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Report on

Anti-Jam Receivers

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SERIAL No. 12

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Problem W52S and X4-28

Navy Department

Report on

Anti-Jam Receivers

Naval Research Laboratory

Anacostia Station

Washington, D. C.

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A. ABSTRACT.

Work on anti-jam circuits for radar receivers has been in progress at this laboratory since 1941. Many types of circuits have been tried and discarded because of being impractical or because of having undesirable characteristics which offset the a.j. advantages offered. The principal a.j. features which have been experimentally proven are now being incorporated in current receiver design are:

1. IF rejection filters.

2. Low frequency degeneration in the earlier IF stages.

3. Amplified back biasing in last IF stages.

4. Balanced video.

5. Variable bandwidth.

Most of the work to date has been with Type A presentation since the inherent resolution of the A scope is in itself an a.j. feature (as compared to PPI). However the main emphasis in a.j. work now will be applied to PPI presentation. Present circuits (when used with the A scope) will be found quite effective against any type jamming signal which the enemy has used up to the present. Except by reduction of receiver bandwidth or change of radar frequency a.j. against a truly random noise jamming signal is impossible since any mechanism for accomplishing this would be used primarily to improve the signal to noise ratio of the receiver.

B. INTRODUCTION.

The first radar anti-jamming work at Naval Research Laboratory started in July 1941 after it had become evident that present radar systems could be easily jammed with almost any type of radiation on the radar frequency. Since radar systems as a whole are inflexible as to frequency of operation because of complicated antenna arrays which will operate over only a narrow frequency band and because of multiple tube transmitters which are difficult to make easily tunable, work was started to reduce the vulnerability of radar receivers to jamming signals. It was realized that any receiving system could be jammed but the work was initiated to design receivers which would be less easily jammed with the ultimate hope that receivers could eventually be designed which would make jamming impractical, or at least much less effective.

An examination of the frequency spectrum of a radar pulse shows an energy distribution spreading out each side of the carrier frequency to a considerable extent, the exact extent depending on the pulse shape and the pulse length. For a search radar pulse of 5 microseconds in length the band is approximately $\pm$ 200 kc. Since this energy spread is more or less uniform it is possible to eliminate interference which falls in only part of the band and pass the pulse side band energy

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outside the interference band with more or less pulse attenuation depending on the extent of the interference band.

If two frequencies are impressed on a non-linear device such as a detector or a converter tube new frequencies are generated equal to the sum and difference of the original frequencies. The new sum or difference frequency can then be amplified without amplifying the original frequencies. This phenomena makes possible the rejection of strong interference which can be eliminated in a detector or converter tube, only the beat frequencies between the pulse signal and interference then being amplified.

Pulse echoes are stationary on a radar indicator oscillograph due to the sweep of the oscillograph beam being synchronized with the outgoing pulse from the radar transmitter. Pulsing interference is usually non-synchronous and consists of "Ghost" pulses floating across the oscillograph screen. If the cathode ray tube is instantaneously blanked when such a signal is received the "ghost" will disappear. However if the time between these "ghost" pulses is great enough for the receiver to recover sensitivity the normal echoes which are not blanked will appear as before.

Methods of making use of the interference rejection available because of the phenomena of freqency band spread of the radar pulse signal, of heterodyning interfering signal and pulse signal, and of oscillograph blanking in the presence of nonsynchronous pulse type interference have been investigated and circuits have been developed which have materially improved the anti-jam properties of radar receivers.

