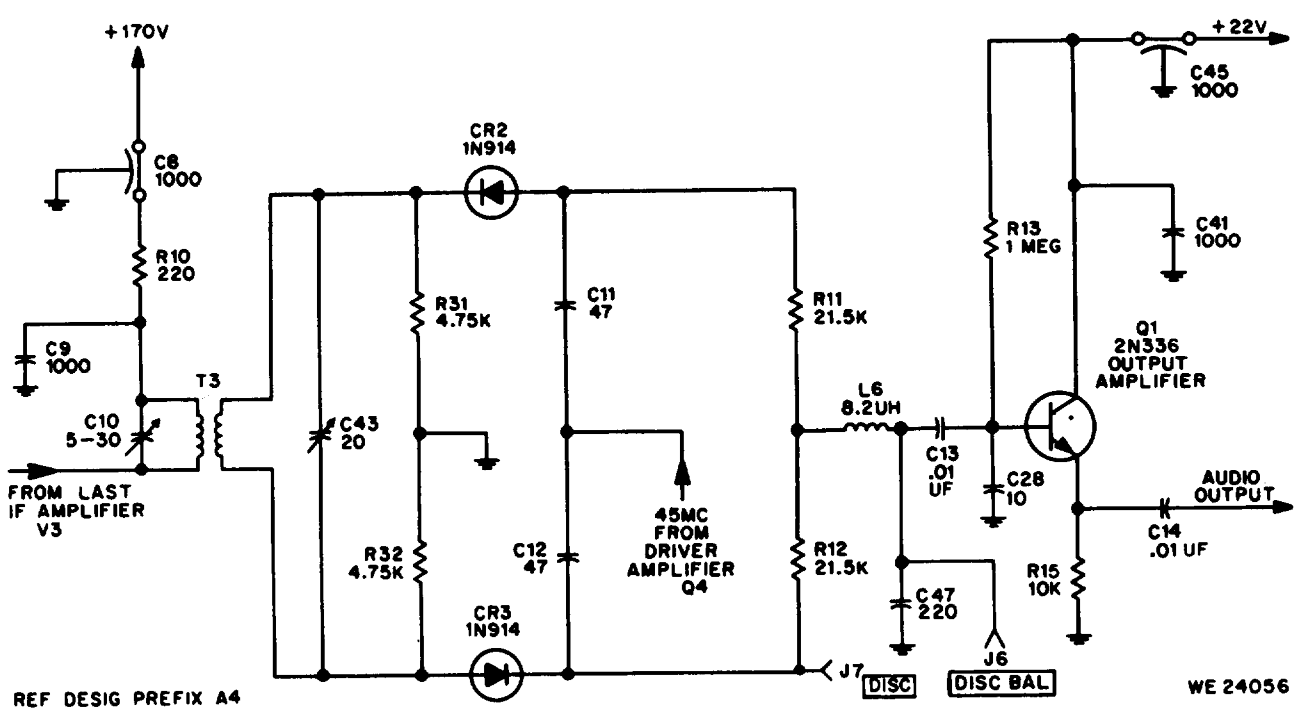


Figure 2-26. Detector circuit - partial schematic diagram.

the secondary flows through resistors R31 and R32 in such a direction that the voltages produced across them and applied to the associated diodes CR2 and CR3 ate of opposite phase at a given instant. This means that during the half cycle of the signal when a negative potential is applied to the cathode of CR2 and a positive potential is applied to the anode of CR3 the two diodes will conduct in series, the current will flow through resistors R11 and R12, and this half-wave signal can be taken off through C13. During the other half cycle of the input signal, the potentials applied to the diodes are of the wrong polarity for conduction, and no signal reaches the output. In the pre-ceding discussion it was assumed that only one signal was present in the circuit. In actual operation, however, a second signal having a precise 45 mc frequency from the driver amplifier is injected into the circuit through capacitors C11 and C12. This signal is fed to the diodes in parallel so that the polarity is the same at the anode of one and the cathode of the other at the same instant, alternately back-biasing each diode (lowering conduction) while aiding conduction in the other. For a simplified case where the two input signals are of the same frequency and of the proper phase relationship (90° apart), this action can be made to block the signal completely so that none reaches the output. For the case where the input frequencies are not the same, the phase difference varies continuously from zero to 360°, then repeats. The pulsing output has a repetition rate equal to the difference between the two input frequencies. Unwanted components, such as the original IF signal and various harmonics and combinations of harmonics of the several signal components, are filtered out by L6 and C47. The detector output is coupled through C13 to the emitter-follower out-put amplifier Q1. The output of Q1 is taken from the emitter load resistor R15 and coupled through C14 to pin M of connector J1. This audio output signal is then fed to the audio frequency amplifier A3.

c. 45 MC Oscillator (fig. 2-27). The function of this oscillator is to supply a precise 45 mc signal to the modulator circuit and to the detector circuit for heterodyning purposes The circuit is basically a Butler oscillator, which is especially suited to stable operation in this frequency range. This circuit uses two transistors in cascade; the first an amplifier in the grounded-emitter configuration with a tuned collector circuit, and the other

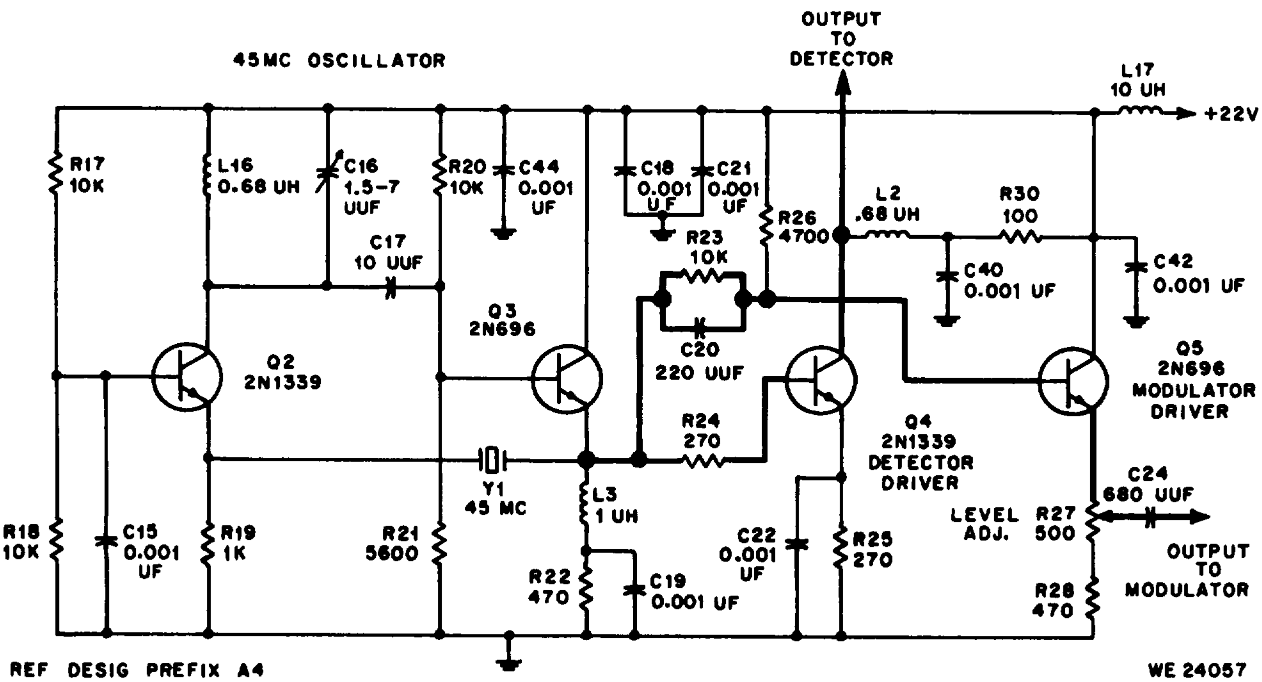


Figure 2-27. 45 MC oscillator circuit - partial schematic diagram.

in the emitter-follower configuration. The frequency of oscillation is controlled primarily by piezoelectric crystal Y1 which acts as a tuned filter in series with the feedback line from the emitter follower to the amplifier. Fine adjustment is made by variable capacitor C16 in the collector circuit of transistor Q2. As oscillation begins, the signal voltage developed across the tuned circuit consisting of C16 and L16 in parallel is coupled to the base of Q3 by capacitor C17. Transistor Q3 develops a voltage across inductance L3 in its emitter leg. A portion of this output signal is returned through crystal Y1 to the emitter of Q2 to reinforce oscillation at the 45 me frequency. The oscillator out-put is taken from L3 and applied to the base of modulator driver amplifier Q5 and to the base of detector driver amplifier Q4.

2-14. Audio-Frequency Amplifier Assembly A3 (fig. 2-28)

a. General. The audio-frequency amplifier A3 chassis is divided into three sections; the audio amplifier, the low-pass filter circuits, and the bandpass filters FL1 through FL9. The functions of these circuits are respectively to amplify the audio signal coming from the detector circuit, to narrow the band of passed frequencies by means of selectable bandpass filters, and to further attenuate any signal components higher than the de-sired frequency range by means of a low-pass filter, thus reducing the effects of noise and other spurious signals.

b. Audio Amplifier Subassembly A3A1 (fig. 2-29). The audio amplifier contains four amplifying transistor stages preceded by a special amplitude-limiting circuit consisting of two transistors and a rectifier-voltage doubler circuit. The gain of the first three audio amplifier stages is automatically controlled by a special AGC circuit also made up of two transistors and a rectifier-doubler circuit. The audio signal from the detector is fed through connector A3P1 of the audio amplifier chassis to A3XA1-1 and A3A1P1-1 of sub-assembly A1. It is then applied to the base of first audio amplifier Q3 through C2, R3, and C5,

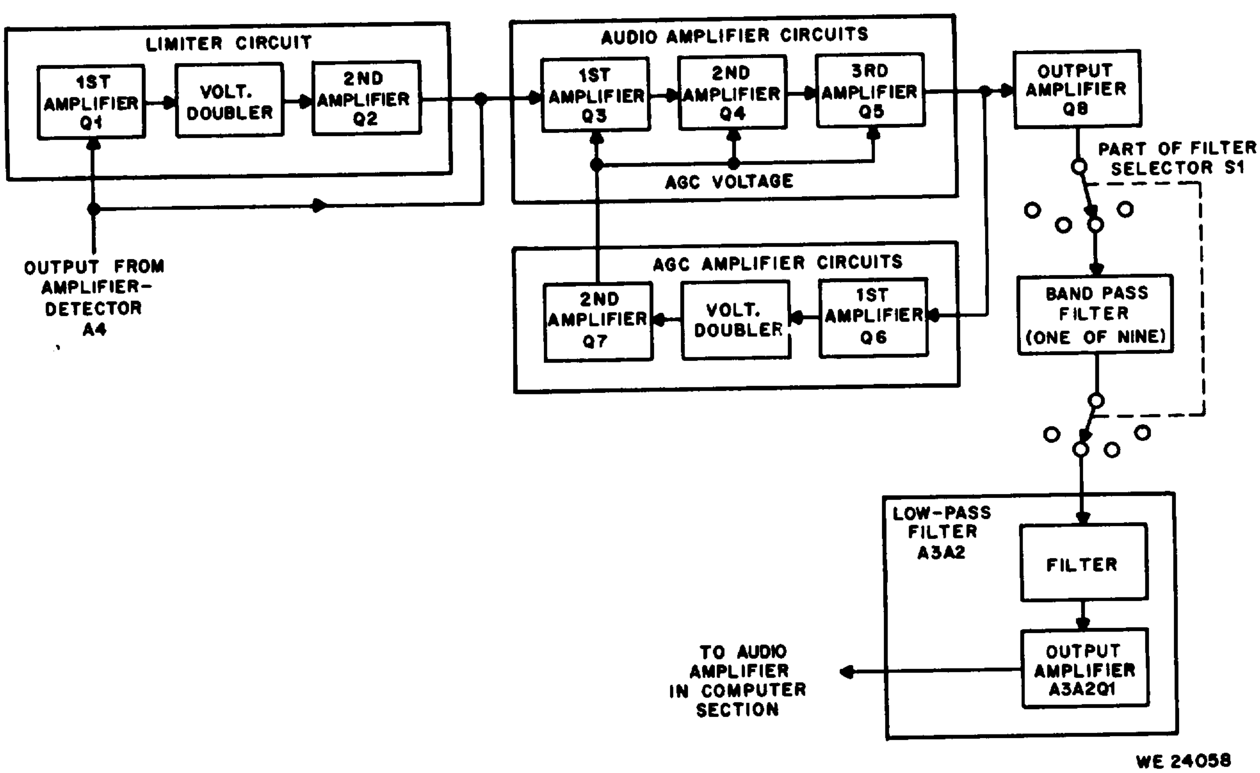


Figure 2-28. Audio frequency amplifier A3 - functional block diagram.

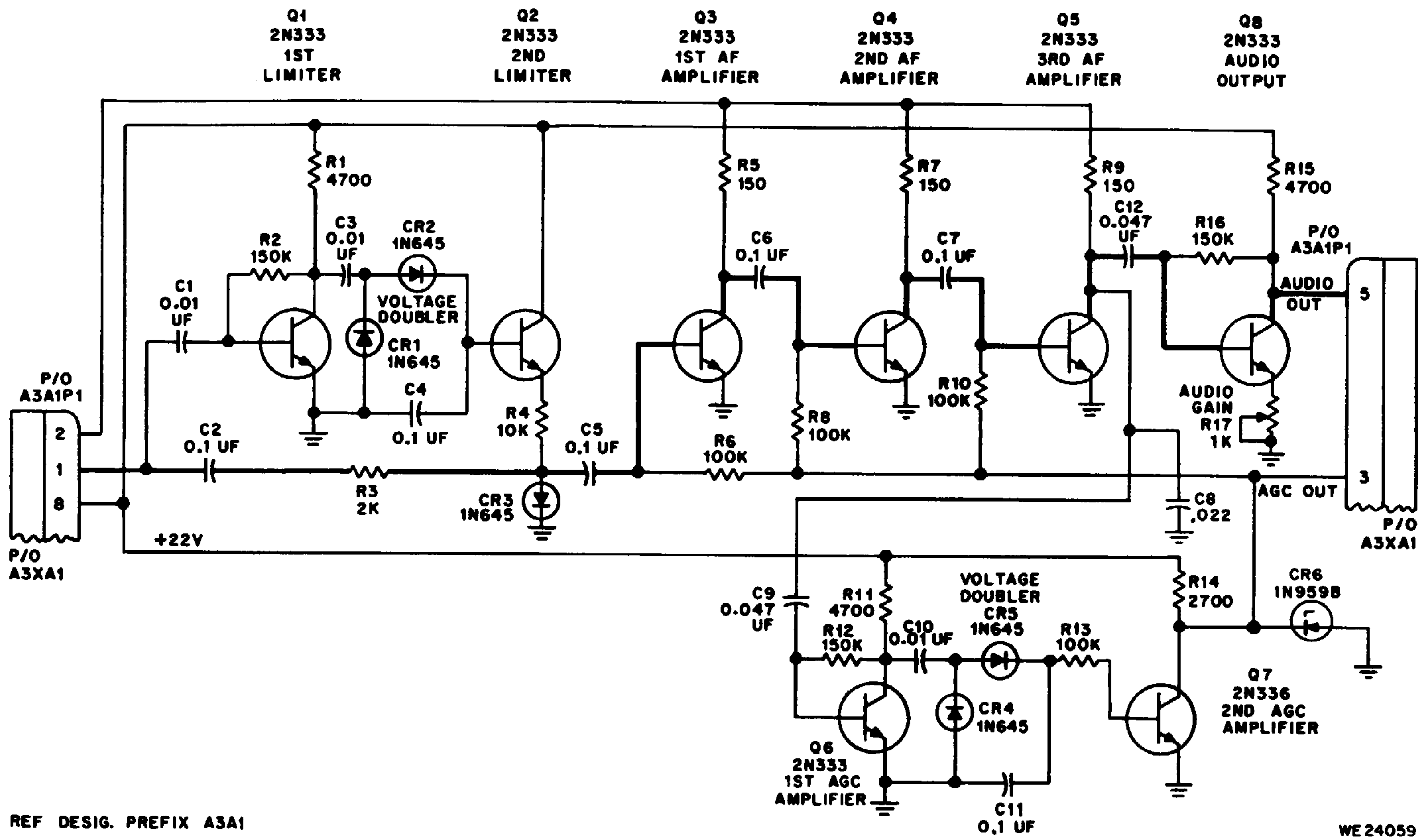


Figure 2-29. Audio amplifier A3A1 - partial schematic diagram.

and also to the first limiter Q1 through C1. Transistor Q1 amplifies the signal and develops an out-put voltage across load resistor R1. This signal is coupled through capacitor C3 to the voltage-doubling circuit consisting of CR1, CR2, and C4. Capacitor C4 is charged through diodes CR1 and CR2 to a dc potential equal to the ac signal peaks This voltage, when applied to the base of Q2, causes it to conduct, raising the positive voltage on the anode of CR3. This causes an increase in conduction of the diode, which presents a lower impedance to the signal passing through C2, and thus applies a lower signal voltage to the base of Q3. The signal is amplified by three cascaded transistor amplifier stages (Q3, Q4, and Q5), then applied through capacitor C12 to the base of the audio output amplifier Q8. The amplifier output is taken from load resistor R15 and routed out of the subassembly through A3A1P1-5 and A3XA1-5. The output from amplifier transistor Q5 is also applied to the two-stage AGC amplifier.

Capacitor C9 couples the signal to the base of Q6, which amplifies the signal and applies it to a voltage-doubler stags The signal is then passed through resistor R18 to the base of Q7. Transistor Q7 draws increased collector current proportional to the signal input, lowering the positive dc potential at its collector. This voltage is applied to the bases of amplifier transistors Q3, Q4, and Q5. Variations in signal level will cause the AGC circuit to put out a voltage which will vary the gain of the amplifiers, thereby maintaining a steady output voltage The AGC voltage also passes through A3A1P-3 and A3XA1-3 to the external monitor selector switch, which in AGC position applies the AGC voltage to the monitor meter.

c. Bandpass Filters(fig. 2-30). The audio signal from audio amplifier Al is routed through isolation resistor R5 in the low-pass filter A3A2, and then applied to the range selector (VELOCITY) switch A3S1 (bandpass filter selector). In all positions, the signal is routed through one of the nine

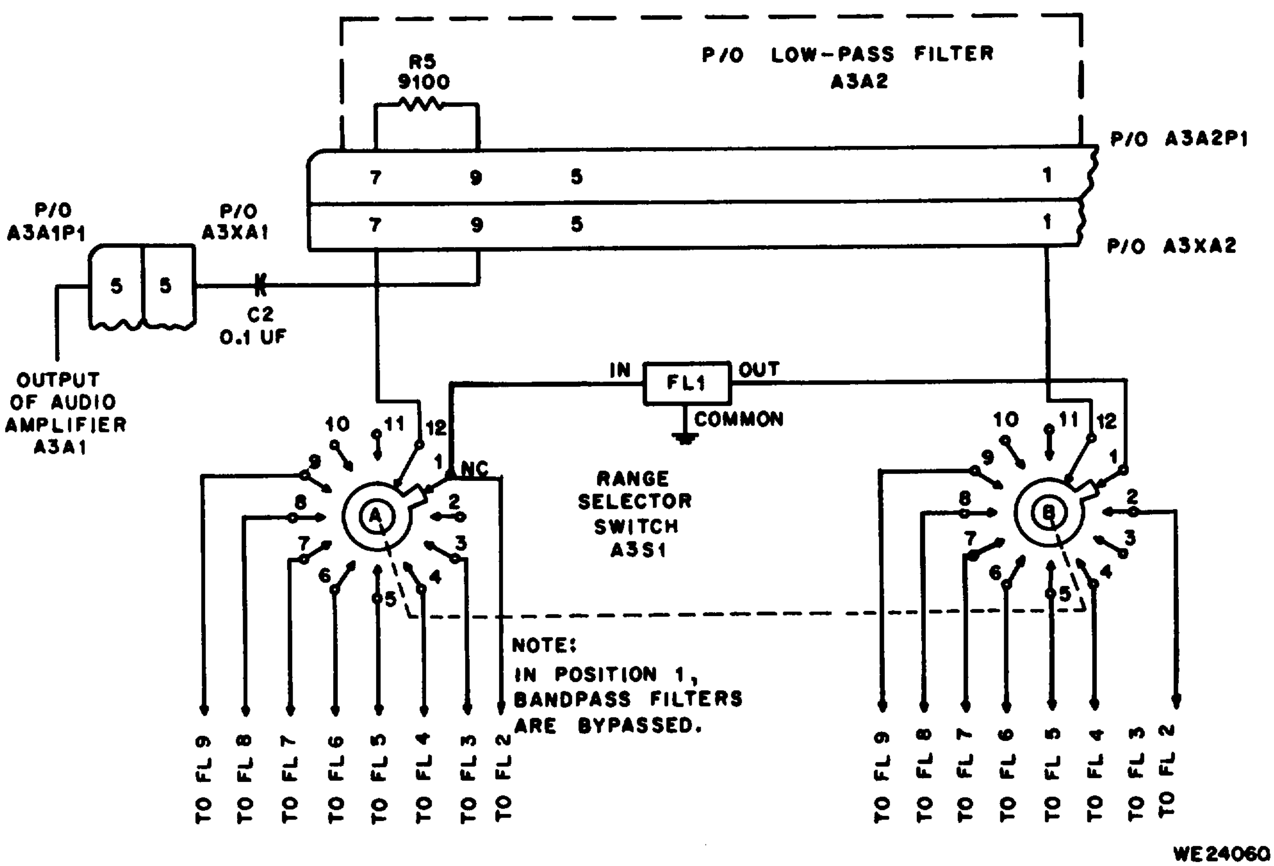


Figure 2-30. Bandpass filter switching circuit - partial schematic diagram.

bandpass filters. The first filter passes a band of frequencies from 8 to 26 kc. Each of the others has a similar pass band in a frequency range corre-sponding to the Dopplershift frequencies en-countered in a particular range of projectile velocities. The output signal is routed through A3XA2-1 to low-pass filter A3A2.

d. Low-Pass Filter A3A2 (fig. 2-31). This filter attenuates all components above 130 kc in the signal from audio amplifier A1. The audio input signal from the bandpass filters passes through connectors A3XA2-1 and A3A2P1-1 of low-pass filter A3A2. Capacitor C1 couples the signals to the filter circuit made up of inductors L1 through 1A and capacitors C2 through C4. From L2 the signal is applied to the base of the emitter-follower Q1 which serves to match the input impedance of the next stage. Capacitor C5 couples the output of Q1 to A3A2P1-4 and A3XA2-4. The signal then passes through A3P1-4 and 1J8-4 to the digital display indicator A5 (counter assembly).

2-15. Digital Display Indicator A5 Counter Assembly

(fig. 2-32)

a. General. The counter assembly contains 19 plug-in units which perform the functions of audio amplification, pulse and signal generation, count-downs (division) by 16 and by decades, and digital indication. DC operating voltages of 170 volts and 22 volts for use by the A5 circuits are supplied from the power supply lines. Other dc voltages of 11 volts, 5.5 volts, and 100 volts are developed within the A5 circuitry. The 11 volts used as a clamping reference voltage in A1, A2, A8, and

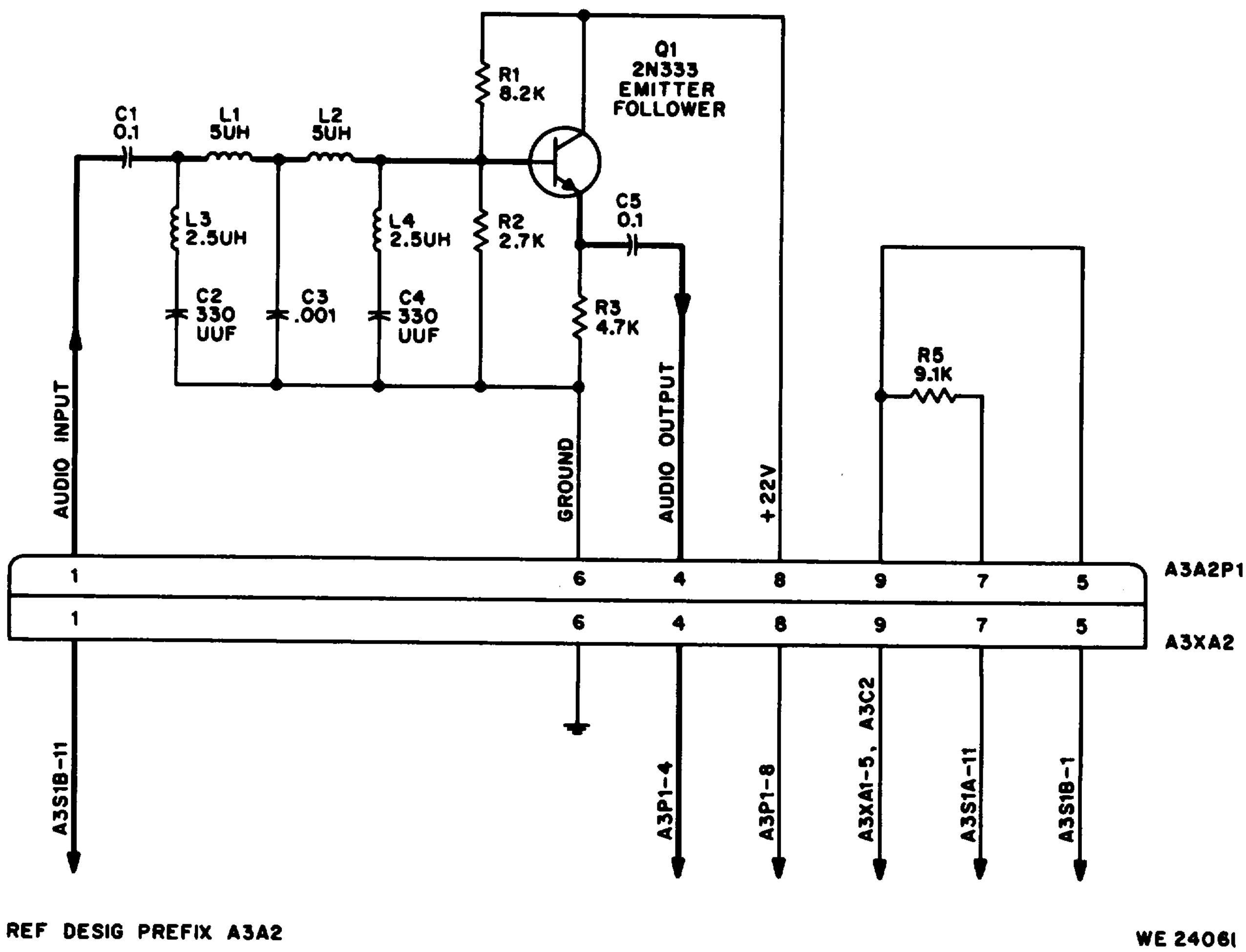


Figure 2-31. Low-pass filter A3A2 - partial schematic diagram.

A11 through A18 is obtained by utilizing the aggregate of the voltage drops across the transistor load resistors of the multivibrators in the ÷16 counters (A11, A12, A13, and A18) and in the decade counters (A14, A15, A16 and A17), as well as the voltage drops across the load resistors of the oscillator and audio gates A1 and A2 and the coincidence gate A8. Since at any one time half of these load resistors (all acting in parallel) will have a voltage drop somewhat higher than 11 volts, this potential is stabilized at 11 volts by reference breakdown diodes CR1 and CR2 in series. The stabilized 11 volts is then used as a clamping reference for the pulse outputs of the counters and gates. The 5.5-volt potential also required by most of the A5 circuits is obtained from a tap between the two reference diodes, CR1 and CR2. RESET switch S2, in a branch of the 5.5-volt line going to the counter circuits, permits removing the voltage momentarily from the multivibrators to return them to their starting conditions. The 100-volt potential required by A6 is obtained from a voltage divider consisting of R2 and R3 connected between the 170-volt line and ground.

b. AF/RF Amplifier A5A5 (fig. 2-33). This audio amplifier serves to amplify the output of the microphone. The microphone signal is fed through connectors A5XA5-1 and A5AP1-1, and through capacitor C2 to the base of amplifier transistor Q1. Q1 is normally conducting fully because of the for-ward bias supplied by voltage divider resistors R2 and R4, and the output voltage level at pin 7 (collector) is approximately 5 volts. When an ac signal from the microphone is fed to Q1

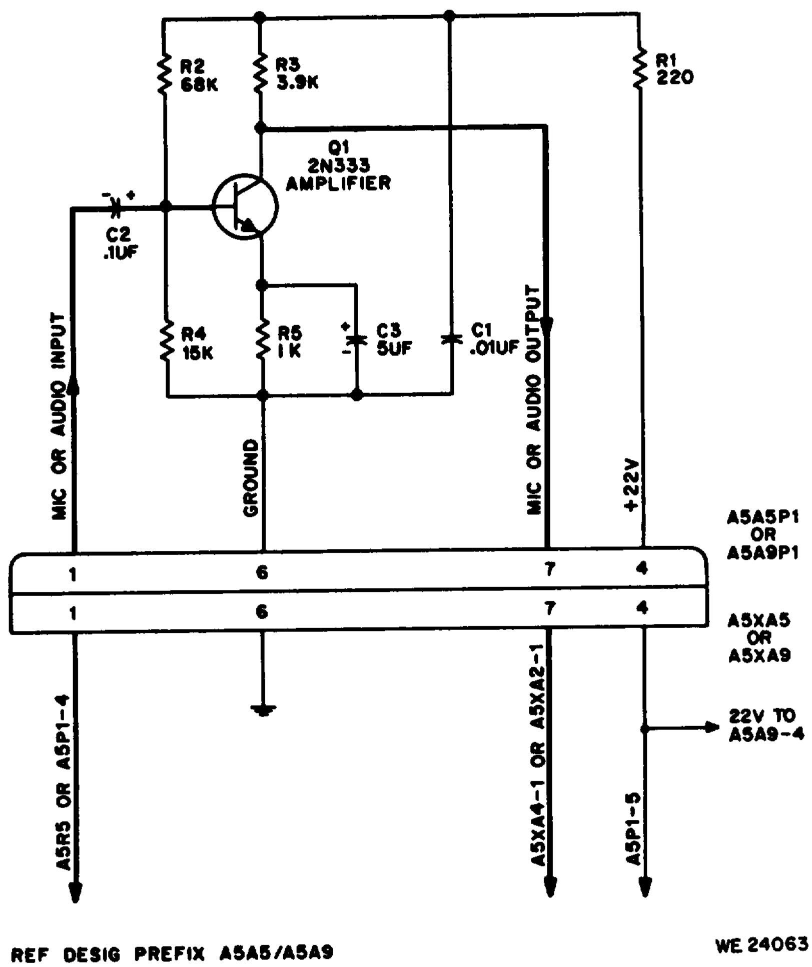


Figure 2-33. AF/RF amplifier A5A5 (microphone) and AF/RF amplifier A5A9 (audio) - partial schematic diagram.

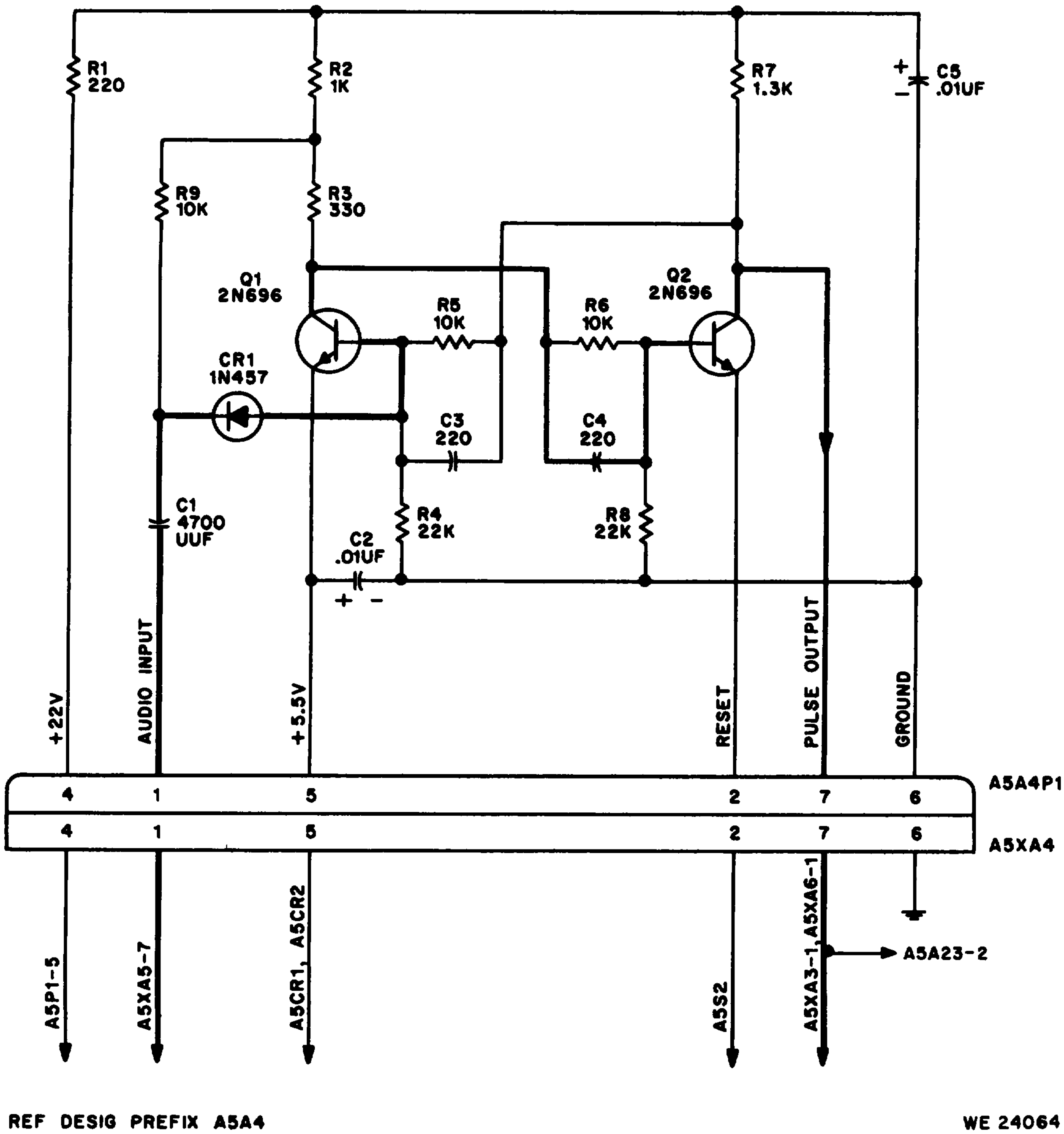


Figure 2-34. Pulse generator A5A4 - partial schematic diagram.

base through C2, the positive peaks have no effect, but the first negative peak causes Q1 to conduct less heavily so that the output voltage rises. On a strong input pulse, Q1 will be driven to cutoff and the out-put voltage will approach the 22-volt source voltage. Capacitor C1 serves as a 22-volt line decoupler. Resistor R5, bypassed by capacitor C#, provides emitter bias for Q1.

c. Pulse generator A5A4 (fig. 2-34). This circuit supplies a pulse which is used to actuate the delay reset circuit (fig. 232) and is itself triggered by the momentary output of AF/RF amplifier A5A5 (microphone). Pulse generator A5A4 is essentially a bistable multivibrator. In the ready or "reset" condition, transistor Q1 is conducting and Q2 is in a non-conducting state. The negative-going part of the momentary microphone signal from A5A5 is passed through A5A4P1-1, C1, and CR1 to the base of Q1. This signal biases Q1 to cutoff, and the voltage rises at the junction of R3 and the collector of Q1. This voltage, when applied to the base of Q2, causes an increase in collector current and a drop in voltage at the junction of R7 and the collector of Q2. The voltage at this junction is ap-plied to A5A4P1-7 as the pulse output signal which is used to actuate gate generator A5A3 and the reset indicator A5A6 (amplifier) (fig. 2-32). Removal of 5.5 volts (reset voltage) from A5A4P1-2 cuts off the flow of Q2 collector current, and the voltage at the junction of R7 and the collector of Q2 then rises. This voltage is ap-plied to the base of Q1, causing collector current to flow, and placing the multivibrator again in the ready condition.

d. Delay Reset A23 (fig. 2-35). This circuit is actuated by the pulsed output of pulse generator. A5A4. The delay reset is a monostable multivibrator with an output driver which supplies 5.5 volts to the reset lines of A5A13, A5A14, A5A15, A5A16, A5A17 and A5A18. The output of A5A4 at pin 7 triggers the input pin 2 of the delay re-set on a negative going pulse. When triggered, the output from transistor driver to pin 6 of the delay reset is cut off, thereby resetting A5A13, A5A14, A5A15, A5A16, A5A17 and A5A18 to zero. This zeroes out the decade counters and the two most significant binary counters. This reset lasts 86 +2 milliseconds. At the end of the reset period, the negative going output of pin 1 of the delay reset triggers the input to pin 1 of A5A3, which then opens the 95 kc oscillator gate to the binary counter. During manual reset, the reset switch breaks the 5.5-volt line to pin 2 of A5A3 and A5A4, and pin B of A5A11 and A5A12, thereby resetting these modules. The 5.5 volts is now applied to pin 4 of the delay reset circuit which cuts off transistor Q3, thus applying a re-set signal on output pin 6 and A5A13, A5A14, A5A15, A5A16, A5A17, and A5A18. Resistors R12 and R13 are connected to the collectors of transistors Q1 and Q2 (pin J and pin E) of A5A18 to increase the drive on the output of A5A18.

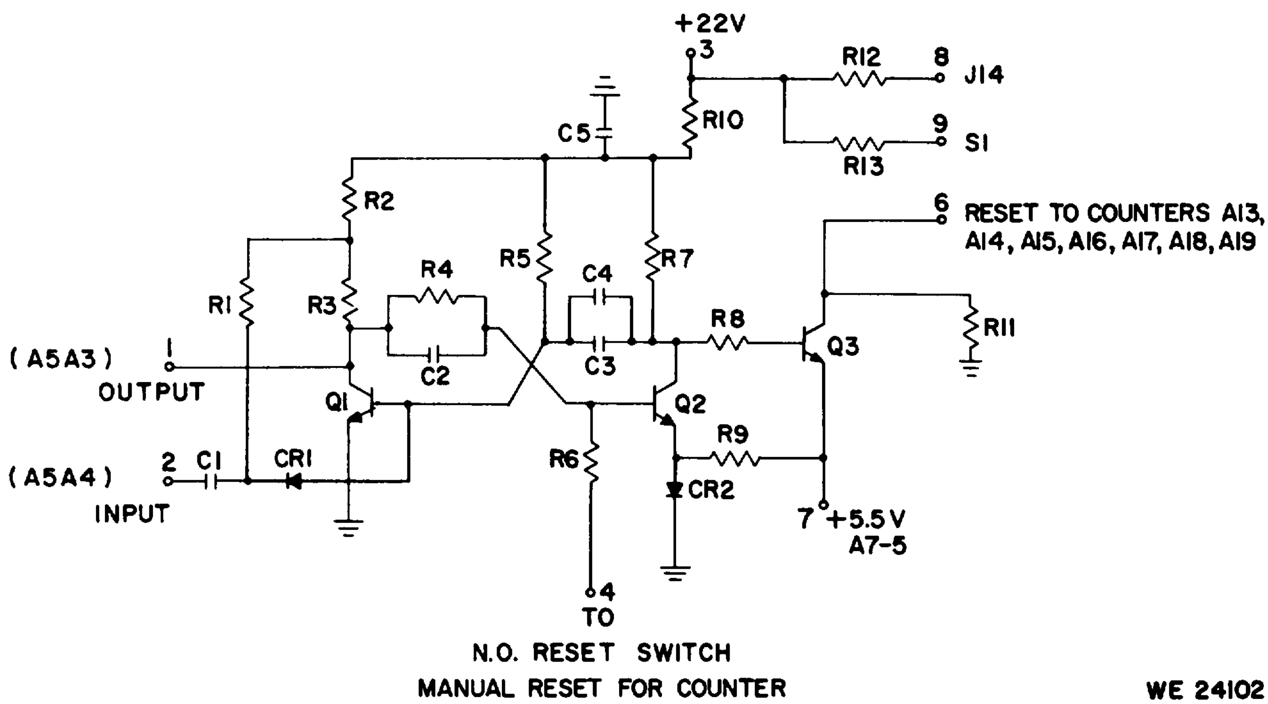


Figure 2-35. Delay reset A23 - partial schematic diagram.

e. Gate Generator A5A3 (fig. 2-36). This circuit supplies a gate pulse which actuates oscillator doppler gate A5A1. Gate generator A5A3 is nearly identical to pulse generator. The signal from A5A4 through A5A23 triggers Q,1 into the cut-off state, causing Q2 to conduct. A negative gate output pulse is produced and fed through A5A3P1-7 to the oscillator gate. The gate generator is "set" by the negative-going trailing edge of the counting period pulse taken from delay gate A5A8 (coincidence gate). This set input pulse, ap-plied through A5A3P1-4, C6 and CR2 to the base of Q2, triggers the gate generator, which closes the oscillator gate in readiness for the next operation.

f. Radio Frequency Oscillator 96.648 kc A5A7 (fig. 2-37). This crystal-controlled oscillator sup-plies a precise 95.648 kc signal which is used as the basis for both the counting period and the delay period. The two-stage oscillator is followed by a squaring stage. As oscillation begins, the signal voltage developed across load resistor R4 is directly coupled to the base of Q2. A portion of the out-put of Q2, taken from the junction of Q2 collector and load resistor R7, is fed back to the base

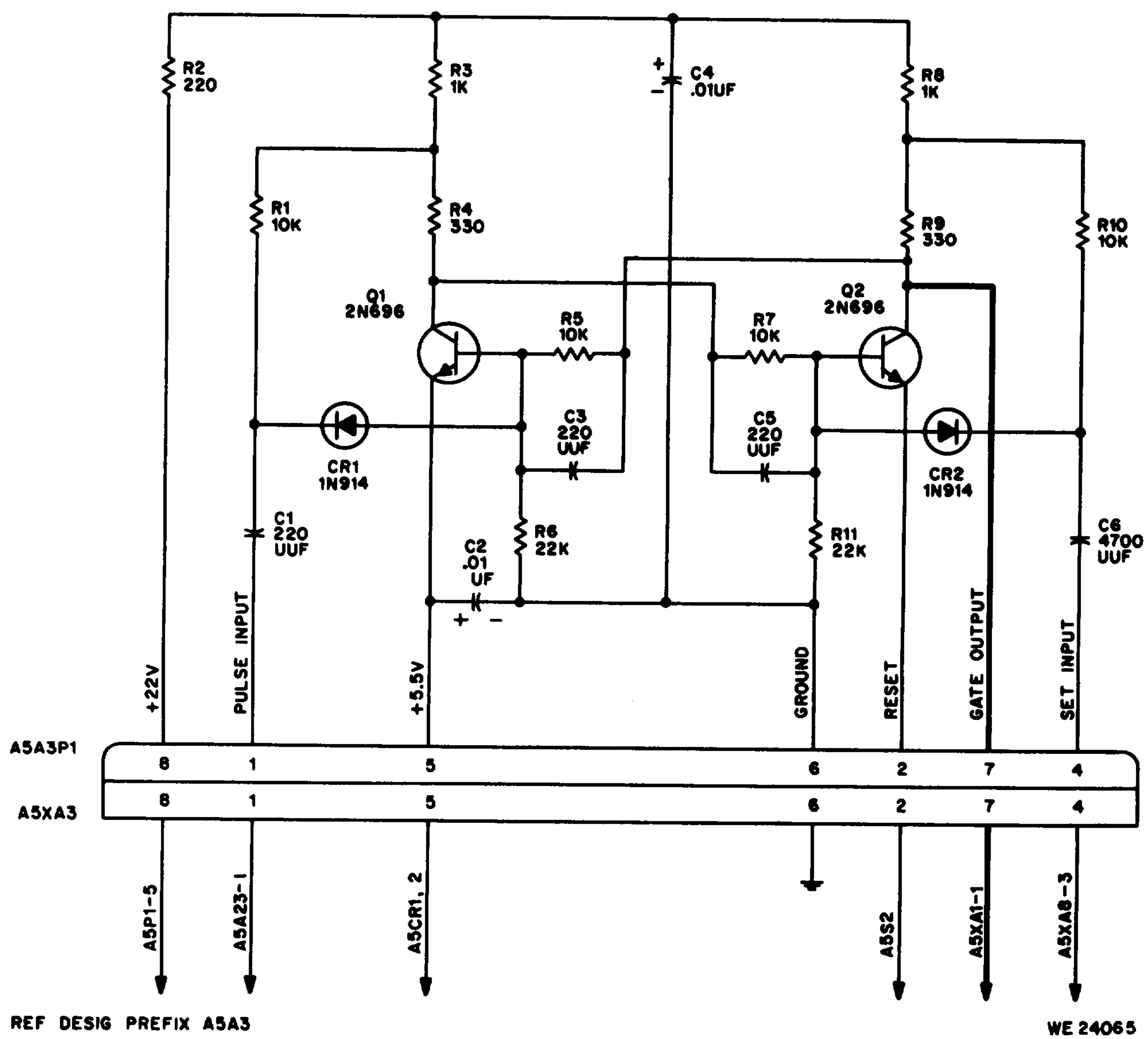


Figure 2-36. Gate generator A5A3 - partial schematic diagram.

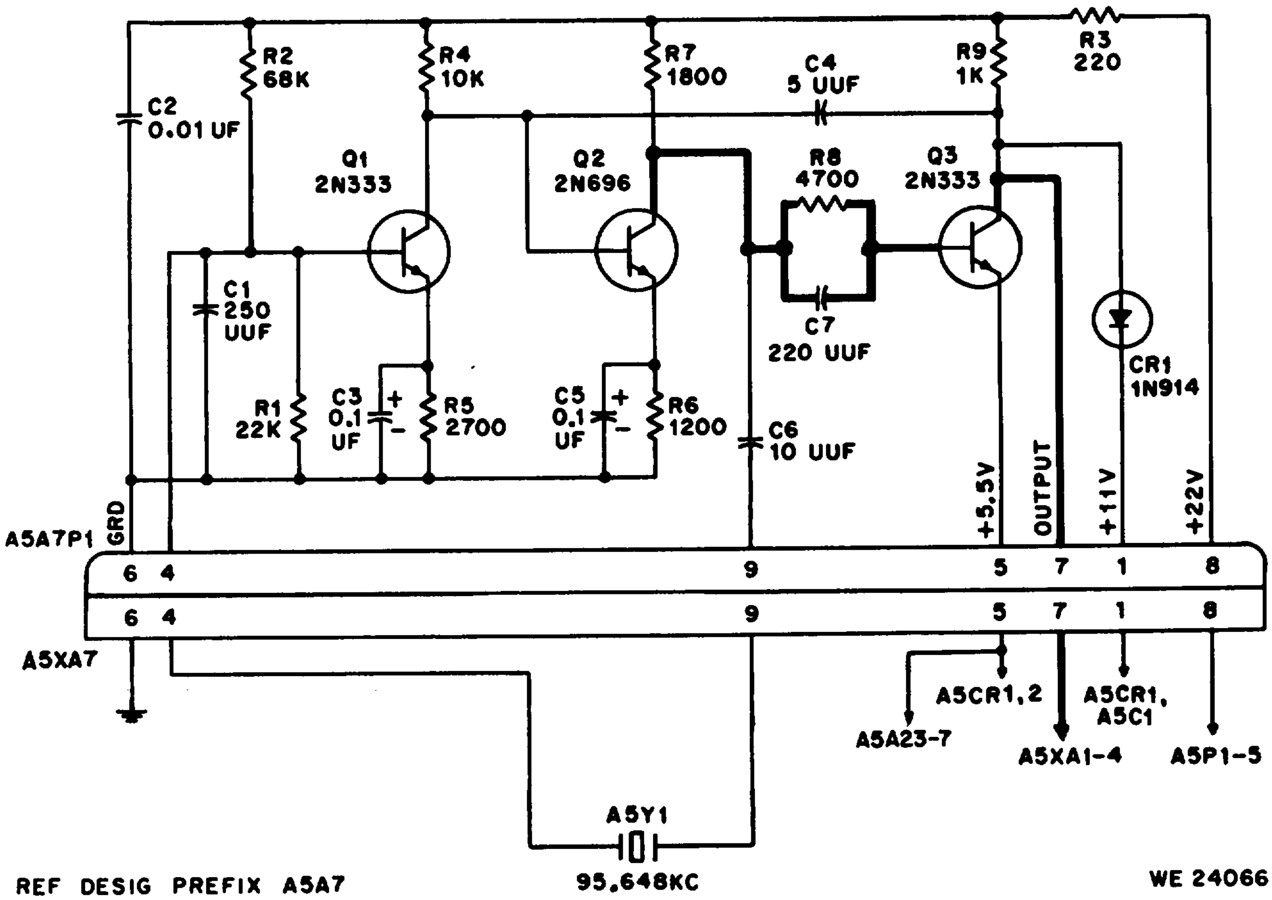


Figure 2-37. Radio frequency oscillator 95.648 kc A5A7 (gating) - partial schematic diagram.

of Q1 through C6, and through external crystal A5Y1. Crystal A5Y1 presents a very low impedance to a signal at its resonant frequency and permits this signal to pass and reinforce oscillation. The output of Q2 is applied to the base of Q3 through capacitor C7 and resistor R8, is amplified, and the output developed across load resistor R9 is applied to output connector A5A7P1-7. The output of Q3 is a square wave developed by driving the transistor into collector-current saturation. Diode CR1 clamps the output to 11 volts.

g. Oscillator Doppler Gate A6A1 (Oscillator) (fig. 2-38). The function of this circuit is to permit the passage of the 95.648 kc signal only during the time when counting is taking place. This is determined by the gating pulse from gate generator A5A3. The 95.648 kc output of A5A7 is applied to the oscillator gate circuit through A5A1P1-4, through semiconductor diode CR2, to the cathode of CR1, and through R1 to the base of Q1. When gate generator A5A3 is in the reset condition, the gating pulse applied to CR2 through A5A1P1-1 and CR1 back-biases CR2 into non-conduction so that the 95.648 kc signal cannot pass. When gate generator A5A3 is triggered, the back-biasing volt-age applied to CR1 drops, permitting conduction through CR2. (Semiconductor diode CR3 clamps the input gating pulse to 11 volts). The 95.648 kc signal next passes through CR2 and R1 to the base of Q1. Transistor Q1 amplifies the signal and develops and output across R3. The output of Q1 is clamped to 11 volts by diode CR4, then coupled to the base of Q2 through capacitor C2 and resistor R4. Transistor Q2 further amplifies the signal and develops an output across resistor R7. Diode CR5 clamps this output to 11 volts. Transistors Q1 and Q2 are both driven into collector current saturation and their outputs clamped to produce a good square-wave output. From Q2 the output pulse is routed out of the

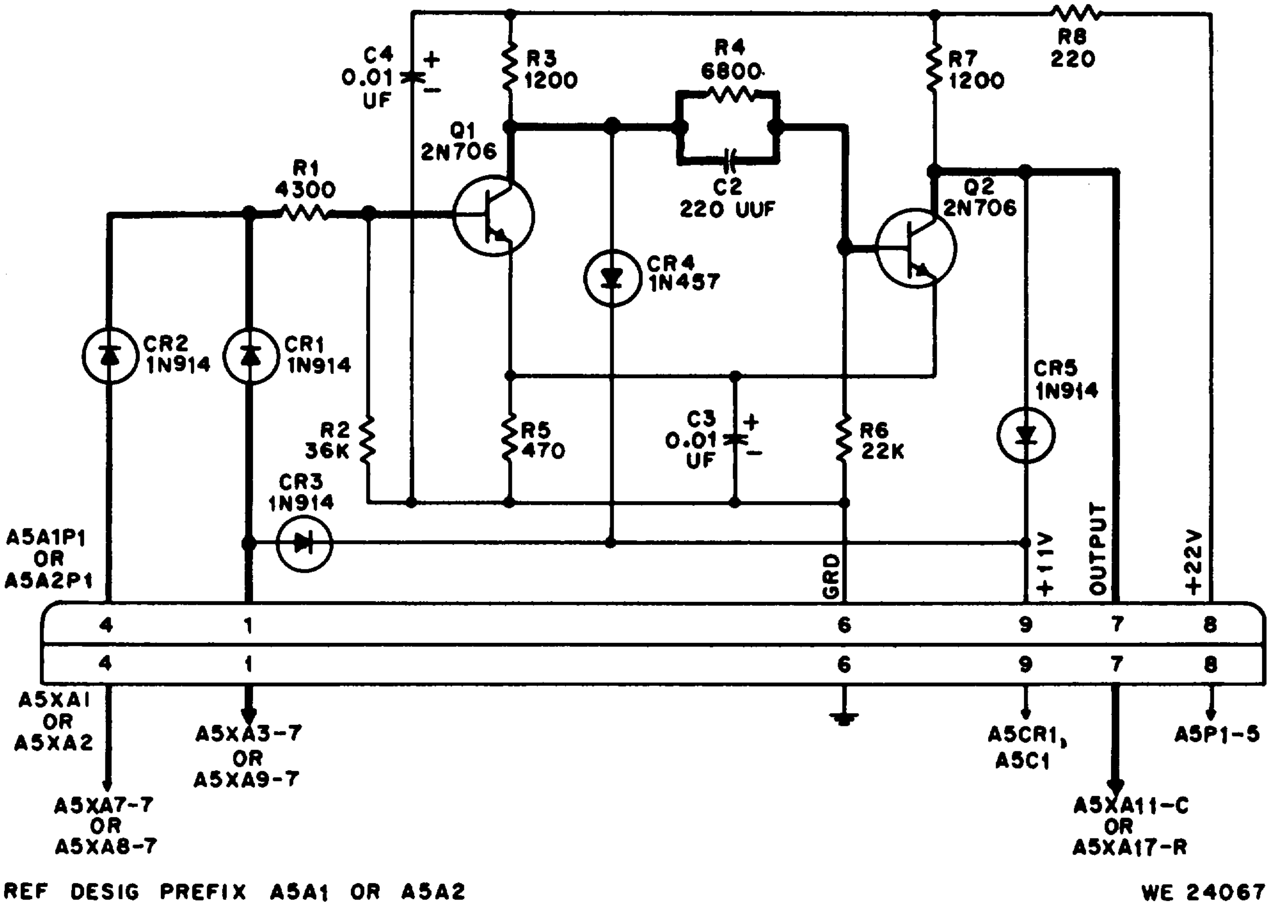


Figure 2-38. Oscillator Doppler gate A5A1 (oscillator) and oscillator Doppler gate A5A2 (audio) - partial schematic diagram.

subassembly through connector A1P1-7 to electronic counter A5A11 (first ÷ 16).

h. Electronic Digital Counter A5A11 (First ÷ 16). The 95.645 kc square wave signal from the oscillator gate A5A1 is applied to the first ÷ 16 circuit (fig. 2-39) through connector A5A11P1-C. It is then passed to terminal 7 of mounting board A5A11A1 and to the base of A1Q1 through capacitor A1C4 and negative steering diode A1CR3. This signal is also passed to the base of A1Q2 through capacitor A1C5 and steering diode A1CR4. The values of A1C4 and A1C5 are chosen to give a differentiating action (i.e., a "spiking" of the ides of the pulse) which has the effect of accentuating the leading edge. Transistors A1Q1 and A1Q2 form a multivibrator circuit (fig. 2-40) so arranged that one transistor is driven to cutoff while the other is driven to collector current saturation (fig. 2-41). As the applied signal goes negative, the A1Q1 collector current abruptly drops so the voltage at the junction of A1R1 and the collector of A1Q1 abruptly increases. This increased voltage, applied to the base of A1Q2, causes its collector current to increase and the voltage at the junction of A1R2 and the collector of A1Q2 to go more negative. The collector voltage of A1Q2 is applied to terminal 9 of A5A11A1 and to the base of A1Q1 to hold the transistor in a nonconducting state. The collector voltage of A1Q1 is applied to terminal 7 of the next multivibrator (A5A11A2). This voltage is positive and does not cause the multivibrator to switch states. The positive pulse of the input signal now reaches the cathodes of negative pulse steering diodes A1CR4 and A1CR5 where it is blocked, preventing any switching action. When the next negative pulse reaches the bases of A1Q1 and A1Q2, transistor A1Q1 is already in a quiescent state and there is no charge. However, the signal applied to A1Q2 causes collector current cutoff and the resulting collector voltage applied to the base of A1Q1 causes that transistor to switch states, so that its collector voltage decreases. This negative-going pulse, applied to terminal 8 of A5A11A1 and to terminal 7 of the next multi-vibrator (A5A11A2), causes that multivibrator to switch in the same manner as the first. Since it takes two complete cycles of input signal for each multivibrator to trigger the following stage, the output frequency of each multivibrator stage is equal to half the input frequency. Semiconductor diodes A1Q1 and A1Q2 clamp the positive potential of the pulses at output terminals 8 and 9 to 11 volts, as determined by the reference voltage on terminal 3. This voltage back-biases both diodes so that they are non-conducting except when the voltage on the output line exceeds the 11-volt level. Under this condition, a portion of the signal overcomes the back bias and causes the diode to conduct, shunting that part of the signal to ground. Subassembly A5A11 contains four identical multivibrator stages, each dividing by two, so the complete subassembly divides its 95.648 kc in-put by 16, producing a 5.978 kc output. After each counting operation the multivibrator stages are reset by pressing RESET switch A5A2, which removes the 5.5 volts from terminal 6 of each multivibrator, causing it to switch to the "ready" condition.

i. Electronic Digital Counter A5A12 (Second ¸ 16) and Electronic Digital Counter A5A13 (Third ¸ 16). These subassemblies are identical to A5A11 described above. A5A12 divides its 5.978 kc input by 16 to get 373.6 cps, while A5A13 divides its 373.6 cps input by 16 to get 23.3516 cps. The output of A5A13 is fed to electronic digital counter A5A18 (delay multivibrator subassembly).

j. Electronic Digital Counter A5A18 (Delay Multivibrator Subassembly). This subassembly is a standard module identical to the ÷16 subassemblies described above. In this application, however, the function of the module is not to perform a simple frequency division but to act in effect as a delay circuit, passing a pulse only after the elapse of a predetermined time period. Like the frequency divider modules, A5A18 contains four cascaded multivibrators. These circuits afford a number of take-off points (fig. 2-42) for pulse signals of different polarities and pulse lengths. Five of these outputs are utilized. They are connected to delay.