C. EARLY AJ EXPERIMENTS AND RESULTS.

1. Considerable CW interference was encountered during laboratory tests of radar systems. This brought home the fact that radar receivers could be easily jammed. The first expedient taken to reduce the effects of CW jamming was to couple the final detector of the receiver to the first video amplifier grid by means of a blocking condenser. This eliminated blocking of the video amplifier caused by rectified DC from the detector biasing the video grid off the operating characteristics of the tube. This method of CW elimination was carried as far as practicable by increasing video amplifier gain and decreasing IF amplifier gain to a point where IF overloading was delayed considerably. The ultimate limit for this simple scheme is determined by the necessary signal required at the 2nd detector to give useable output in the absence of a CW jamming signal. This method of CW elimination is automatic, requiring little, if any, receiver readjustment in the presence of interference. The dynamic range (ratio of interfering CW signal voltage to the minimum detectable pulse voltage) can be increased with a minimum of complications from about 10 for a receiver with direct coupled second detector to about 1000 for a high video gain receiver.

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The dynamic range of such a system can be increased even further by means of two gain controls, one on the IF amplifier and one on the video amplifier. If ample reserve of gain is available in each amplifier and ample gain control possible the dynamic range against CW can be increased as much as desired, being finally limited to the value at which the first IF amplifier tube is overloaded by the interference. Dynamic ranges of 1,000,000 against CW are obtainable in this manner. A system such as this, however, requires continuous variation of two gain controls as the interfering signal level varies, resulting in an awkward operational handicap. In addition to the operational handicap, design of video amplifiers with a gain of 1,000,000 which are suitable for radar use is very difficult.

A modification of this method was tested which had a dynamic range of greater than 100,000 against CW interference. This system used parallel IF and video channels with equal gain, cross connected with side detectors to give automatic control of IF and video gain. As the CW interference level increased, blocking the later IF stages, side detectors ahead of the blocked IF stages fed signal into the video amplifier at which point the interference was eliminated and the signal was amplified to the desired output level. This system was further modified in its final form so that the final detector fed back through an attenuator to the video amplifier with the earlier side detectors coupled in at an appropriate point on the attenuator to give equal output regardless of which detector tube was in operation. Although CW was eliminated in this fashion the difficulty of video amplifier design which would give a sufficiently short recovery time from the transmitted pulse combined with the vulnerability to modulated interference stopped additional effort on this system.

2. The idea was conceived of making use of the interference as the heterodyne oscillator, thereby passing the beats between the interference and the desired echo pulses and eliminating the interference energy at the first converter of the receiver. The IF amplifier would be so designed that it would pass the high frequency video components of the pulse and the higher frequency beats between the interference and the pulse. In this manner CW, AM, or FM with modulation freqencies below or above the frequency pass band of the IF would be eliminated. Several receivers of this type were designed and constructed. These used a zero beat converter followed by a high gain differentiating video amplifier (low frequency IF amplifier) in turn followed by a DC restorer and filter for reforming the pulse.

In operation, two methods of interference rejection were possible with this type of receiver. CW of low modulation rate MCW could be eliminated by retuning the local oscillator to exact zero beat with the interference. All of the DC and low frequency modulation components of the interference were eliminated because they fell outside the response band of the IF amplifier. This allowed the higher frequency components of the pulse signal to come through the amplifier without attenuation. The second method of interference rejection consisted in simply switching off the receiver local oscillator and using the interfering signal as the heterodyne oscillator. FM, as

[redacted]

well as AM and CW, could be eliminated in this fashion.

However, for search radar applications where pulse lengths of four to twenty microseconds were used it was found to be impossible to design a differentiating video amplifier with the necessary high gain which would give sufficient pulse response and at the same time have a short enough recovery time from the transmitted pulse for short minimum range. For example, a receiver of this type designed for operation with a four microsecond transmitted pulse required 25 microseconds for recovery from the transmitted signal, corresponding to a minimum range of two nautical miles. In addition, because of the slow recovery time of the amplifier circuits, railing and other types of interference with high frequency modulation components caused more damage than in normal receiver circuits.

For use with very short pulses a zero-beat conversion receiver is quite practical and recovery times in the order of a few microseconds are possible. Both design and operation of a receiver of this type is relatively simple and many types of interference can be easily eliminated. Experiments were made with double superheterodynes and dual IF receivers making use of zero-beat conversion for interference rejection but none of them proved to be practical because of the impossibility of obtaining short recovery time in the high gain differentiating video amplifiers.