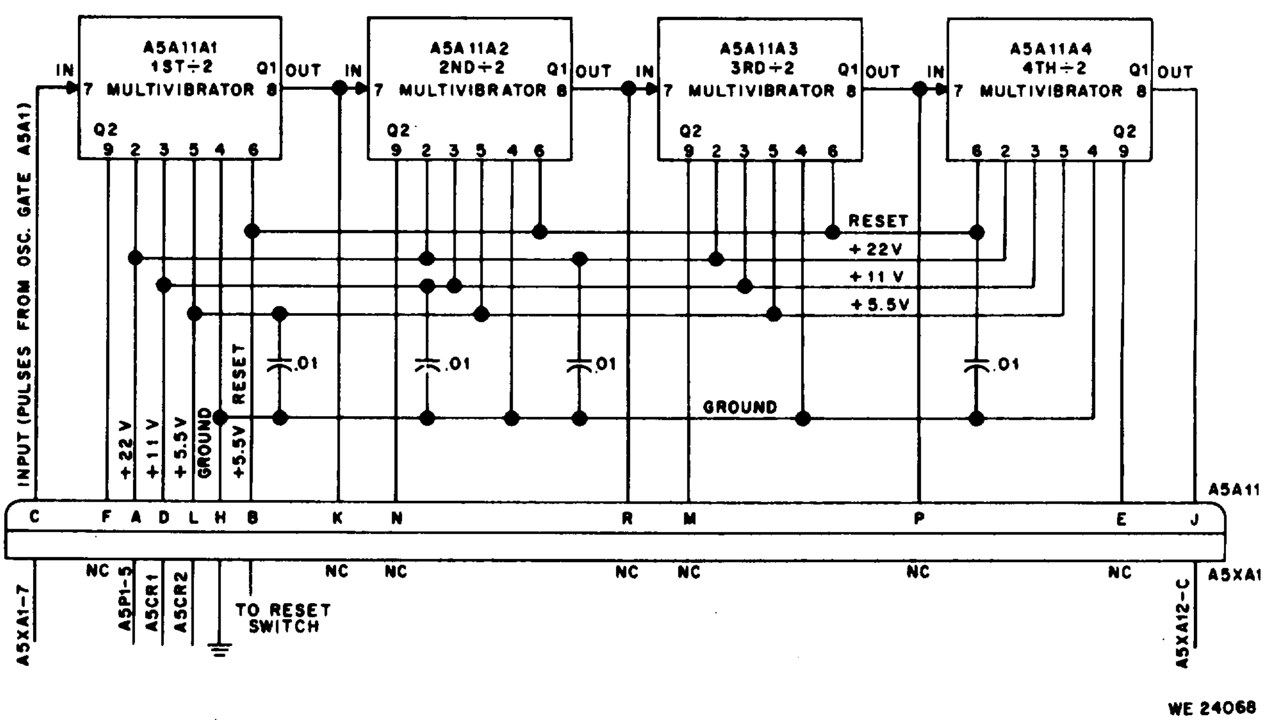


Figure 2-39. Hookup of multivibrators in electronic digital counter A5A11 (first ÷ 16).

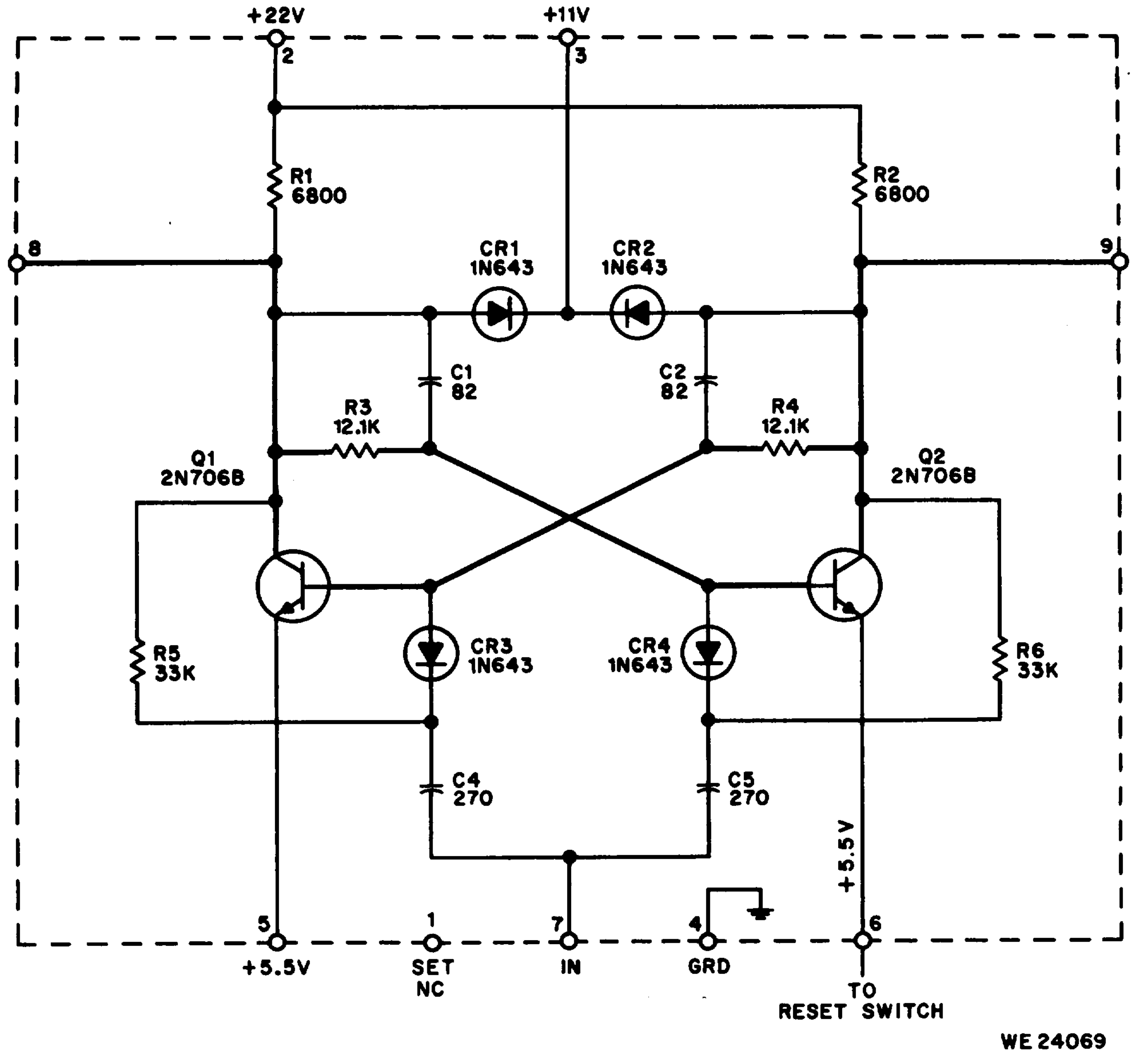


Figure 2-40. Typical multivibrator circuit as used in ÷ 16 circuits.

selector switch A5S1 which selects appropriate combinations (table 2-1) for application to delay gate A5A8 (coincidence gate). By this means it is possible to select one of ten delays ranging from 0.08565-second (twice the basic delay increment) to 0.47105-second (eleven times the basic delay increment) in 0.04282-second increments (fig. 2-43). At the completion of the delay period, the next 0.04282-second pulse is passed on to delay gate A5A8 (coincidence gate) which in turn opens the oscillator doppler gate A5A2 (audio) for the frequency measuring period of 0.04282-second.

k. Delay Gate A5A8 (Coincidence Gate) (fig. 2-44).

(1) The function of this circuit is to supply the gate pulse which triggers oscillator Doppler gate A5A2 (audio). To accomplish this function, A5A8 is fed various combinations of pulses (on its three input lines) from the delay selector switch A5S1. Each combination of pulses is translated.

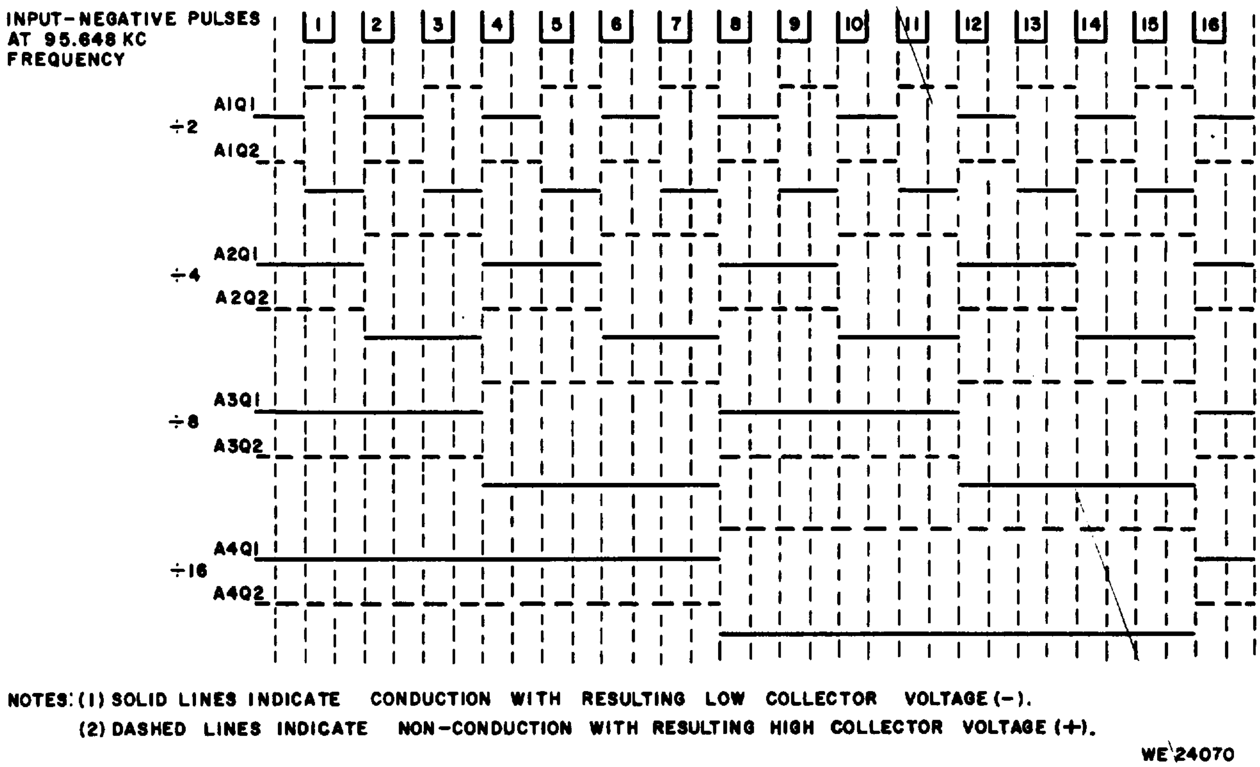


Figure 2-41. Graph of multivibrator conductive and non-conductive states, A5A11.

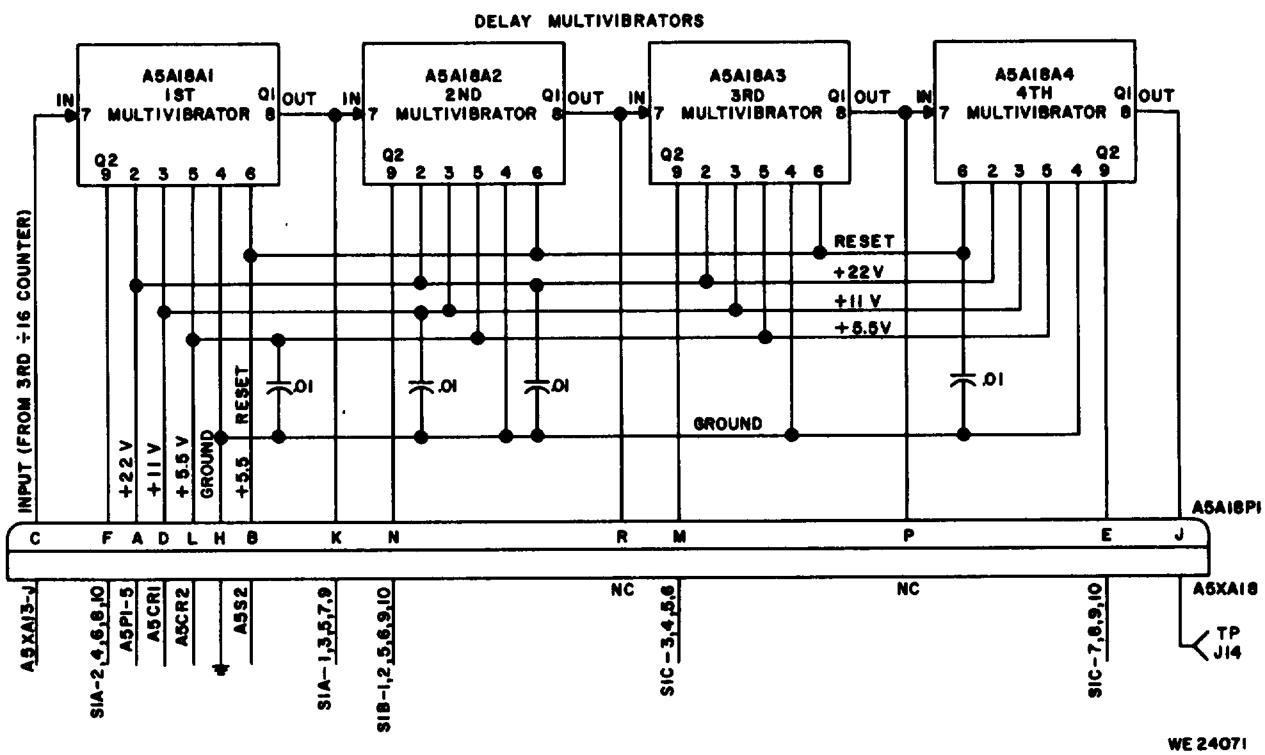


Figure 2-42. Hookup of multivibrators in electronic digital counter A5A18 (delay multivibrators).

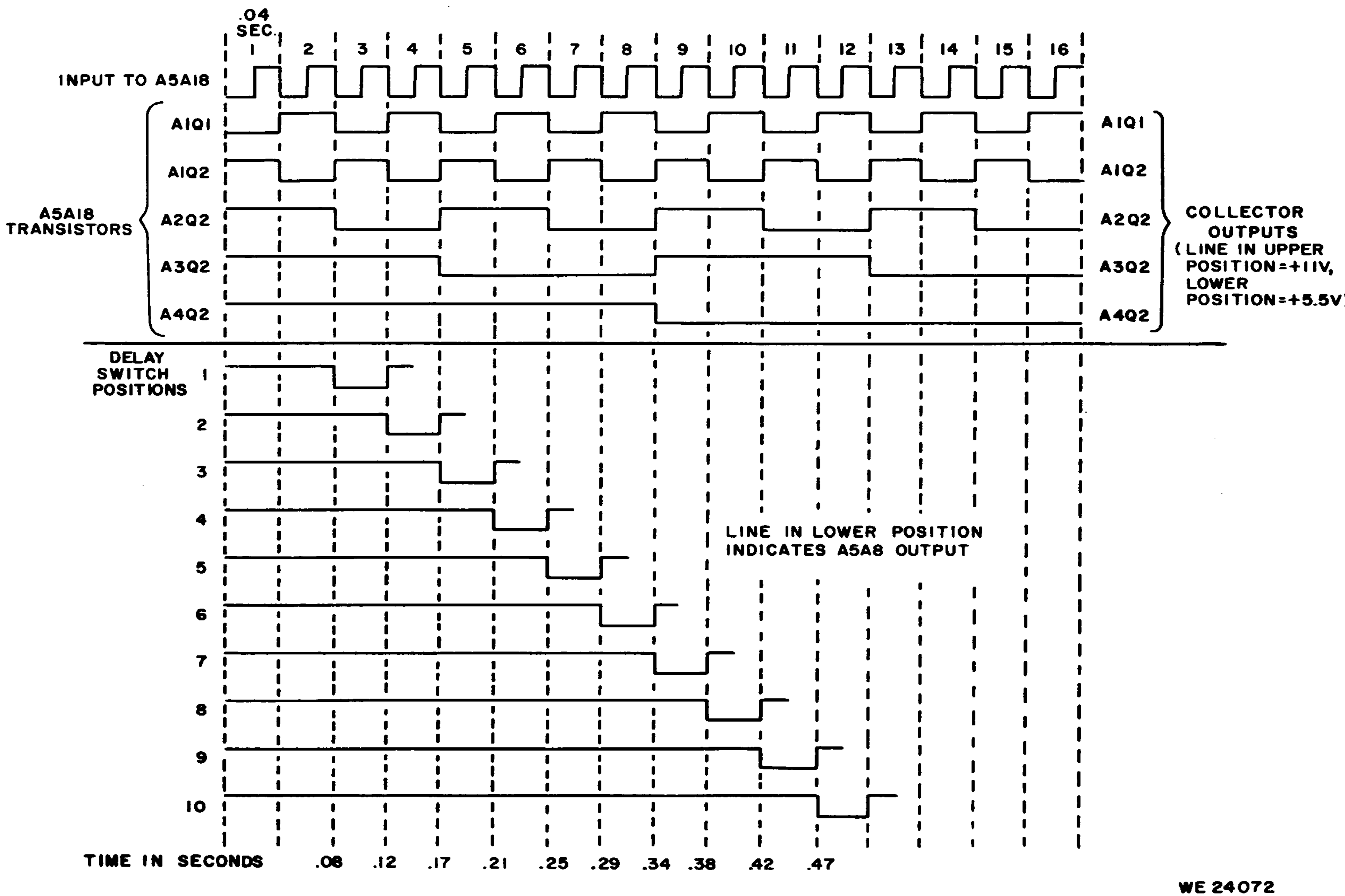


Figure 2-43. Electronic digital counter A5A18 (delay multivibrator) conduction versus delay switch positions.

Table 2-1. Time Decays

A5S1 switch positions	A5A18 collector connections	A5A18 pin connections	A5A8 diode connections [1]	Delay seconds
1-------------------------------------	A1Q1, A2Q2	K, N	CR1, CR3 (CR2 Open)	0.08565
2-------------------------------------	A1Q2, A2Q2	F, N	CR1, CR3 (CR2 Open)	0.12847
3-------------------------------------	A1Q1, A3Q2	K, M	CR1, CR2 (CR3 Open)	0.17129
4-------------------------------------	A1Q2, A3Q2	F, M	CRI, CR2 (CR3 Open)	0.21411
5-------------------------------------	A1Q1, A2Q2, A3Q2	K, N, M	CR1, CR3, CR2	0.25693
6-------------------------------------	A1Q2, A22, A3Q2	F, N, M	CR1, CR3, CR2	0.29976
7-------------------------------------	A1Q1, A4Q2	K, E	CR1, CR2 (CR3 Open)	0.34258
8-------------------------------------	A1Q2, A4Q2	F, E	CR1, CR2 (CR3 Open)	0.38541
9-------------------------------------	A1Q1, A2Q2, A4Q2	K, N, E	CR1, CR3, CR2	0.42823
10------------------------------------	A1Q2, A2Q2, A4Q2	F, N, E	CR1, CR3, CR2	0.47105

[1]Diodes CR1, CR2, and CR3 are connected to pins 1, 2 and 4 of P1.

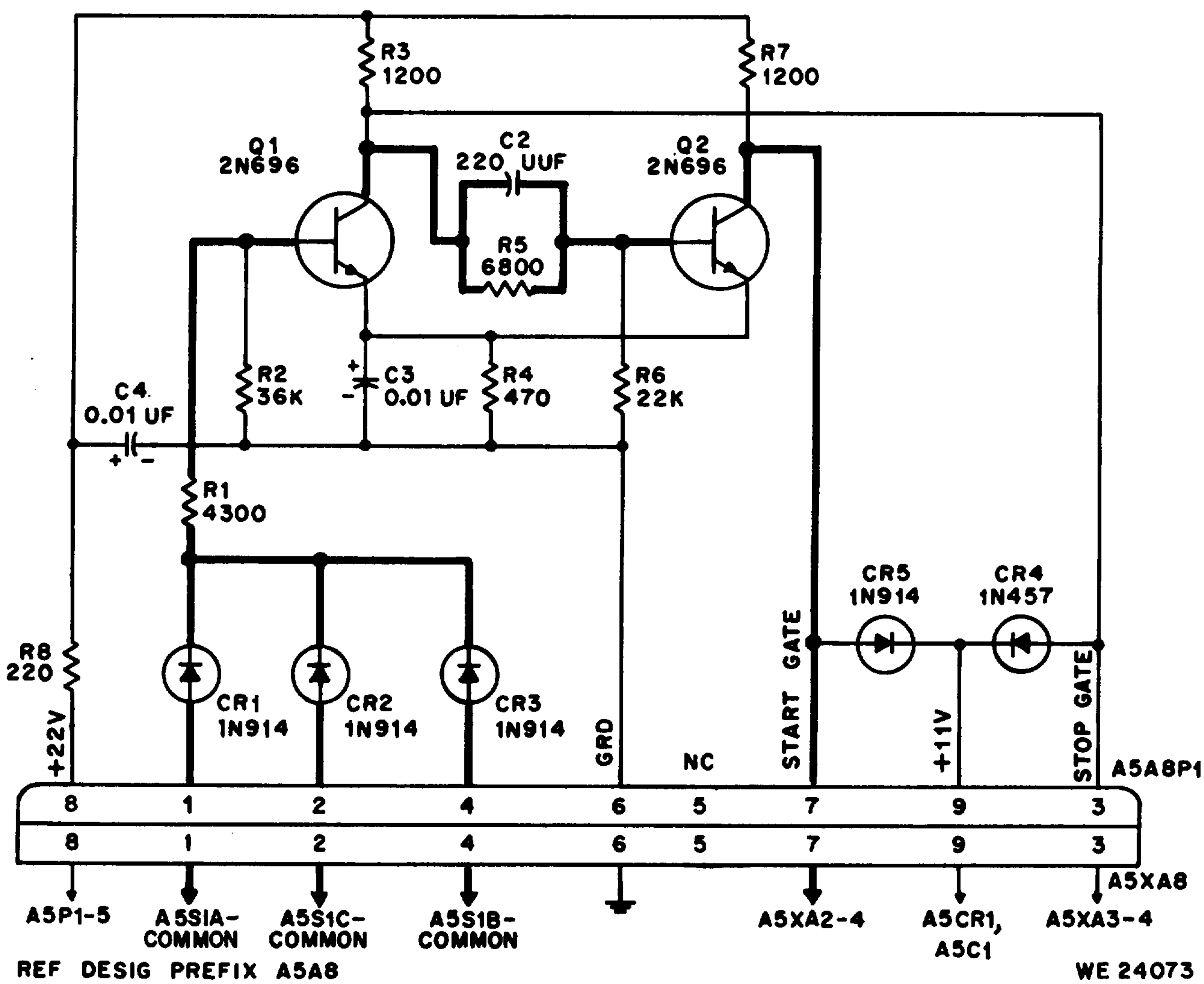


Figure 2-44. Delay gate A5A8 (coincidence gate)—partial schematic diagram.

into one of ten possible delay periods. The combined pulse input determines not only what delay will occur before A5A8 puts out a signal, but also gates a fixed measurement period, after which the output is cut off. Translation of pulse combinations into the appropriate delay is possible by virtue of the fact that coincident lowering of the voltages on the input lines occurs only at the time when the gate is required to pass a pulse. A second pulse signal is fed out of A5A8 through pin 3 of A5A8P1. This is the "stop gate" pulse which is fed to gate generator A5A3 to "set" that circuit. Both of the outputs are clamped at 11 volts by diodes CR4 and CR5.

(2) Three semiconductor diodes (CR1, CR2, and CR3) terminate the three input lines and are connected in parallel to the base of transistor Q1. This transistor is normally conducting and is maintained in this state as long as an 11-volt potential is present on one or more of the three input lines. Whenever the potentials on all of the three input lines drop to 5.5 volts (or the lines are disconnected) in coincidence, conduction stops in Q1, causing the second transistor Q2 to increase conduction and to put out a negative gating pulse. The pulse signals fed into A5A8 consist of various combinations of the simultaneous outputs of five different transistors (A1Q1, A1Q2, A2Q2, AQ2, and A4Q2) in A5A18 (fig. 2-43). The collector of A1Q1 alternately puts out 11-volt and 5.5-volt pulses, each lasting for one complete cycle of the input signal (which has a period of 0.04282 second). This output signal is the only one of the five which starts with the 5.5-volt potential. A1Q2 puts out similar pulses but alternates them in the opposite phase. The collector of A2Q2 alternately puts out 11-volt and 5.5-volt pulses, each lasting for two complete cycles of the input signal. A3Q2 puts out similar pulses, each lasting for four full cycles, while A4Q2 puts out the longest pulses, each lasting for eight input cycles By selecting appropriate combinations of these pulses, along with no input in some cases (no line connected), delay selector switch A5S1 can apply to the coincidence gate coded information corresponding to delay periods from 0.08565-second (twice the basic delay increment) to 0.47105-second (eleven times the basic delay increment) in ten 0.04282-second steps.

(3) As an example, when delay selector switch A5S1 is in position 1, the collector of A1Q1 in the delay multivibrator subassembly (A5A18) (figs. 2-42 and 2-43) is connected to the line going through pin 1 of A8P1 (fig. 2-44) to input diode CR1 in A5A8, and A2Q2 is connected through pin 4 to CR3, while no signal is applied to diode CR2. The collector of A2Q2 puts out an 11-volt pulse during the first and second input cycles, maintaining A8Q1 in the conductive state during this interval. During the third cycle of input signal, however, the output of both A1Q1 and A2Q2 is 5.5 volts, which places a 5.5-volt potential upon CR1 and CR2, and thus upon the base of transistor A8Q1. This causes A8Q1 to cut off, increasing the conduction of A8Q2 and causing a negative pulse to be put out during the period of one input cycle (0.04282-second) (fig. 2-43). This pulse is used to gate on the oscillator Doppler gate A5A2 (audio) permitting the audio signal to pass for a period of 0.04282-second. When this period is ended, A8Q1 is again biased into conduction, causing A8Q1 to put a "stop" pulse through pin 3 of ASP1 to gate generator A5A3, cutting off the flow of the 95.648 kc signal and stopping the counting process.

(4) When delay selector switch A5S1 is in position 2, the collectors of A1Q2 and A2Q2, in the delay multivibrator subassembly are connected to the lines going through pins 1 and 4 of A8P1 to input diodes CR1 and CR3 in A5A8, while no line is connected to CR2. With this combination, a 5.5-volt potential occurs on both lines after the third cycle of input signal (a delay of 0.12847-second). This condition lasts for a period of one input cycle, after which the outputs of A1Q2 and A2Q2 return to 11 volts (at the beginning of the fifth cycle), thus terminating the A5A8 output pulse.

(5) As a final example, when delay selector switch A5S1 is in position 10, the collectors of A1Q2, A2Q2, and A4Q2 in the delay multivibrator subassembly are connected to the three lines going through pins 1, 2, and 4 of A8PI to diodes CR1, CR2, and CR3 in the coincidence gate. In this combination a coincidence of 5.5 volts does not occur on all three lines until after the eleventh cycle (a delay of 0.47105-second) lasting until the beginning of the thirteenth cycle.

l. AF/RF Amplifier A5A9 (Audio). This amplifier, which amplifies the doppler-shift signal before application to A5A2, is identical to AF/RF amplifier A5A5 (microphone). For detailed electrical description and theory of operation, see AF/RF amplifier A5A5 (microphone), *b*, above.

m. Oscillator Doppler Gate A6A2 (Audio). The function of this circuit is to permit the passage of the "audio" signal into the counter circuits only during a period of 0.04282-second. (For significance of this period see para 2-2.) The circuit is identical to that of the oscillator doppler gate A5A1 (oscillator) described in figure 2-38. The signal from AF/RF amplifier A5A9 (audio) is fed in through A2Pl-1, while the gating signal from the delay gate A5A8 (coincidence gate) is fed in through A2P1-4. When triggered by A5A8, A5A2 puts out a pulse on A2P1-7 which is fed to decade frequency counter A5A17 (tenths-thousands), the first of a series of four decade counter modules.

n. Decade Frequency Counter A5A17 (Tenths-Thousands).

(1) This circuit (fig. 2-45) has three distinct functions; it serves as the counter for the tenths indicator and for the thousands indicator, and provides a ÷ 3 function to correct the count obtained during the X3 counting period. A5A17 contains three multivibrators (fig. 2-46), two of which (tenths counter) are in cascade but have a feedback connection from the output of the second multivibrator to the "set" input of the first, while the third multivibrator (thousands counter) is not connected to the first two but is operated independently.

(2) The pulse signal from the audio gate is fed into the tenths counter through pin R of A5A17P1. The second pulse causes the second multivibrator to be triggered, and the first multivibrator is reset via the feedback connection. The third incoming pulse causes

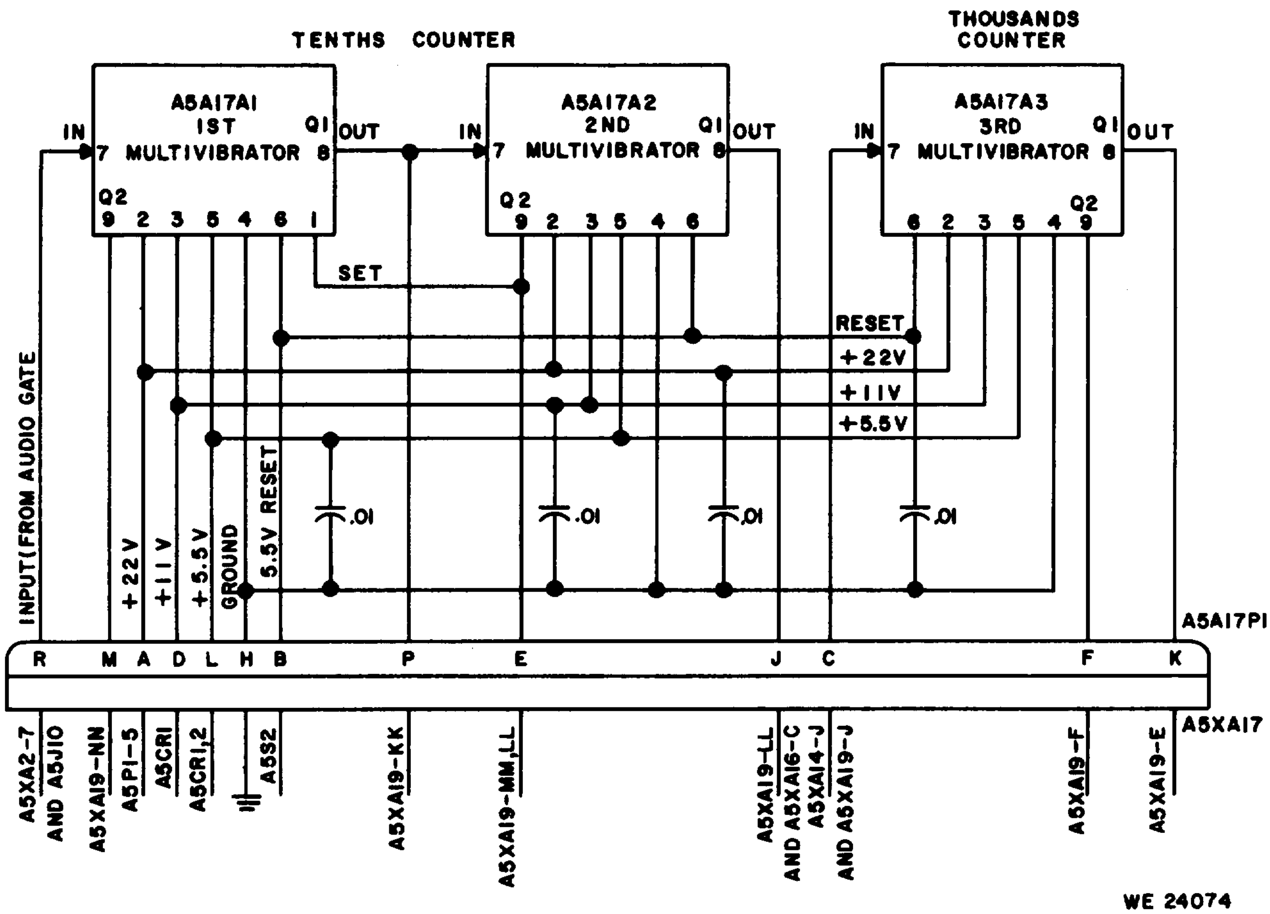


Figure 2-45. Hookup of multivibrators in decade frequency counter A5A17 (tenths-thousands).

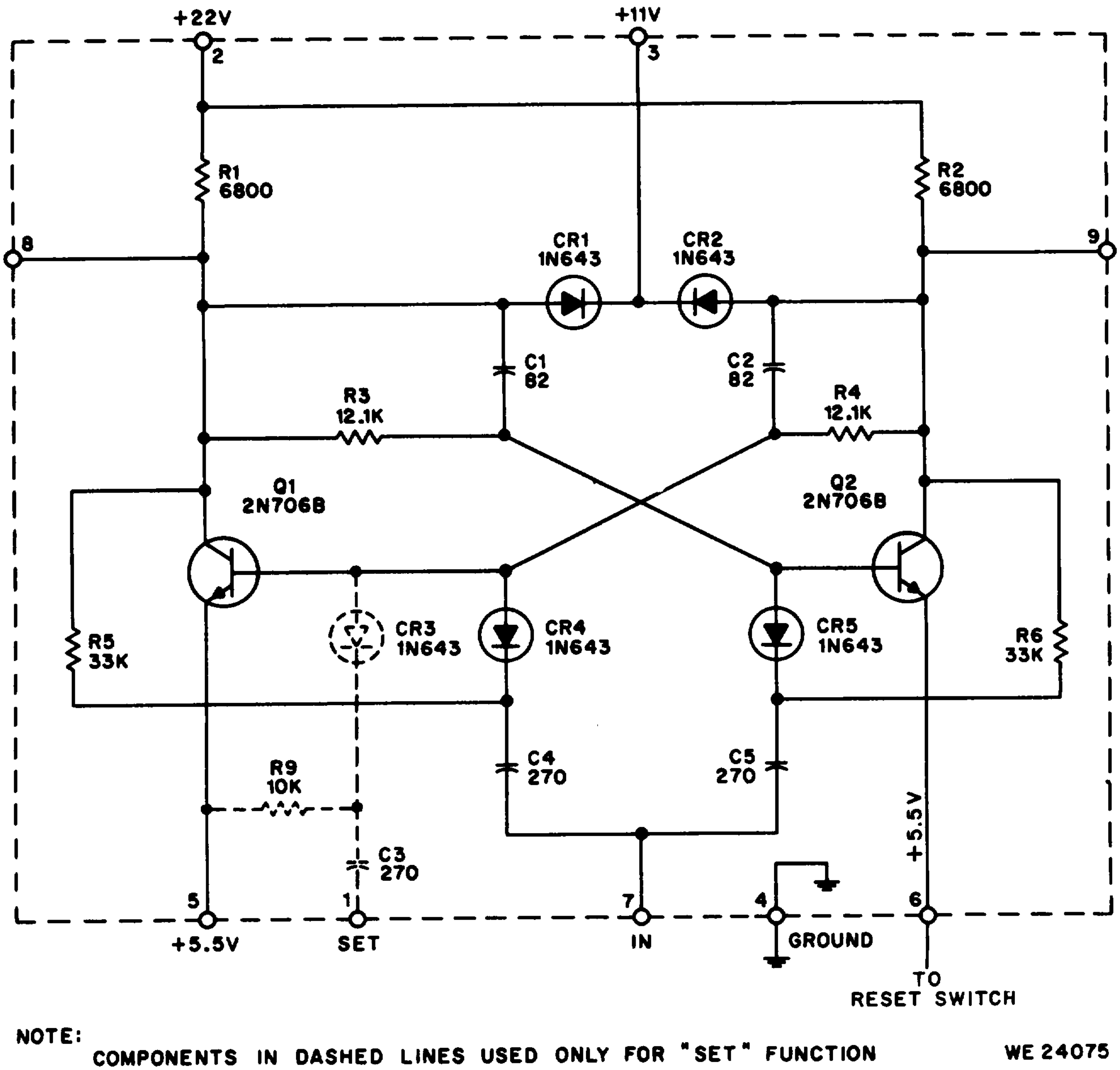


Figure 2-46. Typical multivibrator circuit as used in decade frequency counters.

the second multivibrator to pass a pulse on to the units decade counter A5A16 and to the tenths digital indicator circuit (fig. 2-32). At this time the multivibrators are returned to their original state. (It will be noted that the tenths digital indicator is not connected to display a full decade count, so that a zero indication will be seen until the start of the first tenths multivibrator input pulse, then a 3 indication until the start of the second input pulse and a 7 indication until the end of the second input 2-48 pulse. The third input pulse causes the indication to return to zero.

(3) When ten pulses have been received by the hundreds decade counter A5A14, a pulse is applied to A5A17P1 pin C. This triggers the single thousands multivibrator which counts one thousand and passes a pulse on to the thousands digital indicator circuit. It will be noted that the thousands digital indicator is not connected to display a full decade count, but only 0 and 1, so the second

input pulse will cause a zero thousands indication.

o. Decade Frequency Divider A6A16 (Units Decade Counter) (Fig. 2-47).

(1) This counter circuit is a modification of the basic binary divide-by-16 circuit described in h above. The modification to the basic circuit consists of a feedback path from the fourth to the second and third multivibrators This feedback causes the counter to skip ahead (in effect) from the eighth to the fourteenth count, so that the complete counting sequence takes only ten input pulses instead of sixteen. The negative-going square pulses from the tenths counter are applied to the input of A5A16, which is the first of three identical decade counters. When ten input pulses have been received from the tenths counter, the units counter passes a negative pulse to the tens decade counter.

(2) The counter circuit is set up by pressing RESET switch A5S2. This interrupts the emitter-voltage supply line to A1Q2, A2Q2, A3Q2, and A4Q2 (through pin B of A5A16P1 and terminal 6 on mounting boards), stopping conduction in these transistors, and causing transistors A1Q1, A2Q1, A3Q1 and A4Q1 to conduct. This causes the voltage at pin 8 (Q1 collector) to be low (more negative) while the voltage at pin 9 (Q2 collector) is high (more positive) in each of the four multivibrators.

Note

For simplicity of explanation, the alternate outputs from the multivibrators will be called "positive pulses" and "negative pulses" although it is understood that the outputs are actually de potentials of 11 volts and 5.5 volts Also for simplicity these pulses will be said to "pass through" the various coupling capacitors although the statement is somewhat imprecise

(a) The first negative pulse is applied to the input of the first bistable multivibrator A1 (through pin C of A16 and terminal 7 of the first mounting board). This pulse passes through coupling capacitors C4 and C5 and steering diodes CR4 and CR5 to the bases of both A1Q1 and A1Q2 (fig. 2-45). Since A1Q2 is not conducting, the negative pulse on the base has no effect. A1Q1, however, is conducting and is caused to switch to the non-conducting state. This causes the collector voltage of A1Q1 to go to a higher (more positive) level. This positive-going voltage is passed through coupling resistor R3 and "speedup" capacitor C1 to the base of A1Q2. The more positive base voltage causes A1Q2 to go into conduction, so that AIQ2 collector voltage drops to a more negative level. This negative-going voltage is passed

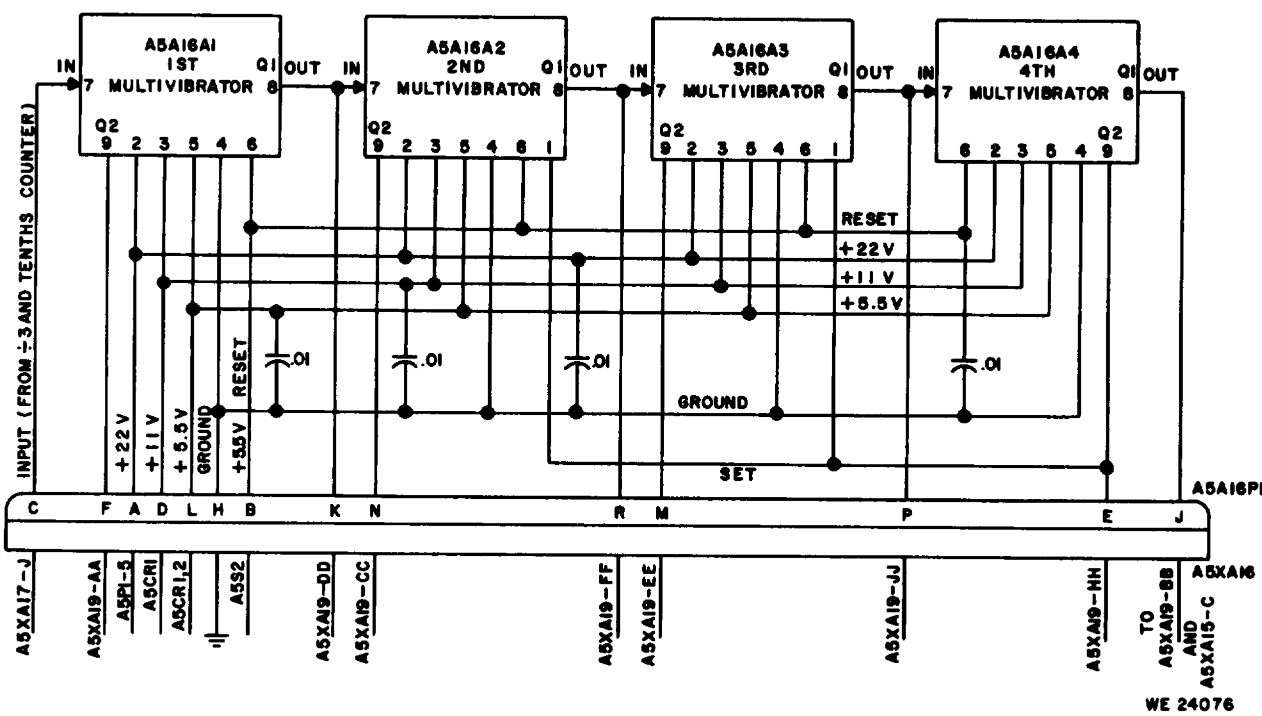


Figure 2-47. Hookup of multivibrators in frequency divider A5A16 (units decade counter).

through coupling resistor R4 and "speedup" capacitor C2 to the base of A1Q1, helping to drive it to cutoff and causing the A1Q1 collector voltage to go more positive. The positive pulse at terminal 8 is fed to the input of the next multivibrator A2, where it is blocked by the steering diodes. The positive collector voltage from A1Q1, in combination with those of A2Q2 and A3Q2, is also passed on to the digital indicator circuits where a count of 1 is registered. Since all of the multivibrators in Al are of the bistable type, A1 remains in this state until a second negative pulse is applied to its input.

(b) The second negative pulse applied to the input of the counter (terminal 7 of board Al) has an effect the opposite of the first, causing A1Q2 to stop conducting and A1Q1 to start, so that the A1Q1 collector goes more negative. This negative pulse at terminal 8 of Al is applied to the input of A2. The negative pulse causes A2Q1 and A2Q2 to switch states, passing on a positive 'pulse to the input of A3, where it has no effect. The positive voltage from A2Q1 collector (combined with those from the collectors of A1Q2 and A3Q2) is also fed to the digital indicator circuits where a count of 2 is registered.

(c) A third negative pulse is applied to the counter input. The pulse again causes A1Q1 and A1Q2 to switch states, this time passing a positive pulse to A2, which has no effect on that circuit. The positive voltage from A1Q1, in combination with those from A2Q1 and A3Q2, is fed to the digital indicator circuits, where a count of 3 is registered.

(d) A fourth negative pulse is applied to the counter input. A1Q1 and A1Q2 switch states, passing a negative pulse to A2 and causing A2Q1 and A2Q2 to switch states. The negative pulse from A2Q1 collector is fed to the input of A3, causing A3Q1 and A3Q2 to switch states The positive pulse from A3Q1 (terminal 8) is fed to the input of A4, where it has no effect. The positive voltage from A3Q1 is also fed to the digital indicator circuits (in combination with that from the collectors of A1Q2 and A2Q2) where a count of 4 is registered.

(e) A fifth negative pulse is applied to the counter input A1Q1 and A1Q2 switch states, passing a positive pulse to A2, which has no effect. The positive voltage from A1Q1 (in combination with those from A2Q2 and A2Q1) is fed to the digital indicator circuits where a count of 5 is registered.

(f) A sixth negative pulse is applied to the counter input. A1Q1 and A1Q2 switch states, passing a negative pulse to A2 and causing A2Q1 and A2Q2 to switch states The positive pulse from A2Q1 collector is fed to A3, having no effect The positive voltage from A2Q1 is also fed to the digital indicator circuits (in combination with those from the collectors of A1Q2, A3Q1, and A4Q2) where a count of 6 is registered.

(g) A seventh negative pulse is applied to the counter input. A1Q1 and A1Q2 switch states, passing a positive pulse to A2, where it has no effect. The positive voltage from A1Q1 is also fed to the digital indicator circuits (in combination with those from A2Q1 and A4Q2) where a count of 7 is registered.

(h) An eighth negative pulse is applied to the counter input. A1Q1 and A1Q2 switch states, passing a negative pulse to A2 and causing A2Q1 and A2Q2 to switch states. A2 passes a negative pulse to A3, causing A3Q1 and A3Q2 to switch states. A3 passes a negative pulse to A4, causing A4Q1 and A4Q2 to switch states. The positive pulse from A4Q1 is passed to the input of the next decade counter, where it has no effect. The positive voltage from A4Q1 is also fed to the digital indicator circuits (in combination with that from A1Q2) where a count of 8 is registered. As A4Q1 and A4Q2 switch states, a negative pulse from A4Q2 (terminal 9) is fed back simultaneously to the "set" inputs (terminal 1) of A2 and AS. This pulse is applied to A2Q1 and A3Q1, both of which are conducting, causing them to stop conducting and A2Q2 and A3Q2 to go into conduction. (It will be noted in the graph of figure 2-48 that this feedback action causes a momentary break in the normal on-off pattern of A2 and AS.)

(i) A ninth negative pulse is applied to the counter input. A1Q1 and A1Q2 switch states, passing a positive pulse to A2 and having no effect. The positive voltage from A1Q1 is also fed to the digital indicator circuits (in combination) with that from A4Q1) where a count of 9 is registered.

(j) tenth negative pulse is applied to the counter input. A1Ql and A1Q2 switch states, passing a negative pulse to A2 and causing A2Q1 and A2Q2 to switch states. A2 passes a negative.

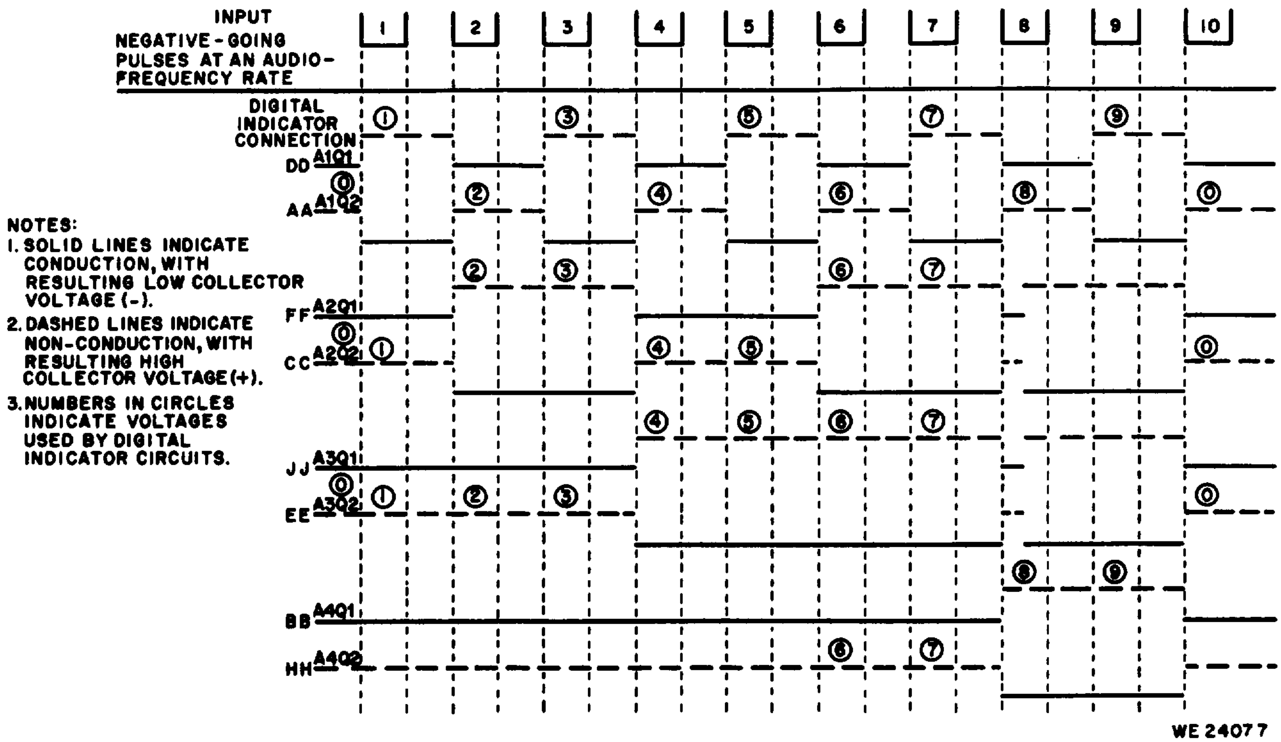


Figure 2-48. Graph of multivibrator conductive and nonconductive states; frequency divider A4A16 (units decade counter).

pulse to A3, causing A3Q1 and A8Q2 to switch states. A3 passes a negative pulse on to A4, causing A4Q1 and A4Q2 to switch states. A4 passes a negative pulse on to the next decade counter, indicating that a count of 10 has been completed. At this time, the positive voltage from A3Q2, A2Q2, and A1Q2 is fed to the digital indicator circuits, causing them to register a 0 (10). At the same time, a positive pulse from A4Q2 (terminal 9) is fed back to the "set" terminals of A2 and A3, but it is blocked by diode CR3 in each case, and has no effect. The units decade counter is now reset to zero, and the next pulse (the 11th) will start the sequence over.

p. Decade Frequency Divider A6A16 (Tens Decade Counter). This circuit operates in the same manner as the units decade counter described in o above except that its output goes to the tens digital indicator and to the hundreds decade counter (fig. 2-32).

q. Decade Frequency Divider A5A14 (Hundreds Decade Counter). This circuit operates in the same manner as the units decade counter described in o above, except that its output goes to the hundreds digital indicator and to the thousands decade counter (fig. 2-32).

r. Digital Display Indicator AA19 (Digital Indicator Assembly). This assembly contains the switching circuits which actuate the tenths, units, tens, hundreds, and thousands digital indicator tubes (fig. 2-5). The units, tens, and hundreds indicator circuits are alike, and the units indicator circuits will be described first.

(1) *Units digital indicator (fig. 2-49).* This circuit contains ten transistor switching amplifiers, each of which controls one glow element in the units digital indicator tube. Each of the transistors is connected as an AND gate, so that each requires two or more activating voltages from the units decade counter to cause the transistor to conduct and apply a firing voltage to the indicator tube electrodes. The AND circuits use a semiconductor diode in each input line, polarized so that the output lead to the switching transistor can never reach a positive potential appreciably above that of the least positive input. The input leads are at a potential of 5.5 volts when no activating signal is present, and since the resistance of R12 (to

use the Q1 circuit as an example) is large in comparison with the forward resistance of the diode units, the potential of the output lead remains close to 5.5 volts as long as any one of the inputs is unactivated. Whenever only 5.5 volts is present on an input line, a path is provided for current to flow from ground through the associated multivibrator transistor in decade counter A5A16, since it is conducting at that time. This electron current, flowing toward the 170-volt source through R12 and through the appropriate diode (CR1, CR2, or CR3), causes a voltage drop across R12 which maintains the base of transistor Q1 at a relatively negative potential, and thus keeps the transistor cut off. (In this type of AND circuit, power for the diodes is supplied by an independent path to the 170-volt source so that the circuit does not load down the driving multivibrators by using them as a power source.) When Q1 goes into conduction, the current flowing through 1-megohm resistor R2 causes a voltage drop which is of a high enough potential to fire the indicator tube electrodes connected across it. In this example, the electrodes are those connected to tube terminals A and O, so that the element shaped like a zero is caused to glow. Each of the other cathode elements in the units digital indicator may be made to glow in a similar manner; however, four inputs are required for the "6" and "7" elements while only two inputs are required for the "8" and "9" elements. When there is no path to ground for this current flow, the voltage drop across R12 is reduced, and the relatively positive voltage applied to the base of Q1 causes it to conduct collector current heavily. In order to actuate only the proper element of the digital indicator tube, and to hold the count when input pulses have stopped, the circuit is arranged so as to make use of the pattern of conducting and non-conducting transistors existing in the series of four units decade counter multivibrators (A5A16) at any point in the pulse count (fig. 2-48). The switching transistor associated with each digital indicator cathode has its collector and emitter connected between a fixed high positive voltage source (170 volts) and a fixed 5.5-volt source. (The actual emitter potential becomes 6.9 volts due to the voltage drop across diodes CR31 and CR32 in the emitter return line.) The controlling base bias voltage for each switching transistor is obtained from a combination of 2, 3, or 4 points in the decade counter multivibrator at which 11 volts is present during the required period (table 2-2). Switching transistor conduction, and consequently indicator firing, will occur only when all of these bias points are at 11 volts. For example, table 2-2B shows that the base of Q1 (the zero element switching transistor) is connected to the collectors of A1Q2, A2Q2, and A3Q2 in A5A16, and figure 2-48 shows that the 11-volt potential appears at all three of these points simultaneously before the first pulse count and at no other time (except for a momentary occurrence during the eighth counting cycle). When 11 volts is applied to all three lines, the indicator switching transistor Q1 is biased to full conduction, and the proper firing potential is applied to the "zero" element of the digital display tube.

(2) *Tens and hundred digital indicators.* These circuits are identical to the units digital indicator circuit (fig. 2-49) except for connector terminals. These connector terminals are shown in figure 2-50 and table 2-2. The description and theoretical discussion will not be repeated here.

(3) *Tenths digital indicator (fig. 2-51).* This circuit is similar to the units digital indicator circuits; however, only three switching transistors are used, those providing 0, 3 and 7 indications on the digital display tube. The theory of operation is essentially the same and will not be repeated here.

Table 2-2. Decade Counter and Digital Indicator Connections

A-Multivibrator Numbering for all Decade Counters

A1		A2		A3		A4	
Q1	Q2	Q1	Q2	Q1	Q2	Q1	Q2

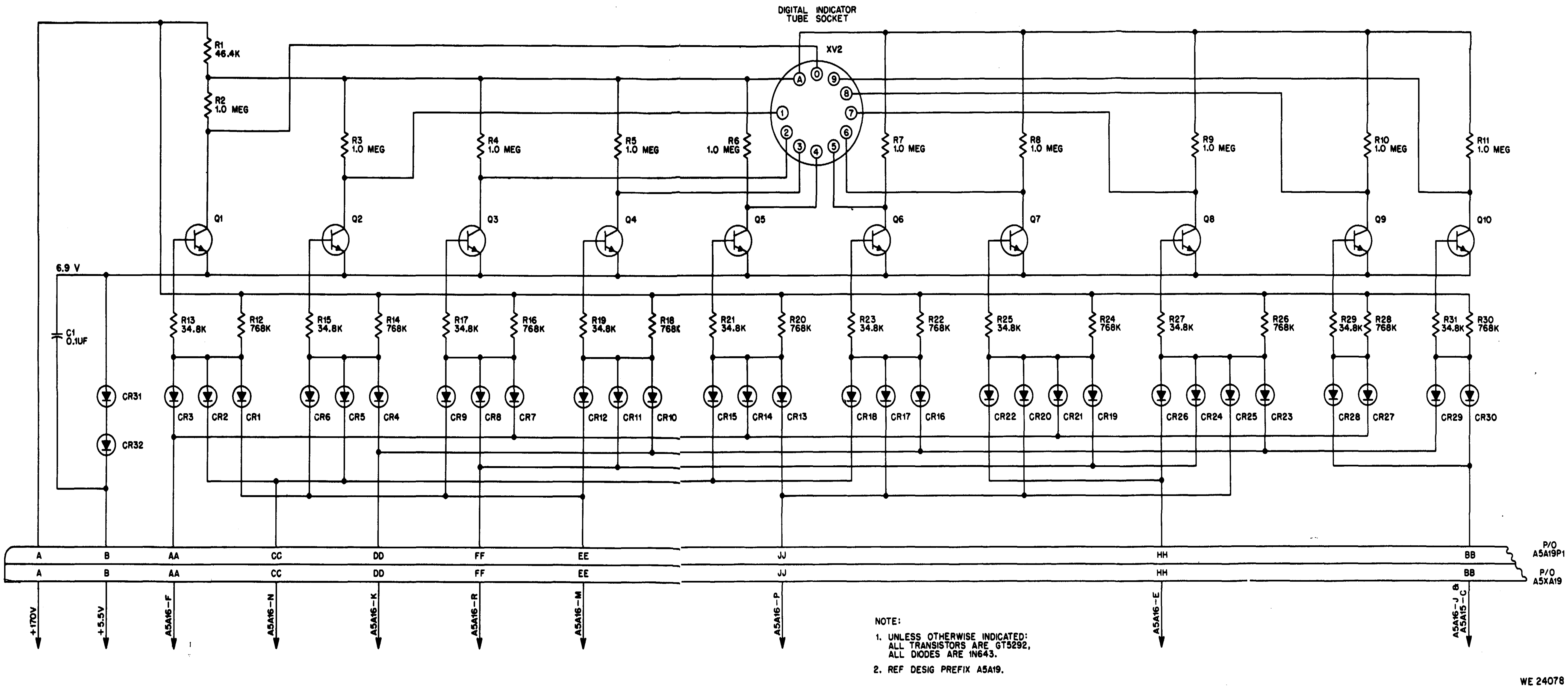


Figure 2-49. Units digital indicator—partial schematic diagram.

Table 2-2. Decade Counter and Digital Indicator Connection Continued

B-Decade Counter Connections

Digital Display	Connections to decade counter transistor collectors						
	Units		Tens & Hundreds		Tenths		Thousands
0	A1Q2	A2Q2		A3Q2	A2Q2	A1Q2	A3Q2
1	A1Q2	A2Q2		A3Q2		A3Q1	
2	A1Q2	A2Q1		A3Q2			
3	A1Q1	A2Q1		A3Q2	A1Q1	A2Q2	
4	A1Q2	A2Q2		A3Q1			
5	A1Q1	A2Q2		A3Q1			
6	A1Q2	A2Q1	A3Q1	A4Q2			
7	A1Q1	A2Q2	A3Q1	A4Q2	A1Q1	A2Q1	
8	A1Q2	A4Q1					
9	A1Q1	A4Q1					

C-Counter and Indicator Connections

Counter transistor	Counter terminal			Digital indicator terminal				
	Tenths	Units, Tens, & Hundreds	Thousands	Tenths	Units	Tens	Hundreds	Thousands
A1Q1	P	D		KK	DD	V	L	
A1Q2	M	F		NN	AA	S	H	
A2Q1	J	R		LL	FF	X	N	
A2Q2	E	N		MM	CC	U	K	
A3Q1		P	K		JJ	Z	R	E
A3Q2		M	F		EE	W	M	F
A4Q1		J			BB	T	J	
A4Q2		E			HH	Y	P	

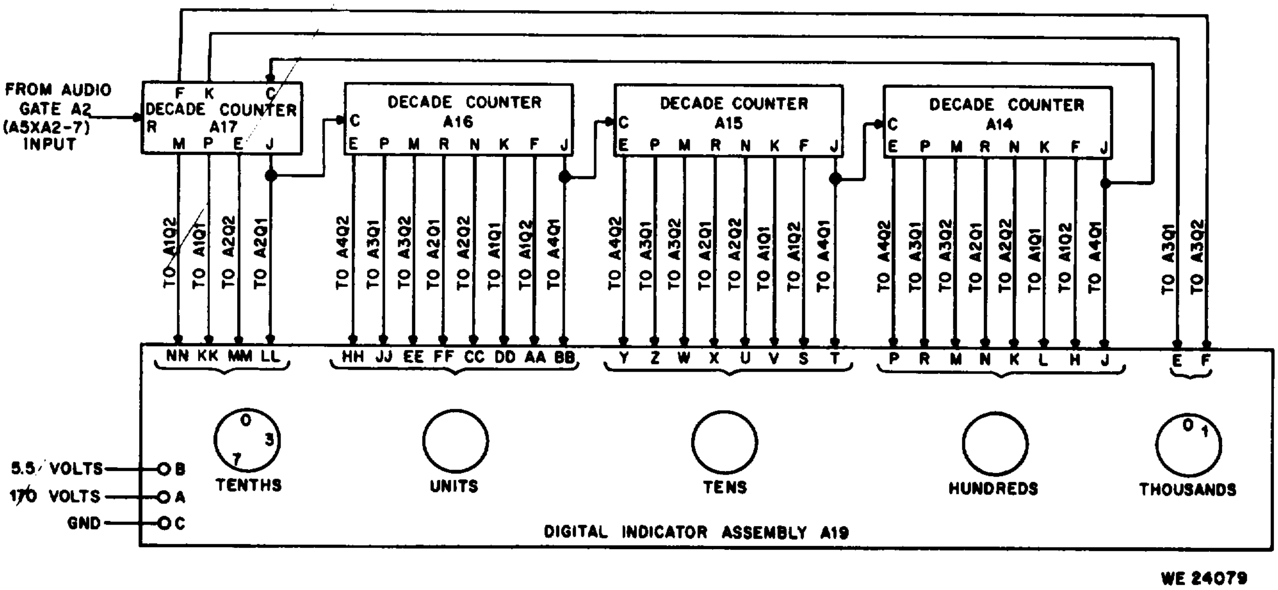


Figure 2-50. Interconnection of decade counters and digital indicator circuits.

(4) *Thousands digital indicator* (fig. 2-52). This circuit is similar to the units digital indicator circuits; however, only two switching transistors are used, those providing. and 1 indications on the digital display tube. The theory of operation is essentially the same and will not be repeated here.

s. Reset Indicator A5A6 (Reset Amplifier) (fig. 2-53). The reset amplifier functions as a switching circuit for the neon RESET lamp on the chronograph rear panel. When RESET pushbutton A5S2 is pressed, the 5.5-volt potential is removed from the pulse generator A5A4. This causes A5A4 to apply a 22-volt potential pulse input to terminal A5A6P1-1 of the reset amplifier. This positive voltage causes Q1 to conduct, and the resulting voltage drop across collector load resistor R4 is applied to the neon RESET lamp A5DS1 across terminals 3 and 7. The lamp is illuminated and remains on until automatically turned off by the initiation of the counting sequence during operation, or by manual actuation of the calibrate switch A5S3. In either case, pulse generator A5A4 applies a reduced potential of approximately 8 volts to terminal A5A6P1-1, reducing the Q1 collector current, and thus reducing the voltage drop across the load resistor R4 to below the point at which the neon RESET lamp is extinguished.

*t. Radio Frequency Oscillator 75 kc A5A10(Calibration) (*fig. 2-44). This 75 kc oscillator is a part of the chronograph self-checking system. It provides a signal which simulates the Doppler-shift signal resulting from a projectile velocity of 1070 meters per second. This signal is injected into the audio frequency amplifier AS, and from there on is processed like a normal Doppler-shift signal. The circuit uses a pair of transistor amplifiers in cascade, with a crystal controlled feedback path. As oscillation starts, the output of transistor Q2 is coupled through capacitor C1 to the base of Q1. The output of Q1 is fed back to the base of Q2 through crystal A5Y2 (located in a socket external to ASA10), completing the feedback loop required to sustain oscillation. The crystal presents a very low impedance to the signal at its resonant frequency (75 kc), and so reinforces oscillation only at that frequency. The output of the oscillator is coupled through capacitor C4, through pin 7 of connectors A5A10P1 and A5XA10, to the CAL 1-OPER-CAL 2 switch A5S1 for application to the audio amplifier during the self-checking operation.

2-16. Power Supply Assembly A6

a. General. The power supply assembly consists of three power supplies furnishing -500 volts, +170 volts, and +22 volts respectively. All

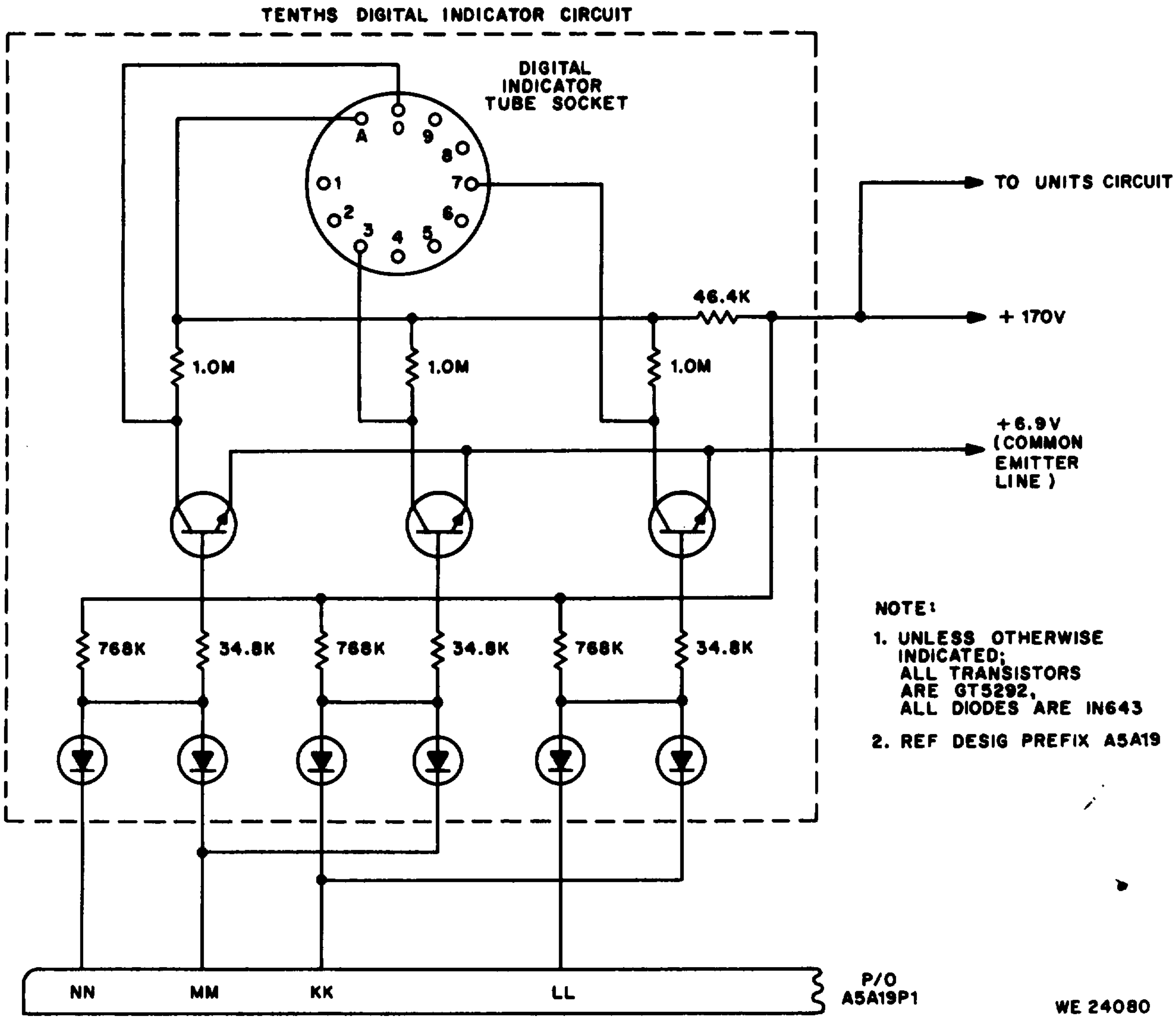


Figure 2-51. Tenths digital indicator—partial schematic diagram.

are powered from a common power transformer, A6T1. This transformer also provides 6.3 volts ac for the heaters of the electron tubes and for the POWER indicator lamp.

b. -600 Volt Supply (fig. 2-45).

(1) Power for the -500 volt supply is taken from secondary terminals 5 and 6 of transformer A6T1. This voltage is applied to the bridge rectifier made up of diodes CRI through CR8. The resulting electron current flows from ground through the emitter and collector of series regulator transistor Q1, through limiting resistor RS, and through the filter network made up of C3, C4, R6, and R7. Breakdown diode CR9 acts as protective shunt across the regulator transistor, breaking down and conducting when there is sufficient increase in the voltage across the collector and emitter of the transistor. (This will occur during the warmup period or when there is an increase in the load.) Diode CR10 acts to maintain the Q1 base voltage at the proper operating potential, approximately the same as the emitter (ground). Capacitor C5 serves as a bypass for transient voltage fluctuations.

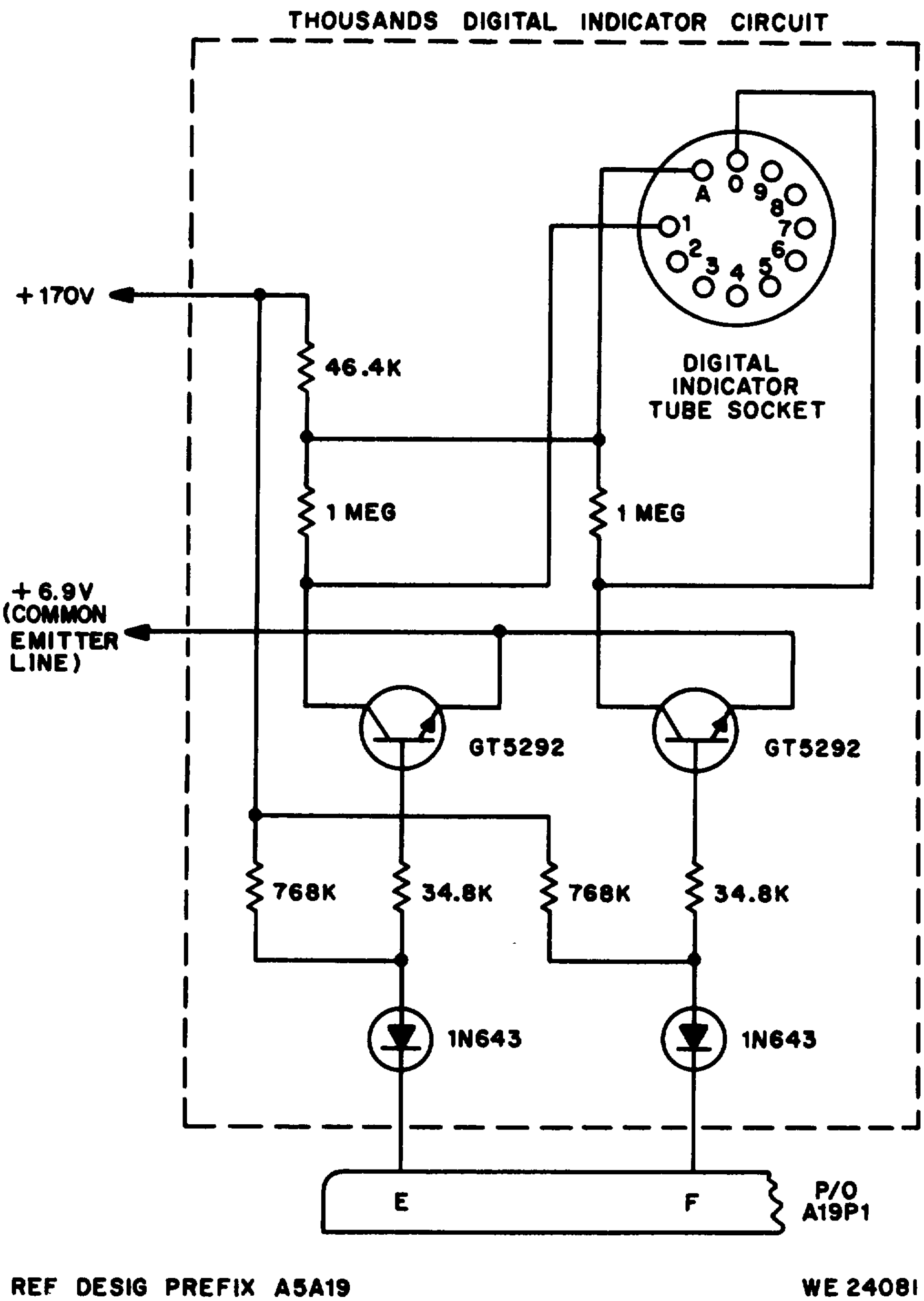


Figure 2-52. Thousands digital indicator—partial schematic diagram.

(2) Power for control amplifier Q2 and error amplifier Q3 is obtained from terminals 9, 10, and 11 of power transformer A6T1. The voltage across terminals 9 and 11 is applied to the full-wave rectifier consisting of CR1 and CR2. The rectified voltage is filtered by the network consisting of C1, C2, R1, and R2. The output is stabilized at the required potentials by breakdown diodes CR3 and CR4 before application to the transistors.

(3) Resistors R10, R12, R13, and

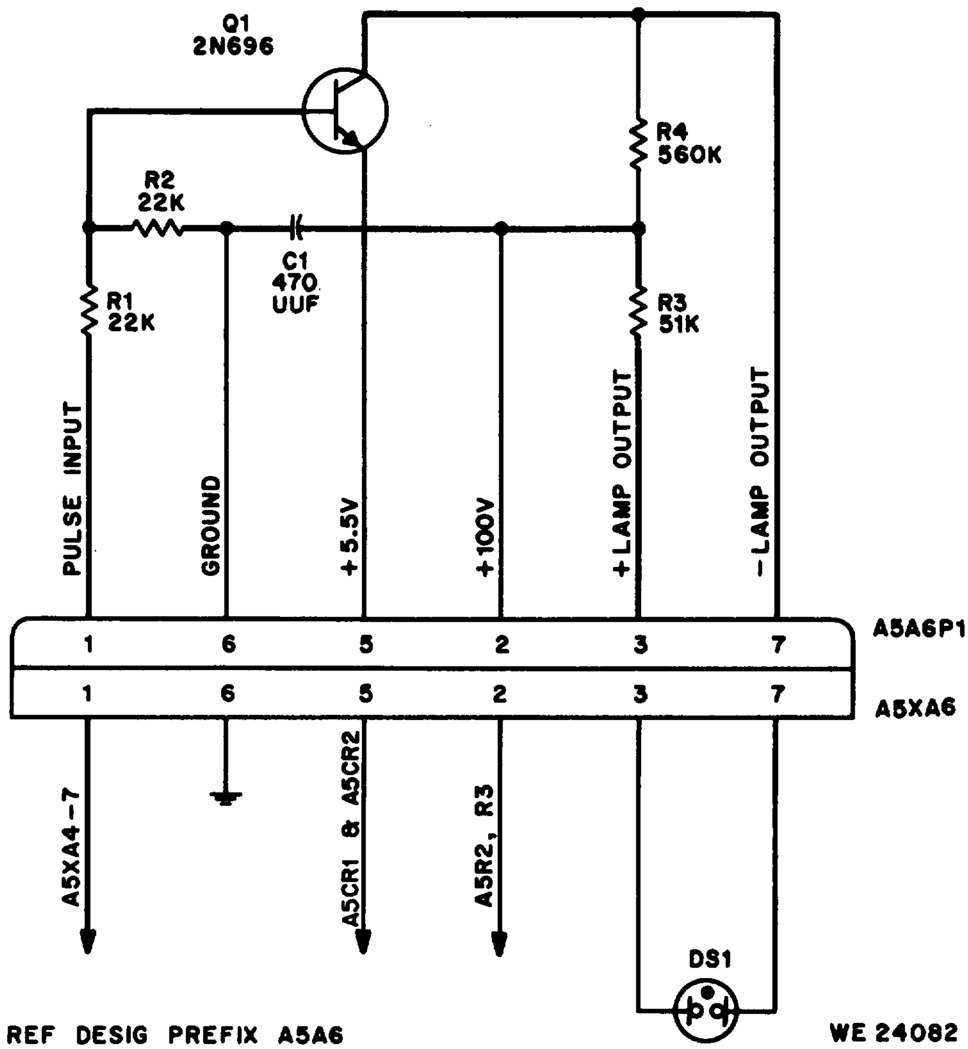


Figure 2-53. Reset indicator A5A6 (reset amplifier)—partial schematic diagram.

potentiometer R11 form a voltage divider across the output of the supply. The potentiometer affords a means of setting the output voltage to the desired level. When there is a decrease in the output voltage, the base voltage of Q3 becomes more positive. (A decrease in the negative output of the supply may be considered the same as going more positive) The Q3 collector current is increased, and the voltage applied to the base of Q2 is reduced (more negative). The collector current of Q2 is also reduced and a proportional positive increase occurs in the control voltage applied to the base of Q1. This positive increase in Q1 base voltage causes an increase in conduction, which compensates for the original decrease in negative output voltage Conversely, an increase in negative output voltage will cause a compensation in the opposite direction.

(4) Thermistor RT1, across resistor R13 in the output voltage divider, is used to compensate for the effects of temperature variations As the temperature rises, the output voltage of the supply tends to increase. At the same time, the resistance of RT1 decreases, reducing the voltage drop across the divider, and thus compensating for the original tendency for the voltage to rise.

(5) The application of --500 volts to the klystron is delayed for approximately 30 seconds after the equipment is turned on to permit warmup

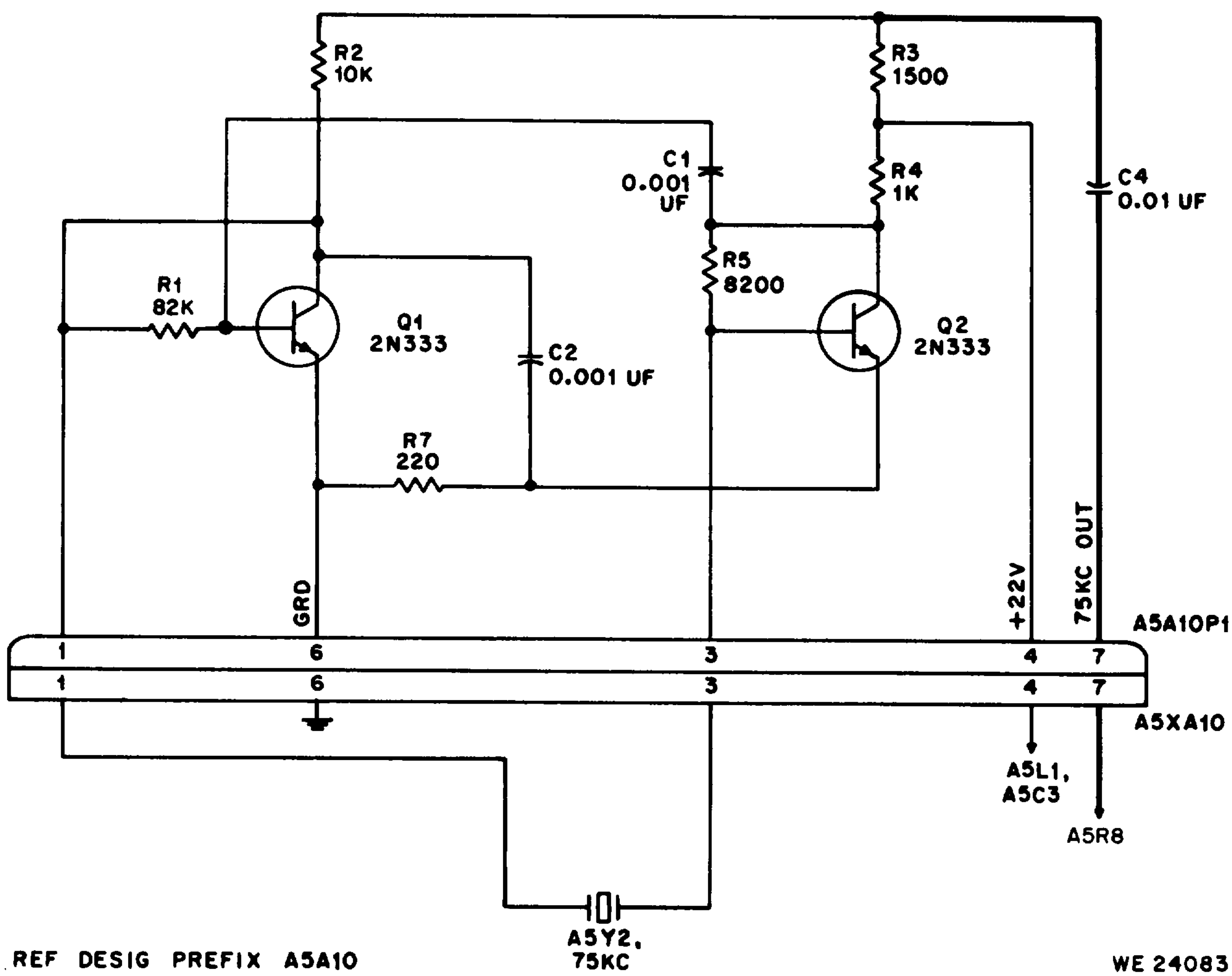


Figure 2-54. Radio frequency oscillator 75 kc A5A10 (calibration)—partial schematic diagram.

and prevent the klystron and AFC from locking on an incorrect voltage mode (weaker mode of oscillation due to wrong repeller voltage). This delay is provided by time delay relay, A6K1 (fig. 2-56). A6K1 actually consists of two relays in one case, one of which is thermally actuated and the other electromagnetically actuated. Both are operated by the output of the 22-volt power supply. When power is turned on, 22 volts is applied to the thermal element (through the normally closed contacts of the other section) causing a current to flow to ground. The thermal element heats up in approximately 15 seconds, and closes contacts which apply 22 volts to the relay coil (which is grounded at the other end) and also open the normally-closed pair of contacts in the –500-volt line. The electromagnetic coil closes contacts which ready the -500-volt line to the klystron, and at the same time removes the 22 volts from the thermal element and switches it to the coil, thus holding the relay in this condition. The thermal element cools again in approximately 15 seconds, (a total delay of 30 seconds) again closing the contacts in the –500-volt line and applying this voltage to the klystron.

c. 170-Volt Supply (fig. 2-57). Except for minor differences in input and output circuits, the 170-volt circuitry is essentially the same as that of the -500-volt supply described in *b* above. At the input of the 170-volt supply, the filter consists

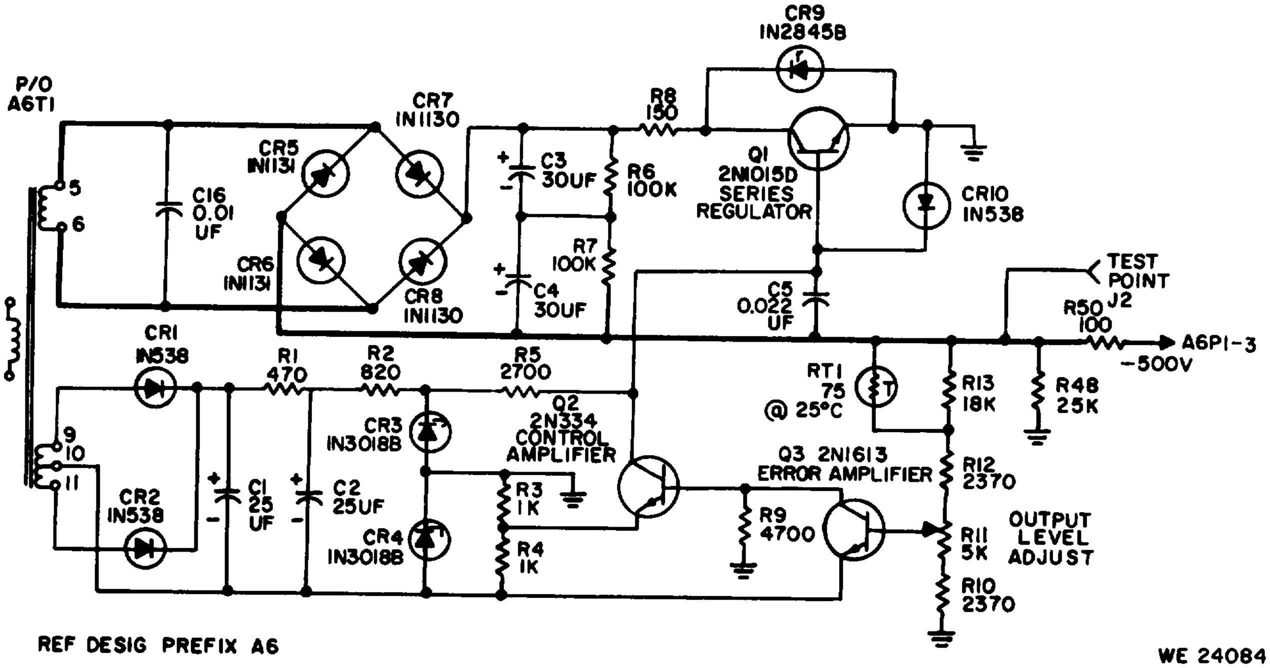


Figure 2-55. –500 volt power supply—partial schematic diagram.

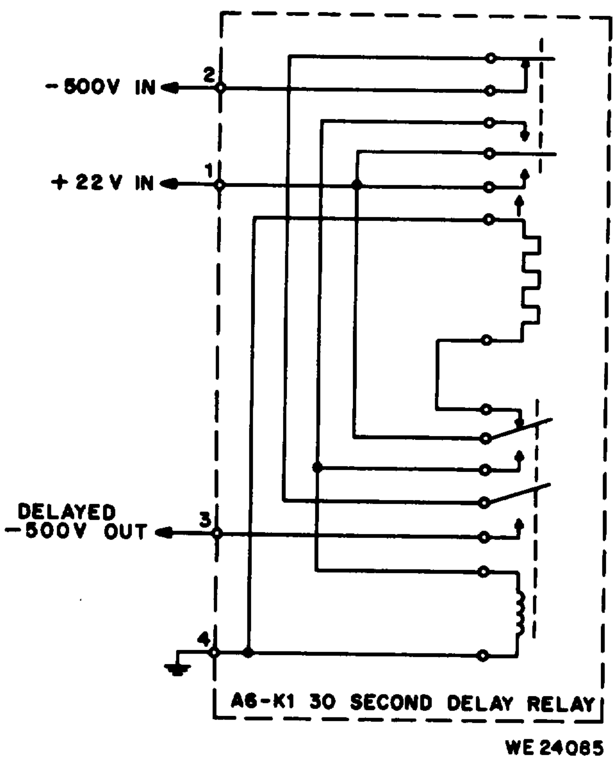


Figure 2-56. Delay relay A6K1—partial schematic diagram.

of C9 only. The 170-volt output is obtained from the junction of the breakdown diodes CR13 and CR14. A voltage dropping resistor R18 is connected to the 170-volt output line, providing a second output of 130 volts.

d. 22-Volt Supply (fig. 2-58).

(1) Power for the 22-volt supply is taken from secondary terminals 19, 20, and 21 of common power transformer T1. The voltage across terminals 19 and 21 is applied to the full-wave rectifier circuit made up of CR21 and CR22. The rectified voltage is applied to the collector of series regulator transistor Q7. The voltage is also applied to the collector of control amplifier transistor Q8 and through a filter consisting of C12, R31, C18, and R32 to the Q8 base resistor, and to the cathode of overvoltage protection diode CR23. The electron current path for series-regulator Q7 is from the load through resistor R86 and diode CR26, and through the emitter and collector of QT7. A voltage divider across the output is formed by R42, R43, R44 and R45. Potentiometer R43 permits adjusting the output voltage to the desired level. R44 is shunted by thermistor RT3 which compensates for variations in temperature. When the output voltage rises because of a change

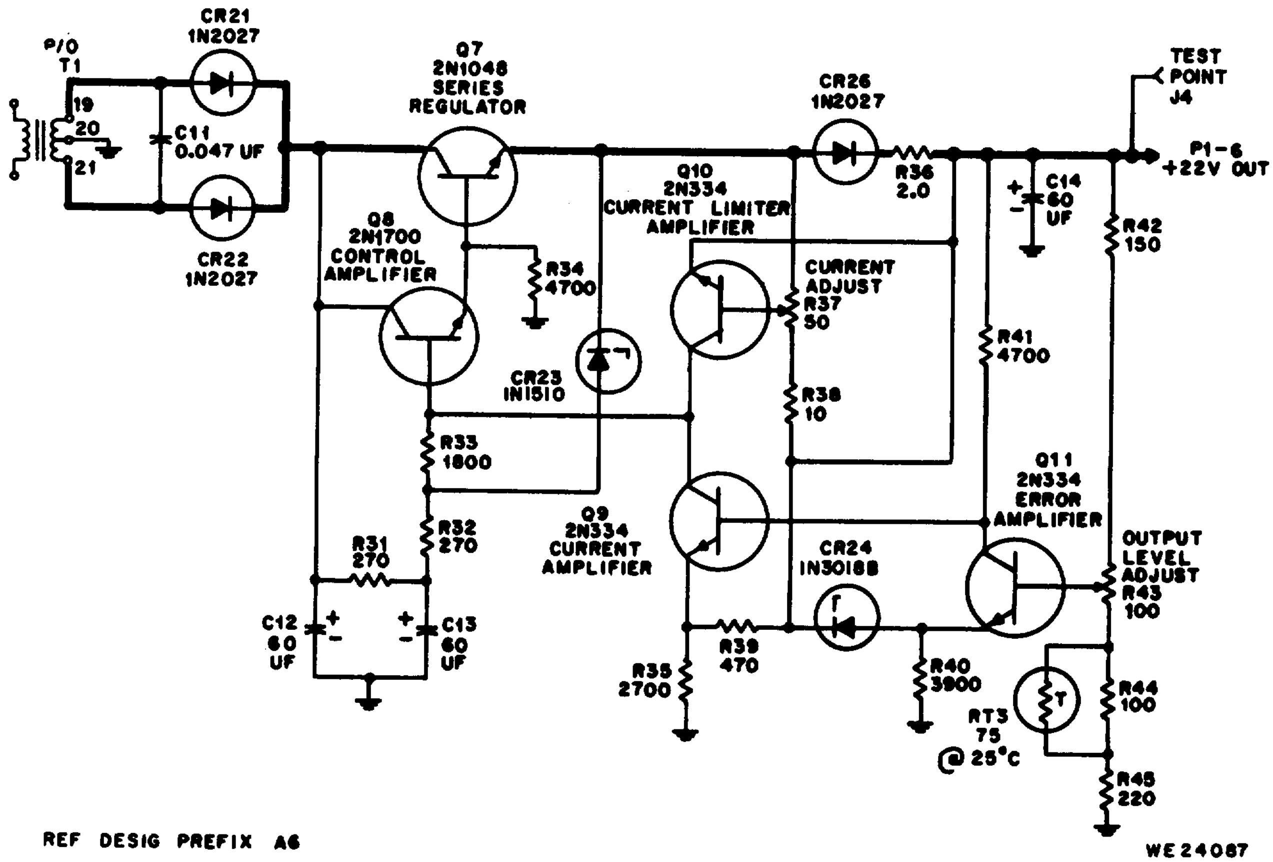


Figure 2-57. 170-volt power supply—partial schematic diagram.

in load, the rise in voltage is applied to the base of error amplifier Q11, but the effect of this voltage is overridden by the more direct application of the voltage change to the Q11 emitter through breakdown diode CR24 (which is conducting). This results in a lowering of Q11 collector current and causes a higher collector voltage at Q11 which is applied to the base of current amplifier Q9. As a result, Q9 draws more collector current, which lowers the voltage applied to the base of control amplifier Q8. The lowered emitter voltage of Q8 in turn reduces the voltage applied to the base of series-regulator Q7. This causes a decrease in Q7 conduction, compensating for the original change.

(2) Transistor Q10 protects Q7 from heavy current. The base of Q10 senses an increase in voltage drop across resistor R36 and diode CR26. Diode CR26 (in series with R36) has a temperature coefficient which causes it to compensate for thermal charges occurring in Q10. This decreases the Q8 base voltage, reducing Q8 emitter current through R34, which decreases the voltage on the base of Q7. This in turn results in a reduction of collector current through series-regulator Q7.

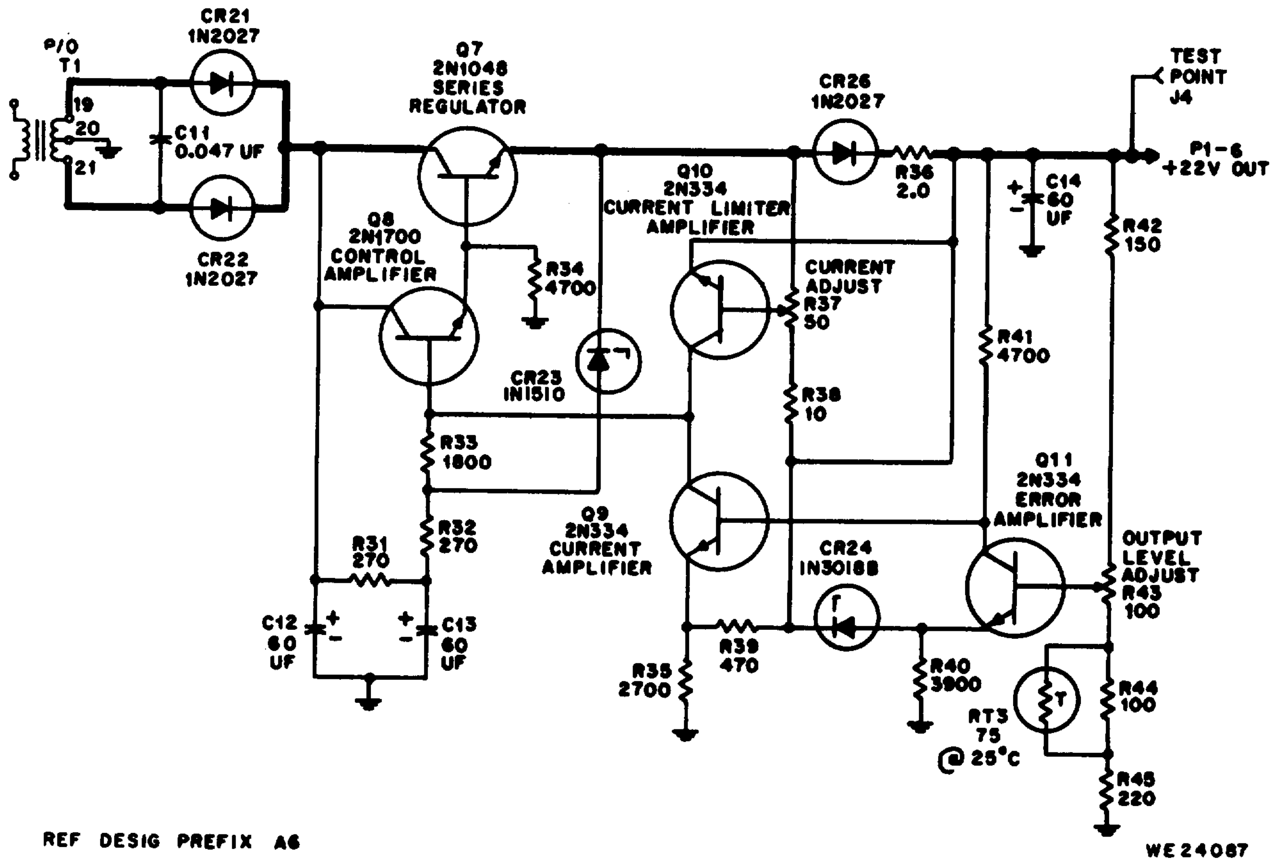


Figure 2-58. 22-volt ower supply – partial schematic diagram.

Section IV. FUNCTIONAL DESCRIPTION OF RADAR CHRONOGRAPH MOUNT

2-17. General

The mount (fig. 2-59) is used to support the radar chronograph on a tripod or bracket installation, and allows the radar chronograph to be leveled quickly and accurately. Regardless of the attitude of its support surface, the mount can be leveled by means of the yoke leveling vial and leveling base vial. The mount also has provisions for tilting the chronograph with respect to the level reference (elevation adjustment), and for swiveling the mount and chronograph about a vertical axis (azimuth deflection). For a physical description of the mount, see TM 9-1290-325-12/1.

2-18. Leveling

Figure 2-60 shows graphically how leveling can quickly be accomplished using the two bubble vials The off-level condition of the supporting surface is deliberately exaggerated to better illustrate the principle involved. The principle illustrated is that on any plane fixed in a tilted position (as this support surface), a series of parallel lines which are perfectly horizontal can always be drawn in one direction. On the lower surface of the mount, one of these lines (line A in fig. 2-60) can readily be found by swiveling the mount until the bubble

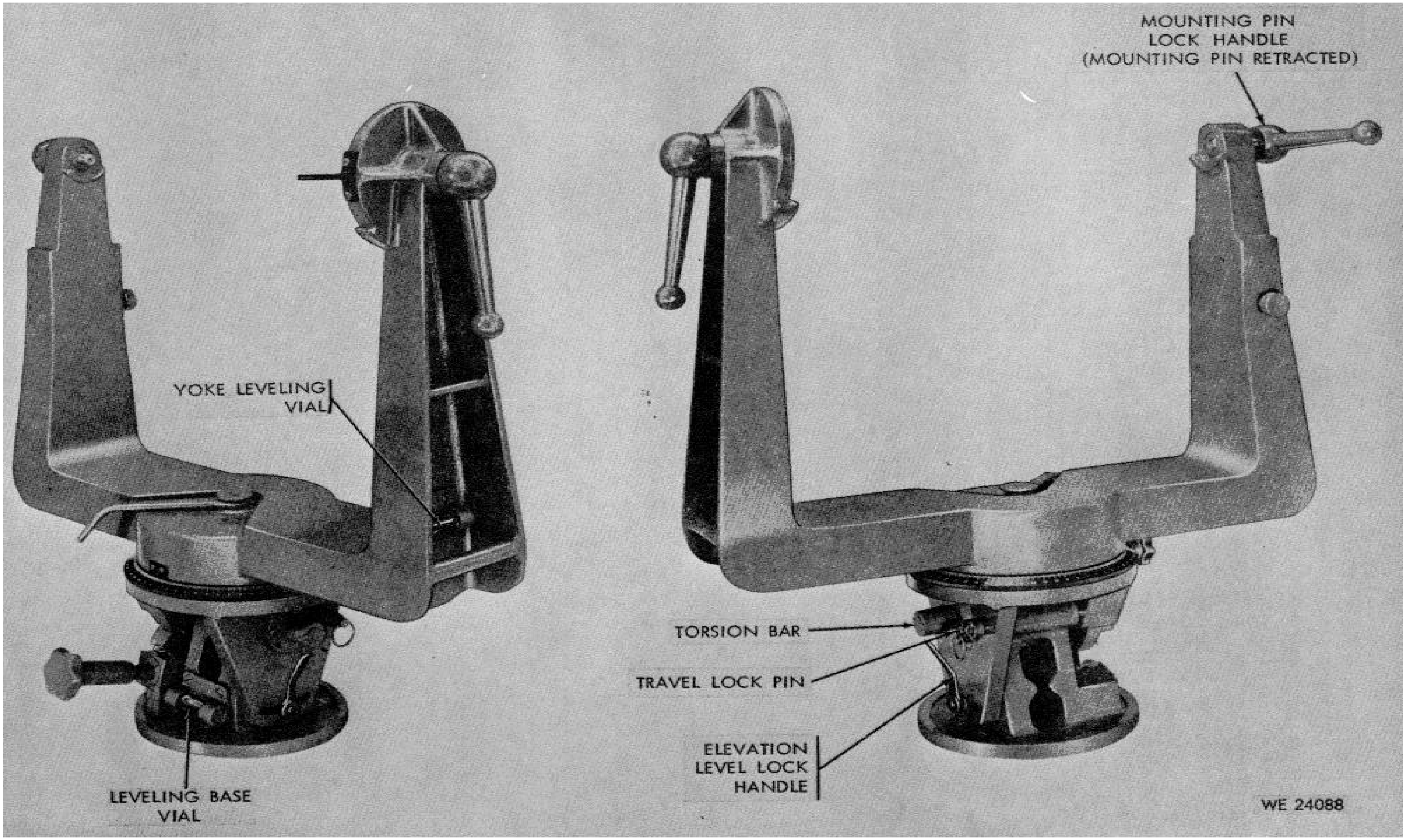


Figure 2-59. Radar chronograph mount.

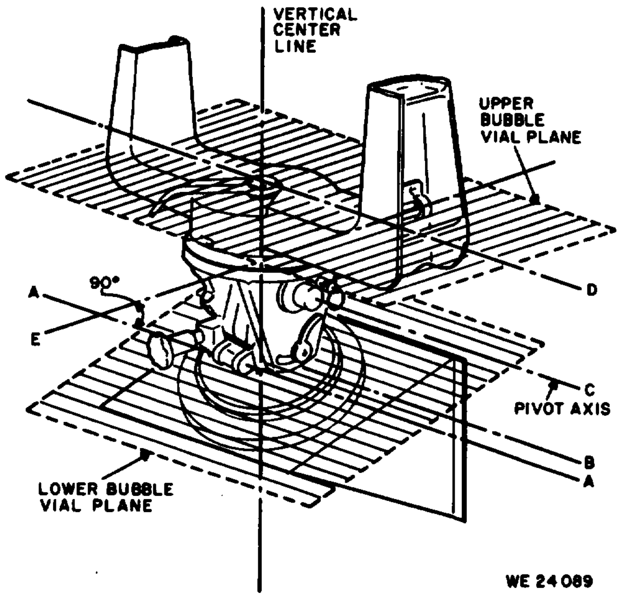


Figure 2-60. Principles of mount leveling

in the lower vial indicates a level position. It may now be seen that another parallel level line (line B) will cross the base of the vertical support members. Still another (line C) which is above line B but parallel to it, will coincide with the axis of the horizontal pivot, so that this axis is also level when the lower bubble vial is level. Since the upper section of the mount is secured rigidly to this pivot, the plane represting the upper mount member is also leveled on a line (line D) parallel to the level line passing through the lower bubble vial. To make this upper plane level in all directions, it is only necessary to establish a second level line (line E) at right angles to the first by means of the upper bubble vial. This is done by turning the upper section to the right-angle position, adjusting for a level position, and swiveling around' while checking that it remains level in all other positions.

Section V. FUNCTIONAL DESCRIPTION OF RADAR TEST RECEIVER

2-19. General

This test receiver (fig. 2-61) is used with the radar chronograph to check the operation and alinement of the transmitted radar beam. It is essentially a microwave receiving antenna to which is coupled a diode rectifier which can convert the rf signal to dc for application to a meter. The test receiver horn is used in conjunction with the chronograph automatic reliability rater (CARR) tester to simulate a doppler shifted signal by modulating. Operation and description of the radar test receiver is ocvered in TM 9-1290-325-12/1.

2-20. Theory of Operation

For sensing rf energy and obtaining certain measurements of the beam emitted by the radar chronograph transmitter, it is necessary to have a device which can intercept the transmitted signal and provide an indication of relative field strength and direction. The test receiver accomplishes this. The horn antenna and associated waveguide are designed to respond to rf energy at the particular frequency used (10.5 kmc). The horn antenna is sufficiently directional so that the beam must be aimed directly into it to obtain maximum response. This makes it possible, by moving the beam and antenna appropriately, to determine the approximate shape and width of the beam, and to determine when the longitudinal axis of the radar beam

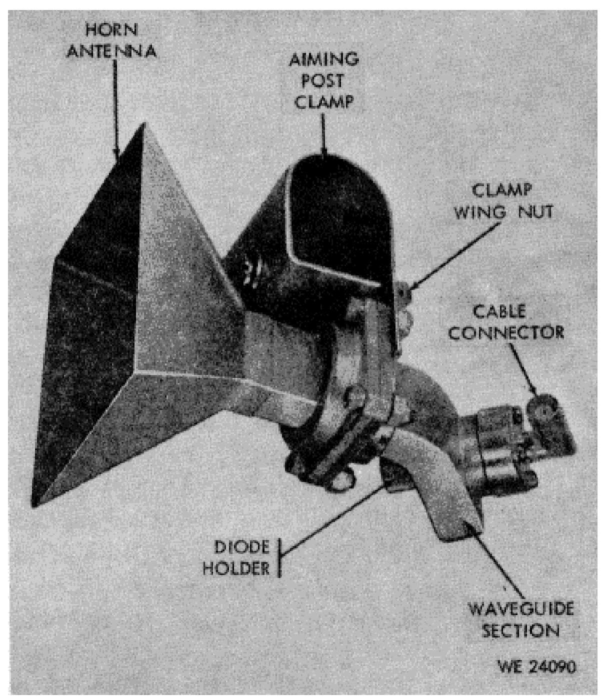


Figure 2-61. Radar test receiver.

is alined with the horn antenna. Rectifying the rf signal by means of a semiconductor diode in the test receiver waveguide makes it possible to conduct the test receiver output through a coaxial cable to voltmeter TS-505D/U or the chronograph automatic reliability rater (CARR).

WARNING

POTENTIAL RADIATION HAZARD When radar is energized, personnel should not be within 6 feet of the radiating feedhorn (located in the center of dish) in the direction of the transmitted beam.

Section VI. FUNCTIONAL DESCRIPTION OF CHRONOGRAPH AUTOMATIC REUABILITY RATER

2-21. General

The basic use for which the CARR simulator(fig. 2-62) is utilized is a field system tester for radar chronograph M36. Operation and description of the chronograph automatic reliability rater (CARR) is covered in TM 9-1290-325-12/1.

2-22. Theory of Operation

The radar chronograph transmits a continuous wave signal at an X-band frequency of 10,500 mc. This energy is intercepted by the crystal diode in the radar test receiver (fig. 2-61). The CARR simulator modulates this intercepted energy at any one of ten crystal controlled frequencies. This modulated energy is reflected back to the receiver section of the chronograph where it is processed for amplification, counting, and display. In the continuous mode of operation when the START button (fig. 2-62) is depressed on the simulator, a start trigger is internally generated in the CARR simulator and sent through the jumper cable to the chronograph. This trigger initiates the gate timing sequence in the chronograph. When the counting gate opens in the chronograph the reflected modulated rf energy from the radar test receiver is counted for one gate period (42.8 msec) and displayed on the digital indicators. For each selected frequency on the CARR simulator, there is a distinct readout on the digital indicators. In the gated mode of operation when the START button is depressed on the CARR simulator, a start trigger is internally generated in the CARR simulator and sent through the jumper cable to the chronograph. This start trigger initiates the gate timing sequence in the chronograph and the internally generated start trigger also initiates the internal gate timing sequence in the CARR simulator. The simulator gates out a burst of crystal controlled modulating signal to the radar test receiver. When the counting gate in the chronograph coincides with the gated out signal from the CARR simulator the correct readout is displayed on the nixie tubes of the digital display. Conversely, if the gates do not coincide, the readout on the digital display is incorrect. The 500 micro-amp dc meter is utilized in alining the telescope XM128 of the chronograph with the radar beam. This is accomplished by aiming the radar beam at the radar test receiver. The crystal diode in the test receiver rectifies the intercepted radar energy and the amount of rectified current is indicated on the meter mounted in the CARR simulator. With a maximum current indication on the meter, the telescope is positioned so that its line of sight is in parallel relationship with the electrical axis of the M36 radar beam. When so positioned, the intersection of the rectile crosshairs as viewed through the telescope, is superimposed on a point 9 1/2 inches above the center of the test receiver aperature, with the vertical crosshair intersecting the center of the test receiver aperature. This completes the alinement of the telescope with the electrical axis on the radar beam.