3. The next receiver was developed with the idea of making use of the good features of the zero beat receiver and yet of eliminating as many of the disadvantages as possible.

A double superheterodyne was decided on which had a relatively high frequency first IF with amplified AVC to prevent overloading by interference, followed by a second converter and a one Mc IF which made possible, under some conditions, using the interference as the heterodyne oscillator. Tunable rejection filters were placed at the input to the 1 Mc IF amplifier for rejection of any desired narrow band of frequencies in the normal pass band of the amplifier. A balanced detector-video amplifier was incorporated for blanking of signals above a controllable amplitude. CW, FM or AM with modulation rates up to 500 Kc. could be rejected by using the interference as the heterodyne oscillator. CW exactly at zero beat which could not be used as the heterodyne oscillator could be eliminated by means of rejection filters provided.

The dynamic range of this receiver was in the region of 50,000 to 5,000 for the types of interference mentioned.

The objection to this system was that highly skilled operators would be required for its operation and the time needed to anti-jam under some conditions would be quite long since eight to twelve control knobs were necessary to make use of the features provided.

4. Experiments were conducted with balancing circuits in various parts of a receiver with the idea of balancing strong signals to zero

output without affecting weaker signals.

Tests were made on balanced IF amplifier circuits which balanced the IF components directly by means of push-pull grid parallel plate circuits in which one channel operated at low bias and other channel operated at high bias. In this fashion strong signals would pass through each channel and cancel in the output circuit but weak signals with random phase relationships to the interference would pass through one channel only. Successful amplifiers of this type were constructed at 1 Mc., 3 Mc., and 15 Mc., and a dynamic range of about 20 was realized in one stage. The action of this circuit was dependent on amplitude differences only and was independent of side band frequency components which was a very desirable feature. However, the operation of this circuit was quite critical and accurate phase control for good interference cancellation was extremely difficult. Although single stages operated satisfactorily cascaded amplifiers of this type proved to be impractical.

A modification of the balanced IF amplifier which balanced the rectified component of the interference against the IF component appeared to be the most satisfactory compromise. The IF components of the interference were reduced to a value which never drove the IF amplifier grids positive by merely feeding back enough of the rectified output to always maintain the amplifier tubes in the negative grid region. By slightly delaying the time of the feedback voltage the higher frequency beats between the interference and the desired pulse were not fed back in phase so these echo beats were passed by the amplifier at the peak G_m point on the crest of the interfering waves. A short time constant in the biasing back circuit allowed operation through fairly high modulation frequencies, either AM or FM. For very high modulation rates a long time constant could be switched in thereby allowing the bias voltage on the amplifiers to build up to a peak value equal to the peak modulation level of the interference. In this way the echo would only be seen when it was phased properly with the interference so that it rode on top of a modulation peak of the interference.

In the type CG-46ACQ receiver designed as a replacement in the SC series radars it has been found that the short or medium time constant position of the feedback circuit will prevent amplifier overload with modulation rates up to about 50 Kc at which point it is preferable to switch to the long time constant and to work on the modulation peaks rather than to try to follow the modulation.

Details of the actual biasing bagk circuits for prevention of overload and for suppression of interference modulation will be discussed later.

Pulsing interference with frequency components similar to those in the radar pulse are not appreciably discriminated against in the biasing back circuits. For rejection of interference of this type, particularly for PPI presentation or pip matching presentation where relative peak voltage ratio of signal to interference is of utmost importance, the balanced video amplifier was developed. This device has a manual control which makes possible inverting the polarity of pulses