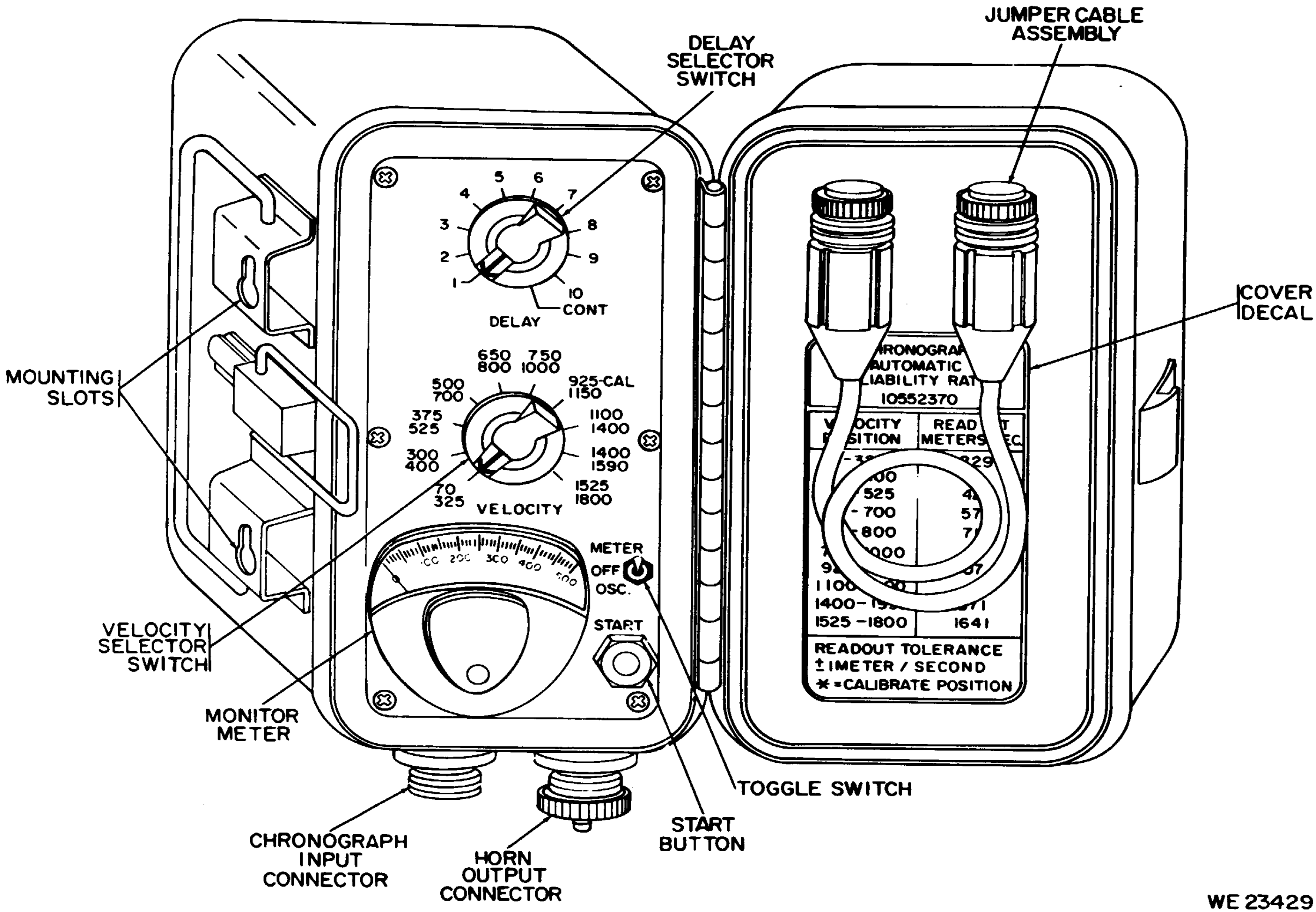


Figure 2-62. Chronograph automatic reliability rater.

CHAPTER 3

DIRECT SUPPORT AND GENERAL SUPPORT MAINTENANCE INSTRUCTIONS

Section I. REPAIR PARTS, SPECIAL TOOLS AND EQUIPMENT

3-1. General

Tools and equipment over and above these available to the using organization are supplied to Direct Support and General Support maintenance units for repair and adjustment of radar chronograph set M36.

3-2. Common Tools and Equipment

Standard and commonly used tools and equipment having general application to this material are authorized for issue by tables of allowances (TA) and tables of organization and equipment (TOE).

3-3. Special Tools and Equipment

No special tools and equipment are required for Direct Support and General Support maintenance operations on the radar chonograph set. However, a list of standard tools and equipment used for Direct Support and General Support maintenance (table 3-1) is included for information only.

Table 3-1. Standard Tools and Equipment for DS and GS Maintenance

Item	Federal stock No.	Use
ADAPTER, WAVEGUIDE, HPX281A	5985-553-6082	Provides convenient means of transmission between waveguide and coaxial systems.
ATTENUATOR, 20 db VARIABLE, Hewlett-Packard H-375A; (8.2-12.4 kmc).	6625-679-0624	Isolate input circuits from rf source.
AUDIO OSCILLATOR, T-382D/U	6625-192-5094	Supplies audio signal to simulate normal signal for checking.
CRYSTAL DETECTOR MOUNT, HP-440A	6625-581-5802	For detecting fast rf pulses.
MULTIMETER, TS-352A/U	6625-242-5023	Resistance voltage measurements throughout tests.
OSCILLOSCOPE, Type AN/USM-50A	6625-668-4676	Waveform checks throughout tests.
RESISTOR, VARIABLE, WIRE-WOUND, 5000 OHM, 12.5 WATT	5905-686-9939	Used during test of power supply to simulate normal operating load: A6P1-8 to ground.
RESISTOR, VARIABLE, WIRE-WOUND, 10,000 OHM, 5 WATT	5905-192-1090	Used during test of power supply to simulate normal operating load: A6P1-10 to ground.
RESISTOR, VARIABLE, WIRE-WOUND, 250 OHM, 4 WATT	5905-899-4515	Used during test of audio frequency amplifier A3 between amplifier input P1-1 and ground.
RESISTOR, VARIABLE, WIRE-WOUND, 100 OHM, 12 WATT	5905-578-4122	Used during test of power supply to simulate normal operating load: A6P1-6 to ground.
RESISTOR, VARIABLE, WIRE-WOUND, 8000 OHM, 50 WATT	5905-539-2964	Used during test of power supply to simulate normal operating load: A6P1-3 to ground.
RESISTOR, VARIABLE, WIRE-WOUND, 10 OHM, 25 WATT	5905-665-7106	Used during test of power supply to simulate normal operating load: A6P1-A to A6P1-B.

Table 3-1. Standard tools and Equipment for DS and GS Maintenance--Continued

Item	Federal stock No.	Use
SIGNAL GENERATOR, AN/USM-44	6625-669-4031	Supplies rf signal to simulate normal signal for checking.
TEST SET, CRYSTAL UNIT RECTIFIER, TS-268/U	6625-669-1215	Check diodes in modulator, mixer, and discriminator.
THERMISTOR MOUNT, X487B	6625-656-2454	Measures average power of low duty cycle pulse.
VACUUM TUBE VOLTMETER, TS-505D/U	6625-243-0562	Do voltage measurements in circuits affected by meter loading.
VOLTMETER, Type ME-30A/U	6625-669-0742	Ac signal voltage measurements.
WATTMETER, AN/URM-98	6625-566-4990	Used to measure power drawn from power source.
WAVEGUIDE FREQUENCY METER, FR-126/U (HP-532A).	6625-787-0248	Check klystron frequency.

Section II. TROUBLESHOOTING

3-4. Purpose

Troubleshooting is the systematic isolation and remedy of a malfunction and defective components by means of symptoms and tests. Close adherence to the procedures covered herein materially reduce the time required to locate trouble and restore the equipment to normal operation.

3-5. Scope

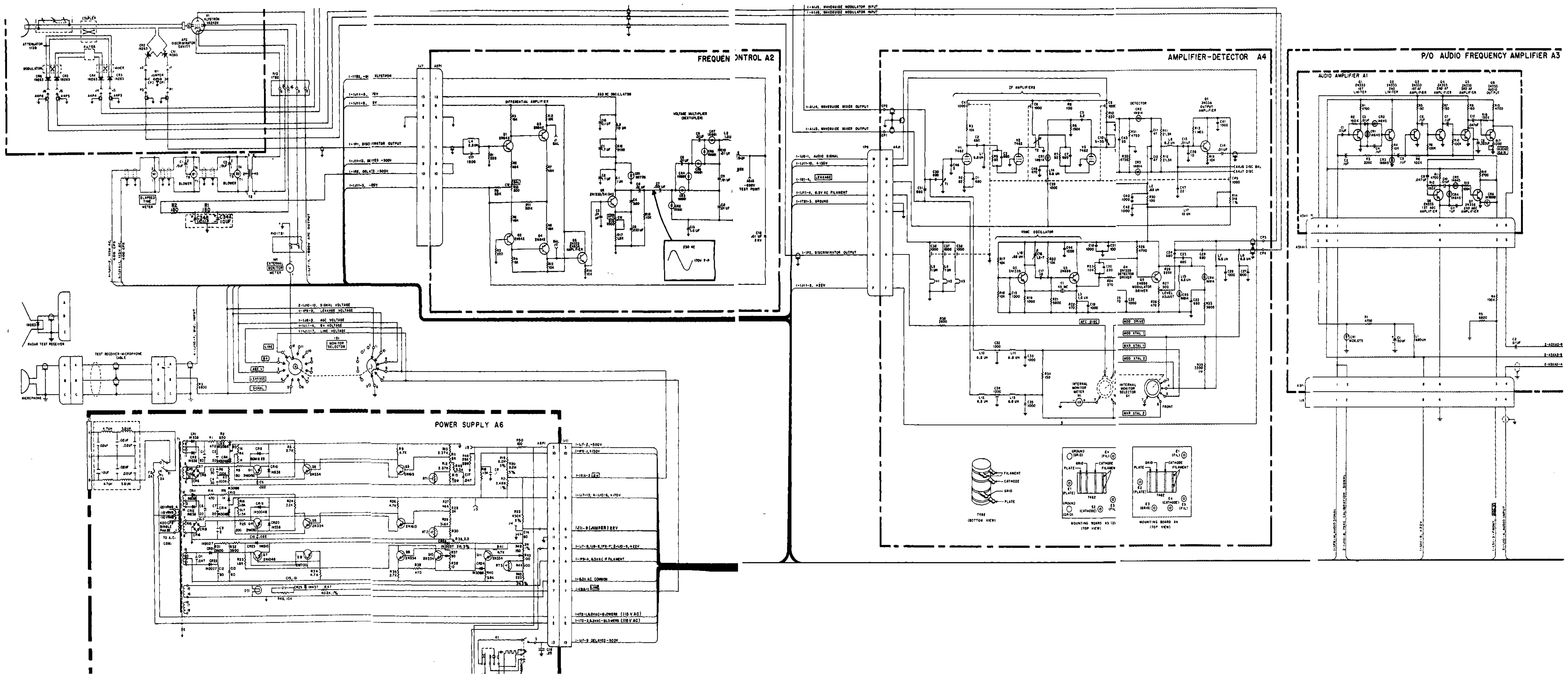
This section covers troubleshooting which is peculiar to Direct Support and General Support maintenance operations only. Information in this section is to be used in conjunction with and as a supplement to the troubleshooting section in TM 9-1290-325-12/1. It provides a continuation of instructions when a remedy in the lower-level maintenance manual refers to Direct Support and General Support maintenance for corrective action. Supplementary information given here for assistance in troubleshooting includes a table of electrical connectors (3-2), a troubleshooting table (3-3) which shows a number of typical troubles, a table of test points (3-4) and power and signal distribution diagrams (figs. 3-1 and 3-2). When tests and adjustments cannot be accomplished after troubleshooting as outlined in this section, the malfunctioning equipment will be returned to depot for further action.

36. Procedure

a. The troubleshooting procedures in this section are used to localize a malfunction to within a circuit

Table 3-2. Chronograph Electrical Connectors

Assembly No.	Connectors	Mating connectors
A1	A1J1	A1CP1 (T-Coupler to 1P1 on cable to 1J7-11)
	A1J2	A1CP2 (T-Coupler to 1P2 on cable to 1P9-N)
	A1J3	A4P3 (on cable)
	A1J4	A4P4 (on cable)
	A1J5	A4P5 (on cable)
	A1J6	A4P6 (on cable)
A2	A2P1 (pins 1-13)	1J7
	A2J1 (BAL TP)	
	A2J2 (BAL TP)	
	A2J3 (-800 V TP)	
A3	A3P1 (pins 1-13)	1J8
	A3XA1	A3A1P1
	A3XA2	A3A2P1
	A3J1 (AUDIO TP)	
A4	A4J1 (pins A-H)	1P9
	A4CP1	Cable to A4P3
	A4CP2	Cable to A4P4
	A4CP3	Cable to A4P5
	A4CP4	Cable to A4P6
	A4J6 (Detector BAL. TP).	
	A4J7 (Detector BAL. (TP).	
A5	A5P1 (pins 1-13)	1J10
	A5J1 (A5A5 Output TP)-	
	A5J2 (A5A4 Output TP)-	



Notes:

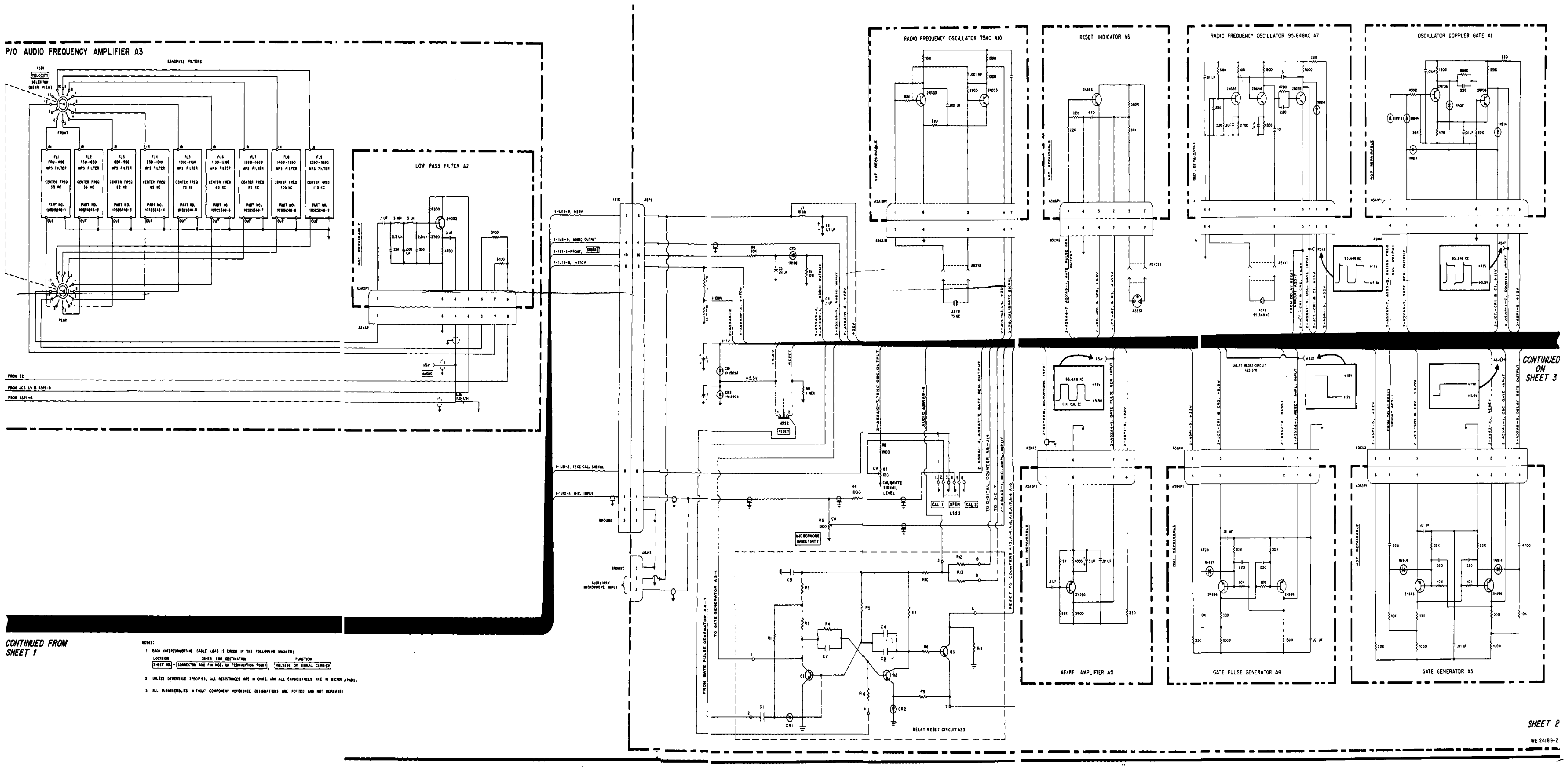
1. EACH INTERCONNECTING CABLE LEAD IS CODED IN THE FOLLOWING MANNER:

LOCATION	OTHER END DESTINATION	FUNCTION
SHEET NO.	- CONNECTORS AND PIN NOS. OR TERMINATION POINT	VOLTAGE OR SIGNAL CARRIED

2. UNLESS OTHERWISE SPECIFIED. ALL RESISTANCES ARE IN OHMS, AND ALL ACAPACITIES ARE MICROMICROFARADS.
3. ALL SUBASSEMBLIES WITHOUT COMPONENT REFERENCE DESTINATION ARE POTTED AND NOT REPAIRABLE.

Figure 3-3. Overall Chronograph electrical schematic diagram (1 of 4)

Sheet 1

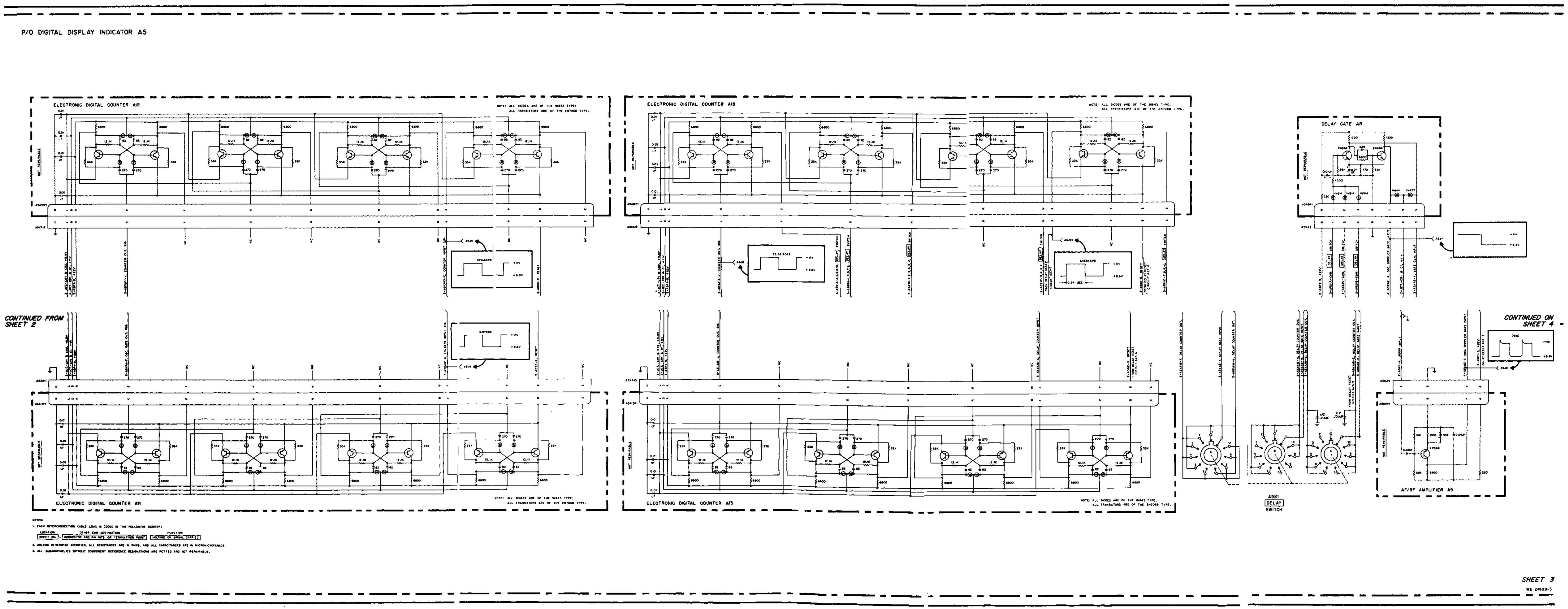


CONTINUED FROM SHEET 1

LOCATION	OTHER END DESTINATION	FUNCTION
SHEET NO.	- CONNECTORS AND PIN NOS. OR TERMINATION POINT	VOLTAGE OR SIGNAL CARRIED

2. UNLESS OTHERWISE SPECIFIED. ALL RESISTANCES ARE IN OHMS, AND ALL CAPACITANCES ARE MICROMICROFARADS.
3. ALL SUBASSEMBLIES WITHOUT COMPONENT REFERENCE DESTINATION ARE POTTED AND NOT REPAIRABLE.

Figure 3-3. Overall chronograph electrical schematic diagram (2 of 4)
Sheet 2



Notes

1. EACH INTERCONNECTING CABLE LEAD IS CODED IN THE FOLLOWING MANNER;

LOCATION	OTHER END DESTINATION	FUNCTION
SHEET NO.	CONNECTOR AND PIN NO'S. OR TERMINATION POINT	VOLTAGE OR SIGNAL CARRIED

2. UNLESS OTHERWISE SPECIFIED, ALL RESISTANCES ARE IN OHMS, AND ALL CAPACITANCES ARE IN MICROMICROFARADS

3. ALL SUBASSEMBLIES WITHOUT COMPONENT DESIGNATIONS ARE POTTED AND NOT REPAIRABLE.

Figure 3-3. Overall chronograph electrical schematic diagram (3 of 4)

Sheet 3

Table 3-2. Chronograph Electrical Connector - Continued

Assembly No.	Connectors	Mailing connectors
A6 -----------	A5J3 (A5A7 Output TP)	
	A5J4 (A5A11 Output TP).	
	A5J5 (A5A12 Output TP).	
	A5J6 (A5A3 Output TP)	
	A5J7 (A5A1 Output TP)	
	A5J8 (A5A13 Output TP).	
	A5J9 (A5A9 Output TP)	
	A5J10 (A5A2 Output TP).	
	A5J11 (A5A11 Output TP).	
	A5J12 (Ground TP) - ----	
	A5J13 (pins A-C) ----------	(Test mike connection)
	A5XA1-----------------------	A5A1P1
	A5XA2-----------------------	A5A2P1
	A5XA3-----------------------	A5A3P1
	A5XA4-----------------------	A5A4P1
	A5XA5 -----------------------	A5A5P1
	A5XA6-----------------------	A5A6P1
	A5XA7-----------------------	A5A7P1
	A5XA8-----------------------	A5A8P1
	A5XA9-----------------------	A5A9P1
	A5XA10---------------------	A5A10P1
	A5XA11---------------------	AA11P1
	A5XA12---------------------	A5A12P1
	A5XA13---------------------	A5A13P1
	A5XA14---------------------	A5A14P1
	A5XA15---------------------	A5A15P1
	A5XA16---------------------	A5A16P1
	A5XA17---------------------	A5A17P1
	A5XA18---------------------	A5A18P1
	A5XA19---------------------	A5A19P1
A6 -----------	A6P1 (pins 1-13)-----------	1J11
	A6J1 (pins A-C)------------	(Power cable con nector)
	A6J2 (-508 V TP)----------	
	A6J3 (+170 V TP) ---------	
	A6J4 (+22 V TP)-----------	

[1]Voltage measured at this point will be approximately 8 volts above the voltage measured at A6P1 (table 3-5, column 3).

cuit or unit. Additional troubleshooting must be done to localize the malfunction to a defective component within the circuit or unit. Perform only those corrective actions which are authorized for Direct Support and General Support maintenance operations. The parts and equipment necessary for repair of those malfunctions whose corrective action refers to depot maintenance are over and above the parts and equipment allotted to Direct Support and General Support maintenance personnel. Repair of these malfunctions should not be attempted.

b. Follow the directions given for each system or unit troubleshooting procedure. When incorrect readings are obtained, isolate malfunctions by referring to the corrective action or trouble localization information listed in troubleshooting table 3-3. System functional diagrams and unit schematic and wiring diagrams are included to aid in troubleshooting.

3-7. Test Points

For convenience in testing and troubleshooting, a number of test point connectors are provided at critical points in the circuits, located where they are readily accessible without breaking electrical connections between chassis. Thirteen of these test point connectors (including a ground point) are associated with the A5 counter circuits and are located on the left side of A5 chassis (fig. 3-6). Three are located on the left side of the power supply A6 chassis (fig. 3-4). Three others are located on the rear of frequency control A2 (fig. 3-8), two are on the rear of the detector amplifier A4, and one is on the rear panel of the audio frequency amplifier A3 (fig. 3-5). Table 3-4 lists the signal or voltage with which each of these test points is associated. In addition to these major test points which are provided with special connectors, a number of other points are readily accessible for electrical checks. These include the five exposed terminals on terminal board TB 1 located in the front of the larger case section, the four exposed terminals on terminal board TB 2, located in the front case section near the klystron, and the terminals of the two blower motors, B1 and B2. Less accessible points may be reached by unplugging connectors or modules. An overall electrical schematic diagram (fig. 3-3) is included to further assist in location and tracing for troubleshooting.

Table 3-3. Troubleshooting

Malfunction	Probable Cause	Corrective action
1 POWER lamp does not light when power switch is on.123	a. POWER lamp is defective b. Burned out fuse. .... c. No power input from generator	a. Replace POWER lamp (fig. 4-14). b. Replace fuse (fig. 4-15). c. Adjust generator output or repair.
2. One or both blowers fail to operate. [1 2 3]	a. Defective blower motor b. Defective wiring .... c. Defective starting capacitor.	a. Replace blower (para 4-11). b. Repair wiring. c. Replace capacitor.
3. MONITOR SELECTOR switch fails to operate (as shown by meter)[1 2 3]	a. Defective MONITOR SELECTOR switch b. Defective wiring	a. Replace MONITOR SELECTOR switch (fig. 4-19). b. Repair wiring.
4. Incorrect LINE voltage reading on external monitor meter. [1]	a. Output of generator not correct. repair. b. Blown fuse A6F1 or A6F2. c. Defective MONITOR meter. (fig. 4-19).	a. Adjust generator output, or b. Replace fuse (fig. 4-15). c. Replace MONITOR meter
5. MONITOR meter indicates above green band with MONITOR SELECTOR in B+ position.[1]	a. Low output from --500 v section of power supply b. High 22 v or 170 v output	a. Repair POWER SUPPLY subassembly A6 (para 4-15). b. Repair POWER SUPPLY subassembly A6 (para 4-15).
6. MONITOR meter indicates full scale with MONITOR SELECTOR in B+ position. [1]	-500 v absent	Repair POWER SUPPLY subassembly A6 (para 4-15).
7. MONITOR meter indicates 1/4 scale or less with MONITOR SELECTOR in B+ position.[1]	Either 22 v or 170 v absent-	Repair POWER SUPPLY subassembly A6 (para 4-15).
8. Monitor meter indicates below normal AGC reading with MONITOR SELECTOR in AGC V position [1]	Excessive noise	a. Adjust LEAKAGE CONTROLS 1 and 2. b. Repair AUDIO AMPLIFIER subassembly A3 (para 4-13). c. Repair IF subassembly A4 (para 4-5).
9. MONITOR meter will not indicate below green band with MONITOR SELECTOR in LEAKAGE position (indicating lower than expected leakage signal).[1]	a. Klystron not oscillating .... b. Mixer crystal diode CR3 or CR4 defective c. Defective modulator crystal diode (CR5 or CR6) d. Defective 45mc oscillator in IF assembly.	a. Check AFC adjustment. Replace klystron if necessary (para 4-9). b. Replace crystal diode CR3 and/or CR4, if defective, check crystal currents on internal monitor meter. c. Replace CR5 and/or CR6 (para 4-8). d. Repair IF subassembly A4 (para 4-5).
10. MONITOR meter will not indicate in green band with MONITOR SELECTOR in LEAKAGE position (indicating high level of leakage signal).1	a. IF amplifier oscillating b. Defective Waveguide c. Incorrect AFC adjustment d. Incorrect LEAKAGE ADJUSTMENT.	a. Repair IF subassembly A4 (para 4-5). b. Notify Depot Maintenance. c. Adjust AFC. d. Adjust LEAKAGE CONTROLS 1 and 2.

See footnotes at end of table.

Table 3-3. Troubleshooting-Continued

Malfunction	Probable Cause	Corrective action
11. MONITOR meter indicates below green band scale with MONITOR SELECTOR in signal position and CAL 1-OPER-CAL 2 switch in CAL 2 position and VELOCITY selector in 925-1150 position (indicating low calibration signal level).[1]	a. 75 kc oscillator (A5A10) not operating b. Audio amplifier AS not operating a. Counter subassembly A5A9 not operating d. Defective VELOCITY selector switch	a. Repair DIGITAL COUNTER subassembly A5 (para 4-14). b. Repair AUDIO AMPLIFIER subassembly A3 (para 4-18). a. Repair DIGITAL COUNTER subassembly A (para 4-14). d. Replace VELOCITY selector switch (fig. 4-8).
12. Counter does not indicate when CAL 1-OPER-CAL 2 switch is in CAL 2 position. [1]	a. Same as 11 above .... b. Faulty counter assembly	a. Check all steps in 11 above. b. Repair DIGITAL COUNTER subassembly A (para 4-14).
13. Internal meter indicates greater than ±2 µa with selector in AFC DISCR position.[1]	a. AFC not alined b. Discriminator crystal diodes CR1 and/or CR2 defective. c. AFC not adjusted.........................	a. Repair AFC subassembly A2 (para 4-12). b. Replace diodes CR1 and/or CR5 (para 4-8). c. Adjust AFC.
14. Internal meter indicates less than +40 to +70 µa with selector in MOD DRIVE position.'	a. A4R27 improperly adjusted b. 45 mc oscillator not operating c. Modulator crystal diode CR5 or CR6 defective	a. Repair IF subassembly A4 (para 4-5). b. Repair IF subassembly A4 (para 4-5). a. Replace crystal diode CR5 and/or CR6 (para 4-8).
15. Internal meter indicates less than +45 to +90 µa with selector in MOD XTAL 1 position and/or less than -45 to -90 µa with selector in MOD XTAL 2 position.'	a. Klystron not oscillating .... b. Modulator crystal CR6, CR6 defective	a. Replace klystron (para 4-9). b. Replace modulator crystal diode CR5 and/or CR8 (para 4-8).
16. Internal meter indicates more than -20 to -80 pa with selector in MXR XTAL 1 position and/or more than +20 to +80 µa with selector in MXR XTAL 2 position.[1]	LEAKAGE adjustments incorrect (too much leakage)	a. Adjust LEAKAGE 1, 2 controls to minimize leakage. b. Repair IF subassembly A4 (para 4-5).
17. Internal meter indicates less than -20 to -80 µa with selector in MXR XTAL 1 position and/or less than +20 to + 80 a µa with selector in MXR XTAL 2 position.1	a. Klystron not operating .... b. Mixer crystal CR3 and/or CR4 defective c. 45 me oscillator not operating	a. Replace klystron (para 4-9). b. Replace crystal diode CR3 and/ or CR4 (para 4-8). a. Repair IF subassembly A4 (para 4-5).
18. Some, but not all counter indicators fail to light. [123]	a. Defective counter indicators b. Defective counter assembly	a. Repair DIGITAL COUNTER subassembly A5 (para 4-14). b. Repair DIGITAL COUNTER sub-assembly A5 (par 4-14).
19. All counter indicators fail to light.1 2 3	a. Defective RESET switch. b. Defective counter assembly c. Defective power supply .... (para 4-1).	a. Repair DIGITAL COUNTER A5 (para 4-14). b. Repair DIGITAL COUNTER A5 (para 4-14). a. Repair POWER SUPPLY A6
20. Counter assembly fails to reset (indication other than 00000).[123]	Defective counter assembly	Repair DIGITAL COUNTER subassembly A5 (para 4-14).
21. RESET indicator falls to light.[123]	a. Detective lamp b. Defective counter module ASA6	a. Replace lamp (fig. 4-12). b. Replace DIGITAL COUNTER subassembly A (para 4-14).
22. Blower B1 or B2 excessively noisy123	Defective blower	Replace blower (para 4-11).

See footnotes at end of table.

Table -3-3. Troubleshooting - Continued

Malfunction	Probable Cause	Corrective action
23. RESET indicator lamp stays lit when microphone is tapped.[1]	a. Defective microphone b. Defective microphone cable. c. Defective counter A5A5, A5A4, or A5A3 d. Microphone sensitivity incorrect.	a. Repair microphone (para 4-39). b. Repair cable. c. Repair DIGITAL COUNTER subassembly A5 (para 4-14). d. Adjust microphone sensitivity.
24. RESET indicator lamp goes out and counter indicators fail to read correctly when microphone is tapped and CAL 1-OPER-CAL 2 switch is in CAL 1 position.'	Defective counter assembly	Repair DIGITAL COUNTER assembly A5 (para 4-14).
25. Counting accuracy consistently off compared with standard readings indicated on CAAR simulator decal·[2]	a. Counting period off due to frequency error in A5A7 b. Klystron frequency off	a. Repair DIGITAL COUNTER subassembly A5 (para 4-14). b. Replace Klystron (para 4-9).
26. Calibrate count consistently off; counter appears to operate normally.'	A5A10 oscillator frequency off 75 kc	Repair DIGITAL COUNTER subassembly A5 (para 4-14).
27. With P1 disconnected AFC not adjustable.[1]---	a. Defective AFC. b. Defective discriminator crystal diodes CR1 and/or CR2	a. Repair AFC subassembly A2 (para 4-12). b. Replace CR1 and/or CR2 discriminator crystal diode (para 4-8).
28. No meter indication on CARR simulator [2]-------	a. Incorrect alinement of radar chronograph and radar test receiver. b. Toggle switch on CARR simulator incorrectly positioned. c. Defective diode in radar test receiver d. Open wire in coal cable---------------- e. Open wire in 50 ft. cable--------------- f. Defective klystron in radar chronograph. g. Defective radar chronograph h. Defective MONITOR METER in CARR simulator.	a. Realine chronograph and test receiver (TM 9-1290-325-12/1). b. Set toggle switch on CARR simulator in METER position. c. Replace diode (IN263) (para 4-30). d. Repair wiring. e. Repair wiring, f. Replace Klystron (para 4-9). g. Repair radar chronograph (para 4-4). h. Replace MONITOR METER (fig. 4-28).

See footnotes at end of table.

Table 3-3. Troubleshooting-Continued

Malfunction	Probable Cause	Corrective action
29. MONITOR meter cannot be made to indicate in green band or higher with switch in SIGNAL position. [2]	a. Incorrect alinement of radar chronograph and radar test receiver	a. Realine radar chronograph and test receiver (TM 9-1290-325-12/1
	b. Toggle switch on CARR simulator incorrectly positioned.	b. Set toggle switch on CARR simulator in OBC position.
	c. DELAY selector CARR simulator incorrectly positioned.	c. Set DELAY selector on CARR simulator in CONT position.
	d. VELOCITY selector switch on radar chronograph and CARR simulator not in coincident positions	d. Set VELOCITY selector switches on chronograph and CARR simulator in coincident positions.
	e. Defective CARR jumper cable.	e. Replace jumper cable.
	f. Defective radar chronograph	f. Repair radar chronograph (para 4-4).
	g. Defective CARR simulator.	g. Repair CARR simulator (para 4-42).
30. RESET indicator light fails to light and/or COUNTER assembly fails to indicate all zeros when reset.[1,2,3]	a. Defective lamp	a. Replace lamp (fig. 4-12).
	b. Defective counter module A5A6	b. Repair DIGITAL COUNTER subassembly A5 (para 4-14).
	c. Defective CARR simulator	c. Repair CARR simulator (para 4-42).
31. RESET indicator lamp does not extinguish when START button on CARR simulator is depressed. [2]	a. MICSENS control on radar chronograph set too low.	a. Reset MICSENS control to position 10.
	b. Defective CARR jumper cable.	b. Replace jumper cable.
	c. Defective counter module A5A6	c. Repair DIGITAL COUNTER subassembly A5 (para 4-14).
	d. Defective CARR simulator	d. Repair CARR simulator (para 4-42).
32. Gross incorrect readout on radar chronograph [2]	a. Defective radar chronograph	a. Repair radar chronograph (para 4-4).
	b. Defective CARR simulator	b. Repair CARR simulator (para 4-42).
33. Out of tolerance readout on radar chronograph as indicated on CARR simulator decal.[2]	a. Incorrect alinement of radar chronograph and radar test receiver	a. Realine radar chronograph and test receiver (TM 9-1290-325-1211).
	b. Defective radar chronograph	b. Repair radar chronograph (para 4-4).
	c. Defective CARR simulator	c. Repair CARR simulator (para 4-42).
34. Incorrect readout on radar chronograph as per table 2-2 in TM 9-1290-325-12/1. [2]	a. Defective counter assembly in chronograph	a. Repair DIGITAL COUNTER subassembly A5 (para 4-14).
	b. Defective CARR simulator.	b. Repair CARR simulator (para 4-42).

[1] During testing or pre-operational

[2] During use of CARR simulator.

[3] During chronographing.

Table 3-4. Chronograph Test Points

Test point	Location	Function Used
A2J1	A2 Front	Differential amplifier balance.
A2J2	A2 Front	Differential amplifier balance.
A2J3 L	A2 Front	800 volt AFC output.
A3J1 (AUDIO)	A3 Rear panel	Audio output (and input for test audio ---signal).
A4J6	A4 Rear	Detector (disc) balance.
A4J7	A4 Rear	Detector (disc) output.
A5J1	A5 Left side	AF/RF amplifier A5A5 microphone output.
A5J2	A5 Left side	Pulse generator A5A4 output.
A5J3	A5 Left side	Radio frequency oscillator 95.648 kc A5A7 ---output.
ASJ4	A5 Left side	Electronic digital counter A5A11 (1st ÷16).
A5J5	A5 Left side	Electronic digital counter A5A12 (2nd ÷16).
A5J6	A5 Left side	Gate generator ASA3 output.
A5J7	A5 Left side	Oscillator doppler gate A5A1 output.
A5J8	A5Left side	Electronic digital counter A5A13 ÷ 16 out ---put.
A5J9	A5 Left side	AF/RF amplifier A5A9 (audio) output.
A5J10	A5 Left side	Oscillator doppler gate A5A2 (audio) out ---put.
A5J11	A5 Left side	Delay gate A5A8 (coincidence) output.
A5J12 (Black)	A5 Left side	Chassis ground.
A5J14	A5 Left side	A5A18 output.
A6J2[1]	A6 Left side	-508 volt do (approx.).
A6J3	A6 Left side	+ 170 volt dc.
A6J4	A6 Left side	+ 22 volt dc.

[1] Voltage measured at this point will be approximately 8 volts above the voltage measured at A6P1-3 (table 3-5, column 3).

Section III. INSPECTION

3-8. Scope

This section provides specific instructions for the technical inspection by maintenance personnel of radar chronograph set M36 either in the hands of troops or when received for repair in a Direct Support or General Support maintenance shop. It defines the technical inspection made by Direct Support and General Support maintenance personnel of the radar chronograph set in the hands of the using organization. It also defines the initial inspection of materiel when received for repair by Direct Support and General Support maintenance units, in-process inspection during repair, and final inspection after repair has been completed.

3-9. Categories of Technical Inspection

a. In the Hands of Troops.

(1) Insure that preventive maintenance services are being performed and are effective.

(2) Ascertain the serviceability, completeness, or readiness of materiel in the hands of troops.

(3) Render any necessary assistance to the using organization.

(4) Provide instructions for organizational supply and maintenance.

(5) Determine the most prevalent deficiencies in maintenance of materiel.

(6) Anticipate unusual supply demands.

(7) Make a record of condition of materiel in the hands of troops.

b. Spot Check Inspection. This is a periodic inspection performed on only a percentage of materiel in the hands of troops by a contact party of Direct Support and General Support maintenance personnel to determine the adequacy and the effectiveness of organizational supply and maintenance.

c. Command Maintenance Inspection. Command maintenance inspections will be performed annually. The purpose of the inspection is to ascertain the serviceability of equipment, to predict maintenance and supply requirements, and to determine the adequacy of facilities and effectiveness of procedures. Information obtained during the inspection should indicate future requirements for depot maintenance and for replacement, as well as disclose immediate needs for maintenance and application of modification work orders. During inspections, corrections or deficiencies will be made on the spot when practical. For additional information relative to these inspections and the forms to be used therewith, refer to AR 750-8.

d. Initial Inspection. This inspection is performed immediately upon receipt of a radar chronograph set in DS or GS maintenance shops. This inspection determines the disposition of the materiel insofar as prompt repair when work can be accomplished by DS and GS maintenance units or evacuation to depot maintenance units when the work is more extensive.

e. In-Process Inspection. This inspection is performed during the process of repairing the materiel and components. It insures that the workmanship is in accordance with approved methods and procedures and that deficiencies not disclosed by the initial inspection are found and corrected.

f. Final Inspection. This is an acceptance inspection performed by a final inspector, after repair has been completed, to insure that the materiel is acceptable for return to the user.

3-10. Inspection in the Hands of Troops

Specific instructions for the technical inspection by Direct Service and General Service maintenance personnel of radar chronograph set M36 are provided in the hands of troops In general, if the radar chronograph set is complete and performs its intended function properly, if all modification work orders classified as urgent have been completed, and if all defects as disclosed by the inspection have been corrected, the radar chronograph set may be considered serviceable.

3-1 1. Forms and Reports

Authorized forms and reports for technical inspections by Direct Service and General Service maintenance personnel are listed in appendix A.

Preventive maintenance logs, if available, will be examined to determine the maintenance background of the materiel.

3-12. Modification Work Orders

All urgent modification work orders must have been applied. Check on application of all authorized modifications to see that no unauthorized alterations have been made, or that no work beyond the authorized scope of the unit is being attempted. Check the index in DA Pamphlet 310-7 and the current modification work order files for any additional modification work orders.

3-13. General Inspection

a. Note the general appearance of the instrument as an indication of the condition of the materiel and the type of treatment it has received.

b. Check exterior of materiel and accessible parts for dented surfaces, bent or broken parts, missing parts, moisture and corrosion, and other evidence of damage or misuse which might indicate a need for repair.

c. Inspect all sealed and painted portions of the materiel to determine whether sealing is complete.

d. Inspect scale numbers, divisions and indexes, and lettering on name and direction plates for legibility.

e. Inspect for bare spots or damaged finish which expose metal surfaces and lead to corrosion.

f. All controls must operate smoothly without binding or rough motion.

g. The equipment must be clean and free from dirt and grit.

h. Check appendix B in TM 9-1290-325-12/1 for completeness of spare parts and equipment.

i. Check organizational spare parts and equipment for general condition and method of storage, and procedures for obtaining replacements.

j. Investigate mechanical and functional difficulties that troops may be experiencing and check for determinable causes such as inadequate design, poor workmanship or material, lack of knowledge, misinformation, neglect, improper handling, storage, or preservation.

k. Instruct the using personnel in supply and preventive maintenance procedures if the need for such instructions is found necessary.

3-14. Inspection of Optical Components

a. Lenses, reticles, windows, etc., must be free from such scratches, pits, dirt, and chips as will interfere with or affect the optical performance of the instrument.

b. When sighting through the instrument, the image and reticle must be properly defined and there must be no indication of excessive parallax. double vision, or aberration.

3-15. Inspection of Electrical and/or Electronic Components

a. Electrical and power materiel will be visually inspected for evidence of circuit faults or possible Sources of trouble as indicated by the conditions in (1) through (19) below.

(1) Burned or carbonized insulation.

(2) High voltage arcs or short circuits.

(3) Resistors for which power dissipation exceeds rating, as indicated by discoloration, cracks, or swelling.

(4) Leaking electrolytic capacitors.

(5) Corrosion on electrolytic capacitors.

(6) Improperly soldered connections; insecure wiring.

(7) Loose hardware.

(8) Loose plug-in subassemblies, digital indicator tubes, or plug-in crystals.

(9) Cracked insulation on sockets or standoffs.

(10) Bleeding transformers.

(11) Breaks in conductors or printed circuit boards.

(12) Swollen capacitors

(13) Bent connector pins on digital indicator tubes and plug-in subassemblies

(14) Cracked glass on digital indicator tubes.

(15) Loose connections in power cable plugs; loose wire ends, bare wire.

(16) Bent meter needles.

(17) Cracked or broken glass on meters.

(18) Broken or bent contacts on wafer switches.

(19) Fuses burned out.

b. Inspect the general condition of the installation and associated items of electrical and electronic materiel.

(1) All meters must be intact and operative.

(2) All knobs, dials, and switches must be intact.

(3) Cables and cable harnesses must be free of kinks and worn or frayed spots, and properly anchored.

(4) Plugs and sockets must be clean and intact.

(5) Connector caps must be screwed on when connectors are not in use.

3-16. Inspection of Mechanical Parts

Inspect the general condition of the mechanical parts and/or components of the radar chronograph set as indicated in (1) through (9) below.

(1) Retaining spring on dovetail-slotted telescope mount not broken.

(2) Teflon cover on antenna feed not loose or missing.

(3) Main chassis frame assembly slides freely on rails without binding.

(4) Removable assemblies (power supply, audio amplifier and digital display indicator assemblies) slide out without binding after their retaining screws have been loosened.

(5) No loose hardware in Waveguide assembly.

(6) Section and worm gears on mount assembly not jamming or binding.

(7) Bubble vials not broken.

(8) Tripod leg extension tubes not binding.

(9) Tripod spider assembly slides freely along its guide tube.

3-17. Performance Tests of Radar Chronograph

Performance tests of the radar chronograph are made to verify the functional serviceability of the unit. The operation of the chronograph is checked while the unit is seated on the mount and tripod unless otherwise noted. The radar chronograph is energized by connecting a primary power source having a nominal output voltage of 115 volts rms. and a nominal output frequency of 400 cpa Before conducting the performance tests, allow the chronograph circuits to operate for a 15-minute warm-up period.

Note

During radar chronograph performance tests an oscilloscope should be connected to the AUDIO connector on the rear panel and observed frequently for oscillation and other spurious outputs

a. Before running tests, turn off the unit and set the controls and selector switches on the chronograph rear panel as follows:

(1) POWER (switch guard down).................. OFF
(2) DELAY... position 1
(3) MIC SENS 0
(4) VELOCITY.. 70-25
(5) MONITOR SELECTOR........................... LINE

b. Loosen the six socket head cap screws around the edge of the rear panel, (fig. 3-4.1) slide out the main chassis assembly until the test jacks and controls are accessible from the left side, and proceed to test the radar chronograph as follows:

(1) Set POWER switch to ON by closing and pushing in the switch guard. Note that MONITOR meter LINE reading is in center of green band, POWER indicator lamp lights, and both blowers operate. Turn MONITOR SELECTOR switch to B+ position. MONITOR meter needle should be in center of green band.

(2) If necessary to adjust the power supply A6 (fig. 3-4) for -508 volts dc, at test point A6J2, +170 volts dc, at test point A6J3, or +22 volts dc, at test point A6J4, proceed as follows:

(a) Turn off chronograph power.

(b) Insert insulated allen wrench into the proper variable resistor (A6R11 for -508 volts dc, A6R28 for 170 volts dc, or A6R43 for 22 volts dc).

Caution: **Because of close spacing between high voltage and ground points, Allen wrenches and test probes should be insulated by covering all but the tip with plastic sleeving to minimize the possibility of shorts.**

(*c*) Using insulated probe, connect multimeter (TS-352A/U) to proper test point jack (A6J2 for -508 volts dc, A6J3 for +170 volts dc, or A6J4 for +22 volts dc).

(d) Turn on chronograph power.

(e) Check that MONITOR SELECTOR switch is in B + position.

(f) Make adjustment as required to obtain proper reading at test point. When the proper reading is obtained, the monitor meter needle should be in the center of the green band.

(3) Slide the main chassis assembly back into place and secure with the six socket head cap screws around the rear panel.

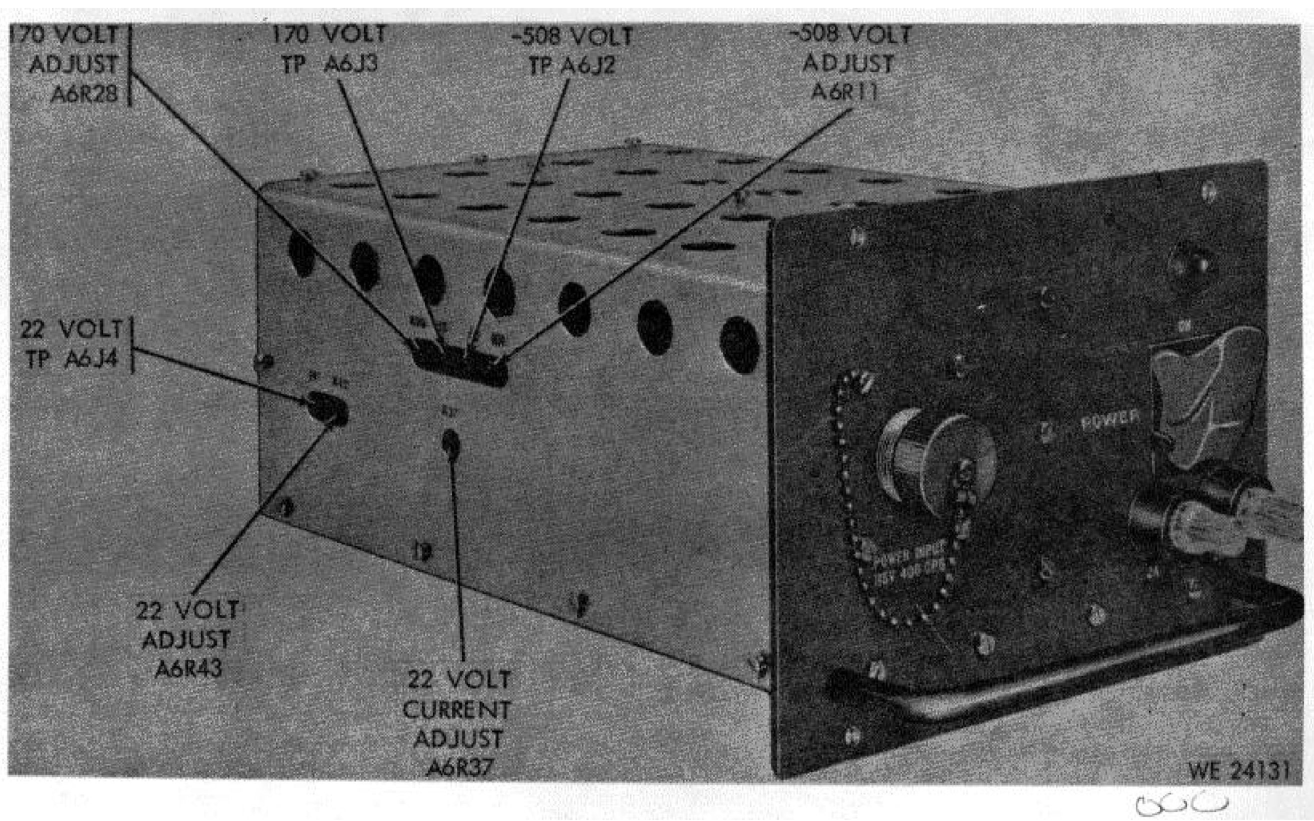


Figure 3-4. Power supply A6 showing test points and adjustments.

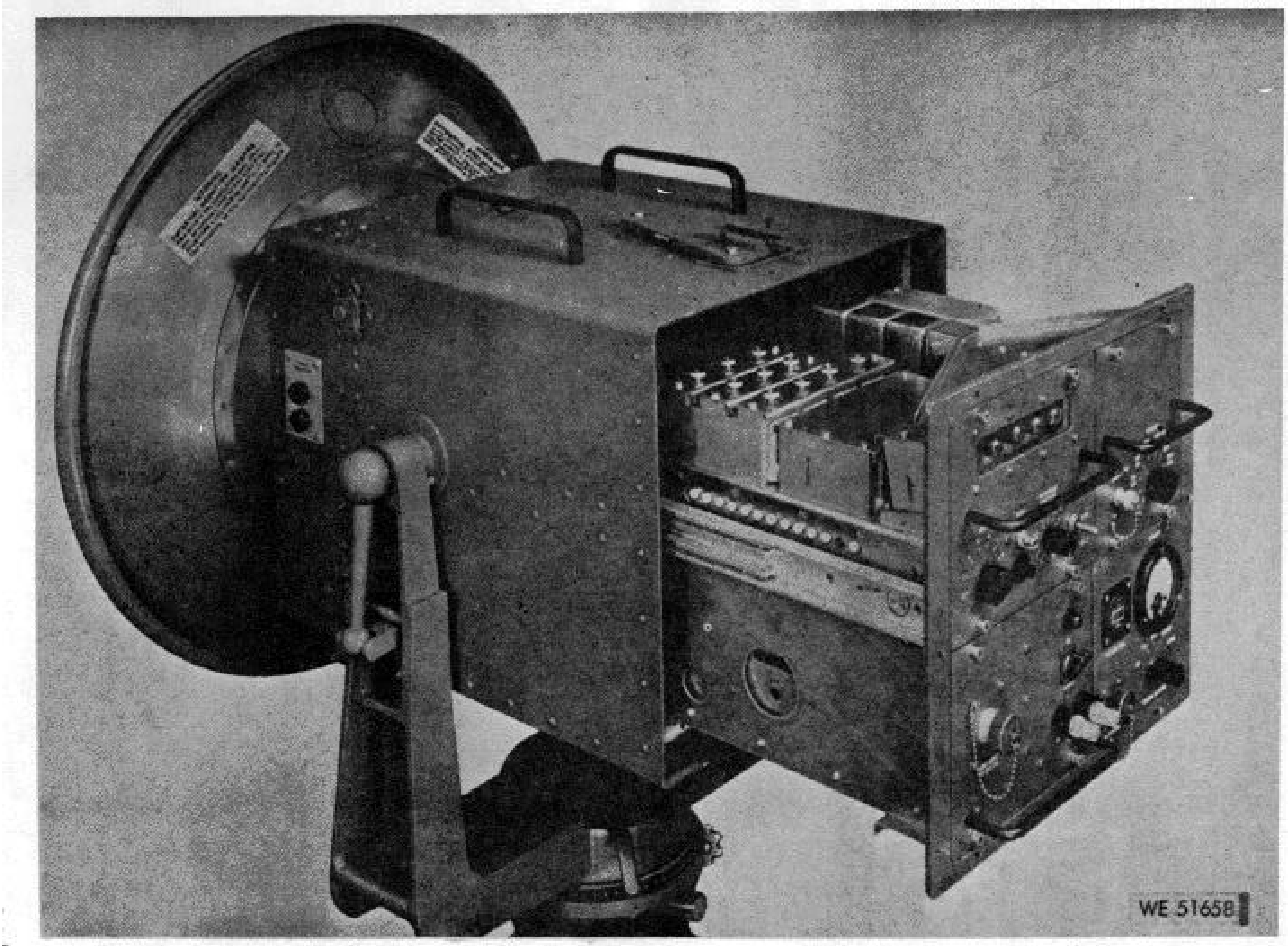


Figure 3-4.1. Chronograph main chassis pulled out from cabinet.

(4) Open the chronograph front section, exposing detector amplifier A4 and Waveguide assembly Al.