[redacted]

above a desired amplitude without inverting weaker pulse signals. In this way normal echoes will appear with positive output showing a bright spot or arc on a PPI screen while stronger pulses will drive negative and give very little output indication. It is possible with this circuit to make weak pulses show indications above any indications resulting from stronger pulses. The balanced video circuit operates in the following fashion: Two diodes are used as final detectors, one rectifying the positive half waves of the IF and the other the negative half waves. The negative output is coupled to the grid of a video amplifier tube which is biased for class A operation. The positive output is coupled to the grid of a video amplifier which is biased for class B or class C operation. The outputs of the two video tubes are connected in parallel. The class A amplifier passes all signals, but the class C amplifier passes strong signals only. In this manner strong signals cancel at the output but weak signals pass through one channel only and give positive output without attenuation. By means of a bias control or a gain control on the class C channel all signals above some desired level can be made to cancel or drive negative which gives no indication on a PPI scope or a pip matching scope.

5. Wide band random noise modulated interference cannot be effectively eliminated by means of rejection filters, biasing back circuits or balanced video amplifiers. Improving signal to noise ratio in the receiver when the noise in question is from an external source and is appreciably higher than the inherent receiver noise appears to be impossible without reducing receiver bandwidth. Improvement in signal to noise ratio obtained by means of integration, feedback through delay lines, etc., is a method of reducing bandwidth without requiring increased pulse length. The maximum improvement in signal to noise ratio obtainable by post detector integration (which seems to be the only practical way of doing it at the present time) appears to be between 3 and 10 db., and such equipment has not as yet been developed to a stage practical for incorporation in a radar receiver.

However, an appreciable improvement in signal to noise ratio can be accomplished if definition can be sacrificed (as it often can be in a search radar) by narrowing the receiver bandwidth and increasing the transmitter pulse length. A practical improvement of 15 db can be accomplished in a radar system if the receiver bandwidth is decreased by 40:1 and the pulse length is increased a similar amount. Particularly in a multi-purpose radar which must have good definition for short range work but also must be capable of good sensitivity for early warning an improvement of 15 db is valuable. This improvement in signal to noise ratio would result in a 60% increase in radar range against aircraft. Variable bandwidth and variable pulse length is being incorporated in the XBF (SR) radar system in the process of development at the Naval Research Laboratory.

D. <u>PRESENT STATE OF RADAR AJ AT NAVAL RESEARCH LABORATORY.</u>

1. Anti-jam circuits of various types have been mentioned. The CG-46ACQ anti-jam receiver was developed at Naval Research Laboratory to replace existing SC, SC-1, SC-2, and SK radar receivers. This receiver

[redacted]

makes use of the most practical of the AJ circuits investigated and contains the following general features:

Frequency band 175 to 225 Mc.
Overall receiver bandwidth 300 Kc.
Sensitivity 6 db.
RF amplifier - 2 stage using GL 446 tubes.
Converter GL 446
Local oscillator GL 446.
IF frequency 15 Mc.
If amplifier 5 stages using 6AC7.
AVC 6AG7.
Detector 6H6.
Balanced video 2 - 6AG7.
Total number of tubes 13.
(See Plate 2 for photographs and plate 5 for wiring diagram).

The AJ features of the CG-46ACQ receiver are as follows;

a. Two IF rejection filters are tunable individually over the IF band. These reject a very narrow band of frequencies so that a pulse signal can be passed due to the side band frequencies present while an interfering signal without side bands (cw) or with only low frequency side bands (modulation frequencies roughly below 1000 cycles without appreciable FM component) or a side band component which consists of essentially a single frequency can be greatly reduced in amplitude.

b. High cathode biasing resistors are used in the second and third IF stages in order that demodulation of the high level interfering signal will take place and demodulated voltage will automatically bias back the amplifiers so that overdriving of the amplifiers into the grid current region is greatly delayed. In order to differentiate between the desired pulse and the interference modulation a small condensor is placed across the cathode resistor and the time constant is so adjusted that high frequency pulse components and high frequency beats between the interference and the desired pulse will not be degenerated but all lower frequency components will beheavily degenerated, resulting in reduced gain to the interference but not to the desired pulse.