(5) Set the internal monitor switch to the AFC DISC position.

(6) Disconnect conductor P1 from J1 on the waveguide assembly.

(7) Vary the AFC potentiometer R16 on the AFC assembly by loosening the locknut and turning the shaft. Observe that the internal monitor meter swings from positive through zero to negative (or vice versa).

(8) Set AFC potentiometer for a meter reading of zero (between the positive and negative peaks observed above) and reconnect P1 to J1 on the waveguide assembly. Note that the internal monitor meter reads zero. Lock R16 by tightening locknut.

(9) Set the internal monitor selector switch to the MOD DRIVE position and note that the internal monitor meter reads between +40 and + 70 microamperes.

(10) If reading is not between +40 and +70 microamperes as indicated in (9) above, adjust potentiometer R27 on the A4 assembly for the desired reading.

(11) Set the internal monitor selector switch to MOD XTAL 1 and note that the internal monitor meter reads between +45 and +90 microamperes.

(12) Set internal monitor selector switch to MOD XTAL 2 and note that the internal monitor meter reads between -45 and -90 microamperes, and that the reading obtained here is approximately the same in amplitude as that in (11) above, indicating a balanced condition.

(13) Set internal monitor selector switch to MXR XTAL 1 and note that the internal monitor meter reads between -20 and -80 microamperes.

(14 Set internal monitor selector switch to MXR XTAL 2 and note that the internal monitor meter reads between +20 and +80 microamperes. The MXR XTAL 1 and MXR XTAL 2 currents should be approximately the same, indicating proper mixer balance.

(15) If readings in (13) and (14) above are high, indicating a high leakage current, set MONITOR SELECTOR switch on chronograph rear panel to LEAKAGE position and adjust LEAKAGE ADJUSTMENT 1 and 2 controls to bring monitor meter needle to center of green band.

(16) Close the front section of the chronograph and secure all the fasteners.

(17) With MONITOR SELECTOR switch on chronograph rear panel set to the LEAKAGE position note that the MONITOR meter needle is near the center of the green band.

***Note.* Closing the front section may cause a change in LEAKAGE reading because of the change in reflected signal.**

(18) If necessary, readjust LEAKAGE ADJUSTMENT 1 and 2 controls for the proper reading as indicated in (17) above.

(19) Set MONITOR SELECTOR switch to the AGC V position and the VELOCITY selector switch to the lowest range (70-325) and note that the MONITOR meter needle is near the center of the green band.

c. Check and adjust klystron oscillator and associated circuits as indicated below:

(1) Checking klystron frequency, output power and antenna beam width. The frequency of the klystron, approximate chronograph output power and antenna beam width may be checked by using a radar test receiver, a waveguide frequency meter (FR-126/U) and VTVM (TS-505D/U).

(a). Set up chronograph on tripod as for operation. Before applying power to chronograph, observe the following warning.

WARNING

POTENTIAL RADIATION HAZARD When radar is energized, personnel should not be within 6 feet of the radiating Feedhorn (located in the center of dish) in the direction of the transmitted beam.

(b) Apply power to chronograph and allow to warm up for 15 minutes.

(c) Install radar test receiver on aiming post so that center of receiver horn will be approximately four feet from the ground.

(d) Set aiming post in the ground 20 feet from the tip of the chronograph antenna feed element.

(e) Connect the VTVM to the test receiver detector output.

(f) Aline chronograph antenna and test receiver horn as closely as possible by eye; fix test receiver in this position.

(g) For subsequent use as a test target when viewing through the chronograph telescope for determining antenna beam width, cut a rectangular piece of heavy white cardboard approximately 2 inches x 4 inches. Using a black marker or crayon, draw a straight line lengthwise through

the center. Draw a perpendicular bisector through the first line with the intersection approximately 1 inch from the end of the cardboard.

(h) Adjust chronograph and test receiver horn to obtain a maximum reading on the VTVM. Note that this reading, indicating the peak-power point, is a minimum of 0.75 volts If reading is low, proceed to (1) below to make sure that the klystron is operating in the correct voltage mode.

(i) Clamp or tape the test target securely to the aiming post, adjusted so that the telescope crosshairs as viewed through the telescope are superimposed on the crosslines of the test target.

(j) To check antenna beam width in both the horizontal and vertical planes proceed as follows:

(1) With chronograph and test receiver adjusted as in *(h)* and *(i)* above, traverse chronograph to the right until 80 percent (half-power point) of the reading obtained in (h) above is indicated on the VTVM. Note the displacement in azimuth as indicated by the telescope reticle. Traverse chronograph to the left until 80 percent of the reading obtained in (h) above is indicated on the VTVM, and again note the displacement in azimuth. The sum of the two azimuth readings obtained shall be within 56.8 and 64 mils.

(2) Repeat step (1) above, except elevate and depress the chronograph in lieu of traversing and record elevation and depression readings. The sum of the elevation and depression readings obtained shall be within 56.8 and 64 mils.

(k) Connect the frequency meter to the radar test receiver by separating the horn from the receiver and mounting the frequency meter between the horn and the detector section. Realine chronograph antenna with test receiver.

(l) Open chronograph front section and break AFC loop by disconnecting P1 from J1 on the waveguide discriminator and grounding P1 center conductor.

(m) While observing meter attached to the test receiver, vary the setting of the AFC control. The klystron output should vary over several peaks, the highest of which should be the correct one.

(n) Check klystron frequency by adjusting frequency meter for a dip in the meter reading. The dip should occur at 10.5 kmc and should coincide with peak output power. If it does not, proceed to adjustment of klystron indicated in (2) below.

(2) Adjustment of klystron frequency. The klystron oscillator is set to its nominal frequency by mechanically altering the dimensions of the resonant cavity, thus changing its resonance over a limited range. Leave equipment setup as indicated in (1) above to check the output frequency.

(a) Open chronograph front section and break AFC loop by disconnecting P1 from J1 on the waveguide discriminator and grounding P1 center conductor.

(b) Connect a VTVM (set to -1000 volt range) to test point J3 on AFC assembly A2.

(c) Loosen locknut and adjust AFC control to obtain a - 800 volt reading on VTVM. Retighten locknut.

(d) Vary frequency meter setting to determine whether dip occurs above or below 10.5 kmc, then set frequency meter for a frequency of 10.5 kmc.

(e) Hold the body of the klystron tube next to the trimming nut with a 1/2-inch open-end wrench and place a 7/16-inch open-end wrench on the trimming nut.

Caution: Avoid striking tube pinch-off as this part is easily damaged and will cause loss of vacuum if cracked

(f) Turn the trimming nut in the direction desired, using a scissors-like motion of the wrenches. To increase the oscillator frequency, turn the trimmer nut counterclockwise until a dip in the frequency meter reading indicates 10.5 kmc has been reached.

(g) To tune to a lower frequency, first turn the trimmer nut clockwise until the frequency is below 10.5 kmc, then turn counterclockwise until the desired frequency is reached. (This reduces the effect of backlash in the tuning mechanism.)

(h) After frequency adjustment, again check power output as indicated in (1) above.

(3) Checking klystron AFC. After checking and adjusting klystron oscillating frequency as indicated in (1) and (2) above, check that the AFC discriminator is tuned to the same frequency.

(a) Leave equipment set up as in (2) above, with AFC loop broken and VTVM attached to test point J3.

(b) Set internal monitor selector switch to AFC DISC position.

(c) Loosen locknut and slowly vary AFC control above and below normal setting, observing the positive and negative peaks on the internal monitor meter. These peaks should be approximately equal and should be centered around the normal setting of the AFC control, as shown in figure 2-14C. (At the normal setting, the frequency meter should indicate 10.5 kmc, the VTVM at J8 should indicate -800 volts, and the internal monitor meter should read zero.) Return control to -800 volt setting and tighten locknut. If the peaks are not centered, proceed to (d) below.

(d) Loosen locknut on discriminator center frequency adjust screw.

(e) Slowly and carefully adjust screw to obtain zero reading on internal monitor meter, indicating that discriminator curve is centered. Tighten locknut.

(f) Check shape of discriminator peaks as indicated in (c) above. If peaks are not equal proceed to *(g)* below.

(g) Loosen locknut on discriminator separation-adjust screw.

(h) Slowly and carefully vary the setting of the screw, at the same time checking centering and shape of peaks. If centering is disturbed by this adjustment, repeat centering procedure.

(i) When correctly shaped and properly centered curve is obtained, tighten locknuts.

(j) Reestablish AFC loop by connecting P1 to J1.

(k) Check that output frequency and power, repeller voltage (at J3 on frequency control A2), and discriminator curve are still correct.

3-18. Inspection of Materiel Received in DS and GS Maintenance Shops

Specific instructions are indicated below for the technical inspection of radar chronograph set M86 by DS and GS maintenance personnel.

3-19. Performance Test of Power Supply A6

a. The performance test of the power supply assembly A6 (fig. 3-3) is conducted on a bench while it is disconnected from the chronograph circuits and connected to a primary power source which delivers a nominal voltage of 115 volts rms. at a nominal frequency of 400 cps.

b. Before connecting the power supply to a primary source, connect external loads (by means of locally fabricated connecting cables) to A6P1 as indicated in table 3-5. This simulates the normal operating loads. Proceed with test as follows:

(1) Place POWER switch on power supply A6 in off position (switch guard and switch in down position).

(2) Connect the primary source (turned off) in series with multimeter (TS352A/U) to the input power supply connector.

(3) Turn on the primary power source and adjust voltage and frequency to 115 volts rms. and 400 cps.

(4) Turn on power supply A6 and note that the POWER light comes on.

(5) Using a VTVM (TS-505D/U), measure the output voltage across the various external load resistors to verify the voltages indicated in table 3-5, column 3.

(6) Check the voltage regulation across the various loads by varying the power supply input

Table 3-5. Power Supply Test Connections

(1) External load resistors Tol ±5%		(2) Test point	(3) Output voltage	(4) Load connections	(5) Ripple voltage RMS
Ohms	Watts				
7700	35	J2 (-508 vdc) approx.	500 vdc (at A6P1-3).	A6P13 to ground ------------------------	75 mv
60	10	J4 ------------------	+22 vdc --------	A6P1-6 to ground -----------------------	10 mv
4250	10	J3 ------------------	+ 170 vdc -----	A6P1-8 to ground -----------------------	40 mv
5420	5	---------------------	+ 130 vdc ------	A6P1-10 to ground----------------------	20 mv
8. 75	8	---------------------	6.3 vac----------	A6P1-A to A6P1B-----------------------	------------------------------------

voltage between 105 volts rms. and 125 volts rms. and input frequency between 380 and 420 cps. Note that the output voltages do not vary more than ±1% of the output voltages indicated in table 3-5, column 3 except the 6.3v output which may vary ±10%. The power drain should not exceed more than 2 amperes under full rated load as indicated on multimeter (2) above.

(7) Using a 1000 vdc, 1.0 mf capacitor in series with oscilloscope (AN/USM-50A) note that the ripple voltages are no greater than the values specified in table 3-5, column 5 when the supply is operating with full rated load at nominal input voltage.

(8) To set 22-volt level and regulation, adjust as follows: (a) Turn variable resistor A6R87 clockwise until it has no further effect.

(b) Adjust A6R43 to get 22 volts at test point. A6J4.

(c) Temporarily overload the circuit by replacing the 60-ohm load resistor with a 50-ohm resistor. At the same time turn A6R37 counterclockwise until it takes effect, then back off slightly. Remove overload resistor.

3-20. Performance Test of Audio Frequency Amplifier A3

a. The performance test of the audio amplifier assembly (fig. 3-5) is conducted on a bench while separate from the rest of the radar chronograph circuits. The chronograph power supply A6 may)e used as the voltage source using same jumper cable referenced in 3-21*a* below connected to the mating connector for the A3 assembly inside chronograph. The jumper cable will not be connected directly to the A3 audio amplifier mating connector A3P1 for the following tests.

(1) Connect a wire between jumper cable pin 8 and pin 8 of ASP1 for +22-volt dc power to the A3 assembly.

***Note*. Electrical contacts compatible for mating with contact pins of the connectors soldered to the ends**

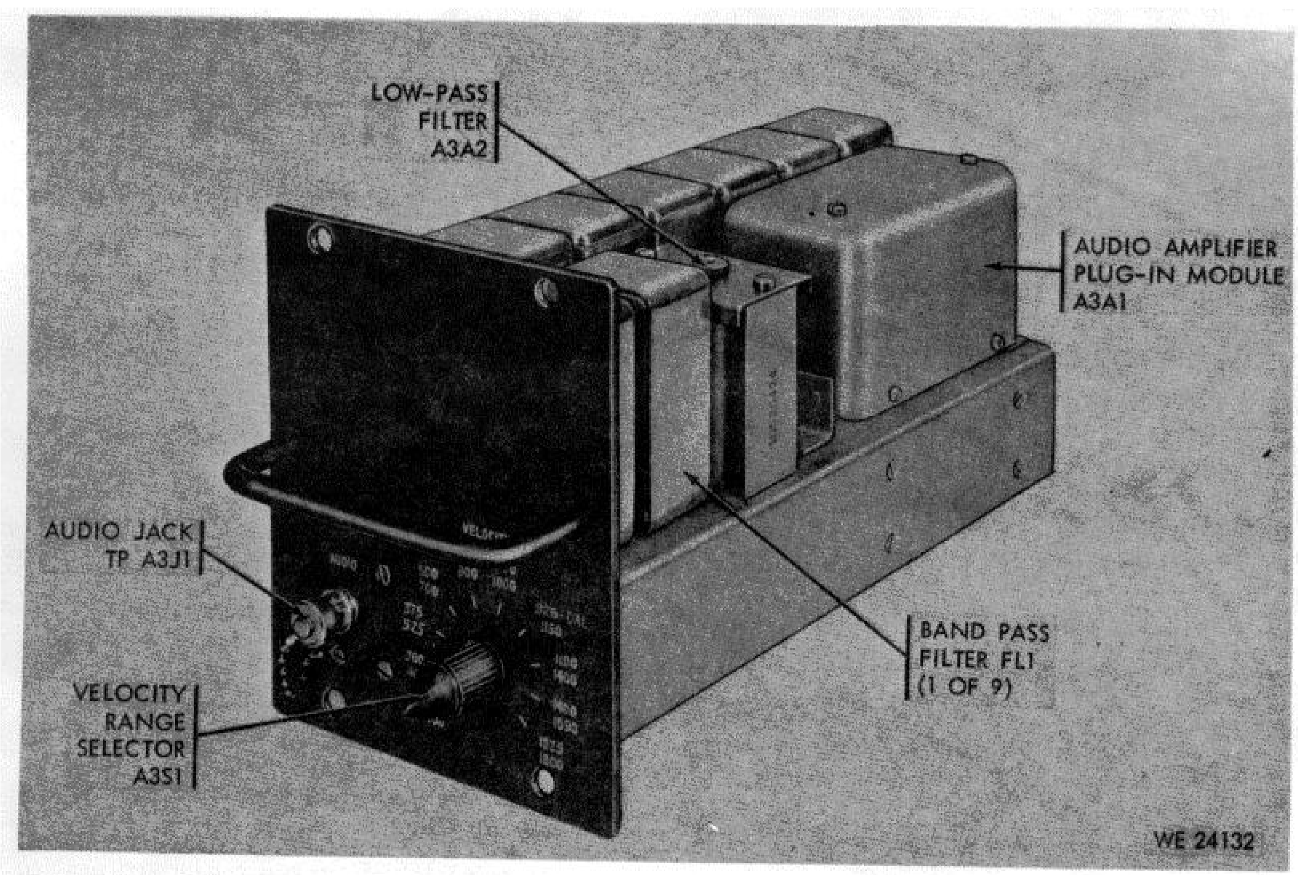


Figure 3-5. Audio frequency amplifier A3--shooting test points and adjustments.

of the connector wire will provide a convenient means of connection between connector contacts. Electrical contacts should be insulated to prevent contact with adjacent pins of connectors.

(2) Connect a wire between jumper cable pin 6 and pin 6 of connector A3P1 (ref note (1) above).

b. To test the gain and AGC action of the audio amplifier assembly, proceed as follows:

(1) Connect a 200-ohm resistor between the amplifier input P1-1 and ground, a(1) above. An alligator clip may be soldered to one end of resistor for grounding to the amplifier chassis.

(2) Connect audio oscillator TS-382D/U across the resistor.

(3) Set the output of the audio oscillator to I mv rms at 33 kc.

(4) Connect a 2000 ohm resistor load between the amplifier output (front panel AUDIO jack) and ground. Connect an ac VTVM (ME30A/U across the load.

(5) Set velocity selector switch A5S1 in position 375-525.

(6) Turn on power supply.

(7) Using oscilloscope (AN/USM-50A), verify that the output of the audio amplifier is an undistorted sinusoidal wave with the amplitude always greater than 250 mv peak-to-peak with a 1 mv rms input, greater than 500 mv peak-to-peak with a 2 mv rms input, and greater than 500 mv peak-to-peak with a 3 mv rms to 175 mv rms input.

(8) With the equipment connected as in (1) through (5) above, set the audio oscillator at an output of 3 mv rms and vary the frequency over the ranges specified in column B, table 3-6 with the velocity selector switch set in the appropriate position specified in column A, table 3-. Note that the output at the AUDIO jack is an undistorted sinusoidal wave greater than 500 mv peak to-peak and less than 2.0 V peak-to-peak.

(9) With the equipment connected as indicated in (2) through (5) above, set the audio oscillator at an output amplitude of 3 mv rms and vary the frequency over the ranges specified in column C, table 3-6, with the velocity selector switch in the appropriate position specified in column A, table 3-6.

***Note*. The output voltage at the audio jack is lower by at least 25 db than the voltage measured in the same velocity range (table 3-6, column B).**

Table 3-6. Frequency Response of Audio Frequency Amplifier AS

A Velocity range (MPS)	B Frequency range (kc/s) output greater than 500 mv P-P and less than 2.0 V P-P	C Frequency range (kc/s) output lower by atleast 25 db than values measured in column B
70-325	12-24. 6	.1-4 and 31-130
300-400	20. 5-31	.1-16.5 and 38-130
375-525	26. 5-39	.1-23.25 and 45-130
500-700	34-51	.1-27.6 and 59-130
650-800	44-60	.1-38 and 72-130
750-1000	51-81	.1-45 and 85-130
925-1150	63-86	.1-55 and 95-130
1100-400	74-100	.1-65 and 105-130
1400-1590	100-110	.1-95 and 135-150
1525-1860	102-110	.1-95 and 135-150

3-21. Performance Test of Digital Display Indicator A5 (Counter Assembly)

The performance test of the counter assembly is conducted on a bench while separate from the rest of the chronograph circuits. It is operated from a power source which delivers 22 and 170 volts dc.

a. Power Connections. Prior to performing tests, make connections to the power source. A chronograph power supply may be used as the power source if no other suitable source is available. A jumper cable may be fabricated locally using amphenol connectors, FSN 5935-034-899 and FSN 5935-704-6019 listed in TM 9-1290-325-35P and (15) seventy-two inch lengths of 20 gauge shielded electrical wire. This cable may be connected from the A5 assembly mating connector inside chronograph.

(1) Connect the 22-volt source (power supply A6P1, pin 6) to pin 5 of A5P1 on the A5 assembly (fig. 3-6).

(2) Connect the 170-volt source (power supply A6P1, pin 8) to pin 6 of A5P1 on the A5 assembly.

(3) Connect an insulated ground between the A5 chassis and frame of chronograph.

b. Testing the RESET Operation To test the RESET circuit operation, proceed from a above to the following:

(1) Set DELAY switch on front panel of the digital display indicator to position 1.

(2) Set MIC SENS control located next to DELAY switch to position 5.

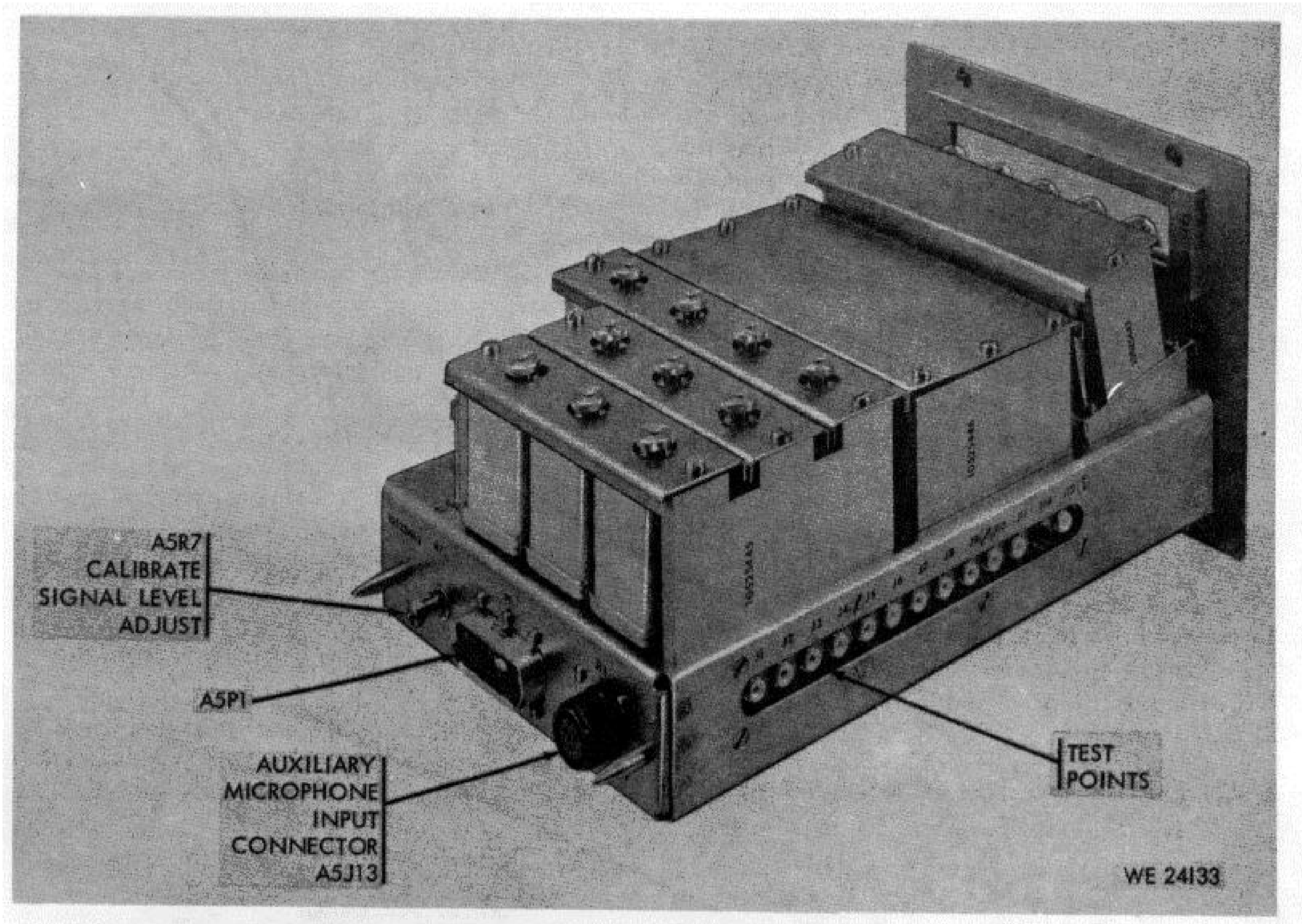


Figure 3-6. Digital display indicator A5 (counter assembly) - showing test points and adjustments.

(3) Connect audio oscillator (TS-382D/U) between pin 4 of connector A5P1 and ground.

(4) Set audio oscillator for an output of 50 mv rms at 25 kc.

(5) Momentarily press the RESET pushbutton on front panel and note that the RESET indicator lamp located above it lights and the digital indicators read 0000.0.

(6) Momentarily hold the CAL 1-OPERCAL 2 switch in the CAL 2 position and note that the RESET lamp goes out and the digital indicators read

$$0356.7^{+3}_{-4}$$

(7) Repeat (5) above, then proceed to the next test.

c. Testing Operation with Different Input Signal Frequencies. Repeat as indicated in b (3) above, then proceed to the following:

(1) Set MIC SENS Control to position 10.

(2) With the counter reset as indicated in b(5) above, note that the RESET lamp goes out when a 100 mv peak-to-peak, 12 kc signal is applied, and a readout of $0171.3^{+0.4}_{-0.3}$ mps is indicated when the OPER switch is moved to the CAL 2 position. When a 110 kc signal is applied, a readout of $1570.3^{+0.4}_{-0.3}$ should be indicated.

d. Testing the Calibration Signal Output. To test the calibration signal output, proceed as follows:

(1) Connect oscilloscope (AN/USM-50A) to pin 8 of connector A5P1. Note that the ac voltage is a minimum of 30 mv peak-to-peak.

(2) Momentarily hold CAL 1-OPERCAL 2 switch in CAL 1 position and note that the output voltage has a frequency of 75 kc.

e. Testing Reset Indicator Response. To test the reset indicator response, proceed as follows:

(1) Connect as indicated in a above.

(2) Connect audio oscillator (TS-382D/U) to A5P1, pin 1 and ground (pin 2 of A5P1).

(3) With the counter reset, and the microphone sensitivity control set on 10, note that the RESET lamp goes out when a 500 mv peak-to-peak, 1 kc signal, and a 75 mv peak-to-peak, 15 kc signal is applied.

f. Testing the Gate Delay Circuit. To test the operation of the gate delay circuit, proceed as follows:

(1) Install digital display indicator A5 (counter assembly) in a serviceable radar chronograph M36.

(2) Using a serviceable chronograph automatic reliability rater (CARR), perform operational checks and adjustments outlined in TM 9-1290-325-12/1, section III, paragraph 2-9.

(3) If the requirements for the delay settings do not conform to table 2-2 of the checks referenced in (2) above, the digital display indicator should be referred to Depot maintenance for overhaul.

3-22. Performance Test of Detector Amplifier A4 (IF Amplifier-Detector Assembly)

The performance test of the A4 assembly (fig. 3-7) is conducted on a bench while it is disconnected and removed from the rest of the chronograph circuits. A chronograph power supply A6, operating from an appropriate primary power source, may be used to supply the 130 and 22 volts dc required by the A4 assembly.

a. Power Connections. Prior to running any tests, make the following connections between the power supply and the A4 assembly (para 4-6a below).

Caution: **Before making connections to power supply, turn off input power.**

(1) Connect the 130-volt dc line from the power supply connector A6P1, pin 10 to pin J of connector A4J1 on the A4 assembly.

(2) Connect the 22-volt dc line from the power supply connector A6P1, pin 6 to pin F of connector A4J1.

(3) Connect 6.3-volt ac line from power supply A6P1, pin A to pin of connector A4J1.

b. Testing the 45 me Oscillator Frequency. To check the approximate frequency of the 45 mc oscillator, proceed from a above to the following:

(1) Connect rf signal generator (AN/USM44) to plug A4CP4.

(2) Connect voltmeter TS-505D/U between test point A4J6 and ground.

(3) Set signal generator to approximately 45 mc.

(4) Turn on 6.3-volt ac tube heater voltage, then 130-volt plate supply.

(5) Vary signal generator frequency slowly around 45 me until a null indication is seen on voltmeter (indicating that frequency of oscillator in A4 is same as that of signal generator). This should occur at 45 mc.

c. Testing the Peak Frequency Output. Connect as indicated in a above and proceed as follows:

(1) Connect oscilloscope (AN/USM-50A, set at an input frequency of 75 kc to J1, pin M.

(2) Set the signal generator to 44.925 mc at 1 mv. The output seen on the oscilloscope should have a frequency of 75 - 25 kc. Peak the output by adjusting C10, T2, and T1 (fig. 4-1) in the given sequence.

(3) Readjust C10, T2, and T1 several times in the same sequence, if required, to ensure peak output.

3-23. Performance Test of Frequency Control A2 (AFC)

Prior to running the performance test on the AFC assembly (fig. 3-8) it is necessary to remove this assembly from the rest of the chronograph circuits. This is accomplished by loosening the two Dzus fasteners which secure the AFC assembly to the inner front end of the main frame.

a. General. The performance test of the AFC assembly is conducted on a bench and operated from a power supply which is capable of delivering to the AFC input (P1) the voltages specified below. The chronograph power supply A6 may be used as the voltage source using same jumper cable referenced in 3-21*a* above, connected to mating connector for the A2 assembly inside chronograph.

After making all necessary connections between the AFC assembly and the power supply, proceed with the AFC circuit performance test.

(1) Connect -500 volts (power supply A6P1, pin 3) to pin 2 of A2P1 on the A2 assembly.

(2) Connect +22 volts (power supply A6P1, pin 6) to pin 8 of A2P1 on the A2 assembly.

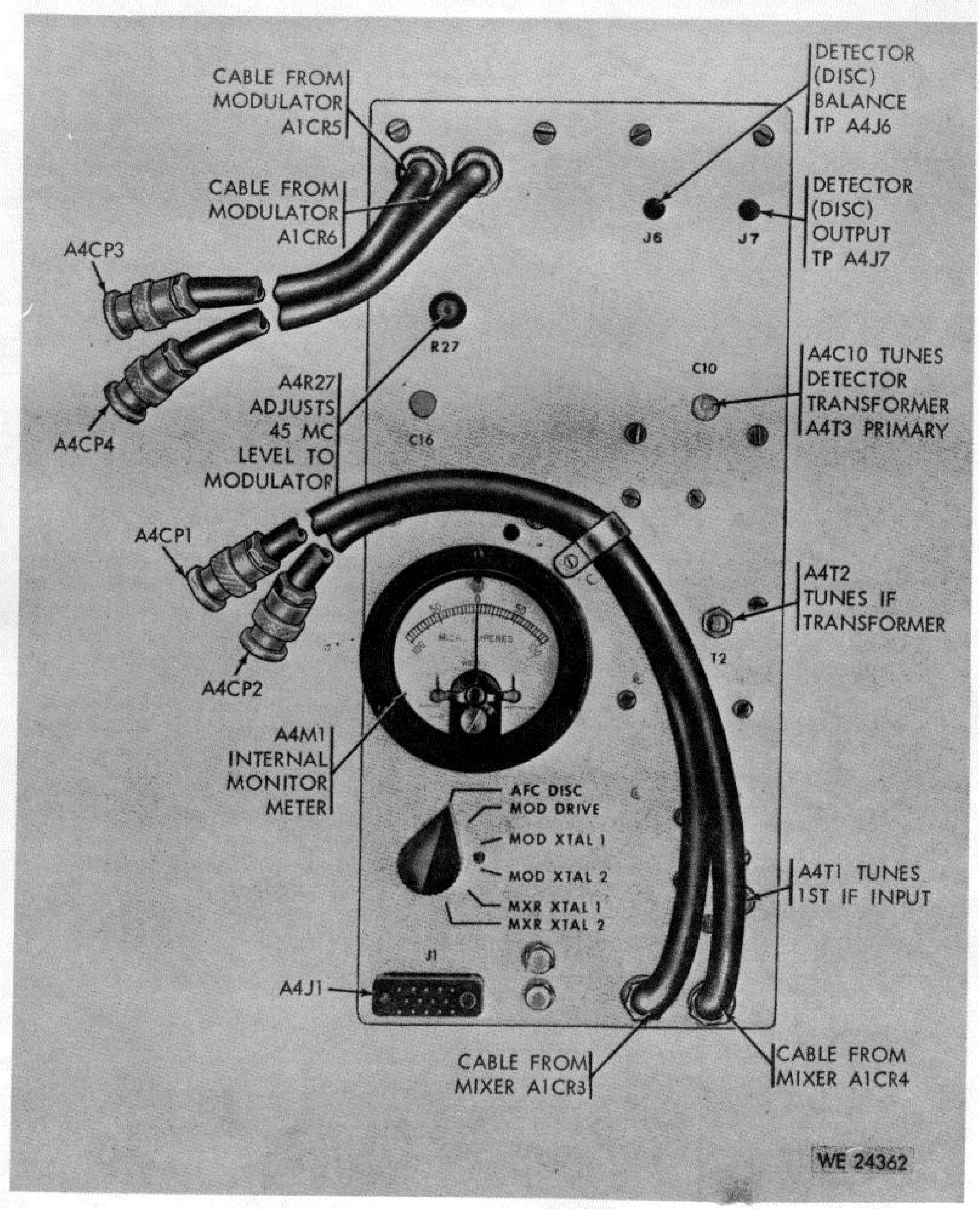


Figure 3-7. Amplifier detector A4 showing test points.

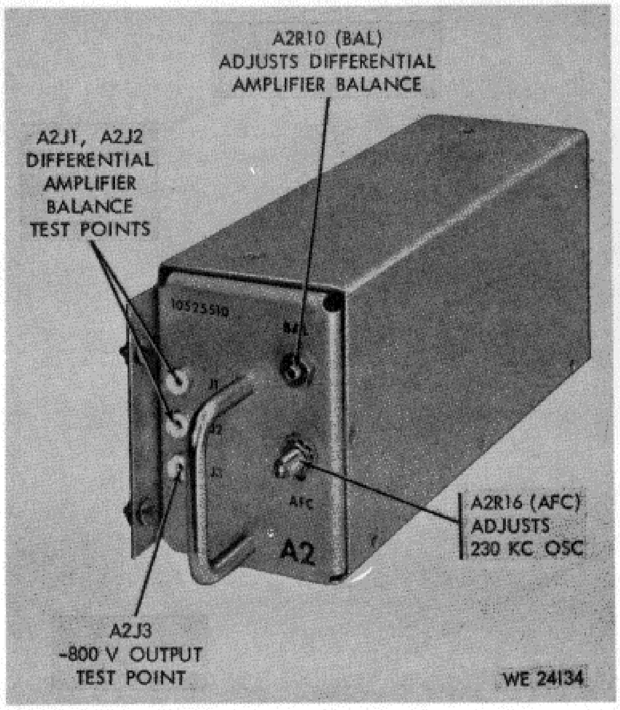


Figure 3-8. Frenzy control A2 (AFC)--showing test points and adjustments.

(3) Connect + 170 volts (power supply A6P1, pin 8) to pin 13 of A2P1 on the A2 assembly.

(4) Connect ground between A2 assembly chassis and chronograph frame.

Caution: Care must be observed when handling the exposed P1 connector pins as dangerous potentials are present at pins 1, 2, 8 and 13.

b. Testing the Input Balance. To test the balance of the AFC input amplifier with no input signal at the P1-11 connector proceed as follows:

(1) Connect multimeter (TS-352A/U) between test points A2J1 and A2J2.

(2) Vary the setting of BAL potentiometer A2R10 and note that the output across the test points can be varied between -2 volts de through j zero to + 2 volts de.

(3) Set BAL adjust A2R10 so that the multimeter reads zero.

(4) It may not be possible to maintain zero balance on meter due to inherent drift. This condition should not be interpreted as a malfunction affecting serviceability.

c. Testing the Output Voltage. To tests the output voltage at A2J3 with no input signal at P1-11 proceed from b above to the following:

(1) Connect VTVM (TS-505D/U) between test point A2J3 and ground.

(2) Set VTVM to the 1000 volt dc range.

(3) Vary the setting of AFC potentiometer A2R16, and note that the output of A2J3 can be varied between -790 and -830 volts dc.

d. Testing the Output Ripple Voltage. To test the output ripple voltage, proceed to the following:

(1) Connect oscilloscope (AN/USM-50A) in series with a 1.0 , µf, 1000, volt dc isolating capacitor to AFC output test point A2J3.

(2) Measure the ripple voltage at the AFC output and note that this voltage is less than 50 mv peak-to-peak.

3-24. Performance Test of Chronograph Automatic Reliability Rater (CARR Simulator)

All adjustments of CARR simulator authorized up to and including DS and GS maintenance levels are included as a part of the troubleshooting table. For adjustments of circuits or subassemblies not covered in this table, refer the CARR simulator to depot level maintenance. An overall electrical schematic diagram (fig. 3-9) is included to further assist in location and tracing for troubleshooting.

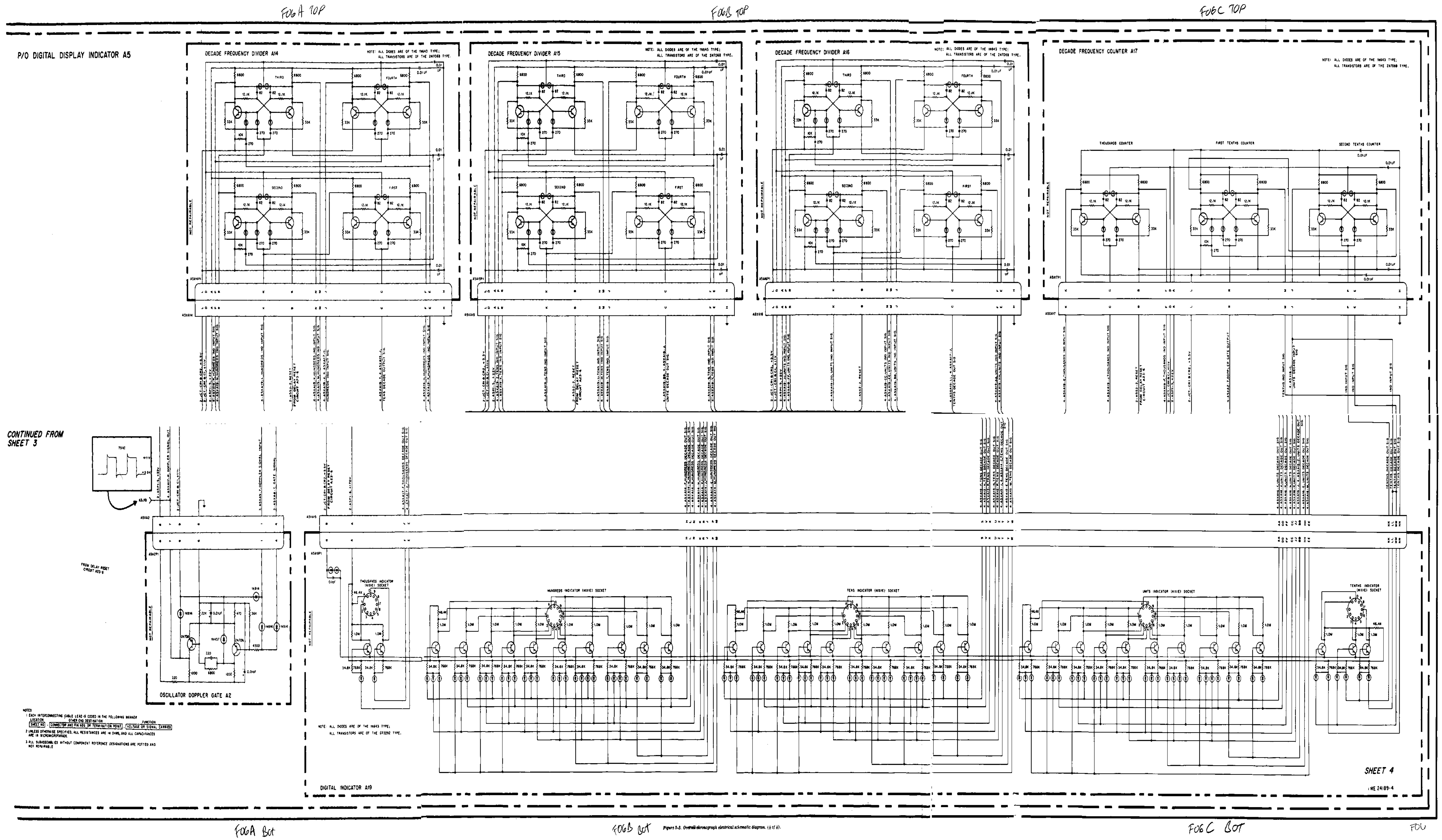


Figure 3-3. Overall chronograph electrical schematic diagram (4 of 4)

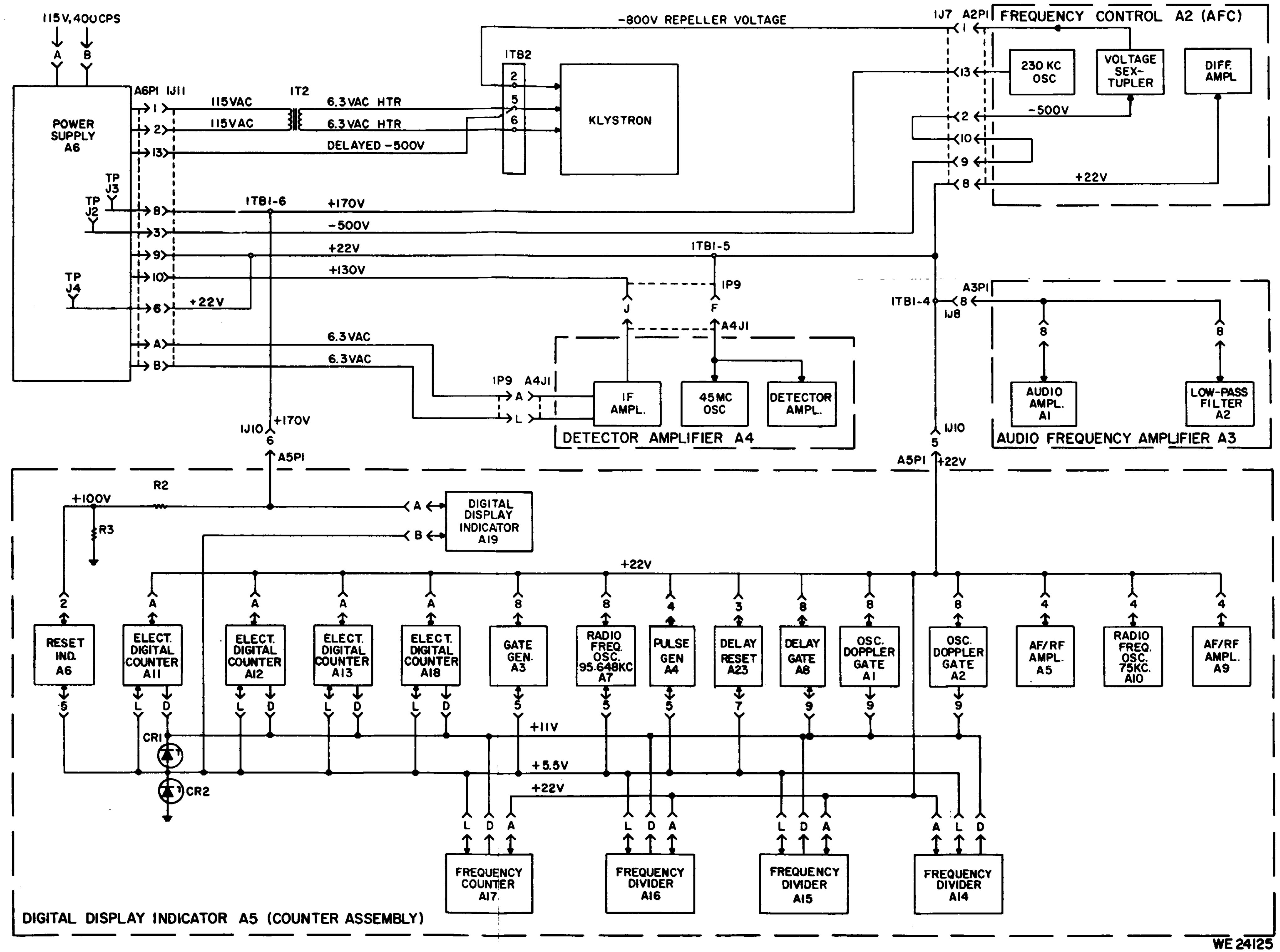


Figure 3-1. Radar chronograph power distribution diagram.

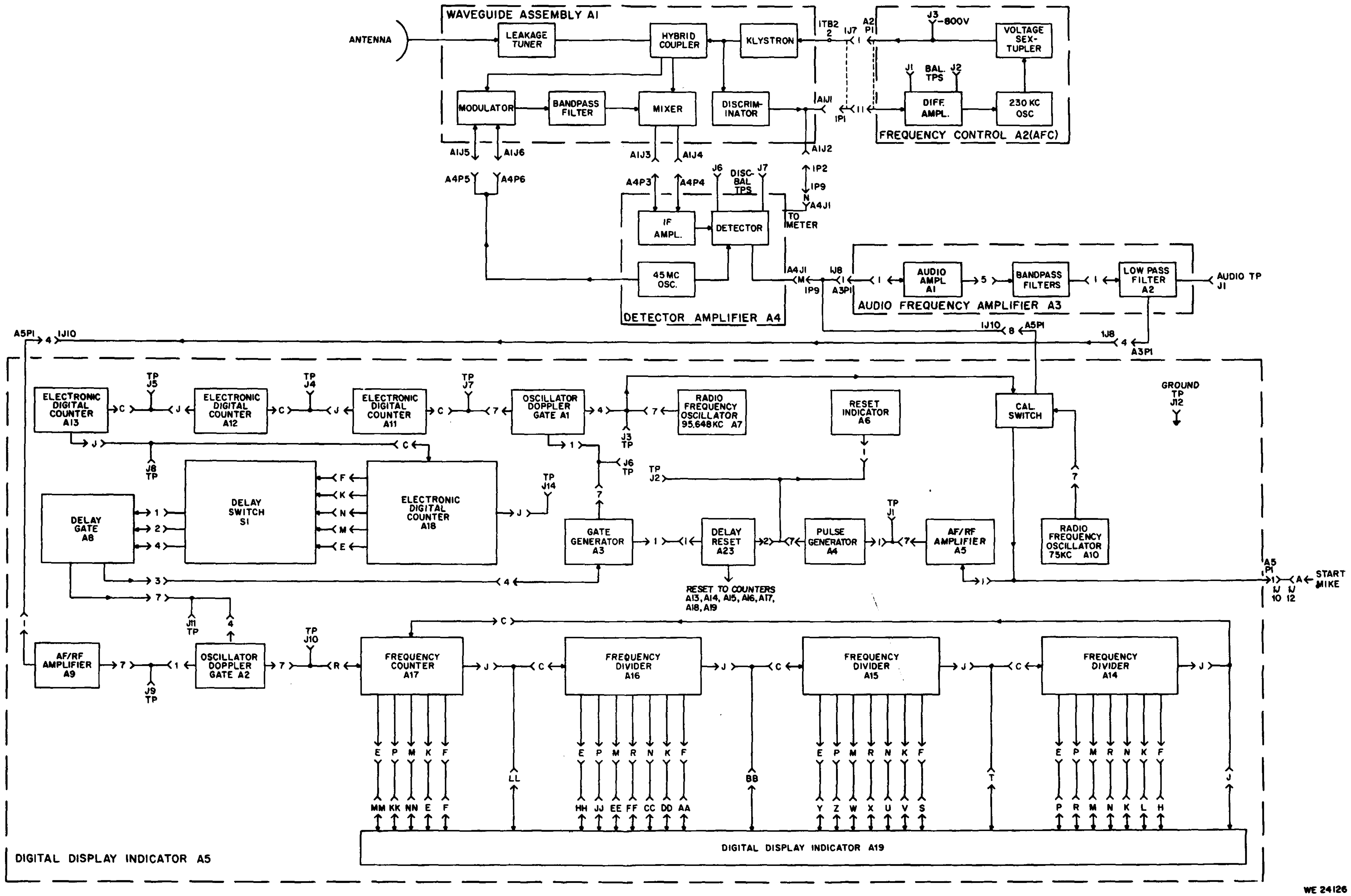
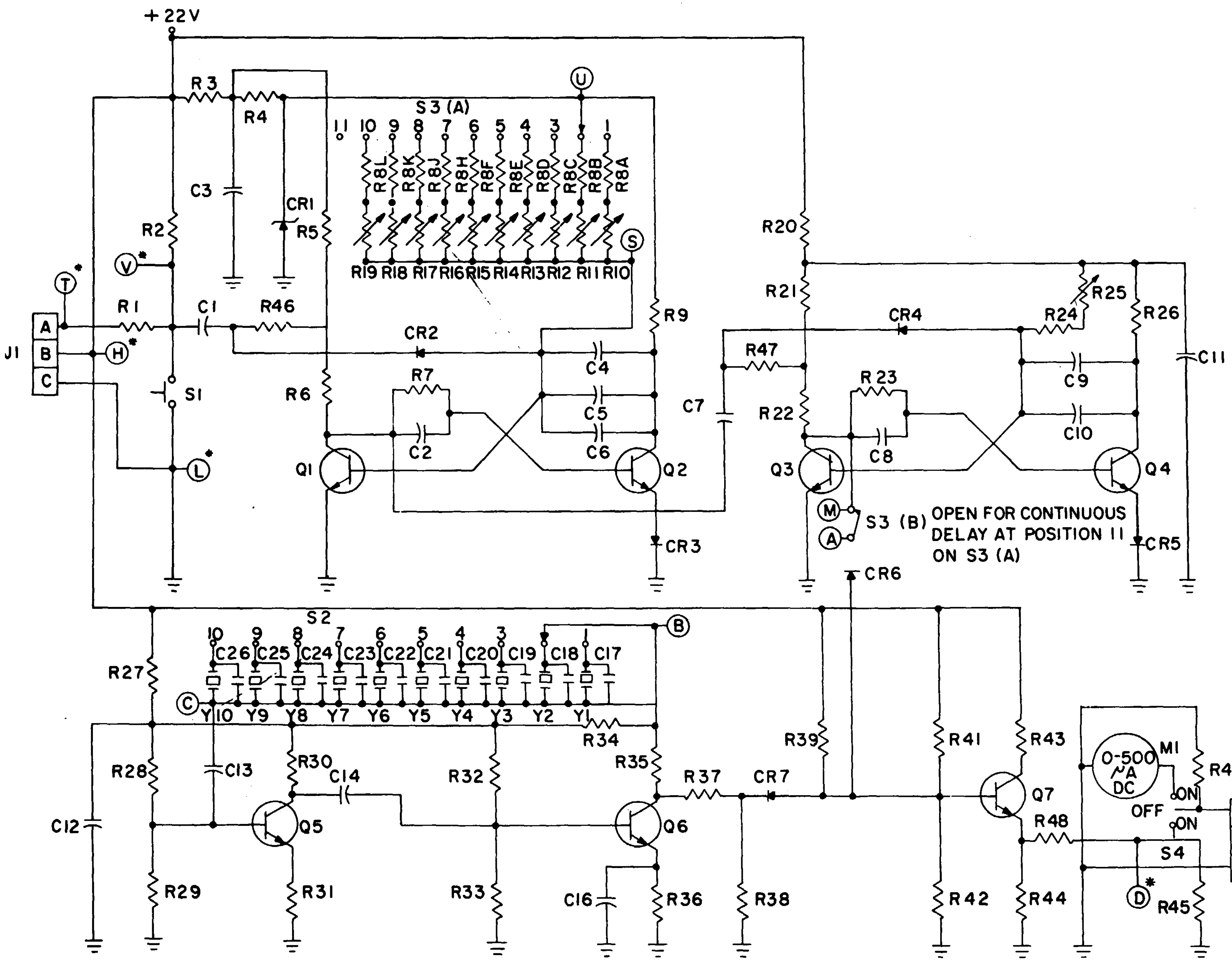


Figure 3-2. Radar chronograph signal interconnection diagram



CHART

WITH THE CORRESPONDING POTENTIOMETER SET AT MID-RANGE SELECT A RESISTOR NEAREST THE RESISTANCE THAT GIVES THE DELAY TIME SHOWN.
RE-ADJUST POTENTIOMETER FOR DELAY TIME SHOWN.

⊕ RESISTOR	DELAY TIME @70° ± 3°F
R8A	158.0 ± .1 MILLISECOND
R8B	200.8 ±
R8C	243.6 ±
R8D	286.4 ±
R8E	329.2 ±
R8F	372.0 ±
R8H	414.8 ±
R8J	457.6 ±
R8K	500.4 ±
R8L	543.2 ±
R24	68 ± .1 MILLISECOND

⊕ = TO BE SELECTED FROM FOLLOWING RESISTORS:

10K ± 1% 1/8 WATT
15K
20K
25.2K
30.1K
35.2K
40.2K
44.8K
50.5K
54.9K
60.4K
64.9K
70.6K
75K
80.6K
85.6K
89.8K
95.3K
98.8K ±1% 1/8 WATT

WE24144

Figure 3-9. Chronograph automatic reliability rater-electrical schematic

CHAPTER 4
REPAIR INSTRUCTIONS

Section I. GENERAL

4-1. Scope

a. This chapter contains maintenance information for the radar chronograph set M36 that is within the scope of Direct Support and General Support maintenance personnel.

b. The scope of Direct Support and General Support maintenance is determined by the listing of maintenance parts and special tools authorized to Direct Support and General Support maintenance in TM 9-1290-325-12/1.

4-2. General Maintenance

The general maintenance procedures applicable to the repair of the chronograph set are described in TM 9-254.

4-3. References

Organizational maintenance of the radar chronograph is covered in TM 9-1290-325-12/1. In this chapter, no maintenance information is furnished for those chassis-mounted electronic components (resistors, capacitors, etc.) which are attached only by being soldered in place (not attached by hardware). These components are identified on the schematic diagram. It is especially important that personnel become familiar with the general maintenance procedures of TM 9-254.

Section II. MAINTENANCE OF RADAR CHRONOGRAPH

4-4. General

Much of the chronograph electronic circuitry is contained in plug-in modules which are potted and sealed and are not repairable. When these modules are found to be faulty, they are to be removed and replaced with new modules. Circuits having repairable components are found in the main frame assembly, frequency control A2 (fig. 4-20), detector amplifier assembly (IF amplifier-detector) A4 (fig. 4-1) audio frequency amplifier A3 (fig. 4-20), under the chassis of digital indicator A5 (fig. 4-20), and in power supply A6 (fig. 4-20). In addition, certain repair can be done on the antenna assembly.

4-5. Removal and Disassembly of Detector Amplifier Assembly A4 (IF Amplifier-Detector

a. To remove detector amplifier assembly A4 from cabinet, proceed as follows:

(1) Disconnect P3, P4, P5 and P6 from waveguide assembly Al (fig. 4-1).

(2) Loosen two retaining screws on P9 and disengage P9 from J1.

(3) Remove detector amplifier A4 from cabinet (fig. 4-2).

b. Refer to figures 4-3, 4-4, and 4-5 for removal of parts from the detector amplifier assembly. Procedure for disassembly and assembly is obvious and does not require detailed explanation.

4-6. Alinement of Detector Amplifier IF Circuits

a. Connect detector amplifier assembly A4 (fig. 4-1) to power supply, providing separately switched lines for the 6.3 volt ac heater supply (connector J1-A), 130 volt supply (connector J1J) and 22 volt supply (connector J1-F). Place all switches in OFF position.

Note. See figure 4-1 for connector J1. Pin numbers are marked on the connector.

b. Connect rf signal generator AN/USM-44 to plug P4 (fig. 4-1). Set generator for approximately 45 mc at 1 mv output.

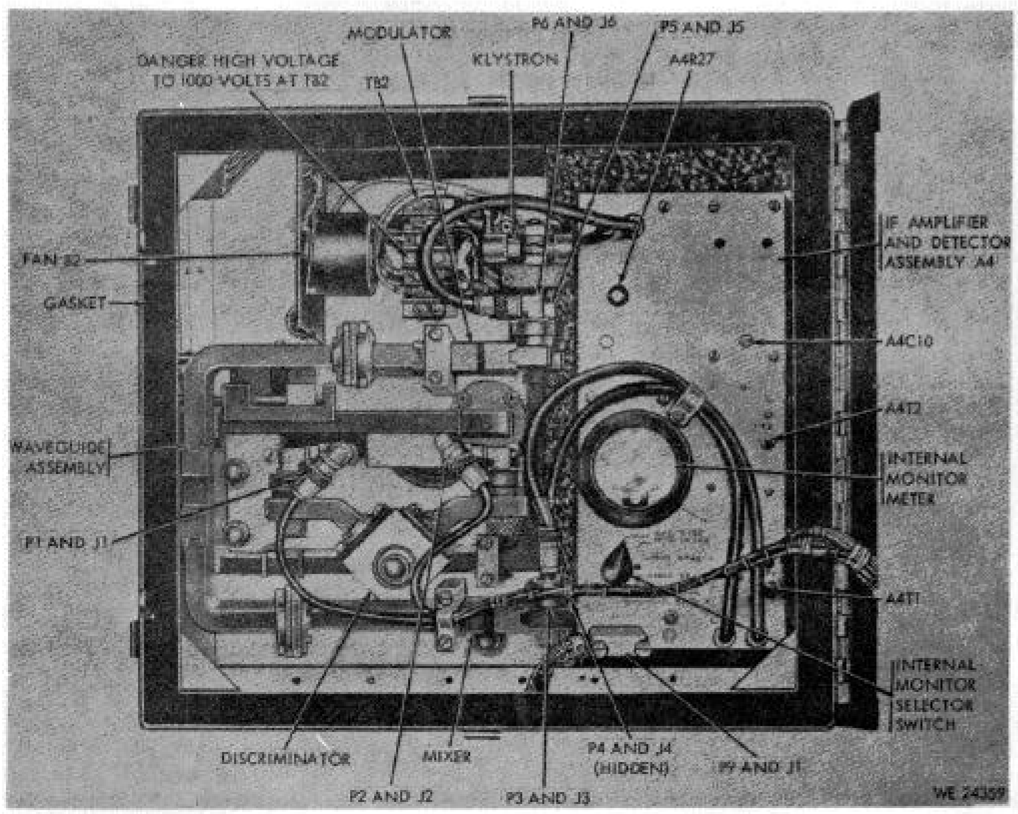


Figure 4-1. Chronograph cabinet front section-interior view.

c. Connect a VTVM (TS-505D/U) to test point J6.

d. Turn on main power supply, then 6.3 volt ac, 130 volt dc, and 22 volt dc outputs.

e. Vary signal generator frequency around 45 mc until a null indication is seen on voltmeter. This should occur at 45 mc.

f. Connect oscilloscope (AN/USM-50A), set at an input frequency of 75 kc to J1, pin M.

g. Set the signal generator to 44.925 mc at 1 mv. The output seen on the oscilloscope should have a frequency of 75 $\pm$ 25 kc. Peak the output by adjusting C10, T2, and T1 (fig. 4-1) in the given sequence.

h. Readjust C10, T2, and T1 several times in the same sequence, if required to ensure good alinement.

4-7. Removal and Disassembly, of Antenna Assembly

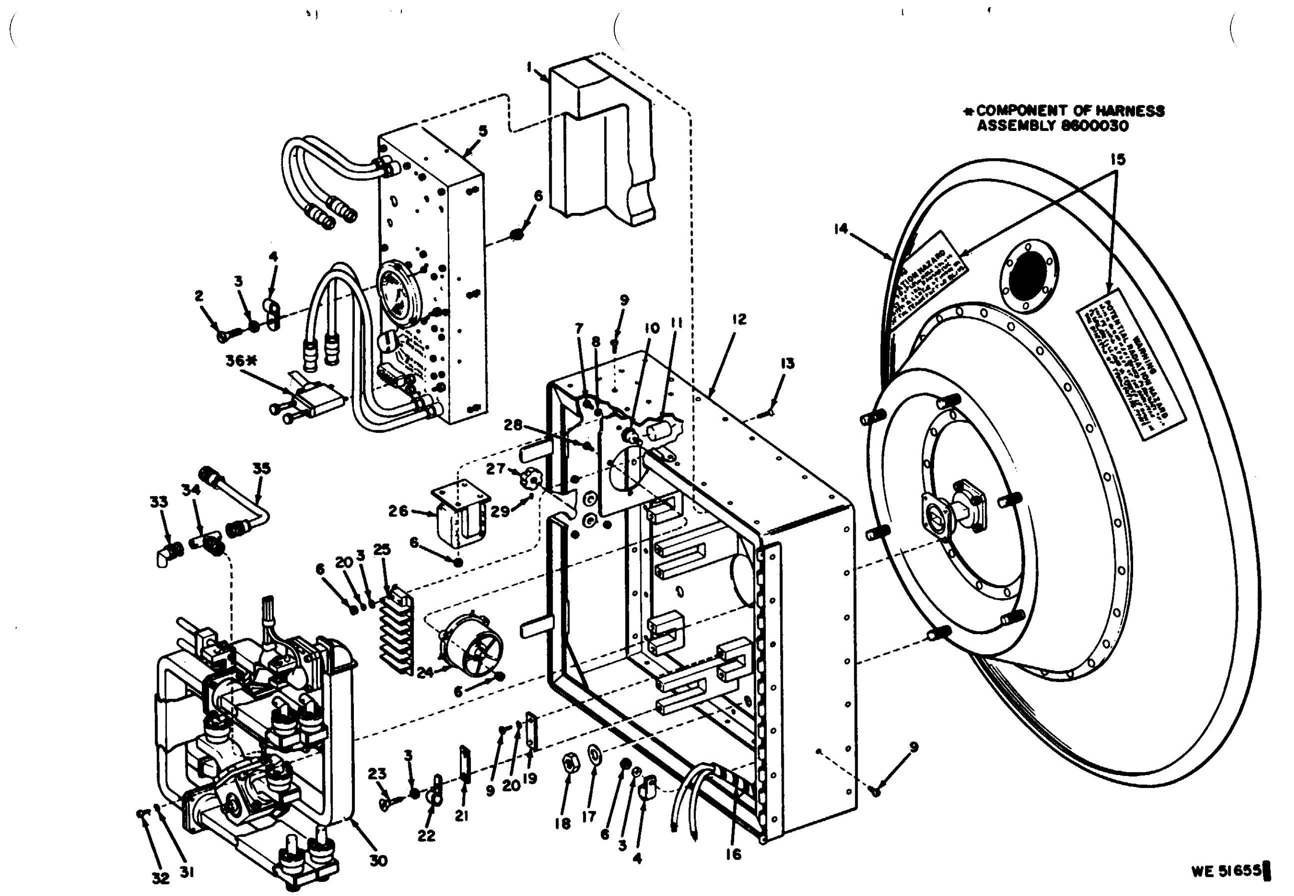
To perform any repair work on the antenna assembly or its feed element, it is necessary to first remove the antenna assembly from the chronograph cabinet. This entails removing the detector amplifier assembly (para 4-5).

***Note*. Key numbers shown below in parentheses refer to figure 4-2, unless otherwise indicated.**

a. Remove detector amplifier A4 (5) as indicated in paragraph 4-5.

(1) Disconnect plugs P1 and P2 from J1 and J2 on waveguide assembly (30).

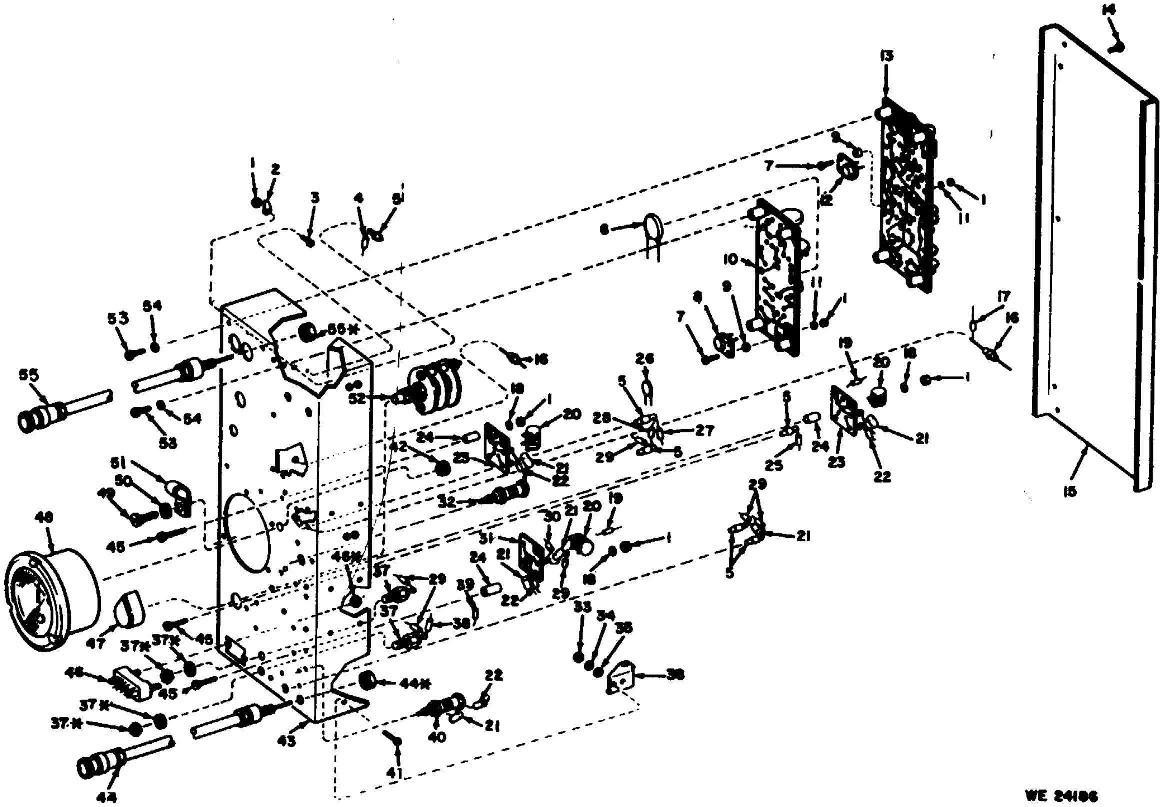
(2) Loosen the two setscrews (29) on each of the LEAKAGE ADJUSTMENT knobs (27) and remove knobs (27).



1 Mount 5340-956-4862
2 Screw 5305-811-6852
3 Washer 5310-722-5998
4 Clamp MS25281-4P
5 Amplifier, detector 1290-870-3749
6 Nut 5310-034-4875
7 Screw 5305-054-5647
8 Washer 5310-933-8118
9 Screw 5305-054-6654
10 Lug terminal 5940-204-8023
11 Capacitor 5910-889-4359
12 Cabinet 10531895
13 Screw 5305-811-6851
14 Antenna 1290-863-3198
15 Decal 1290-179-5284
16 Harness 8600030
17 Washer 5310-620-8186
18 Nut 5310-810-1786
19 Clamp 10531840-1
20 Washer 5310-929-6345
21 Clamp 10531840-2
22 Clamp MS25281-6P
23 Screw 5305-811-6834
24 Fan 4140-791-8459
25 Terminal board 10525529
26 Transformer 5950-984-7126
27 Knob 5355-080-8917
28 Screw 5305-054-6655
29 Setscrew 5305-717-6948
30 Waveguide assembly 10525550
31 Washer 5310-933-8119
32 Screw 5305-988-7601
33 Adapter 5935-847-2600
34 Adapter 5935-683-7892
35 Cable assembly 1290-022-9843
36 Shield 10525710[1]

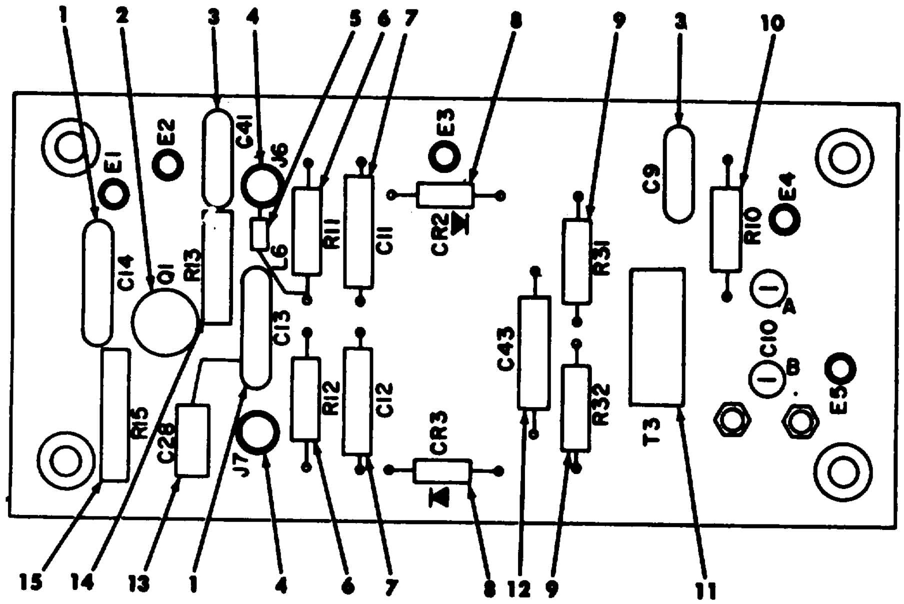
[1]Component of harness assembly 8600030

Figure 4-2. Radar chronograph 10525300-exploded front view.



1 Nut 5310-034-4874
2 Lug terminal 5940-614-0537
3 Screw 5305-054-5648
4 Resistor 5905-087-4204
5 Insulator 10525689
6 Capacitor 5910-950-9873
7 Screw 5305-054-5651
8 Capacitor 5910-646-6357
9 Spacer 10525460-3
10 Amplifier detector 10525651
11 Washer 5310-782-1349
12 Capacitor 5910-084-3236
13 Detector amplifier subassembly 10525655
14 Screw 5305-054-6652
15 Cover 10525679
16 Capacitor 5910-034-0900
17 Resistor 5905-190-8889
18 Washer 5310-595-6211
19 Coil 5950-042-9865
20 Electron tube 5960-752-5460
21 Capacitor 5910-034-0903
22 Resistor 5905-279-1894
23 Printed circuit board 10525646
24 Spacer 10525460-1
25 Resistor 5905-279-3505
26 Capacitor 5910-051-6214
27 Resistor 5905-279-2522
28 Semiconductor device diode 5961-061-9492
29 Coil 5950-058-9074
30.Resistor 5905-195-6761
31 Printed circuit board 10525643
32 Transformer 5950-034-4878
33 Nut 5310-271-4640
34 Washer 5310-058-3829
35 Washer 5310-595-6761
36 Plate nut 10525677
37 Capacitor 5910-823-1822
38 Resistor 5905-299-1541
39 Capacitor 5910-577-6859
40 Transformer 5950-083-2791
41 Screw 5305-054-5637
42 Nut 5310-034-4875
43 Chassis 10525673
44 Cable assembly 1290-022-9841
45 Screw 5305-054-5652
46 Connector 1290-945-6958
47 Knob 5355-644-2013
48 Ammeter 6625-080-6992
49 Screw 5305-054-6653
50 Washer 5310-722-5998
51 Clamp MS25281-8P
52 Switch 5930-970-8661
53 Screw 5305-054-6651
54 Washer 5310-011-1041
55 Cable assembly 1290-020-8707

Figure 4-3. Amplifier, detector (1290-870-3749) exploded view.



WE 24107

1 Capacitor 5910-081-6733
2 Transistor 5961-843-6883
3 Capacitor 5910-838-9421
4 Jack 10525668
5 Coil 5950-724-6209
6 Resistor 5905-615-7339
7 Capacitor 5910-816-6613
8 Semiconductor device diode 5961-061-9492
9 Resistor 5905-984-7680
10 Resistor 5905-279-3513
11 Transformer 5950-034-4879
12 Capacitor 5910-838-3852
13 Capacitor 5910-084-3235
14 Resistor 5905-192-0390
15 Resistor 5905-195-6761

Figure 4-4. Amplifier, detector subassembly 10525651--assembled view.

(3) Disconnect klystron leads from terminal board TB2 (fig. 4-1); identify each lead.

(4) Remove two screws (9) and washers (20) from each clamp (19) and two screws (23) and washers (3) from each clamp (22).

(5) Remove four screws (32) and washers (31) holding waveguide to antenna feed.

(6) Remove waveguide assembly (30).

(7) Remove six nuts (18) and washers (17) on threaded studs holding antenna (14) to front cabinet section.

(8) Carefully remove antenna (14) by sliding antenna mounting studs forward and out of holes in the cabinet wall.

b. Remove antenna feed subassembly (fig. 4-6).

(1) Remove six rivets (1), retaining washer (2) and wire fabric (3) from reflector (4).

(2) Remove four screws (5) and nuts (8) holding antenna feed subassembly (7) to antenna reflector (4).

(3) Draw antenna subassembly (7) out through hole in reflector (4).

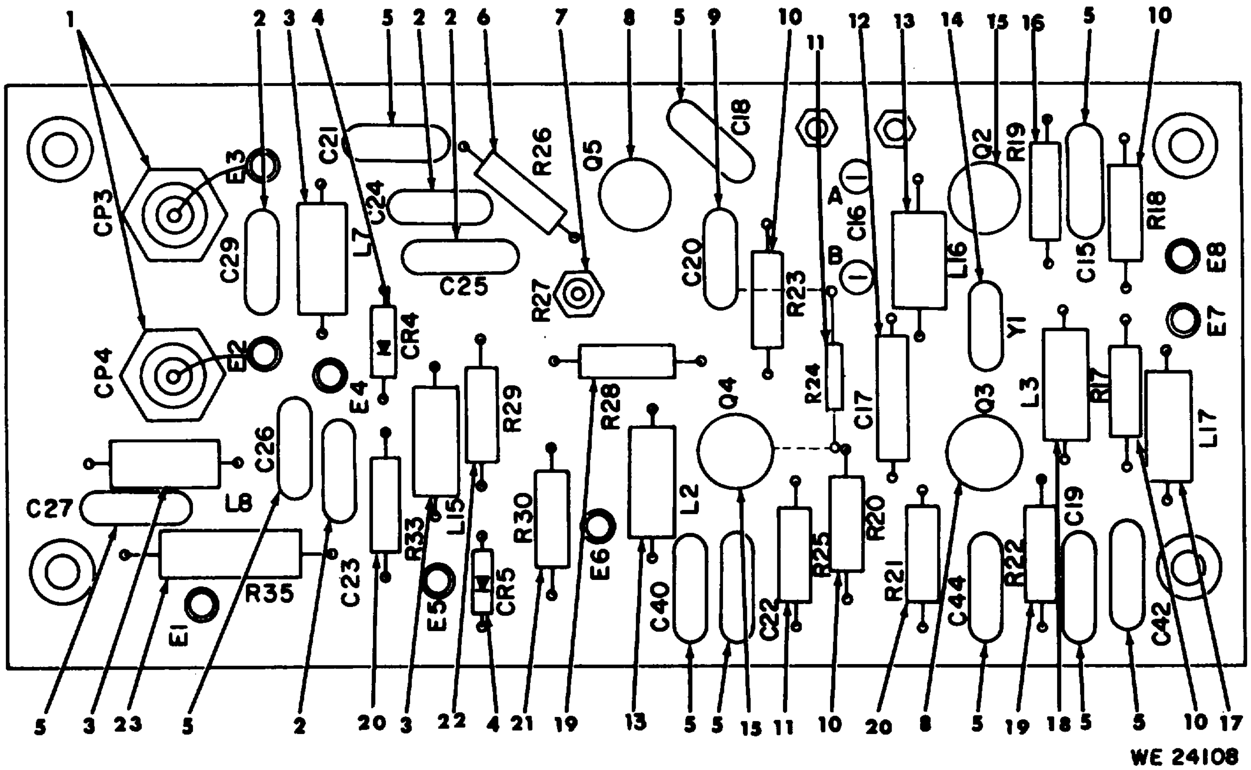
c. Procedure for the reassembly of the antenna assembly is obvious and does not require detailed explanation.

4-8. Removal and Replacement of Waveguide Diodes

The procedure for removal and replacement of the waveguide diodes does not require detailed explanation. Refer to TM 9-1290-324-12/1 for illustration and removal procedures.

4-9. Removal and Replacement of Klystron Electron Tube

The procedure for removal and replacement of the klystron tube does not require detailed explanation. Refer to TM 9-1290-325-12/1 for illustration and removal procedures.



1 Cable assembly 1290-020-8707
2 Capacitor 5910-034-0903
3 Coil 5950-058-9074
4 Semiconductor device diode 5961-061-9492
5 Capacitor 5910-838-9421
6 Resistor 5905-279-3504
7 Resistor 5905-084-3232
8 Transistor 5961-840-3561
9 Capacitor 5910-045-6541
10 Resistor 5905-195-6761
11 Resistor 5905-171-2006
12 Capacitor 5910-084-3235
13 Coil 10525658
14 Crystal 5955-083-2788
15 Transistor 5960-022-9842
16 Resistor 5905-195-6806
17 Coil 5950-704-1993
18 Coil 5950-042-9865
19 Resistor 5905-192-3973
20 Resistor 5905-195-6453
21 Resistor 5905-190-8889
22 Resistor 5905-192-0667
23 Resistor 5905-101-7892

Figure 4-5. Amplifier, detector .subassembly 10525655--assembled view.

4-10. Removal and Replacement of Heater Transformer T2

See figure 4-2 for removal and replacement of heater transformer T2. Procedures are obvious and do not require detailed explanation.

4-11. Removal and Replacement of Fan B2

See figure 4-2 for removal and replacement of fan B2. Procedures are obvious and do not require detailed explanation.

4-12. Removal, Disassembly and Assembly of Frequency Control A2

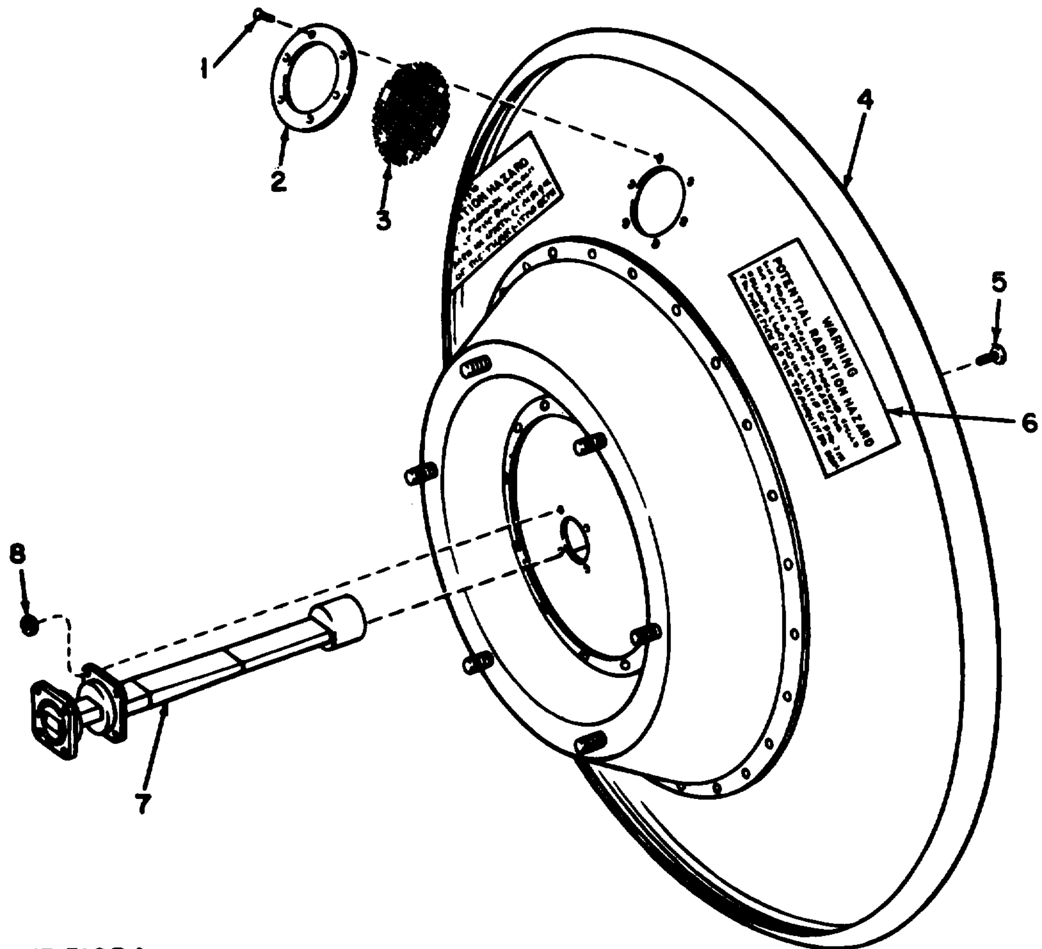
a. The procedure for removal and replacement of frequency control A2 does not require detailed explanation. Refer to TM 9-1290-32512/1 for illustration and removal procedures.

b. Refer to figure 4-7 for removal of parts from the frequency control assembly. Procedures for disassembly and assembly is obvious, and does not require detailed explanation.

4-13. Removal, Disassembly, and Assembly of Audio Frequency Amplifier A3

a. The procedure for removal and replacement of audio frequency amplifier A3 does not require detailed explanation. Refer to TM 9-1290-325-12/1 for illustration and removal procedures.

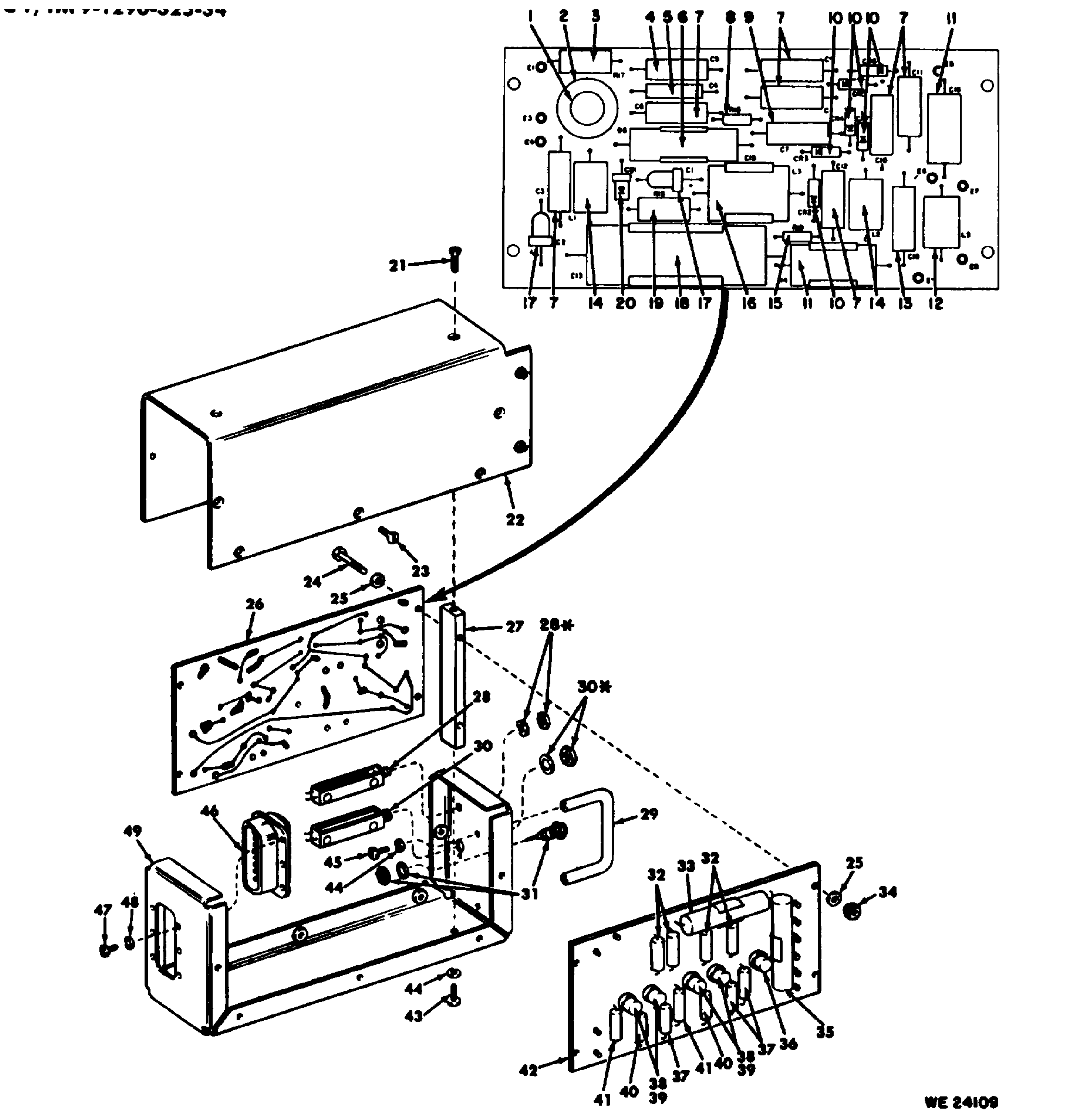
b. Refer to figures 4-8, 4-9, 4-10, and 4-11 for removal of parts from audio frequency amplifier A3. Procedures for disassembly and assembly are obvious and do not require detailed explanation.



WE 51654

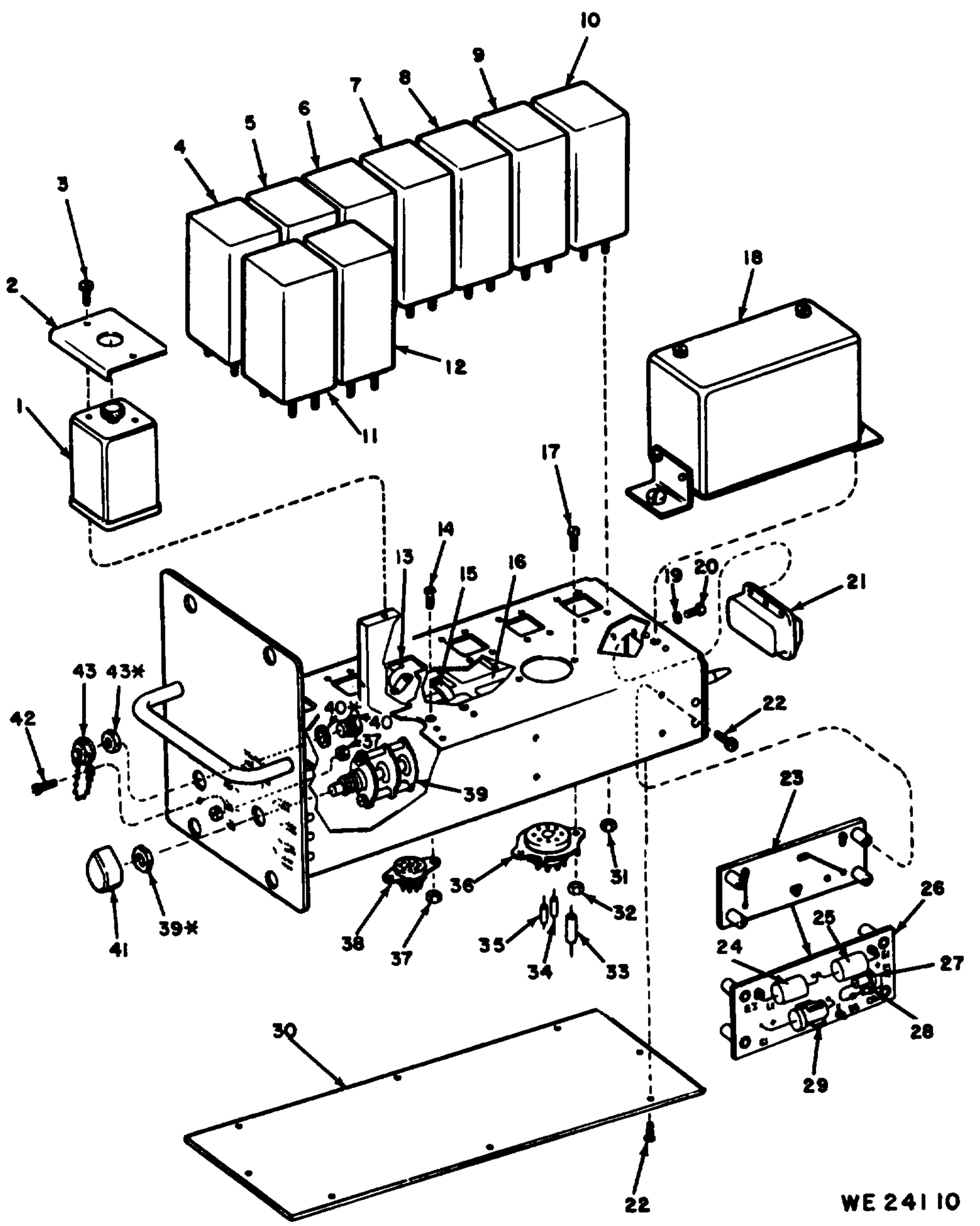
1 Rivet MS20470AD3-6
1 Washer 10525622
3 Wire fabric 10525621
4 Reflector 1290-020-2378
5 Screw 5305-054-6671
6 Decal 1290-179-5284
7 Antenna subassembly 1290-863-3192
8 Nut 5310-034-4876

Figure 4-6. Antenna 1290-863-S198-exploded view.



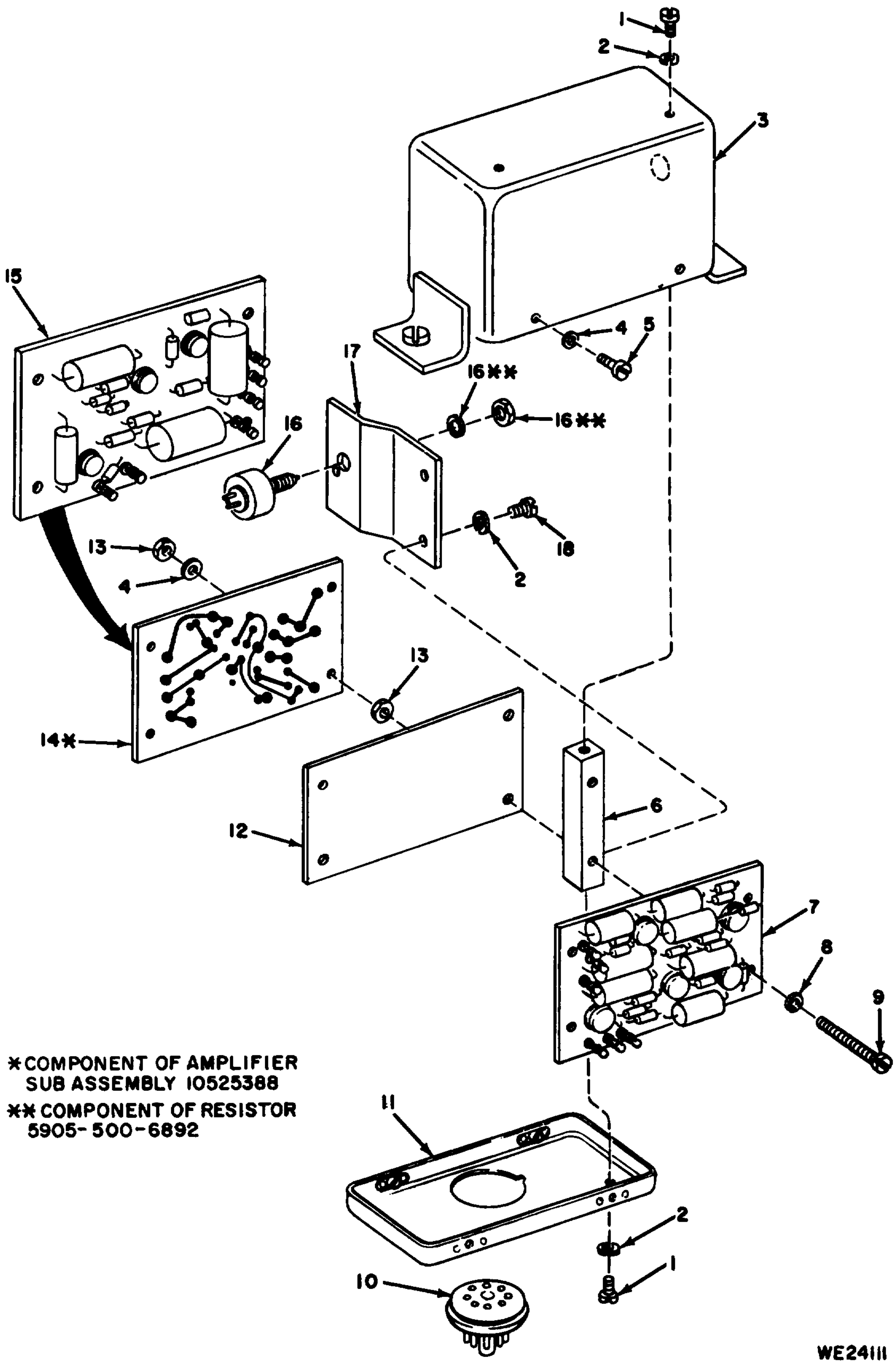
1 Transistor 5961-807-7339
2 Dissipator 10525540
3 Resistor 5905-279-3507
4 Capacitor 5910-823-1145
5 Capacitor 5910-022-9850
6 Capacitor 5910-807-5570
7 Capacitor 5910-821-4702
8 Resistor 5905-185-8510
9 Capacitor 5910-833-7797
10 Semiconductor device diode 5961-765-6597
11 Capacitor 5910-543-9502
12 Coil 5950-802-0914
13 Capacitor 5910-810-0182
14 Coil 5950-835-8848
15 Resistor 5905-279-2510
16 Coil 5950-686-2821
17 Capacitor 5910-721-2272
18 Capacitor 5910-034-0902
19 Resistor 5905-185-8507
20 Semiconductor device diode 5961-772-9030
21 Screw 5305-811-6833
22 Cover 10525507
23 Screw 5305-811-6840
24 Screw 5305-054-6658
25 Washer 5310-722-5998
26 Frequency control subassembly 10525469
27 Post 10525506
28 Resistor 5905-950-3197
29 Handle 10525574
30 Resistor 5905-552-5490
31 Jack MS16108-1A
32 Resistor 5905-834-0019
33 Resistor 5905-973-3936
34 Nut 5310-034-4875
35 Resistor 5905-978-8625
36 Transistor 5961-583-1553
37 Resistor 5905-752-3692
38 Transistor 5960-831-2886
39 Pad 5840-774-7688
40 Resistor 5905-811-4309
41 Resistor 5905-279-3513
42 Frequency control subassembly 10525468
43 Screw 5305-054-6651
44 Washer 5310-011-1041
45 Screw 5305-054-6652
46 Connector 5935-034-0899
47 Screw 5305-054-5647
48 Washer 5310-042-9609
49 Chassis 10525508

Figure 4-7. Control, frequency A£ (1290-863-5644)-exploded view.



1 Filter 5915-863-5660
2 Cap assembly 10525427
3 Screw 5305-083-2790
4 Filter 5915-078-2745
5 Filter 5915-850-4274
6 Filter 5915-850-4277
7 Filter 5915-850-4278
8 Filter 5915-850-4279
9 Filter 5915-078-2742
10 Filter 5915-851-1572
11 Filter 5915-078-2744
12 Filter 5915-078-2743
13 Lug terminal 5940-838-2651
14 Screw 5305-080-4326
15 Clamp MS25281-5
16 Harness 8600029
17 Screw 5305-054-6651
18 Amplifier 10525373
19 Washer 5310-042-9609
20 Screw 5305-054-5647
21 Connector 5935-034-0899
22 Screw 5305-080-6502
23 Printed circuit board 10525418
24 Coil 5950-727-0593
25 Resistor 5905-185-6580
26 Amplifier subassembly 10525419
27 Capacitor 5910-814-9754
28 Semiconductor device diode 5961-060-8983
29 Capacitor 5910-772-9807
30 Cover 10525423
31 Nut 5310-034-4876
32 Nut 5310-034-4875
33 Capacitor 5910-899-4395
34 Resistor 5905-279-3503
35 Resistor 5905-195-6761
36 Socket 5935-160-1364
37 Nut 5310-034-4874
38 Socket 5935-577-8695
39 Switch 5930-970-8662
40 Connector 5935-552-7660
41 Knob 5355-644-2018
42 Screw 5305-054-5650
43 Cover 5935-252-6340

Figure 4-8. Amplifier, audio frequency AS (12990-020-2379)--exploded view.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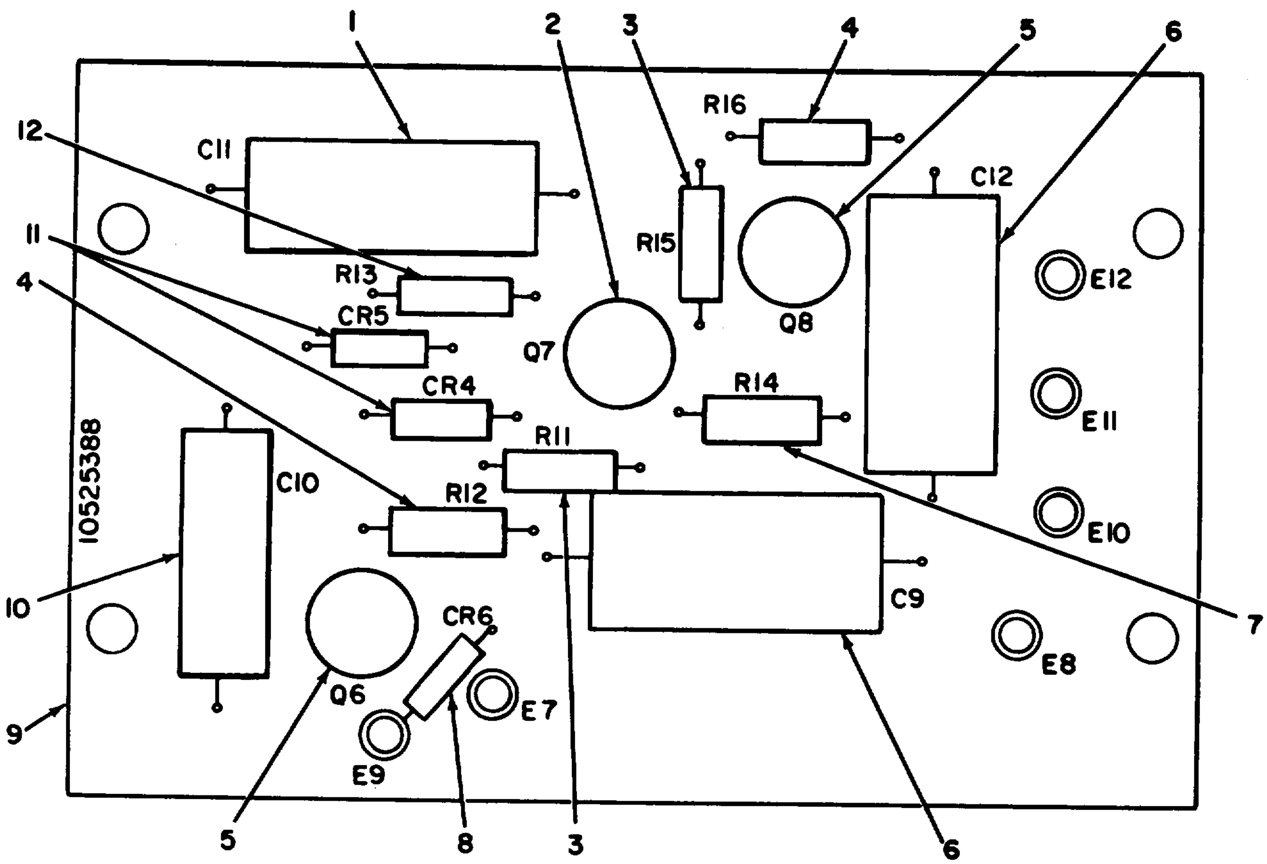
*COMPONENT OF AMPLIFIER SUB ASSEMBLY 10525388
**COMPONENT OF RESISTOR 5905-500-6892
WE24111

1 Screw 5305-054-6651
2 Washer 5310-011-1041
3 Case 10525375
4 Washer 5310-042-9609
5 Screw 5305-054-5647
6 Post 10525378
7 Amplifier subassembly 10525389
8 Washer 5310-595-6211
9 Screw 5305-054-5653
10 Connector 5935-258-0199
11 Cover 10525376
12 Shield 8600034
13 Nut 5310-271-4642
14 Printed circuit board 10525387 [1]
15 Amplifier subassembly 10525388
16 Resistor 5905-500-6892
17 Bracket 10525377
18 Screw 5305-054-6652

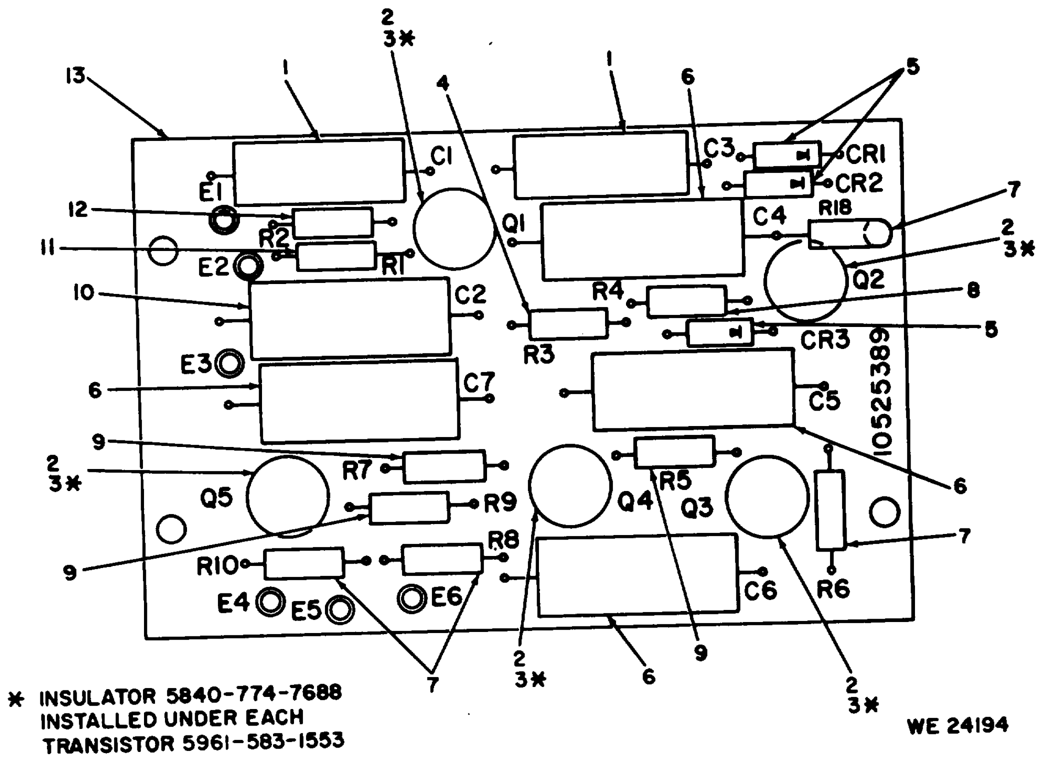
Figure 4-9. Amplifier A3A1 (10525373)- exploded view

[1] Component of amplifier subassembly 10525388.



1 Capacitor 5910-818-9758
2 Transistor 5961-843-6883
3 Resistor 5905-279-3504
4 Resistor 5905-279-2522
5 Transistor 5961-583-1553
6 Capacitor 5910-833-9280
7 Resistor 5905-279-1880
8 Semiconductor device diode 5961-761-2030
9 Printed circuit board 10525387
10 Capacitor 5910-821-4702
11 Semiconductor device diode 5961-765-6597
12 Resistor 5905-195-6761

Figure 4-10. Amplifier subassembly 10525388. assembled view.



1 Capacitor 5910-821-4702
2 Transistor 5961-583-1553
3 Insulator pad 5840-774-7688 [1]
4 Resistor 5905-190-8887
5 Semiconductor device diode 5961-617-4357
6 Capacitor 5910-899-4395
7 Resistor 5905-195-6761
8 Resistor 5905-185-8510
9 Resistor 5905-279-1756
10 Capacitor 5910-894-1614
11 Resistor 5905-279-3504
12 Resistor 5905-279-252
13 Printed circuit board 10525386

Figure 4-11. Amplifier subassembly 10525389 - assembled view.

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[1] **Insulator 5840-774-7688 installed under each transistor 5961-583-1553.**

4-14. Removal, Disassembly, and Assembly of Digital Display Indicator A5

(figs. 4-12, 4-13, 4-14, and 4-15)

a. The procedure for removal and replacement of digital display indicator A5 does not require detailed explanation. Refer to TM 9-1290-32512/1 for illustration and removal procedures.

b. Refer to figure 4-12 for removal of parts from top of digital display indicator A5 and to figures 4-13, 4-14, and 4-15 for removal of parts from bottom. Procedures for disassembly and assembly are obvious and do not require detailed explanation.

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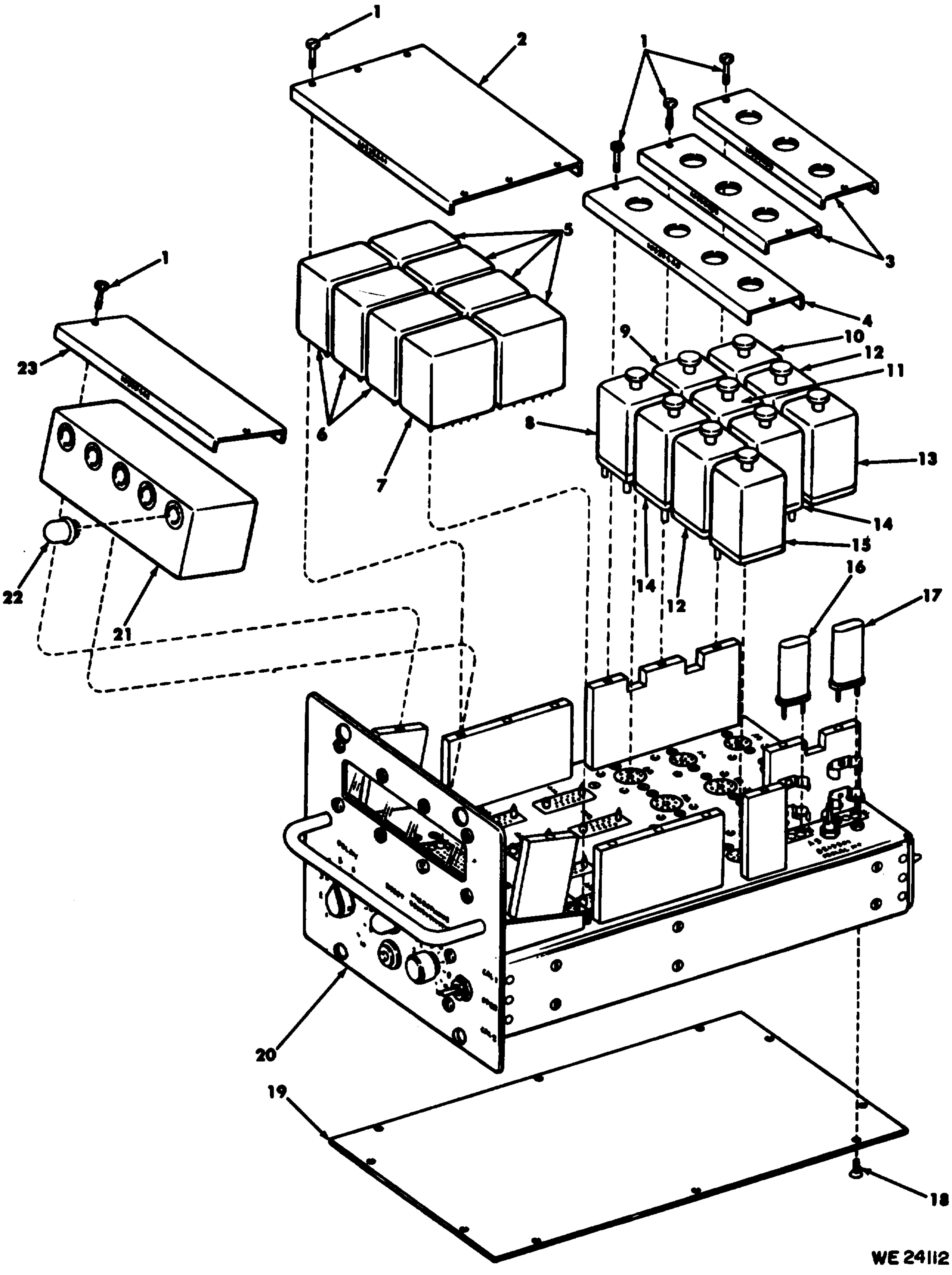
1 Screw 5305-083-2790
2 Cover 10525441
3 Cover 10525439
4 Cover 10525440
5 Counter 1290-863-3191
6 Counter 1290-863-3190
7 Frequency divider 1290-974-3876
8 Gate 1290-870-3755
9 Indicator 1290-870-3754
10 Generator 1290-864-0358
11 Generator 1290-864-0357
12 Amplifier 1290-863-5659
13 Oscillator 1290-084-3238
14 Gate 1290-870-3753
15 Oscillator 1290-083-2792
16 Crystal 5955-774-5951
17 Crystal 5955-083-2788
18 Screw 5305-080-6502
19 Cover 10525430
20 Indicator subassembly 8215495
21 Indicator 1290-020-2370
22 Electron tube 5960-808-6976
23 Cover 10525442

Figure 4-12. Indicator, digital display A5 (1290-020-2369)-exploded view of top.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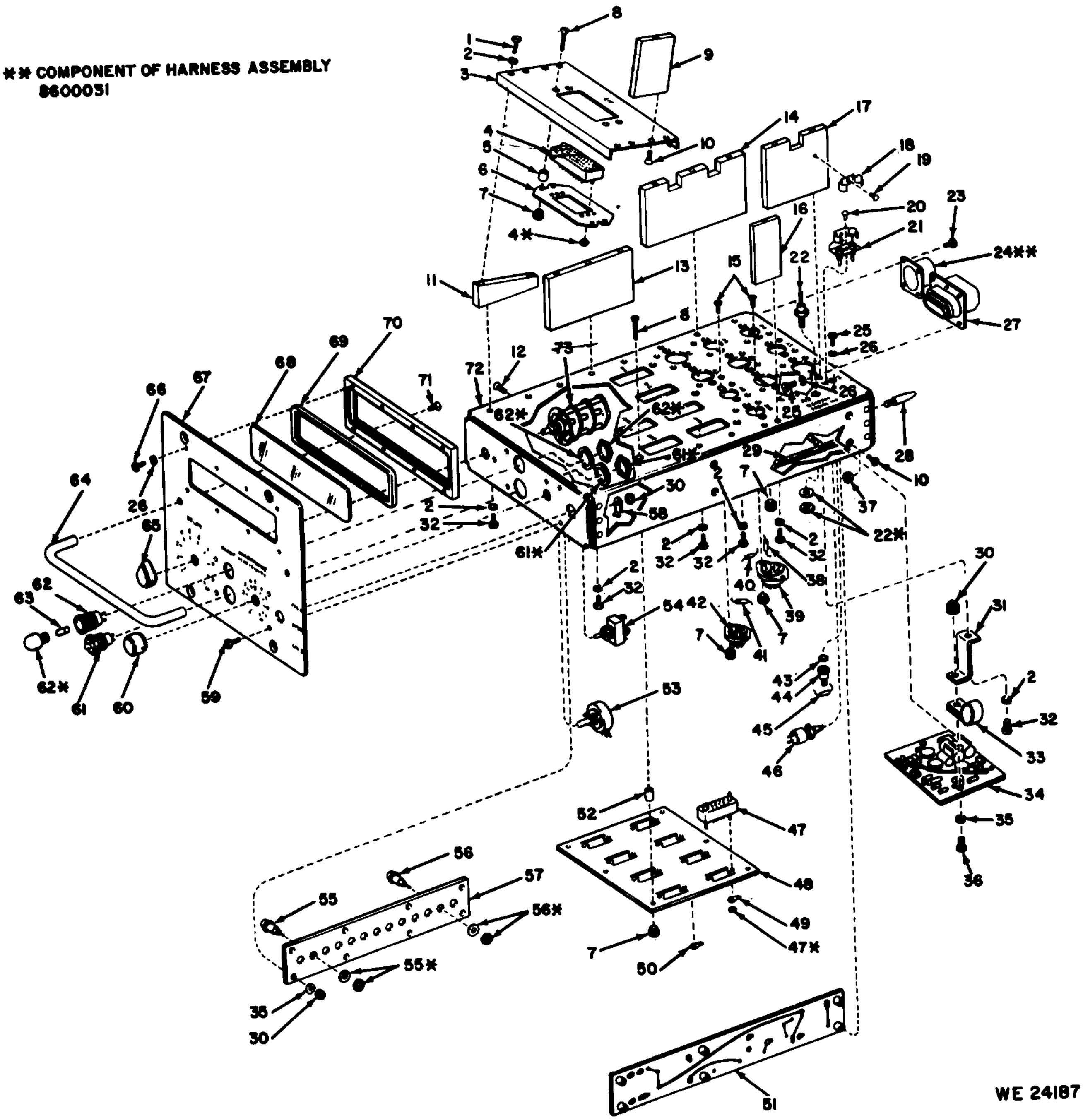
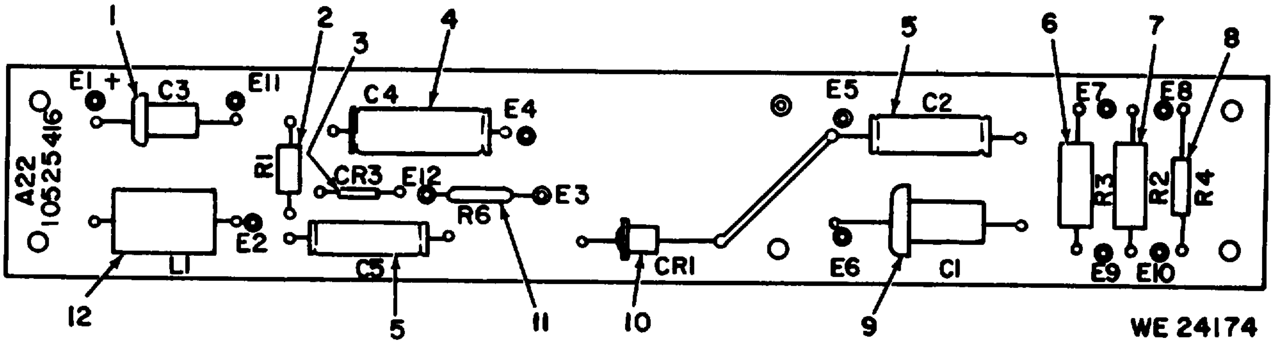


1 Screw 5305-054-6651
2 Washer 5310-011-1041
3 Support 8215509
4 Connector MS24021-1
5 Spacer 10525460-1
6 Plate 8215511
7 Nut 5310-034-4874
8 Screw 5305-811-6827
9 Support 10525447
10 Screw 5305-811-6834
11 Support 10525458
12 Screw 5305-655-6827
13 Support 10525446
14 Support 10525445
15 Screw 5305-811-6840
16 Support 10525443
17 Support 10525444
18 Clip 10525541
19 Rivet MS16535-70
20 Rivet MS16535-64
21 Socket 5935-840-2025
22 Semiconductor device diode 5961-060-8984
23 Screw 5305-054-5648
24 Connector 5935-755-3688 [1]
25 Screw 5305-054-5647
26 Washer 5310-042-9609
27 Connector 5935-034-0899
28 Pin 10512542
29 Harness 8600031



1 Capacitor 5910-721-2272
2 Resistor 5905-279-3502
3 Semiconductor device diode 5961-284-6516
4 Capacitor 5910-899-4895
5 Capacitor 5910-821-4702
6 Resistor 5905-299-2021
7 Resistor 5905-279-3831
8 Resistor 5905-195-6806
9 Capacitor 5910-806-9977
10 Semiconductor device diode 5960-060-8985
11 Resistor 5905-192-0649
12 Coil 5950-686-2821

Figure 4-14. Indicator subassembly 105254168--assembled view.