The fourth and fifth IF amplifiers have amplified DC feedback for the purpose of maximum suppression of interference with minimum loss of gain to the desired pulse signals. The cathodes of these two amplifiers are returned (through decoupling networks) to the plate of the 6AG7 back bias amplifier. The grid of the 6AG7 is directly connected to the negative detector output. As the negative output from the detector is increased (the 6AG7 bias is increased) raising the plate impedance and increasing the bias on the IF amplifier tubes. Sufficient gain is available in the 6AG7 that the second detector output can never exceed one to two volts regardless of the signal level at the IF grids. This feature prevents any possibility of video amplifier overloading. A time constant switch is provided which allows a choice of frequency response in the feedback circuit for operation through various types of interference.

[redacted]

Another feature of this biasing back circuit which is not obvious at a glance is brought about by the manner in which the 6AG7 biasing back amplifier operates. Normally in the absence of interference the 6AG7 is operating at low bias on its diode characteristic with a plate impedance of about 4000 ohms. In series with the 6AG7 are the IF amplifier tubes which are operating with high bias and high plate impedance. In the presence of strong pulsing or railing interference the grid of the 6AG7 is driven far negative past cutoff blocking the tube completely. Bias then builds up on the IF amplifier at a rate dependent on the tube impedance and the cathode to ground capacity. However, the instant the pulse goes off, the 6AG7 grid is returned to normal bias and the bias voltage developed across the condenser from IF cathodes to ground is very quickly returned to normal through the low impedance tube. This ratio of buildup time to recovery time in the AVC amplifier circuit is about 5:1 and helps to maintain a short receiver recovery time from the main transmitted pulse and from railing interference.

The second detector-video circuit gives the balanced video operation previously described. The two sections of the 6H6 diode are so connected that one element rectifies the positive half cycle and the other rectifies the negative half cycle of the IF wave. The negative diode is coupled to the normal video amplifier tube (6AG7) which operates class A. The positive diode is coupled (through a variable attenuator) to the grid of the balancing tube (6AG7) which is operated with cutoff bias. The balancing tube will only amplify signals which are sufficiently strong to drive the grid voltage high enough so the tube will conduct. The signal level required to make the tube conduct is controlled by the potentiometer at its grid. Since the plate of the balancing tube is in parallel with the plate of the normal video amplifier it is possible to make all signals above some level determined by the input potentiometer setting cancel to zero output while all signals below that level will still give positive output. This circuit is particularly useful in blanking out pulse interference on PPI indicators, and to reduce the masking effect of nonsynchronous pulses and railings on pip-matching scopes.

2. The following table shows the comparison between the AJ receiver and a conventional receiver with no AJ protection for various types of interference: (See also appendix - plate 4)

	Dynamic Range	
Type of Interference	AJ Receiver	Conventional Receiver
CW	100,000	15
400 cycle 50% modulated CW	100,000	25
1000 cycle 50% modulated CW	100,000	25
10,000 cycle sq. wave 50% modulated CW	100,000	50
100 Kc. 50% modulated CW	25,000	50

[redacted]

(Table continued)

Type of Interference	Dynamic Range: AJ Receiver	Dynamic Range: Conventional Receiver
100 Kc. 100% modulated CW (Railings)	100,000	2000
100 Kc. 50% modulated CW plus)) - 1000 cycle 50% modulated CW)	25,000	25

3. A standard AJ receiving system has been developed at Naval Research Laboratory for use with the XBF, CXCB, SR and ST radar systems which makes use of the AJ features of the CG-46ACQ receiver plus (except the ST) incorporation of a variable bandwidth circuit which makes available bandwidths of 2 Mc, 250 Kc, or 50 Kc.