4-15. Removal, Disassembly and Assembly of Power Supply A6
(figs. 4-16, 4-17, and 4-18)

a. The procedure for removal and replacement of power supply A6 does not require detailed explanation. Refer to TM 9-1290-325-12/1 for illustration and removal procedures.

b. Refer to figures 4-16, 4-17, and 4-18 for removal of parts from power supply. Procedures for disassembly and assembly are obvious and do not require detailed explanation.

4-16. Removal and Replacement of Elevation Dial
(fig. 4-19)

Refer to figure P19. Procedures are obvious and do not require detailed explanation.

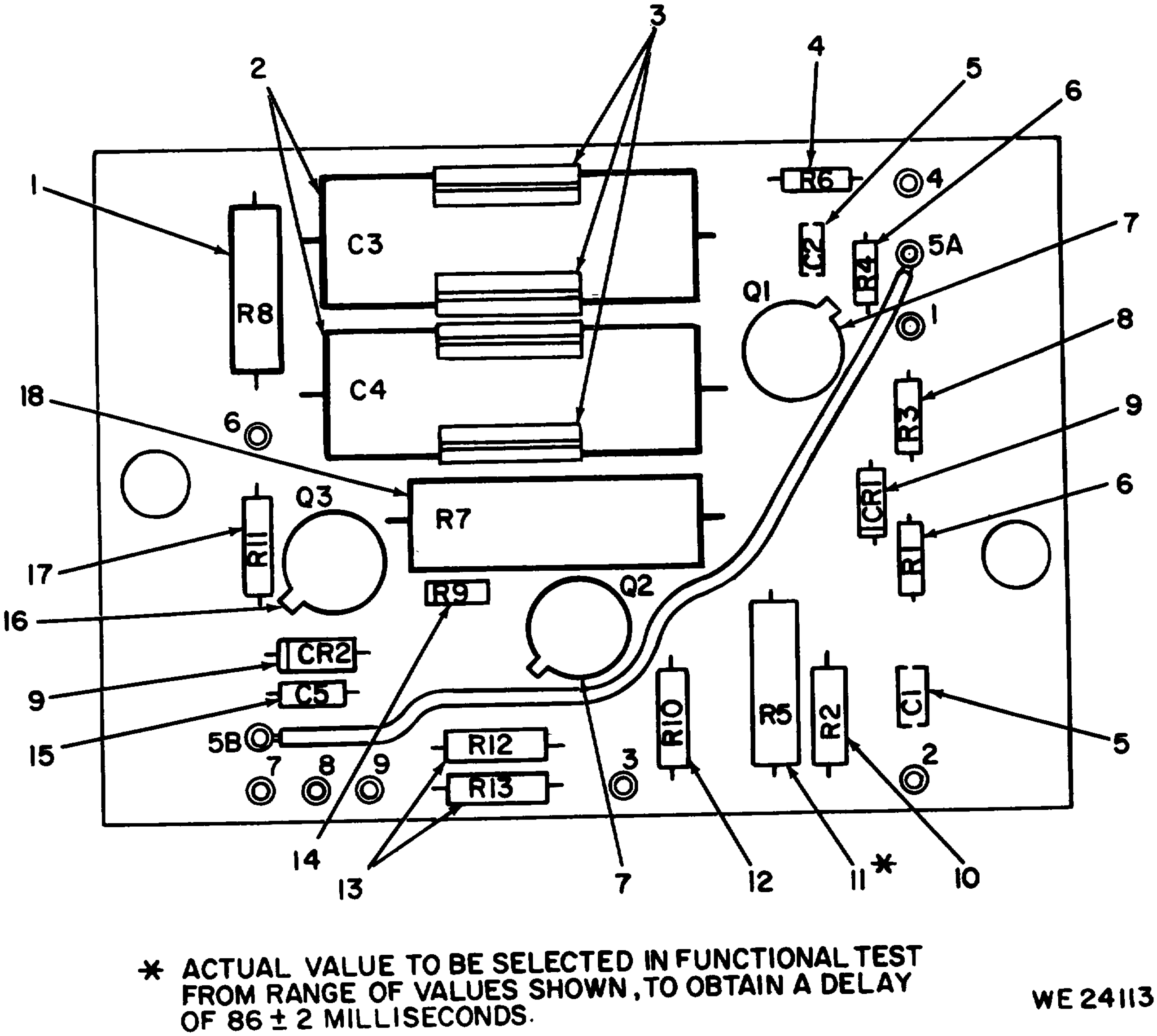
4-17. Repair of Air Filters 4310-083-2789

The procedure for repairing the air filters does not require detailed explanation. Refer to TM 9-1290-325-12/1 for illustration and removal procedures.

30 Nut 5310-034-4875
31 Bracket 8577949
32 Screw 5305-054-6652
33 Clamp MS25281-8P
34 Delay reset assembly 10549950
35 Washer 5310-722-5998
36 Screw 5305-054-6654
37 Nut 5310-596-6878
38 Resistor 5905-683-2238
39 Socket 5935-577-8695
40 Resistor 5905-686-3798
41 Resistor 5905-192-0390
42 Socket 5935-581-6400
43 Washer 5310-595-6211
44 Terminal 5940-204-8023
45 Resistor 5905-195-6806
46 Resistor 5905-581-1403
47 Connector 5935-899-4727
48 Support 8215507
49 Terminal 7653708
50 Terminal 507009
51 Printed circuit board subassembly 10525416
52 Spacer 10525460-1
53 Resistor 5905-581-0447
54 Switch 5930-548-5335
55 Jack MS16108-1A
56 Jack MS16108-3A
57 Board 8215506
58 Lub terminal MS35431-3
59 Screw 5305-054-6653
60 Knob 5355-080-8916
61 Switch 5930-501-1749
62 Indicator light 6210-034-0905
63 Lamp 6240-581-1598
64 Handle 10525607-1
65 Knob 5355-644-2013
66 Screw 5305-054-5649
67 Panel 10512503
68 Window 1290-080-5316
69 Seal 10525638
70 Frame 10525485
71 Screw 5305-811-6836
72 Chassis 8215508
73 Switch 5930-970-8660

Figure 4-13. Indicator, digital display subassembly A5 (8215495)x-exploded view.

[1]**Component of harness assembly 8600031.**



1 Resistor 5905-752-3602
2 Capacitor 5910-837-2813
3 Clip 10525542-9
4 Resistor 5905-723-5251
5 Capacitor 5910-811-8200
6 Resistor 5905-683-2238
7 Transistor 5961-837-7262
8 Resistor 5905-686-3369
9 Semiconductor device diode 5961-985-4900
10 Resistor 5905-195-6806
11 Resistor 5905-682-0202 [1]
Resistor 5905-883-0981 [1]
Resistor 5905-851-9537 [1]
Resistor 5905-823-3474 [1]
Resistor 5905-059-7485 [1]
Resistor 5905-823-3524 [1]
Resistor 5905-866-0250 [1]
12 Resistor 5905-279-3513
13 Resistor 5905-279-3503
14 Resistor 5905-686-3370
15 Capacitor 5910-011-8821
16 Transistor 5961-829-0194
17 Resistor 5905-192-0890
18 Resistor 5905-879-2889

Figure 4-15. Delay reset assembly 10549950-assembled view.

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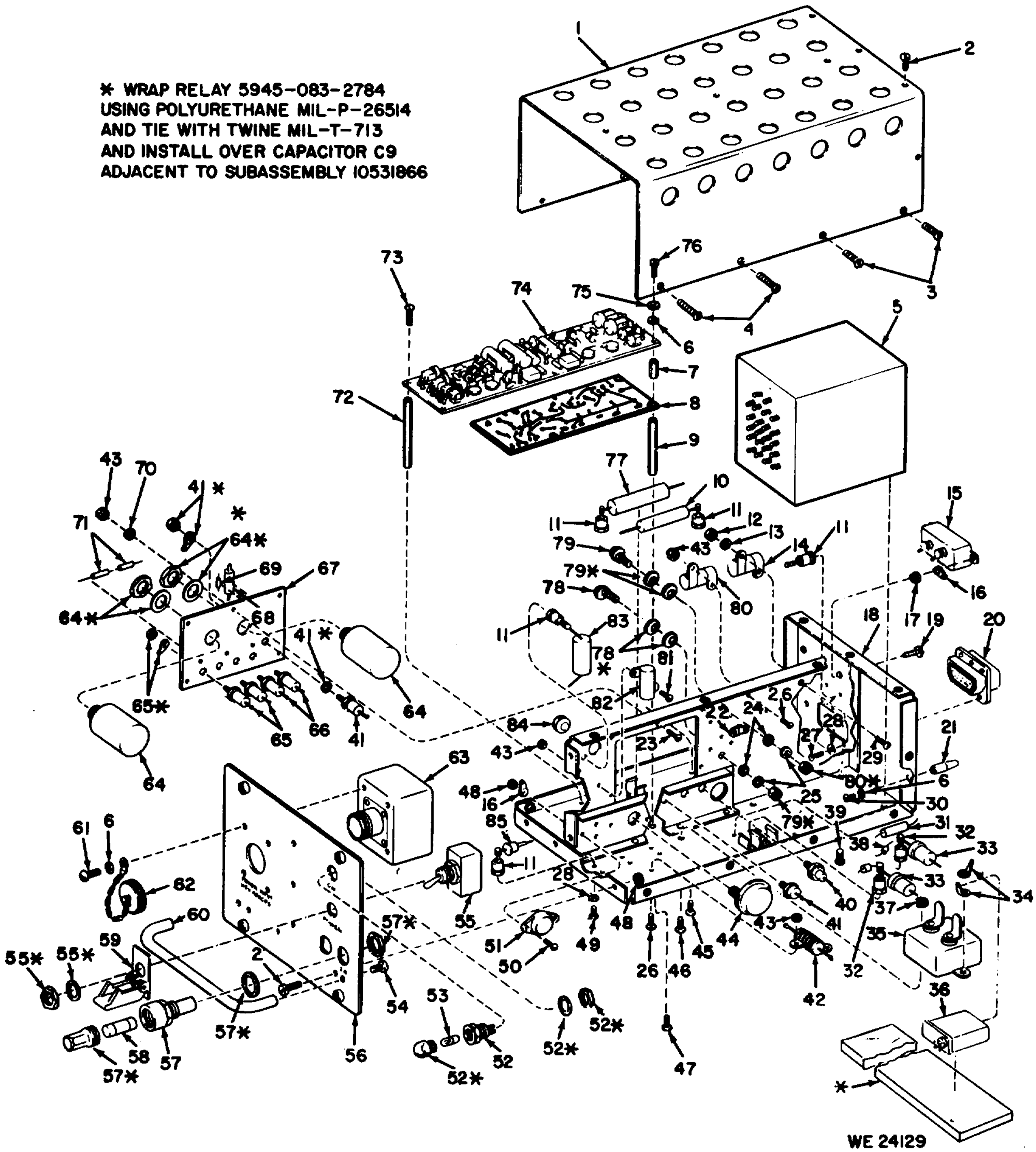
[1]Actual value to be selected in functional test from range of values shown to obtain a delay of 86 ± 2 milliseconds.

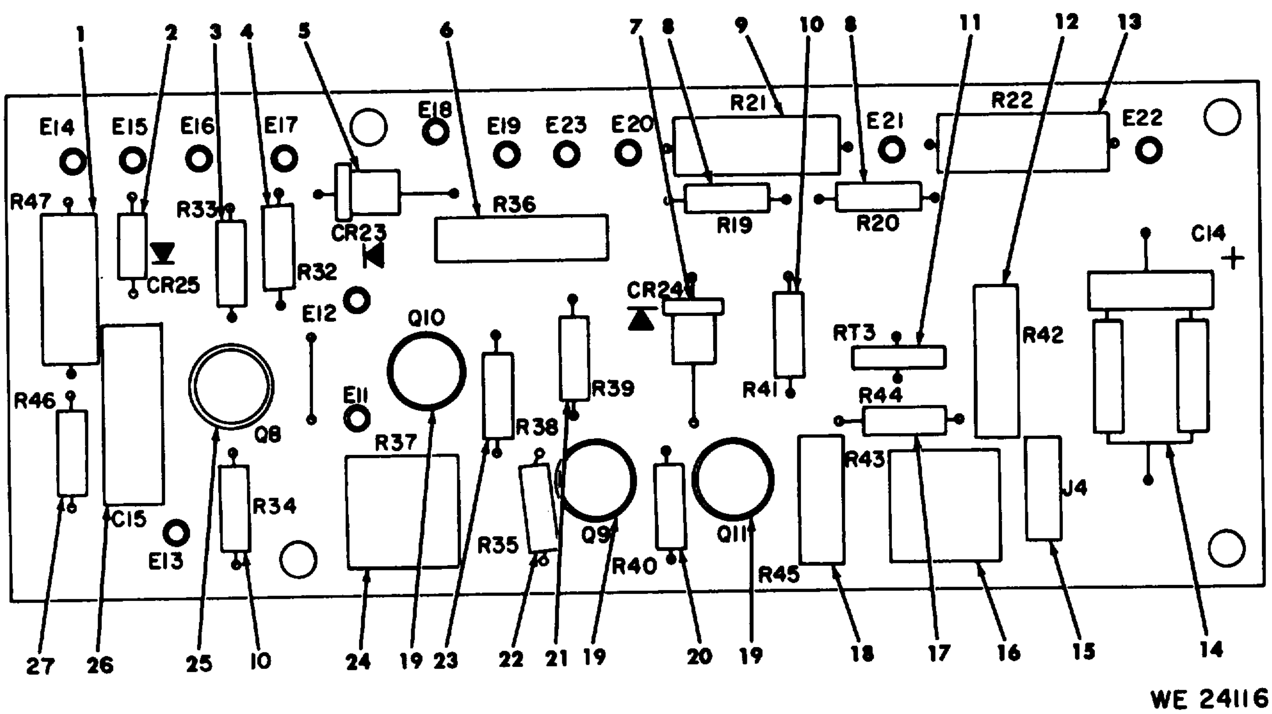


1 Cover 10531877
2 Screw 5305-054-6651
3 Screw 5305-174-3885
4 Screw 5305-811-6833
5 Transformer 5950-084-3237
6 Washer 5310-011-1041
7 Spacer 10531887
8 Power supply subassembly 10531846
9 Spacer 10531879-1
10 Resistor 5905-081-2084
11 Lug terminal 5940-204-8023
12 Nut 5310-271-4640
13 Washer 5310-058-3829
14 Resistor 5905-878-7275
15 Capacitor 5910-474-4853
16 Lug terminal 5940-620-8424
17 Nut 5310-982-6814

Exploded view numbers continued on following page.

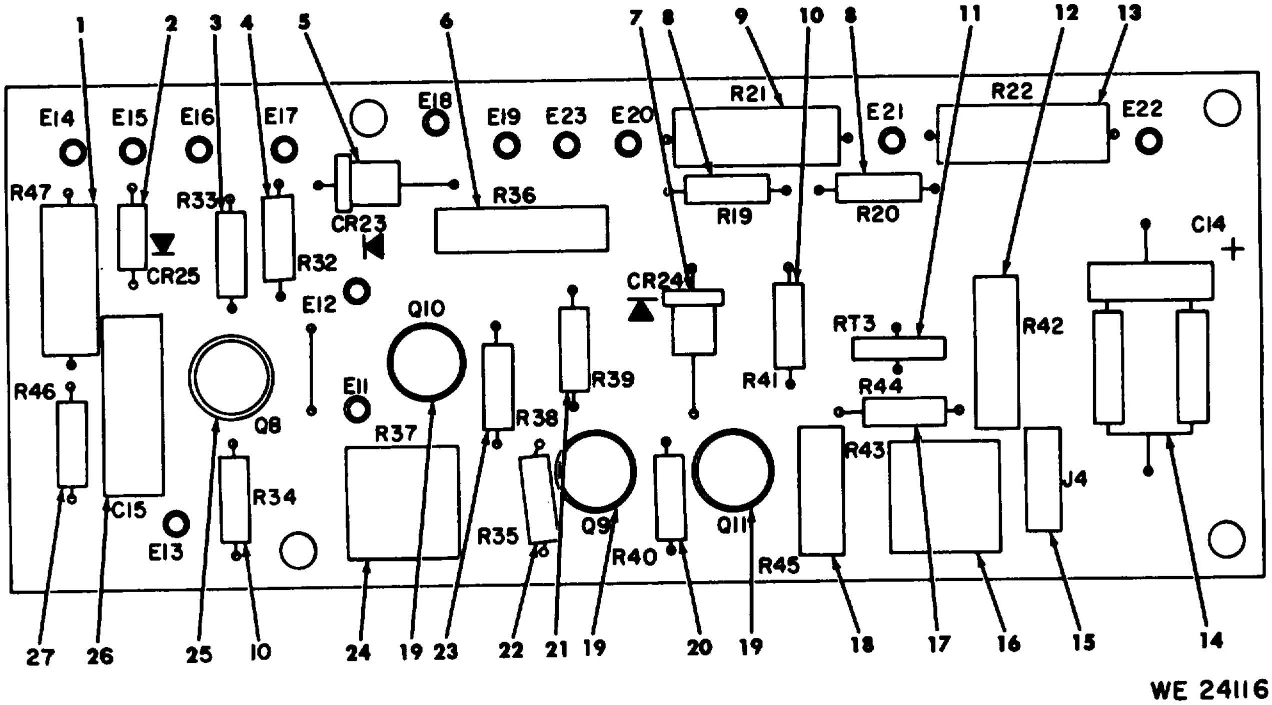
18 Power supply subassembly 10531858
19 Screw 5305-054-6668
20 Connector 5935-704-6019
21 Pin 10512543
22 Lug terminal 5940-681-8183
23 Screw 5305-054-5650
24 Spacer 10525460-4
25 Spacer 10525460-5
26 Screw 5305-811-6845
27 Screw 5305-054-5647
28 Washer 5310-042-9609
29 Screw 5305-764-2964
30 Screw 5305-054-6653
31 Capacitor 5910-833-9280
32 Stud terminal 5940-900-3755
33 Capacitor 5910-082-4790
34 Lug terminal 5940-838-2651
35 Capacitor 5910-193-0359
36 Relay 5945-083-2784
37 Nut 5310-034-4876
38 Resistor 5905-171-2001
39 Screw 5305-080-6503
40 Semiconductor device diode 5961-061-8979
41 Semiconductor device diode 10525561
42 Resistor 5905-081-0607
43 Nut 5310-034-4874
44 Transistor 5961-839-6607
45 Screw 5305-080-4326
46 Screw 5305-080-6504
47 Screw 5305-080-6502
48 Nut 5310-034-4875
49 Screw 5305-811-6840
50 Screw 5305-054-6655
51 Semiconductor device diode 5961-983-7284
52 Indicator light 6210-974-3875
53 Lamp 6240-155-7857
54 Screw 5305-811-6836
55 Switch 5930-655-1575
56 Panel subassembly 10512500
57 Fuse holder 5920-583-6092
58 Fuse 5920-474-6125
59 Guard 5930-617-9718
60 Handle 10525607-1
61 Screw 5305-054-6652
62 Cover 5935-081-4047
63 Filter 5915-060-8384
64 Capacitor 5910-034-0904
65 Semiconductor device diode 5961-865-6177
66 Semiconductor device diode 5961-060-8976
67 Board 10531857
68 Capacitor 5910-810-0704
69 Resistor 5905-279-3506
70 Washer 5310-782-1349
71 Resistor 5905-195-6761
72 Spacer 10531879-2
73 Screw 5305-054-6654
74 Power supply subassembly 10531845
75 Washer 5310-722-5998
76 Screw 5305-054-6658
77 Resistor 5905-084-3230
78 Transistor 5961-061-8172
79 Transistor 5961-892-3652
80 Resistor 5905-081-0606
81 Screw 5305-054-5649
82 Resistor 5905-083-2787
83 Capacitor 5910-081-3185
84 Grommet MS35489-6
85 Semiconductor device diode 5961-978-7660

Figure 4-16. Power supply A6 (1290-020-2372)-exploded view .



1 Resistor 5905-556-4008
2 Semiconductor device diode 5961-866-0476
3 Resistor 5905-190-8881
4 Resistor 5905-171-2001
5 Semiconductor device diode 5961-060-8998
6 Resistor 5905-812-4612
7 Semiconductor device diode 5961-842-6181
8 Resistor 5905-279-1888
9 Resistor 5905-539-0133
10 Resistor 5905-279-3504
11 Resistor 5905-022-9849
12 Resistor 5905-812-4611
13 Resistor 5905-279-2518
14 Capacitor 5910-082-4790
15 Jack 10531916
16 Resistor 5905-080-8203
17 Resistor 5905-190-8889
18 Resistor 5905-812-4609
19 Transistor 5961-809-9046
20 Resistor 5905-279-3505
21 Resistor 5905-192-3973
22 Resistor 5905-279-1860
23 Resistor 5905-190-8883
24 Resistor 5905-061-9490
25 Transistor 5960-022-9845
26 Capacitor 5910-821-4702
27 Resistor 5905-195-6761

Figure 4-17. Power supply subassembly 10531864--assembled view.



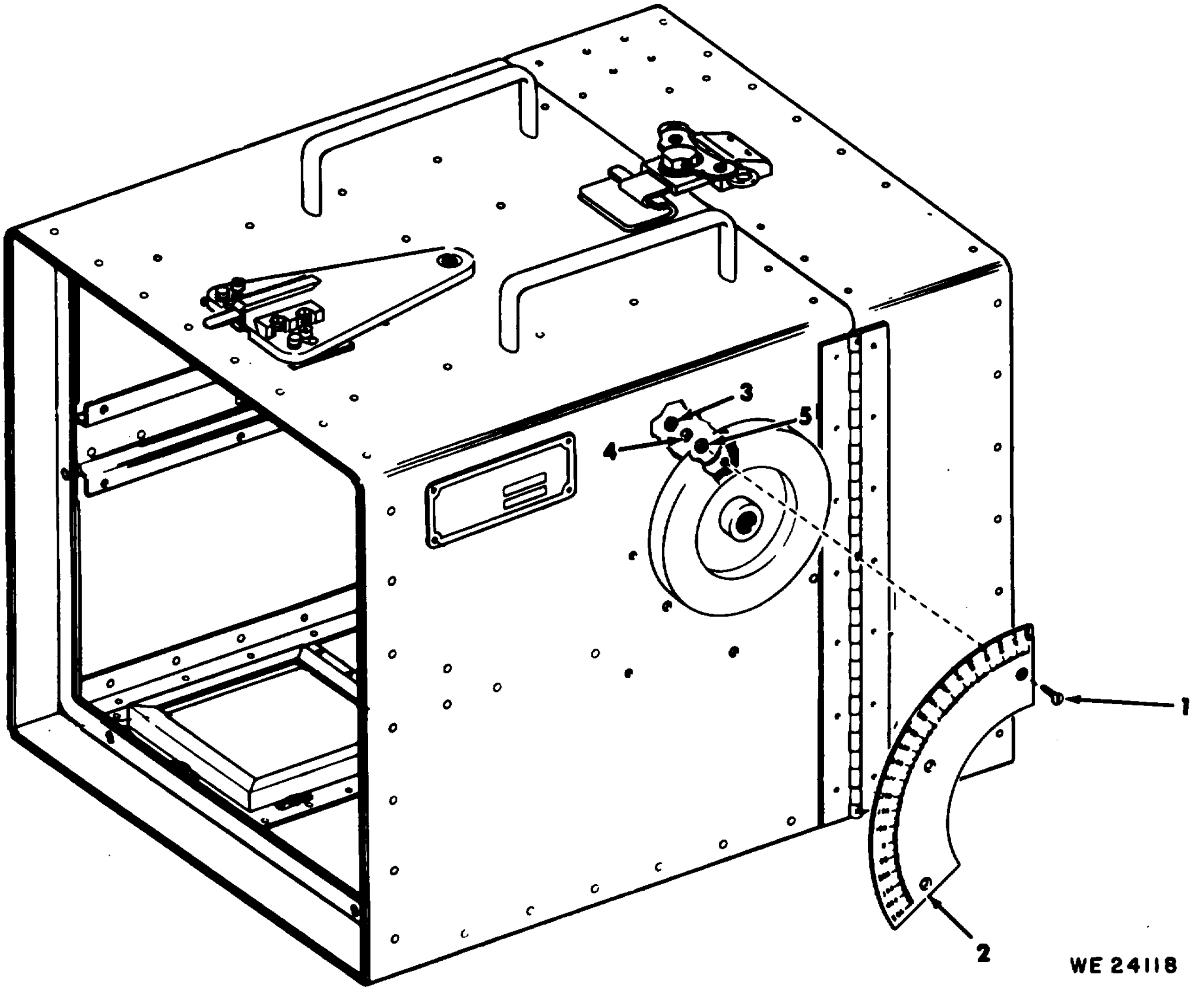
1 Resistor 5905-556-4008
2 Semiconductor device diode 5961-866-0476
3 Resistor 5905-190-8881
4 Resistor 5905-171-2001
5 Semiconductor device diode 5961-060-8998
6 Resistor 5905-812-4612
7 Semiconductor device diode 5961-842-6181
8 Resistor 5905-279-1888
9 Resistor 5905-539-0133
10 Resistor 5905-279-3504
11 Resistor 5905-022-9849
12 Resistor 5905-812-4611
13 Resistor 5905-279-2518
14 Capacitor 5910-082-4790
15 Jack 10531916
16 Resistor 5905-080-8203
17 Resistor 5905-190-8889
18 Resistor 5905-812-4609
19 Transistor 5961-809-9046
20 Resistor 5905-279-3505
21 Resistor 5905-192-3973
22 Resistor 5905-279-1880
23 Resistor 5905-190-8883
24 Resistor 5905-061-9490
25 Transistor 5960-022-9845
26 Capacitor 5910-821-4702
27 Resistor 5905-195-6761

Figure 4-18. Power Supply subassembly 10531845--assembled view.

4-18. Removal and Replacement of Components on Main Frame

(fig. 4-20)

The removal and replacement of the components mounted on the fixed portion of the rear panel, attached to the main frame, is shown in figure 4-20. Before working on these components, remove the audio frequency amplifier A3 (26), digital display indicator A5 (3), and power supply A6 (25). Release and slide out main frame as far as it will go, and open up the front cabinet section to permit as much light and ease of access as possible. Procedures for the removal and replacement of the individual components are obvious and do not require detailed explanation.



1 Screw 5305-080-6503
2 Dial 5355-081-3187
3 Nut 5310-270-8810
4 Washer 5310-054-1831
5 Washer 5310-595-6772

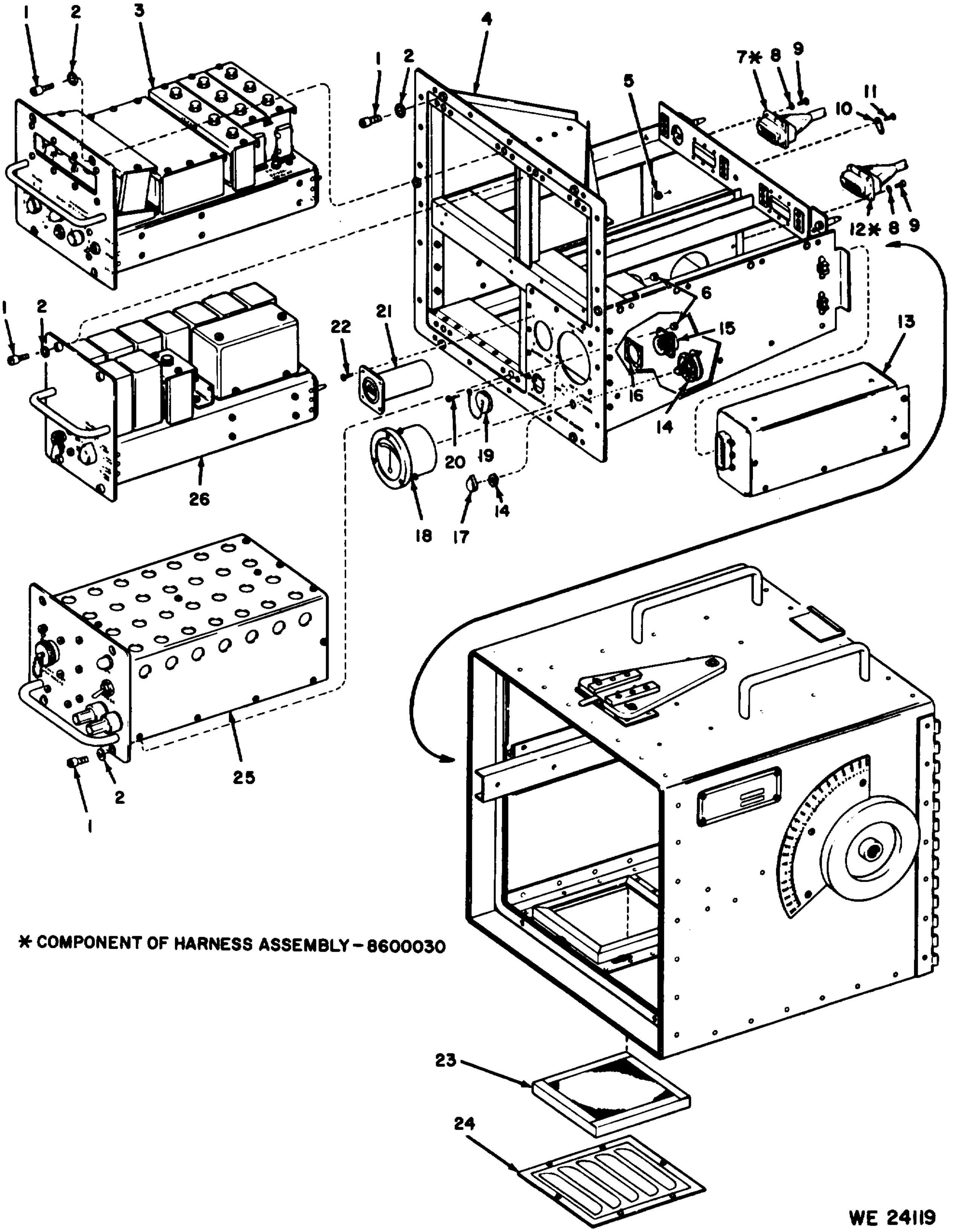
Figure 4-19. Chronograph cabinet 10531895--partial exploded view.

---

1 Screw 5305-959-1909
2 Seal 1290-947-3063
3 Indicator A5 1290-020-2369
4 Frame 10512506
5 Nut 5310-034-4875
6 Nut 5310-034-4874
7 Connector 5935-704-6019[1]
8 Washer 5310-042-9609
9 Screw 5305-054-5647
10 Lug terminal 5940-620-8424
11 Screw 5305-054-6652
12 Connector 5935-034-0899 [1]
13 Control A2 1290-863-5644
14 Switch 5930-970-8663
15 Connector 5935-755-3688
16 Gasket 5330-904-9381
17 Knob 5355-616-9604
18 Ammeter 6625-085-7128
19 Cover 5935-081-4046
20 Screw 5305-054-5650
21 Timer 6645-061-9491
22 Screw 5305-054-5649
23 Air Filter 4310-083-2789
24 Louver plate 10531883
25 Power supply A6 1290-020-2372
26 Amplifier A3 1290-020-2379

Figure 4-20. Radar chronograph 10525300-partial exploded view.

[1] Component of harness assembly 8600030.


1
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* COMPONENT OF HARNESS ASSEMBLY - 8600030
WE 24119

Section III. MAINTENANCE OF RADAR CHRONOGRAPH MOUNT

4-19. Removal and Replacement of Elevation Lock Handles

(fig. 4-21)

Remove handle (1) from either right or left yoke arm by punching out pin (2) and replace with new handle (1).

4-20. Removal and Replacement of Quick-Release Latch and Lock-Handle Latch Springs

(fig. 4-21)

a. Punch out pin (38) and remove two spacers (40), latch (41), and spring (42).

b. Remove pin (43) and spring (44) by removing ring (37) and washer (39) from pin (43).

Replace latch (41) and spring (42). Procedure for the reassembly is obvious and does not require detailed explanation.

4-21. Removal and Replacement of Level Vial Tube Assembly

(fig. 4-21)

a. Remove two screws (16) and pin (15).

b. Unscrew and remove plug (11) and housing (14).

c. Remove tube (13) from housing by pushing tube (13) through cover (18).

d. Hold cover (18) in place and replace new tube (13) and cover in housing (14). Replace plug (11) in housing (14) at one end of tube (13).

e. Return vial assembly to mount by replacing two screws (16) and pin (15).

4-22. Removal and Replacement of Elevation Dial Pointer

(fig. 4-21)

a. Remove two screws (8) and pointer (9) from mount.

b. Replace with new pointer (9), secure with two screws (8), and adjust pointer (9) as necessary to point to correct scale marking.

4-23. Removal and Replacement of Azimuth Dial Pointer

(fig. 4-21)

a. Remove two screws (81) and pointer (32) from mount.

b. Replace with new pointer (32), secure with two screws (31) and adjust pointer as necessary to point to correct scale marking. Tighten screws (31).

4-24. Removal and Replacement of Azimuth Dial Lock Knob

(fig. 4-21)

a. Punch out pin (34) holding knob (35) to shaft.

b. Slip knob (35) and washer (36) off shaft (33) and replace with new knob (35).

4-25. Removal and Replacement of Quick-Release Pin

(fig. 4-21)

a. Loosen screw (20) securing captive chain (22) to mount.

b. Pull out quick-release pin (19) and replace with new pin (19).

c. Secure captive chain to mount with screw (20).

4-26. Removal and Replacement of Elevation Adjust Drive Knob

(fig. 4-21)

a. Punch out pin (30) holding knob (29) to shaft.

b. Slip knob (29) off shaft and replace with new knob (29).

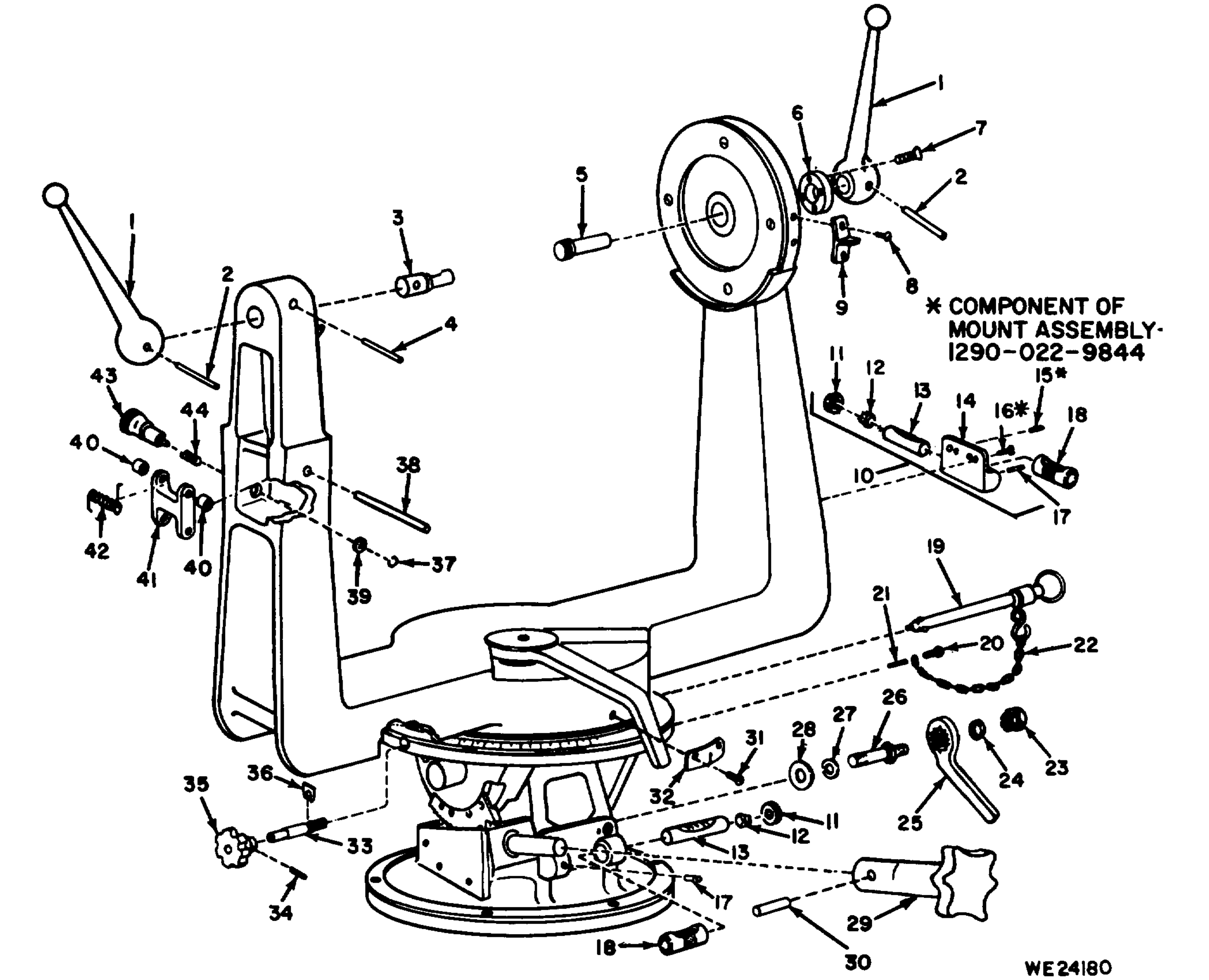
4-27. Removal and Replacement of Elevation Lock Handle

(fig. 4-21)

a. Remove nut (23) and washer (24).

b. Remove handle (25) from stud (26).

c. Unscrew and remove stud (26) from mount along with lockwasher (27) and washer (28). Replace with new handle (25).



1	Handle 1290-018-3295
2	Pin 10525260-3
3	Shaft 10525284
4	Pin 10525260-2
5	Shaft 10525283
6	Plate 10525254
7	Screw 5305-811-6827
8	Screw 5305-054-6669
9	Pointer 5355-063-4349
10	Level vial assembly 8585560
11	Plug 8202181
12	Eccentric 8202177
13	Tube 1290-692-1498
14	Housing 8585561
15	Pin MS16556-601 [1]
16	Screw 5305-050-9227 [1]
17	Pin MS16555-625
18	Cover 8215835
19	Pin 5340-018-3296
20	Screw 5305-050-9231
21	Pin MS171590
22	Chain 8566487
23	Nut 5310-947-3066
24	Washer 5310-550-5054
25	Handle 1290-945-5243
26	Stud 5307-959-7400
27	Washer 5310-042-6758
28	Washer 5310-965-1803
29	Knob 5355-061-9731
30	Pin 10525260-4
31	Screw 5305-054-5647
32	Pointer 5355-060-8383
33	Shaft 1290-997-4601
34	Pin 5315-069-4704
35	Knob 5355-997-4602
36	Dial stop 5355-997-4600
37	Ring 5340-725-0969
38	Pin 10525260-1
39	Washer 10525288
40	Spacer 10525262
41	Latch 10525294
42	Spring 1290-080-5311
43	Pin 10525293
44	Spring 5340-950-2663

Figure 4-21. Mount, radar chronograph 1290-029844-partial exploded view.

[1] Component of mount assembly 1290-022-9844.

Section IV. MAINTENANCE OF TRIPOD ASSEMBLY

4-28. Removal and Replacement of Leveling Base Locking Handle

(fig. 4-22)

a. Remove nut (3) securing handle (4) to shaft.

b. Remove handle (4) from shaft by pulling upward.

c. Remove setscrew (6) and unscrew shaft (5) from adapter.

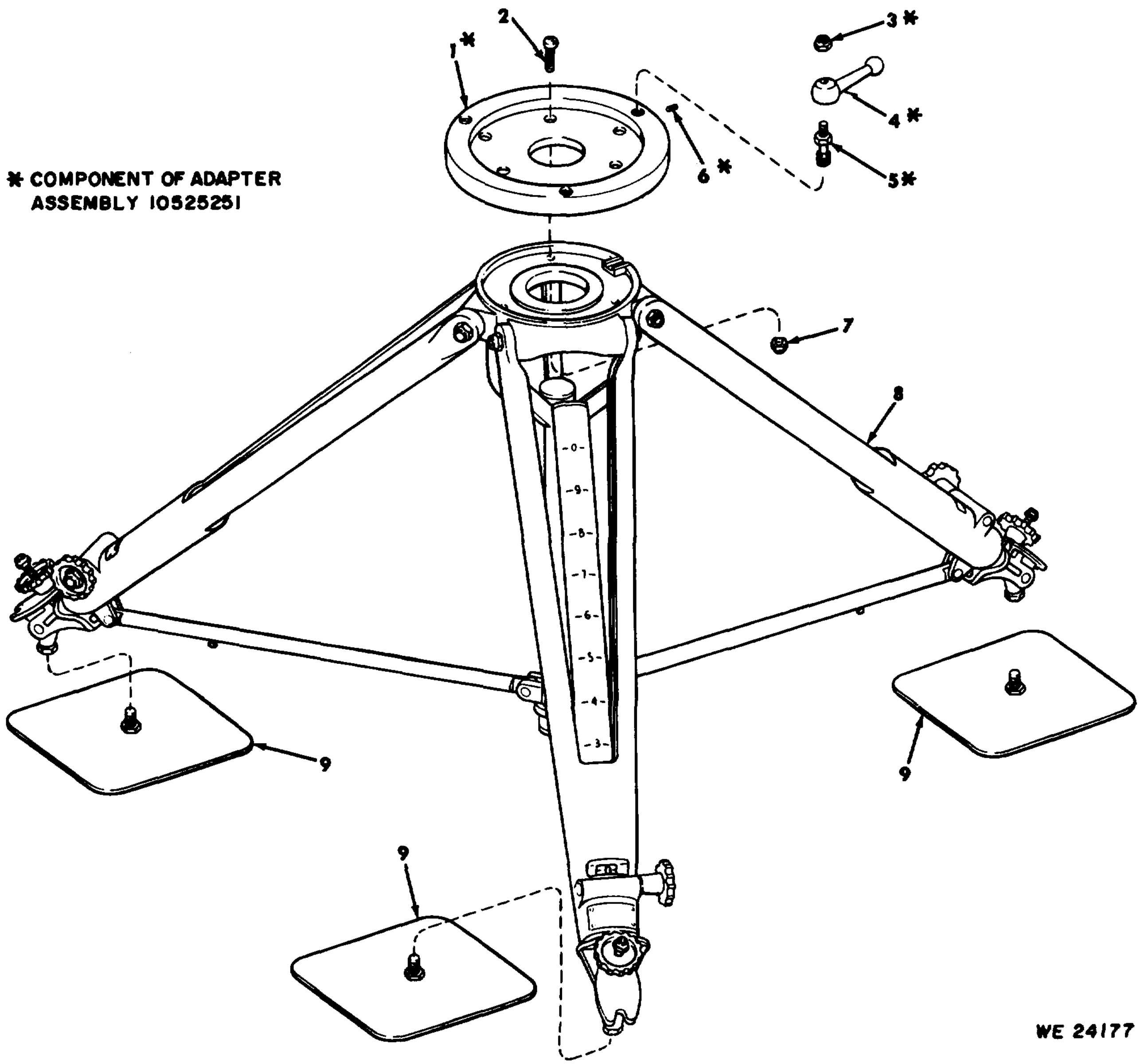
d. Remove six nuts (7) and screws (2) holding adapter to tripod.

e. Remove adapter (1) from tripod (8). Replace with new handle (4). Procedure for the reassembly is obvious and does not require detailed explanation.

4-29. Removal and Replacement of Auxiliary Foot Pad

(fig. 4-22)

If one of the three pads (9) is damaged, remove from tripod by turning counterclockwise.



1	Adapter 10525255[1]	4	Handle 1290-018-3297[1]	7	Nut 5810-970-1218
2	Screw 5305-071-2094	5	Shaft 10525281[1]	8	Tripod 10296
8	Nut 5310-877-5796[1]	6	setscrew 5305-717-6948[1]	9	Pad 129-018-3301

Figure 4-22. Tripod assembly 1290-863-3194-exploded view.

[1]Component of adapter assembly 0525251.

Section V. MAINTENANCE OF RADAR TEST RECEIVER

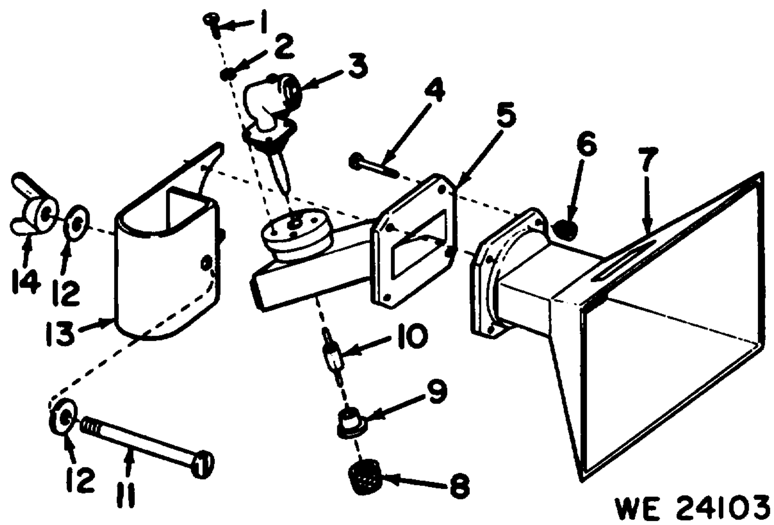
4-30. Removal and Replacement of Semi-conductor Device Diode
(fig. 4-23)

a. Remove knurled diode holder cap (8).

b. Remove diode (10) and holder (9).

c. Replace with new diode (10), checking that polarity is correct.

d. Return diode (10), holder (9), and cap (8) to socket.



1	Screw 5305-054-5647	7	Horn 5985-083-2782	11	Screw 5305-071-2101
2	Washer 5310-042-9609	8	Cap 5961-018-3292	12	Washer 5310-965-1803
3	Probe 1290-018-3294	9	Holder 5960-083-2786	13	Bracket 10525560
4	Screw 5305-988-7603	10	Semiconductor device diode 5961-548-8171	14	Nut 5310-063-6716
5	Holder 10525247				
6	Nut 5310-034-4876				

Figure 4-23. Receiver, radar test 1290-86-0005-exploded view.

4-31. Removal and Replacement of Cable Connector and Probe

(fig. 4-23)

a. Remove four screws (1) and lockwashers (2) holding probe (3) to holder (5).

b. Remove probe (3) from holder (5).

c. Carefully replace with new probe (3), checking that connector is in original position and secure with four screws (1) and lockwashers (2).

4-32. Removal and Replacement of Horn

(fig. 4-23)

a. Remove four screws (4) and nuts (6) holding horn (7) and bracket (18) to holder (5).

b. Replace with new horn (7), securing with four screws (4) and nuts (6) to holder (5). Secure bracket (13) under two screws (4).

4-33. Removal and Replacement of Past Clamp Screw

(fig. 4-23)

a. Remove wing nut (14) and washer (12).

b. Pull screw (11) out of bracket (13) along with second washer (12) Replace with new screw (11).

Section VI. MAINTENANCE AND INSTALLATION OF BRACKET (JEEP MOUNTING)

4-34. Installation of Bracket

(fig. 4-24)

The mounting bracket is used for mounting the radar chronograph on the 1/4 ton, 4 x 4 utility truck M151. The installation drawing (fig. 4-25) shows that the bracket is to be mounted inside the truck body on the left rear wheelwell. The bracket is positioned forward on the rear axle centerline with the cutout to the rear.

a. Preparing the Vehicle. Before installing the mounting bracket in the truck, remove the rear seat. Clean the under side of the left rear wheelwell thoroughly. Jack up the truck, remove the left rear wheel, and use a steam gun, water hose, cleaning compound, or wire brush to insure a clean surface.

b. Installing the Bracket (Fig. 4-24).

(1) Remove six screws (10), spacers (12), washers (2), and nuts (1) which hold together bracket assembly (9),plate (11), and bracket (13) and are used to mount the bracket to the wheelwell wall.

(2) Remove five screws (7), washers (2), and nuts (1) on top of bracket assembly.

(3) Use bracket assembly (9) with plate (11) as a template for locating the nine -5/16 inch holes which must be drilled in the vehicle body, six in the wall and three in the top surface of the left rear wheelwell.

(4) Drill, deburr, and prime the edges of the nine holes.

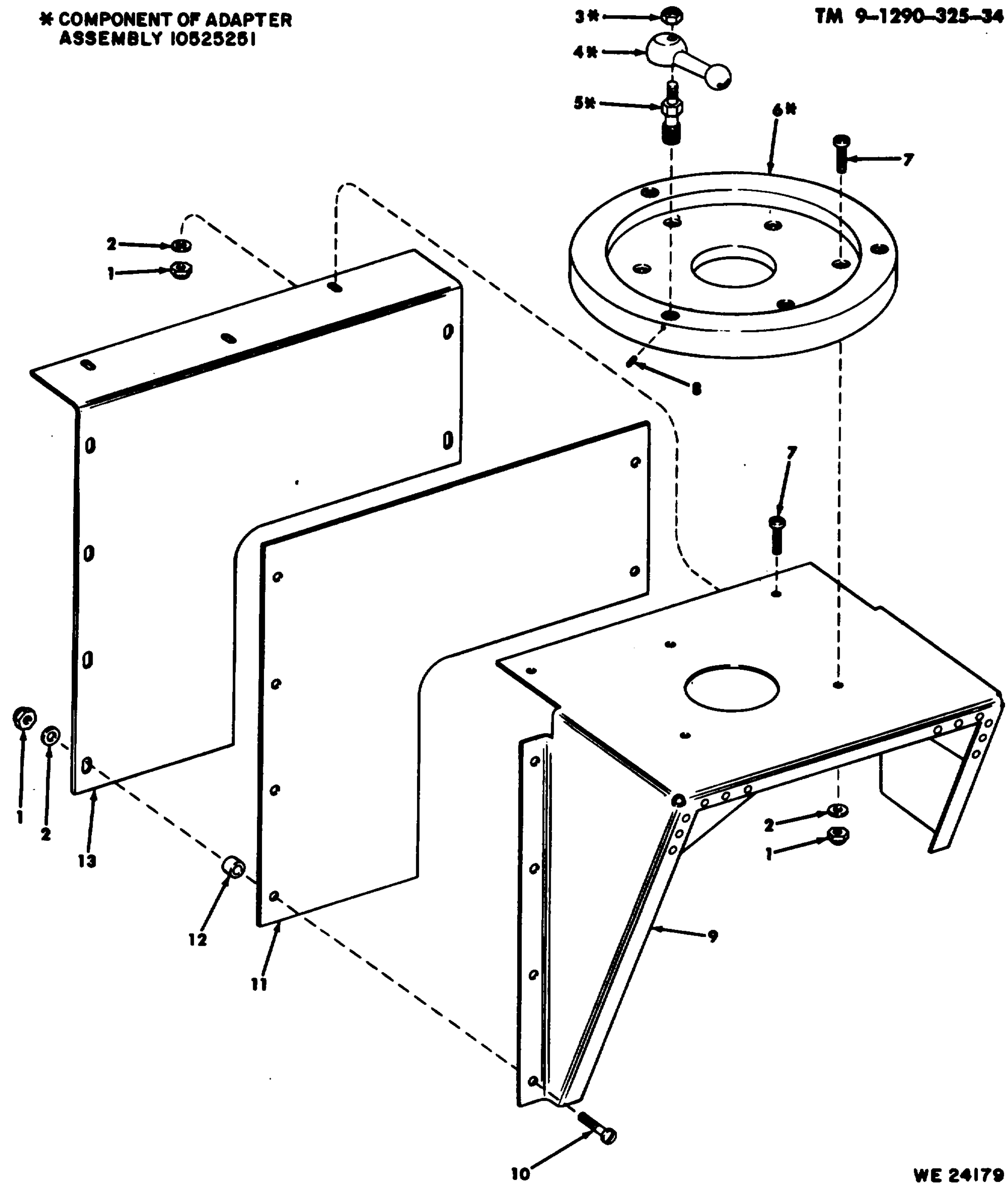
(5) Put six screws (10) through holes in bracket assembly (9) and plate (11).