The flexibility of this receiving system is increased by splitting the receiver into two parts. The RF circuits complete with a conventional IF amplifier feed a monitor scope in the transmitter frame. From the 2nd IF amplifier of the monitor receiver a line goes to the AJ unit at the main indicator frame where PPI and A scope presentation is available. Remote PPI units are then fed from the main indicator. The AJ unit contains variable bandwidth circuits, rejection filters, amplified short time constant back biasing circuits and balanced video circuits.

4. An AJ adapter to be used with Mark III and Mark IV radar systems has been developed (Plate 3 and Plate 6) This unit consists of an IF rejection filter, four IF amplifiers, short time constant amplified back biasing and balanced video. The dynamic ranges of the CG-46ACQ receiver shown in the table are representative of the other AJ systems because the basic AJ features are the same.

E. CONCLUSIONS.

1. The surface of radar anti-jamming has been scratched and considerable improvement against CW, MCW, and FMCW interference has been realized. More improvement with reduction in operational complexity is in order.

The AJ work which has been done will prevent the enemy jamming our radars with the simpler types of interference such as CW, sine wave or square wave amplitude or frequency modulated CW with modulation rates below 50 Kc. and will make it appreciably more difficult than it was previously to jam with modulation rates above 50 Kc.

The power necessary to seriously jam an SC receiver is about 10 watts of CW or MCW at 20 miles. The CG-46ACQ receiver could operate through nearly 40 million watts of CW at that range without serious loss of sensitivity.

[redacted]

In the final analysis it may be stated that the AJ problem has been carried to the point where in order to jam our radars effectively the enemy must use complex wide band modulation (such as noise) on his jammers. As yet no complete answer to the problem of noise jamming has been evolved except to shift the radar operating frequency off the band which is being jammed. Work is progressing on easily tunable radar systems and that will probably be the best AJ feature available in any radar.

2. Following is a list of AJ features which are to be investigated at Naval Research Laboratory in the immediate future for possible value in improving AJ performance of radar receivers:

a. Side band balancing circuits for elimination of any amplitude modulated interference.

b. Side band blanking circuits for elimination of any frequency modulated signal.

c. Pulse length discriminator circuits for rejecting any pulses either longer or shorter than the radar pulse.

d. Improved back biasing circuits for shorter recovery time and elimination of manual controls.

e. Improved clipper circuits for cleaning up presentation on PPI in presence of jamming.

f. Automatic control circuits to keep echo amplitude independent of jamming level in order to prevent PPI blanking in jammed sector and to prevent bearing inaccuracies in fire control systems due to off bearing interference.

g. Improved variable bandwidth circuits.

With the above features properly incorporated it is the eventual hope that a radar AJ receiving system will be developed which is virtually impossible to jam except with true random noise. In the meantime it is hoped that experiments on noise reduction will lead to a practical method of combating noise jamming.

At the present state of the art the only completely sure fire AJ device is a second radar on an unjammed frequency and this may always be the case.

It is recommended that work be continued on AJ receivers but that in addition, every effort be made to make all future radar systems very easily tunable over at least a 10% frequency range, preferably with rapid automatic variation in steps.

[redacted]

Appendix:

7 a. <u>60 ABY of OAV Jamming Signal Generator.</u>

The 60 ABY jamming signal generator was developed to furnish typical jamming signals to be used with the CG 46 ACQ receiver for operator training aboard ship.

The jamming signal generator contains an oscillator, tunable between 150 and 250 Mc., a built-in multivibrator, and a modulator. An attenuation range of approximately .2 volts to 100 microvolts is available with modulation of about 50% at 100 cycles, 1000 cycles, 10,000 cycles, or 100,000 cycles per second and pulse modulation with the same frequencies of repetition rate at a pulse length of about six microseconds. An attenuator control (calibrated in approximate output volts), an RF tuning control calibrated in approximate megacycles per second, a pulse-modulation switch, a 5 position tap switch to select modulation frequency, and a power switch, are the controls on the front panel. One 60 ABY signal generator is to be furnished with each CG 46 ACQ replacement receiver.