(6) Put bracket assembly (9) and plate (11) in place with the six screws (10) through the holes in the wall.

(7) On the other side of the wall put spacer (12) on each of the six screws (10).

(8) Put bracket (13) in place on screws (10).

(9) Place washer (2) and nut (1) on each screw (10) Do not tighten nuts.



1	Nut 5310-727-5223	6	Adapter 10525255 [1]	10	Screw 5305-071-2088
2	Washer 5310-965-1803	7	Screw 5305-071-2087	11	Plate 8215516
3	Nut 5310-877-5796 [1]	8	Setscrew 5305-717-6948	12	Spacer 8215518
4	Handle 1290-018-3297 [1]	9	Bracket assembly 8215515	13	Bracket 8215517
5	Shaft 10525281 [1]				

Figure 4-24. Bracket installation (jeep mounting) 8215513-exploded view.

[1]Component of adapter assembly 10525251.

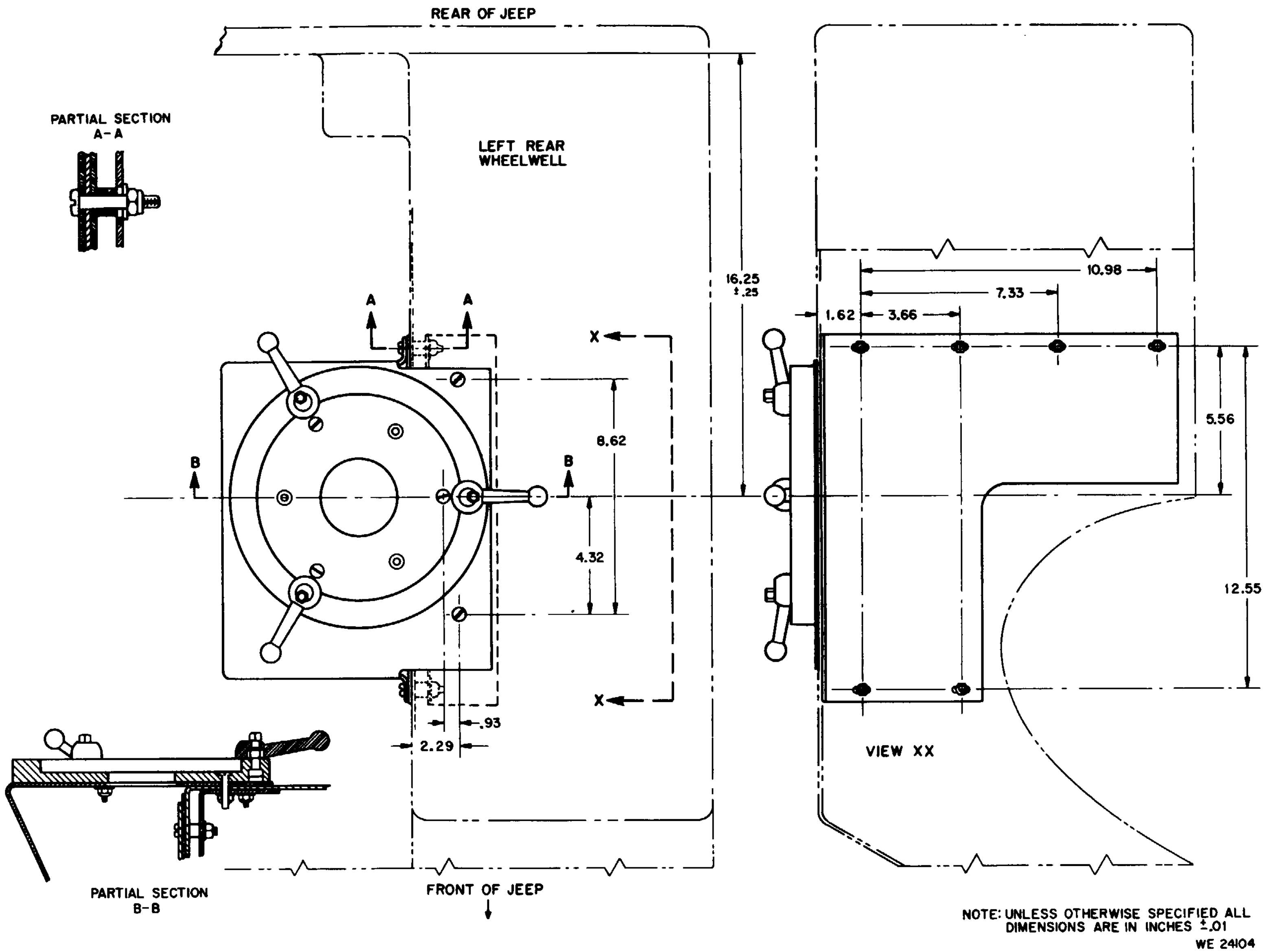


Figure 4-25. Bracket installation drawing.

(10) Put two screws (7) through top of bracket assembly (9), through top of wheelwell surface, and through bracket (13).

(11) Put washer (2) and nut (1) on two screws inside wheelwell but do not tighten nuts.

(12) Place adapter (6) on top of bracket (13).

(13) Put three screws (7) through holes in adapter (6) and through bracket assembly (9). (Note that one of the screws goes on through into the wheelwell.

(14) Put washer (2) and nut (1) on two screws (7) visible under bracket and on one screw (7) protruding into wheelwell.

(15) Tighten down all screws and nuts.

(16) Replace vehicle wheel

4-35. Repairs

(fig. 4-24)

To replace handle (4), remove nut (3) securing handle (4) to shaft (5) and remove handle (4) from shaft (5) by pulling upward.

Section VII. MAINTENANCE OF CABLE AND REEL ASSEMBLY

4-36. Defective Cable Assemblies

(fig. 4-26)

a. If conductor in power cable assembly (3) or special purpose cable assembly (10) is defective, remove cable assembly from reel (1) and replace entire cable assembly.

b. If sleeve (4) or connector (7) on power cable assembly (3) or connector (12) on special purpose cable assembly (10) is damaged, remove sleeve and/or connector from cable and replace with new sleeve and/or connector of same type.

c. If cover (6) or (8) on power cable assembly (3) or cover (11) on special purpose cable assembly (10) is damaged, remove by loosening retaining screw, and replace with new part.

4-37. Damaged Cable Reel Assembly

(fig. 4-26)

a. Remove cable assembly (3 or 10) from reel (1).

b. Remove reel from mounting plate by releasing fasteners.

c. Replace reel (1).

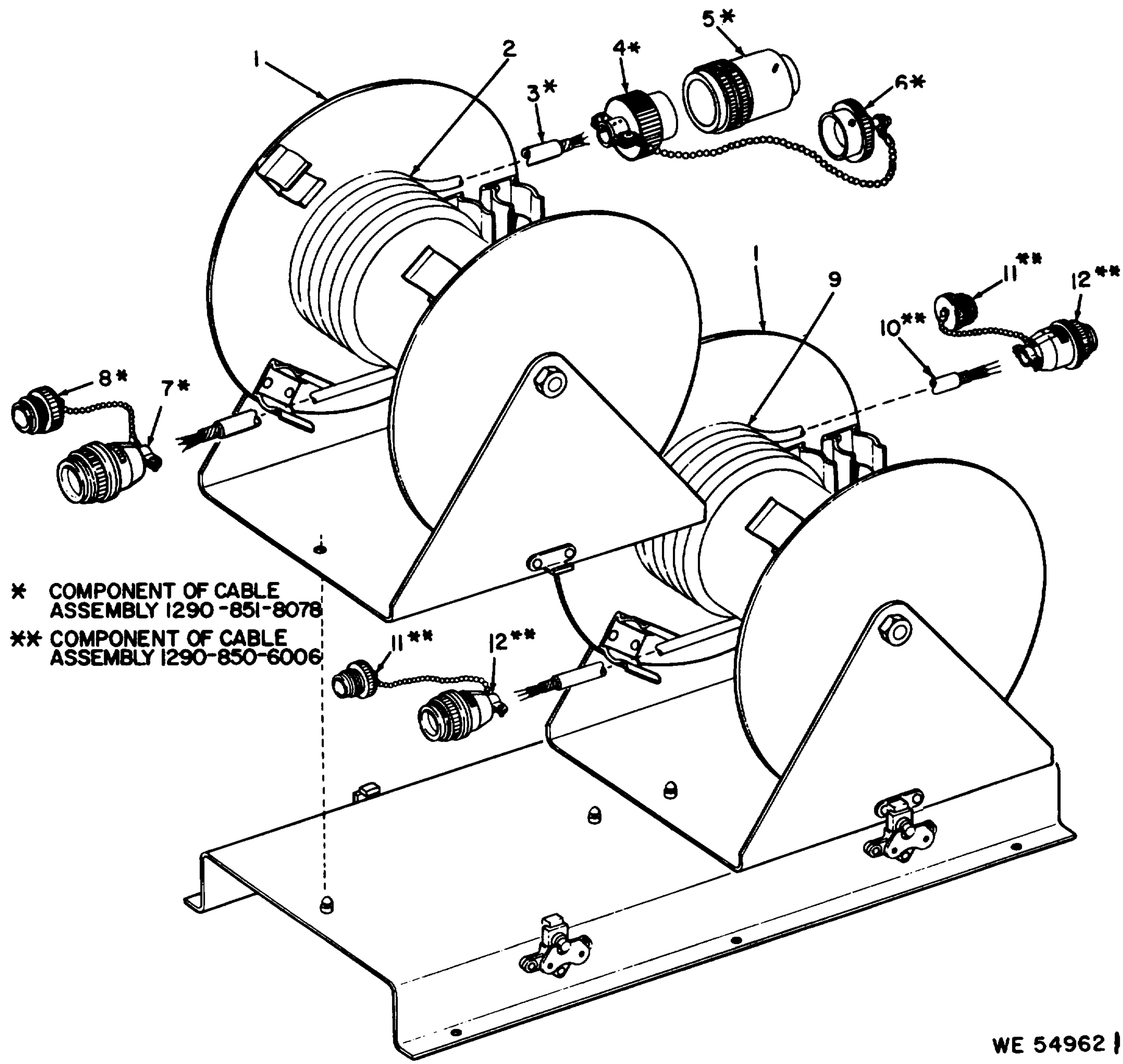


Figure 4-26. Cable and Reel Assembly 8213855-exploded view.

1 Cable reel 10525702
2 Cable assembly 1290-851-8078
3 Cable 10525693[1]
4 Sleeve 1220-832-6990[1]
5 Plug assembly 1290-181-5302[1]
6 Cover 5935-832-7366[1]
7 Connector 5935-755-3493[1]
8 Cover 5935-729-3666[1]
9 Cable assembly 1290-850-6006
10 Cable 10525692[2]
11 Cover 5935-081-4045[2]
12 Connector 5935-201-6655[2]

[1] Component of cable assembly 1290-851-8078

[2] Component of cable assembly 1290-850-6006

Section VII.1 MAINTENANCE AND INSTALLATION OF ADAPTER ASSEMBLY

4-37.1. Installation of Adapter Assembly (fig. 4-26.1)

The adapter assembly (fig. 4-26.1) is comprised mainly of a bracket and mounting clamp. Two cable assemblies mounted on the main bracket are for connecting to generator output terminals and ground. Connectors of the cable assemblies, which are mounted on the main bracket, are for mating with Radar Chronograph power cable connectors. These two connectors are provided in the event two chronographs are to be operated simultaneously. The necessary mounting hardware is supplied as components of the adapter assembly.

CAUTION

Prior to connecting adapter assembly 1290181-5303 electrical leads to engine generator, place the generator voltage output selector switch (fig. 4-26.2) to the 120 volt position to prevent damage to the Radar Chronograph electrical circuits.

a. Install bracket (13) on frame of generator set 6115-917-7354 as shown installed in (fig. 4-26.2).

b. Install clamp (5) and secure with two screws (4), two flat washers (3), two lock washers (2), and two nuts (1).

c. Connect the adapter assembly electrical wire leads to engine generator output as follows:

(1) Connect two white wires (16) to generator set terminal L1.

(2) Connect two red wires (17) to generator set terminal L2.

(3) Connect two black wires (15) to generator set ground terminals.

NOTE

Plate instruction (12) indicates proper connecting instructions of wire leads to engine generator output terminals and also indicates CAUTION instructions to be taken prior to connecting adapter assembly electrical leads to engine generator.

d. Adapter assembly 1290-181-5303 should be retained with Radar Chronograph Set: M36 when the generator is separated from the system.

4-37.2. Disassembly

For complete disassembly of adapter assembly 1290181-5303 refer to figure 4-26.1.

4-37.3. Assembly

Assemble Adapter assembly 1290-181-5303 in reverse legend sequence (fig. 4-26.1).

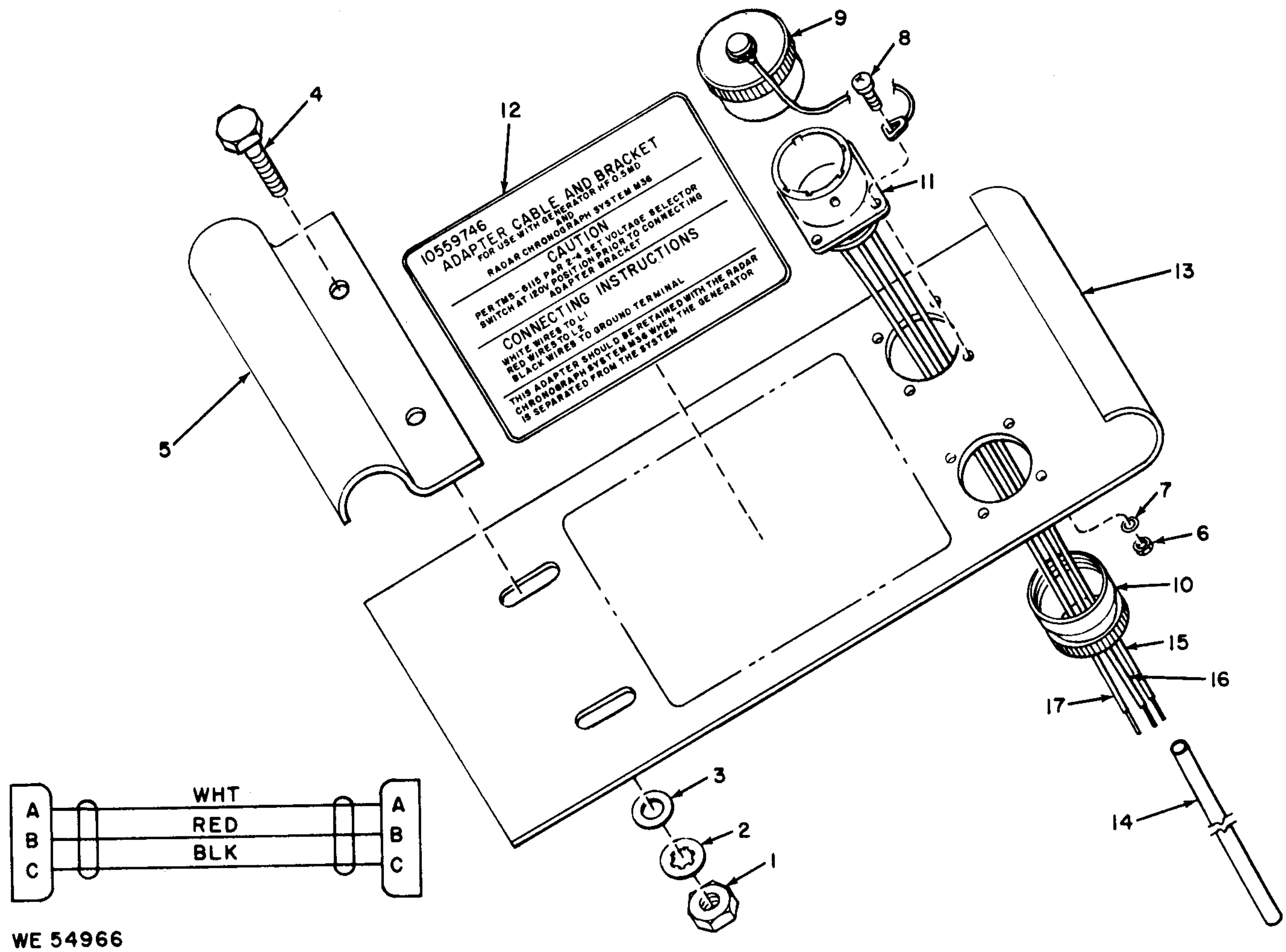


Figure 4-26.1. Adapter Assembly 1290-181-5303-exploded view.

1 Nut 5310-903-5966
2 Washer 5310-543-2740
3 Washer 5310-582-5677
4 Screw 5305-579-5238
5 Clamp 10559744
6 Nut 5310-934-9748
7 Washer MS35338-154
8 Screw 5305-054-5651
9 Cap 8623432-1
10 Connector 8623440-3[1]
11 Cable assembly 10559748
12 Plate, instruction 10559747
13 Bracket 10559745
14 Insulation sleeving 23053/8-187
15 Wire 16878/4-T-E16-B
16 Wire 16878/4-T-E16-W
17 Wire 16878/4-T-E16-R

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[1]Component of cable assembly 10559748

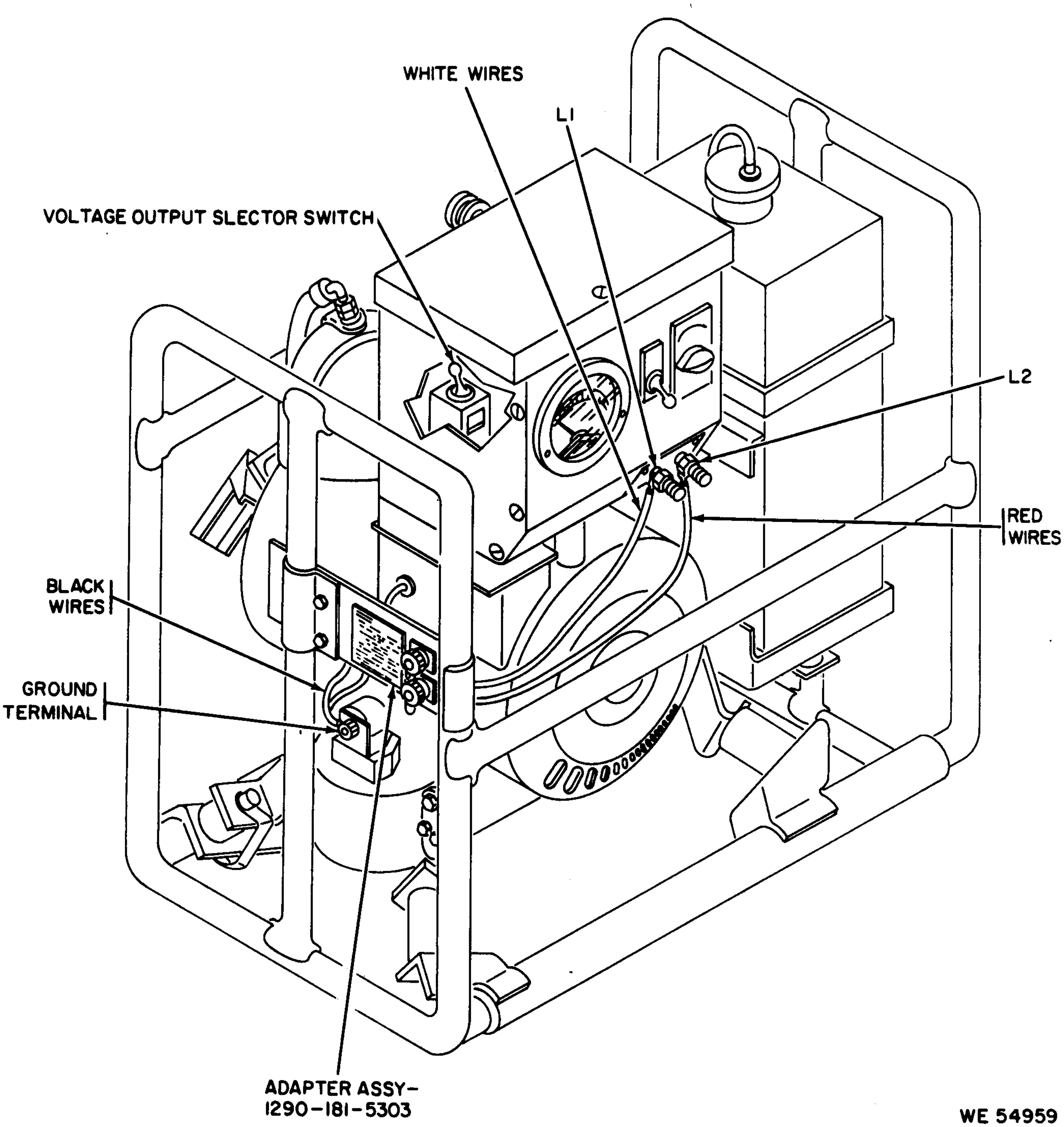


Figure 4-26.2. Adapter Assembly 1290-181-5303-installed on generator set 6115-917-7354.

Section VIII. MAINTENANCE OF MICROPHONE

4-38. General

The electrical components of the microphone are repairable at the direct and general support levels.

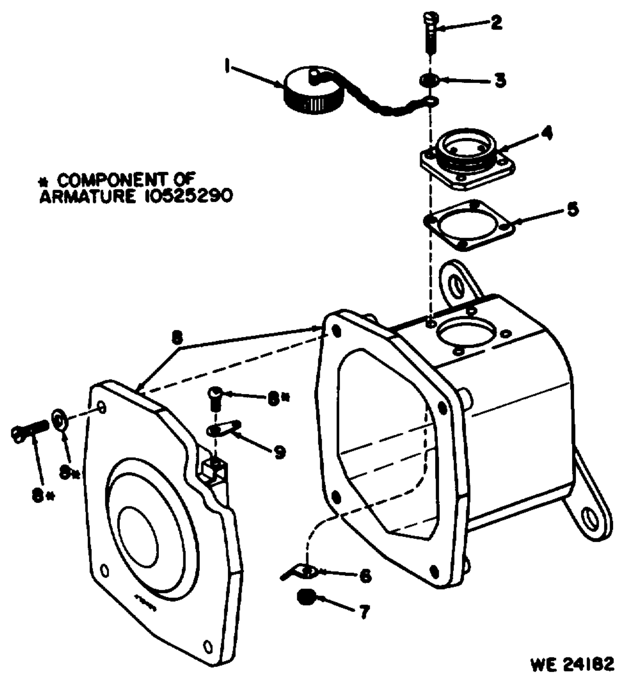
4-39. Disassembly and Assembly of Microphone
(fig. 4-27)

a. Remove component hardware consisting of four screws and washers holding cover and armature (8) to case.

b. Carefully pull cover and armature (8) off case far enough to expose terminals on microphone cover and case.

c. Remove component screw (8), releasing terminal lug (9) from cover.

d. Remove four nuts (7), screws (2), washers (3), holding connector (4) to case. This also releases chain on cover (1), gasket (5) for connector cap on cover (1) together with terminal lug (6) from armature case. Procedure for the assembly of the microphone is obvious and does not require detailed explanation.



1 Cover 5935-081-4046
2 Screw 5305-054-5650
3 Washer 5310-595-6211
4 Connector 5935-755-3688
5 Gasket 5330-904-9381
6 Lug terminal 5940-614-0587
7 Nut 5310-034-4874
8 Armature 10525290
Screw [1]
Washer [1]
Cover [1]
9 Lug terminal 5940-620-8424

Figure 4-27. Microphone 1290-863-3195 loaded View.

---

[1]Component of armature 10525290.

Section IX. MAINTENANCE OF TELESCOPE XM128

4-40. Telescope XM128

For repair procedures and physical description of telescope XM128, refer to TM 9-1290-25-12/1.

4-41. Replacement Parts

Replacement parts for the telescope XM128 are contained in TM 9-1290-3212/1 and TM 9-1240-211-35.

Section X. MAINTENANCE OF CHRONOGRAPH AUTOMATIC RELIABILITY RATER

4-42. Removal, Disassembly and Assembly of Chronograph Automatic Reliability Rater (CARR)

(fig. 4-28)

a. Remove panel assembly (3) from case assembly (13) by removing six fillister-head screws (1) located underneath gasket (2) of panel assembly.

b. Remove nut (12), screw (9), and washer (10) for disassembly of connectors (7) and (11) and attaching covers (8).

c. Separate gasket (6) from connectors. Procedure for the assembly of the CARR is obvious and does not require detailed explanation.

4-43. Repair of Panel Assembly 10552366

(fig. 4-29)

a. Refer to figure 4-29 for removal of parts from panel assembly. Procedure for disassembly and assembly is obvious and does not require detailed explanation.

b. Items 4, 13 and 20 illustrated in figure 4-29 are authorized for depot maintenance only.

4-44. Repair of Circuit Board Assembly 10552368

(fig 4-30 and 4-31)

a. Refer to figures 4-30 and 4-31 for removal of parts from circuit board assembly. Procedure for disassembly and assembly is obvious and does not require detailed explanation.

b. Items 1 and 2, figure 4-30 and item 5, figure 4-31 are authorized for depot maintenance only.

4-45. Repair of Cable Assembly 10552347

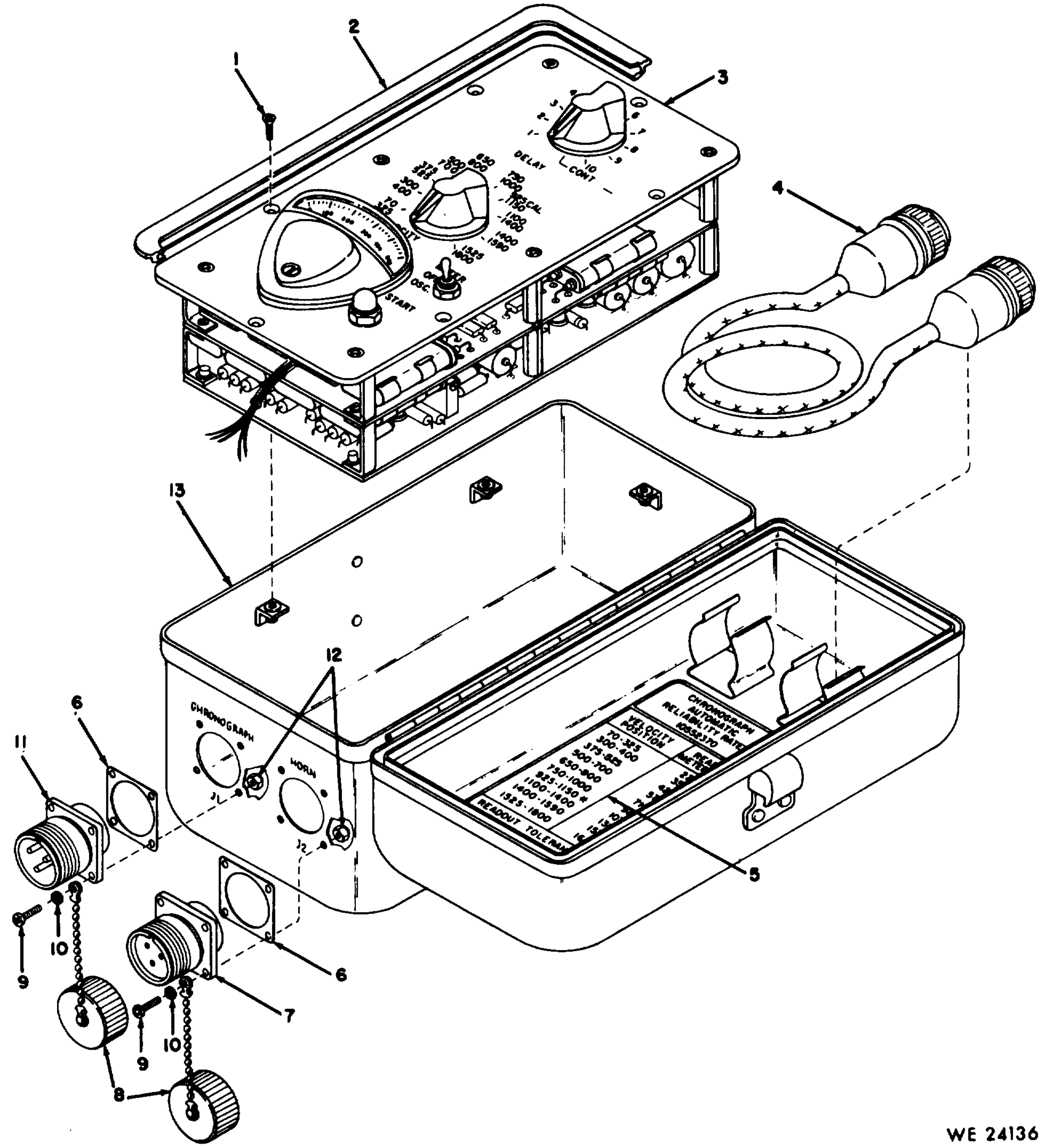
(fig. 4-32)

Refer to figure 4-32 for removal of parts from cable assembly. Procedure for disassembly and assembly is obvious and does not require detailed explanation.

4-46. Repair of Case Assembly 10552369

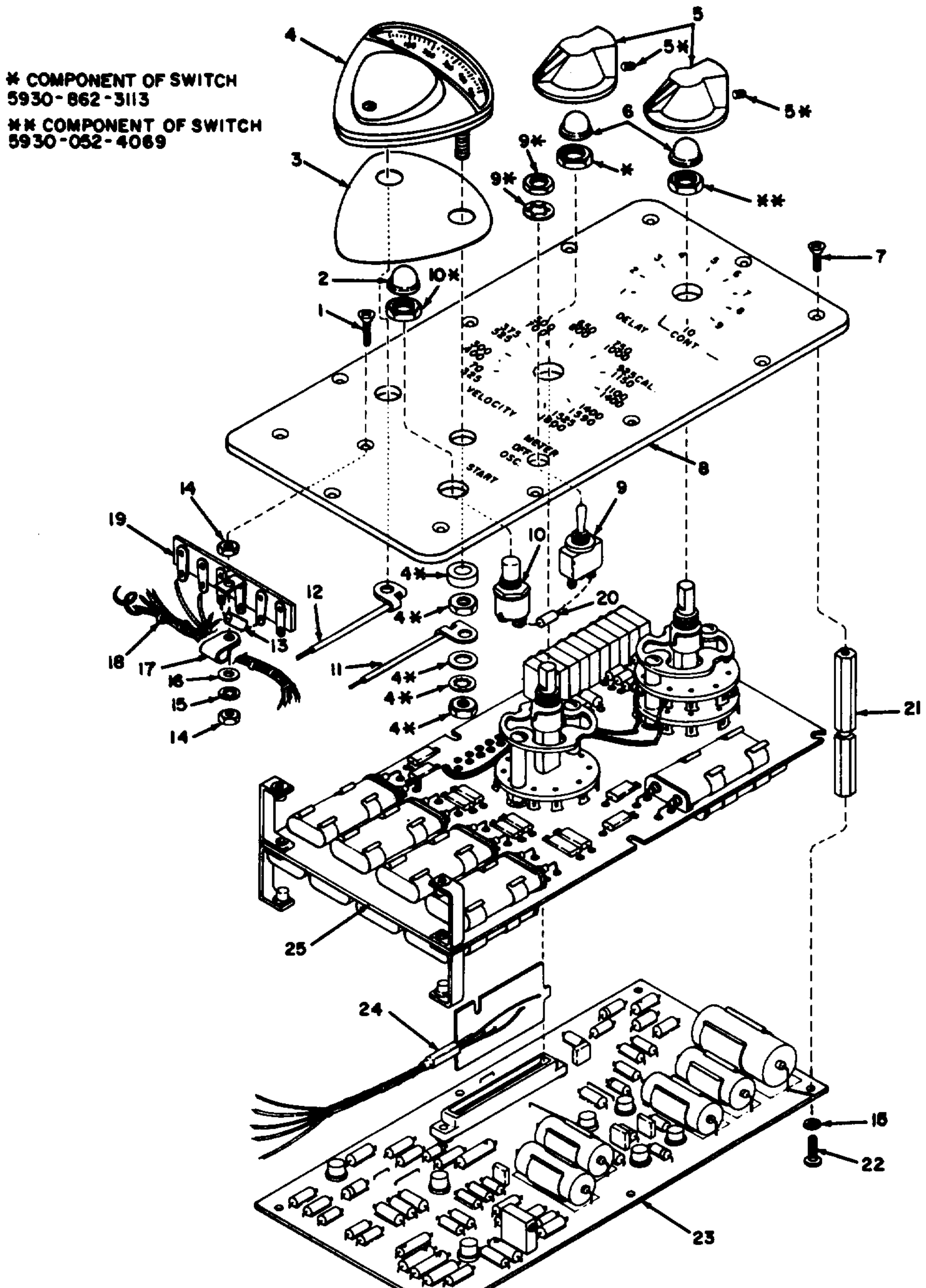
(fig. 4-33)

Refer to figure 4-33 for removal of parts from case assembly. Procedure for disassembly and assembly is obvious and does not require detailed explanation.



1 Screw 5305-770-2533
2 Gasket 5330-019-4577
3 Panel assembly 10552366
4 Cable assembly 1290-997-4597
5 Decal 10552309
6 Gasket 5330-079-7839
7 Connector 5935-755-3688
8 Cover 5935-257-7581
9 Screw 5305-054-5649
10 Washer 5310-550-3715
11 Connector 5935-801-6616
12 Nut 5310-271-4642
13 Case assembly 10552369

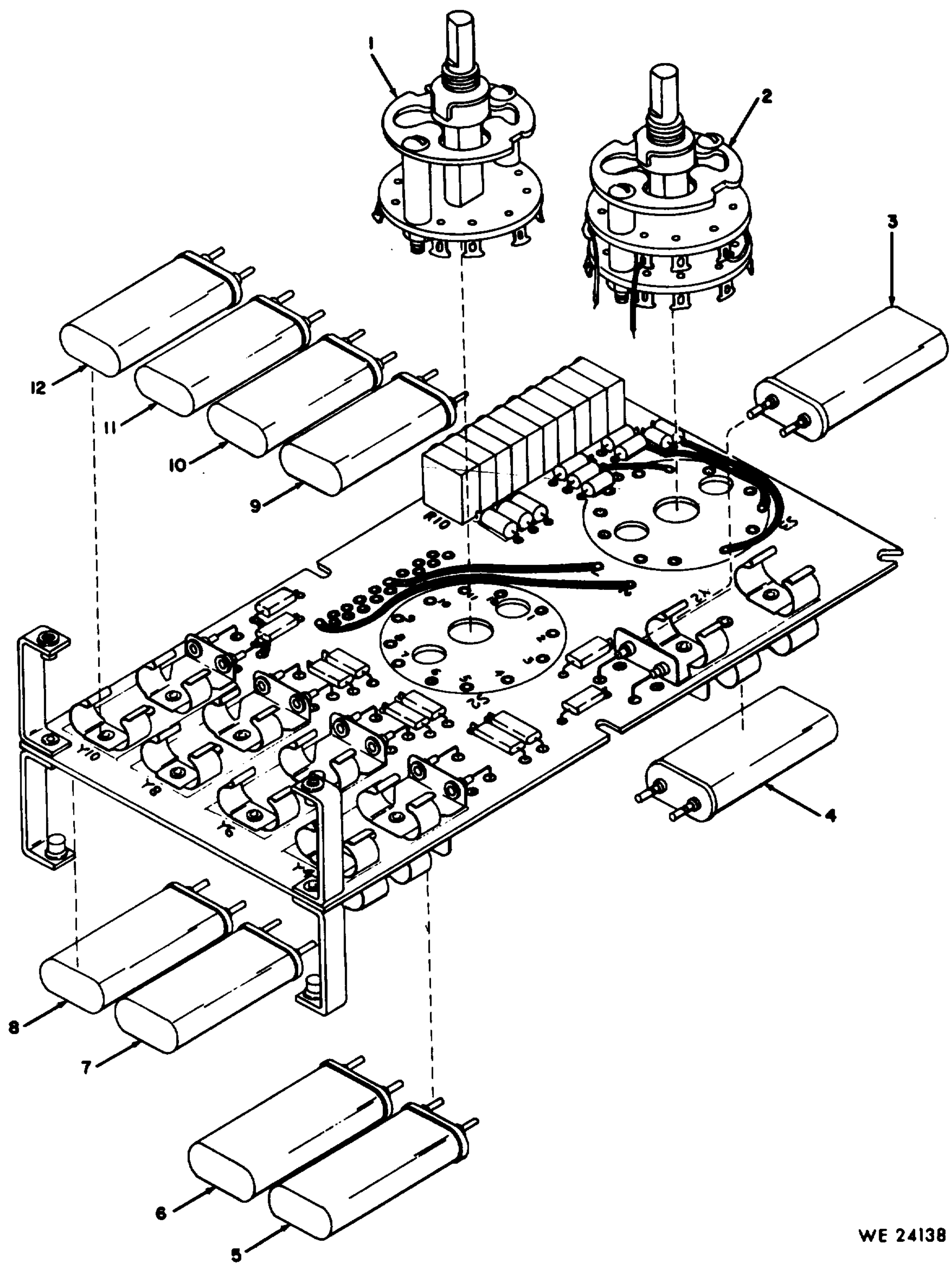
Figure 4-28. Chronograph automatic reliability rater 1290-937--6200-partial exploded view.



WE 24137

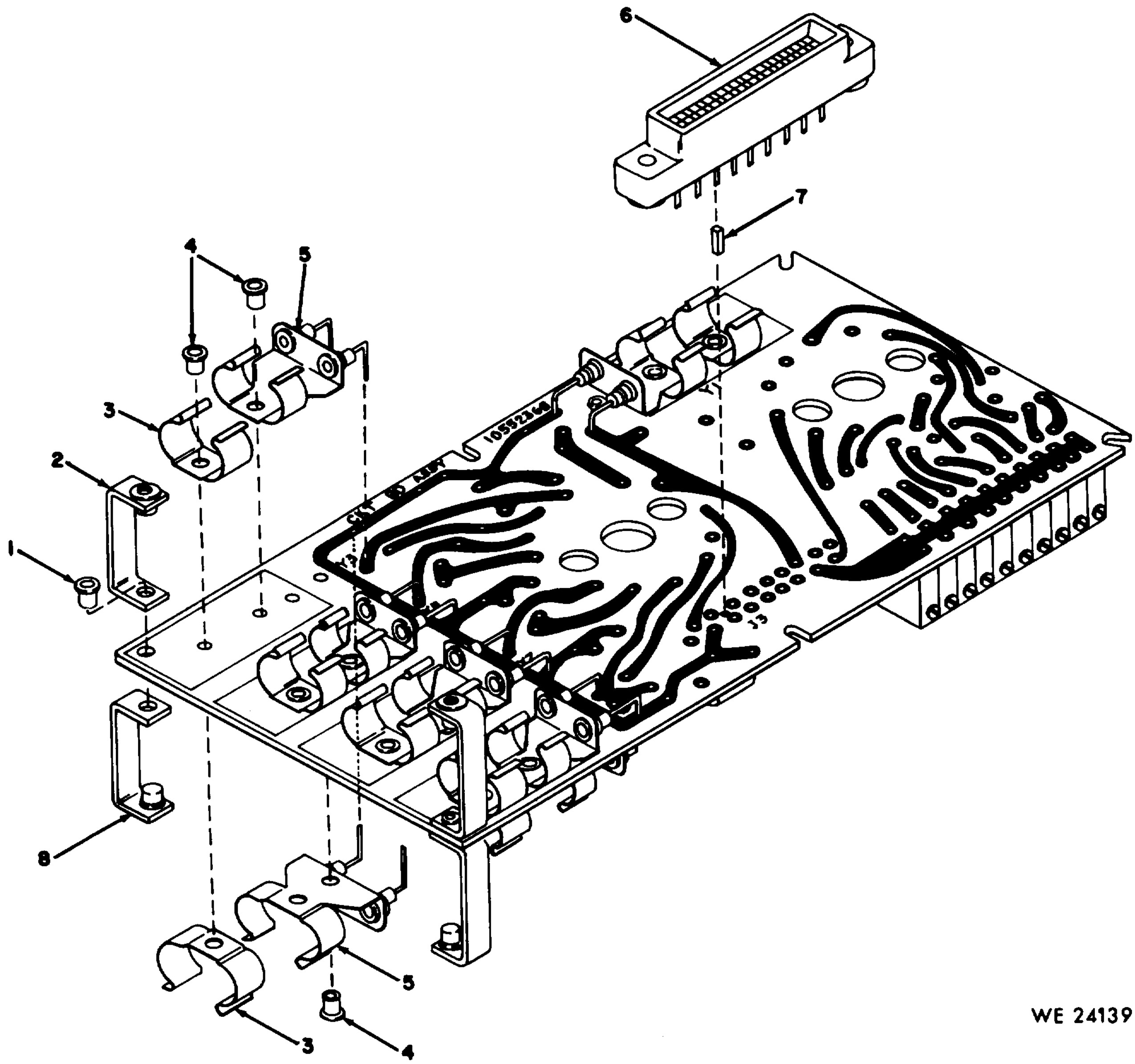
1 Screw MS51959-17
2 Boot 5975-823-0392
3 Gasket 5330-019-4592
4 Meter 6625-886-1284
5 Knob 5355-579-2896
6 Boot 5975-982-9261
7 Screw 5305-770-2579
8 Panel 10552351
9 Switch 5930-943-6612
10 Switch 5930-064-3537
11 Wire 10552321-2
12 Wire 10552321-1
13 Resistor 5905-279-3512
14 Nut 5310-271-4642
15 Washer 5310-550-3715
16 Washer 5910-782-1340
17 Clamp 10552307
18 Cable assembly 10552322
19 Terminal strip 10552308
20 Resistor 5905-279-1758
21 Post 10552300
22 Screw 5305-054-5649
23 Circuit board assembly 10552367
24 Cable assembly 10552347
25 Circuit board assembly 10552368

Figure 4-29. Panel assembly 10552366--exploded view.



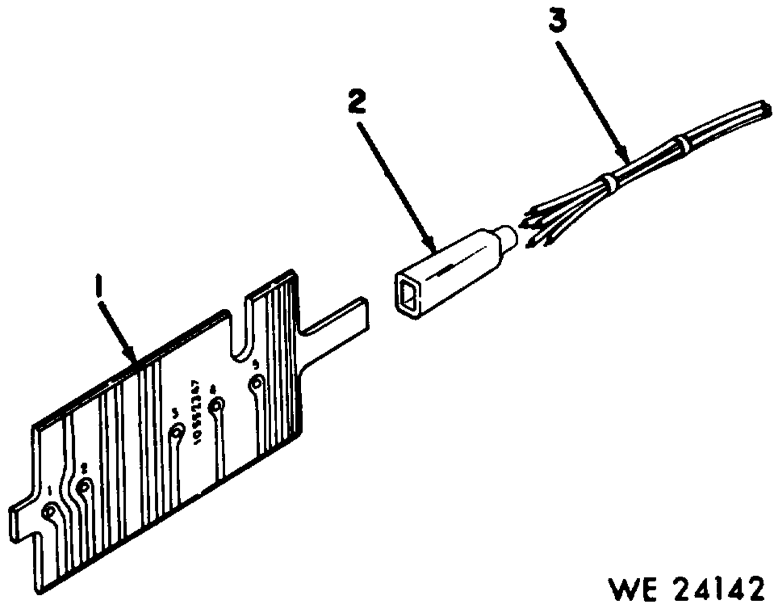
1 Switch 5930-862-8113	5 Crystal 5955-727-5168	9 Crystal 5955-082-4012
2 Switch 5930-052-4069	6 Crystal 5955-892-3377	10 Crystal 5955-848-2320
3 Crystal 5955-860-7749	7 Crystal 5955-774-5951	11 Crystal 5955-848-2015
4 Crystal 5955-087-7896	8 Crystal 10552329-1	12 Crystal 5955-935-5048

Figure 4-30. Circuit board assembly 10552368-partial exploded view.



1 Eyelet 10552305-3
2 Bracket assembly 10552323-1
3 Clip 10525541
4 Eyelet 10552305-2
5 Socket assembly MIL-S-242, part 2, 403.3
6 Connector 10552330
7 Key 10552304
8 Bracket assembly 10552323-2

Figure 4-31. Circuit board assembly 10552368--partial exploded view.



1 Circuit board 10552328
2 Insulation MIL-I-23053
8 Wire MIL-W-16878/4

Figure 4-32. Cable assembly 10552347-exploded view.

Section XI. MAINTENANCE OF INSTRUMENT LIGHT M53E1

4-47. Instrument Light M53E1

For repair procedures and physical description of the instrument light M53E1, refer to TM 9-1290-325-12/1.

4-48. Replacement Parts

Replacement parts for the instrument light are contained in TM 9-1290-325-12/1 and TM 9-1290-325-35P.

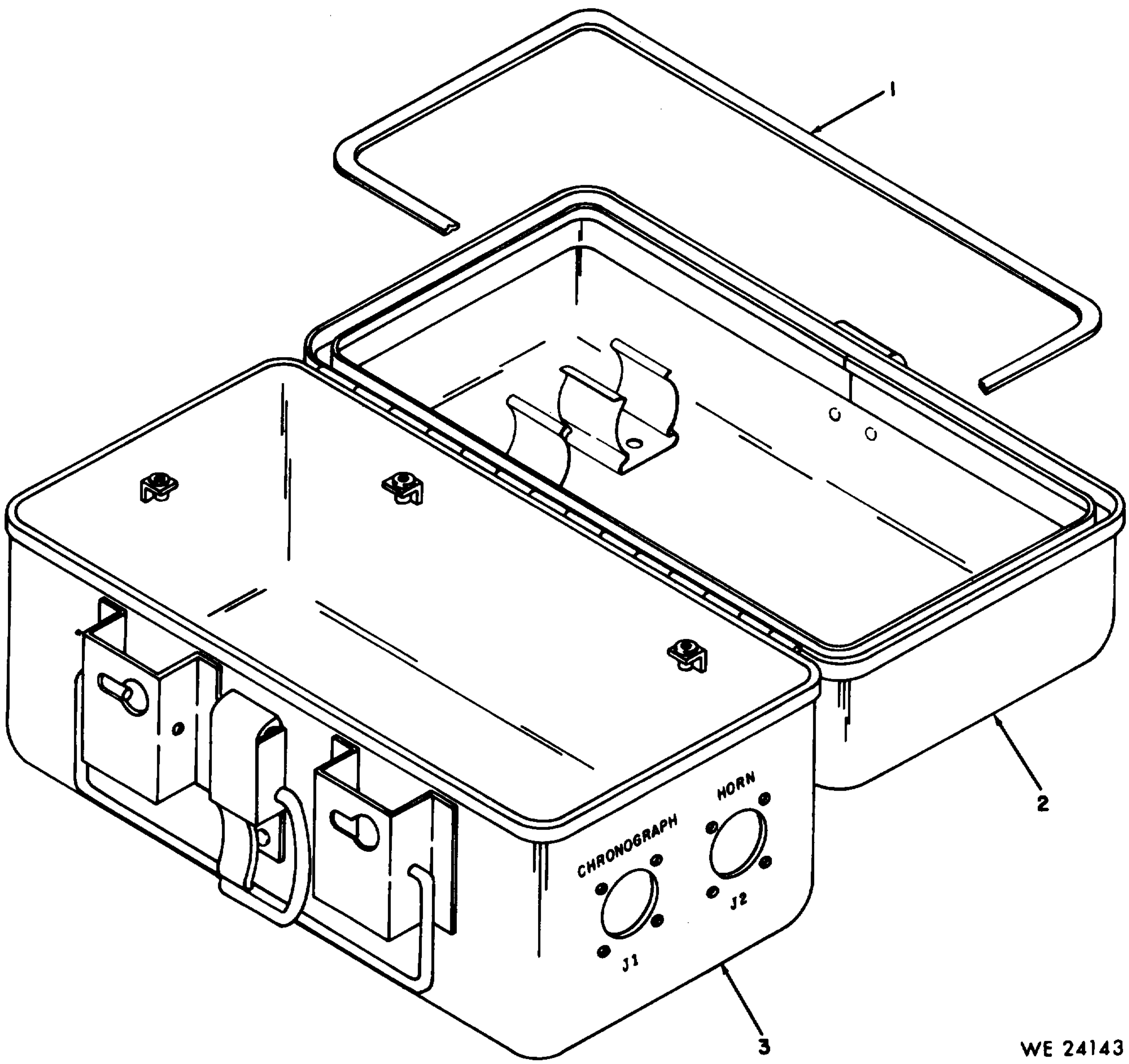


Figure 4-33. Case assembly 10552369--partial exploded view.

1 Gasket 6530-019-4576   2 Lid 10552357   3 Body 10552858

CHAPTER 5

FINAL INSPECTION

5-1. General

Final inspection is completed after repair has been completed to insure that the material is serviceable according to established serviceability standards. Any item containing defects disclosed by the final inspection will be further adjusted or repaired to place it in serviceable condition.

5-2. Mechanical-Visual and Electrical Inspection

Perform the mechanical-visual and electrical inspection contained in paragraphs 3-13 through 3-24.

APPENDIX

REFERENCES

A-1. Publication Indexes

The following publication indexes should be consulted frequently for latest changes or revisions of references given in the appendix and for new publications relating to materiel covered in this manual.

Military Publications:

Index of Administrative Publications	DA Pam 310-1
Index of Blank Forms	DA Pam 310-2
Index of Doctrinal Training and Organizational Publications	DA Pam 310-3
Index of Army Films, Transparencies, GTA Charts, and Recordings	DA Pam 108-1
Index of Supply Catalogs and Supply Manuals (excluding types 7, 8, and 9)	DA Pam 310-6
Index of Technical Manuals, Technical Bulletins, Supply Manuals (types 7, 8, and 9), Supply Bulletins and Lubrication Orders.	DA Pam 310-4
U.S. Army Equipment Index of Modification Work Orders	DA Pam 310-7

A-2. Supply Catalogs

The following Department of the Army Supply Catalogs pertain to this materiel:

Sets, kits, and outfits components list: Fire control maintenance and repair shop specialized equipment tool set, DS, GS, and depot maintenance: General purpose tools (FSN 4931-574-6433).	SC 4931-95-CL-J51
Fire control maintenance and repair shop specialized equipment wrench set, spanner, DS, GS, and depot maintenance: tubr, dble-end concave inserted blade, set of 76 wrenches, FSN 4931-580-0012.	SC 4931-95-CL-J52
Tool kit, fire control repairman: (4931-357-7735) (line item W38621 formerly line item 453790).	SC 4931-95-CL-A04
Shop set instrument and fire control: Field maintenance basic (4931-754-0740) (line item T31784 formerly line item 440618) and shop set instrument and fire control: Field maintenance basic map only (4931-919-0101).	SC 4931-95-CL-A07

A-3. Forms

The following forms pertain to this materiel:

DA Form 9-1, Materiel Inspection Tag
DA Form 9-79, Parts Requisition
DA Form 829, Rejection Memorandum
DA Form 1296, Stock Accounting Record
DA Form 2765, Title Insert (Formal Accountability)
DA Form 1546, Request for Issue or Turn-in
DA Form 2028, Recommended Changes to DA Publications Parts List or Supply Manual 7, 8, or 9
DA Form 2402, Exchange Tag
DA Form 2405, Maintenance Request Register
DA Form 2407, Maintenance Request
DD Form 6, Report of Packaging and Handling Deficiencies
DD Form 250 Materiel Inspection and Receiving Report

A-4. Other Publications

a. Camouflage.

Camouflage, Basic Principles and Field Camouflage	FM 5-20

b. Decontamination.

Chemical, Biological, and Radiological (CBR) Decontamination	TM 3-220
Chemical, Biological and Nuclear Defense	FM 21-40

c. Destruction to Prevent Enemy Use.

Ammunition Service in the Theater of Operation	FM 9-6

d. General.

Accident Reporting and Records-	AR 385-40
Authorized Abbreviations and Brevity Code	AR 320-50
Dictionary of United States Army Terms	AR 320-5
Malfunctions Involving Ammunition and Explosives	AR 700-1300-8
Military Symbols	FM 21-30, AFM 5-3
Military Training Management	FM 21-5
Principles of Fire Control Materiel	TM 9-3305-2
Shop Mathematics	TM 9-2820
Techniques of Military Instruction	FM 21-6
Army Equipment Record Procedures	TM 38-750

e. Maintenance.

Adhesive, Epoxy Resin, Metal to Metal Structural Bonding	MIL-A-8623
Cleaning of Ordnance Materiel	TM 9-208-1
Command Maintenance Management Inspections	AR 750-8
Direct Support, General Support and Depot Maintenance Repair Parts and Special Tools List for Radar Chronograph Set M36.	TM 9-1290-326-35P
Finishing of Metal and Wood Surfaces	MIL-STD-171
General Maintenance Procedures for Fire Control Materiel	TM 9-254
General Specification for Soldering Process	MIL-S-6872
Grease, Aircraft and Instrument (For Low and High Temperature)	MIL-G-23827
Lubricating Grease, Pneumatic System	MIL-L-4343
Lubricating Oil, Instrument, Aircraft, Low Volatility	MIL-L-6085
Electrical and Electronic Reference Designations	MIL-STD-15C
Operator and Organizational Maintenance Manual: Radar Chronograph Set M36.	TM 9-1290-325-12/1
Direct Support, General Support and Depot Maintenance Manual (Including Repair Parts and Special Tools List) Telescope M9OC, M9OD, M9OF, and XM128.	TM 9-1240-211-35
Lubrication of Ordnance Materiel	TM 9-273
Materials Used for Cleaning, Preserving, Abrading and Cementing Ordnance Materiel; and Related Materials Including Chemicals.	TM 9-247
Painting and Finishing Systems for Fire Control Instruments	MIL-STD-194
Painting Instructions for Field Use	TM 9-213
Sealing Compound, Adhesive, Curing (Polysulfide Base)	MIL-S-11031
Sealing Compound, Non-Curing, Polysulfide Base	MIL-S-11030
Elementary Optics and Application to Fire Control Instruments	TM 9-258
Use and Care of Hand Tools and Measuring Tools	TM 9-243
Chronograph Automatic Reliability Rater: 10552370	MIL-C-60690A (MU)

f. Operations.

Northern Operations -- FM 31-71
Operation and Maintenance of Ordnance Materiel in Extreme Cold Weather, TM 9-207
0° to 65° F.
Data Sheets for Ordnance Type Materiel -- TM 9-500

g. Shipment and Storage.

Paper, Lens, Tissue, Antitarnish Wrapping --- MIL-P-13988
Preservation, Methods of--- MIL-P-116
Preservation-Packaging, Packing and Marking of Items of Supply--- AR 700-15
Protection of Ordnance General Supplies in Open Storage--- TB ORD 379
Report of Packaging and Handling Deficiencies--- AR 700-58
Requisitioning, Receipt and Issue System --- AR 725-50

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The Adjutant General.

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