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ZERO BEAT RECEIVER

PLATE 1

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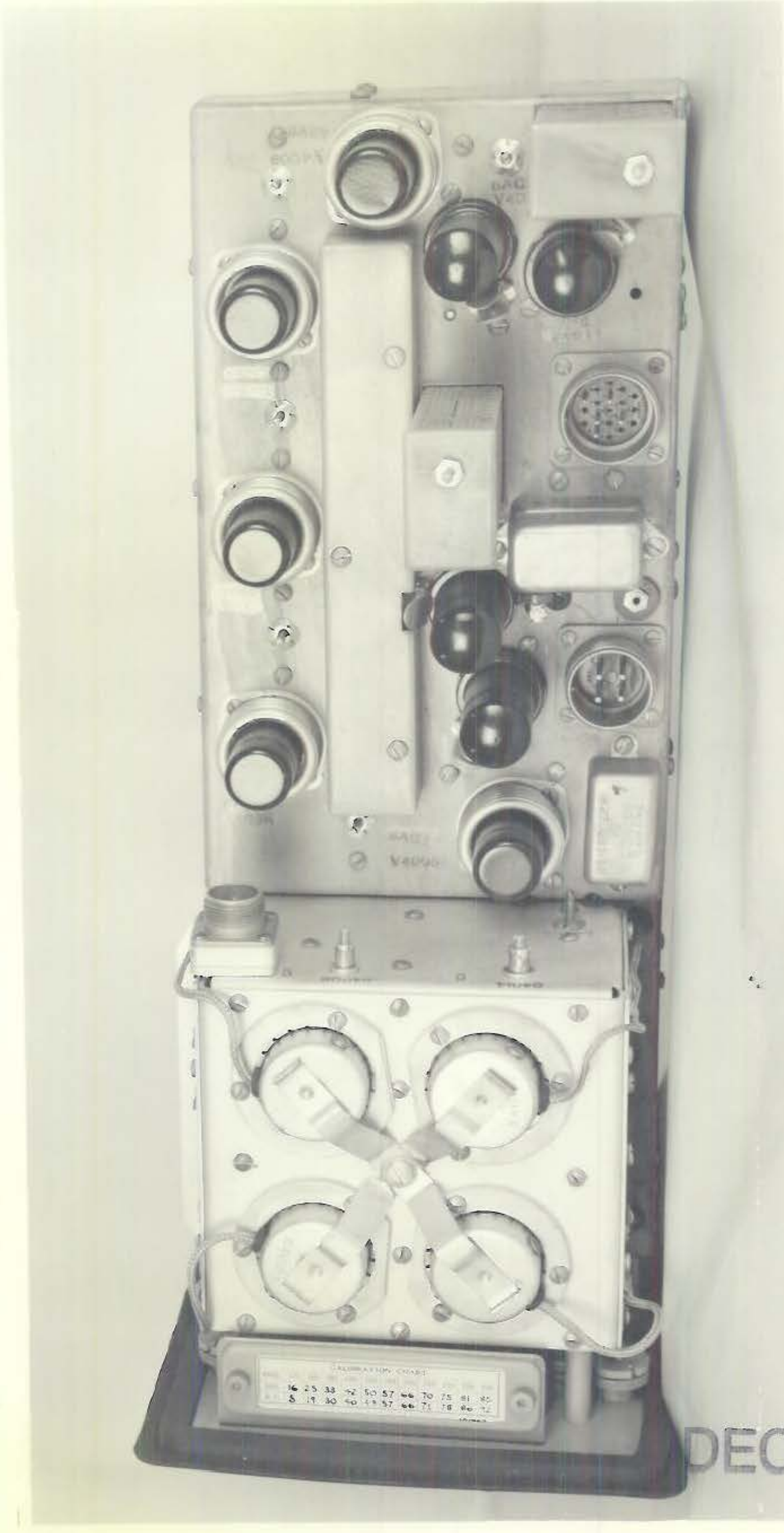
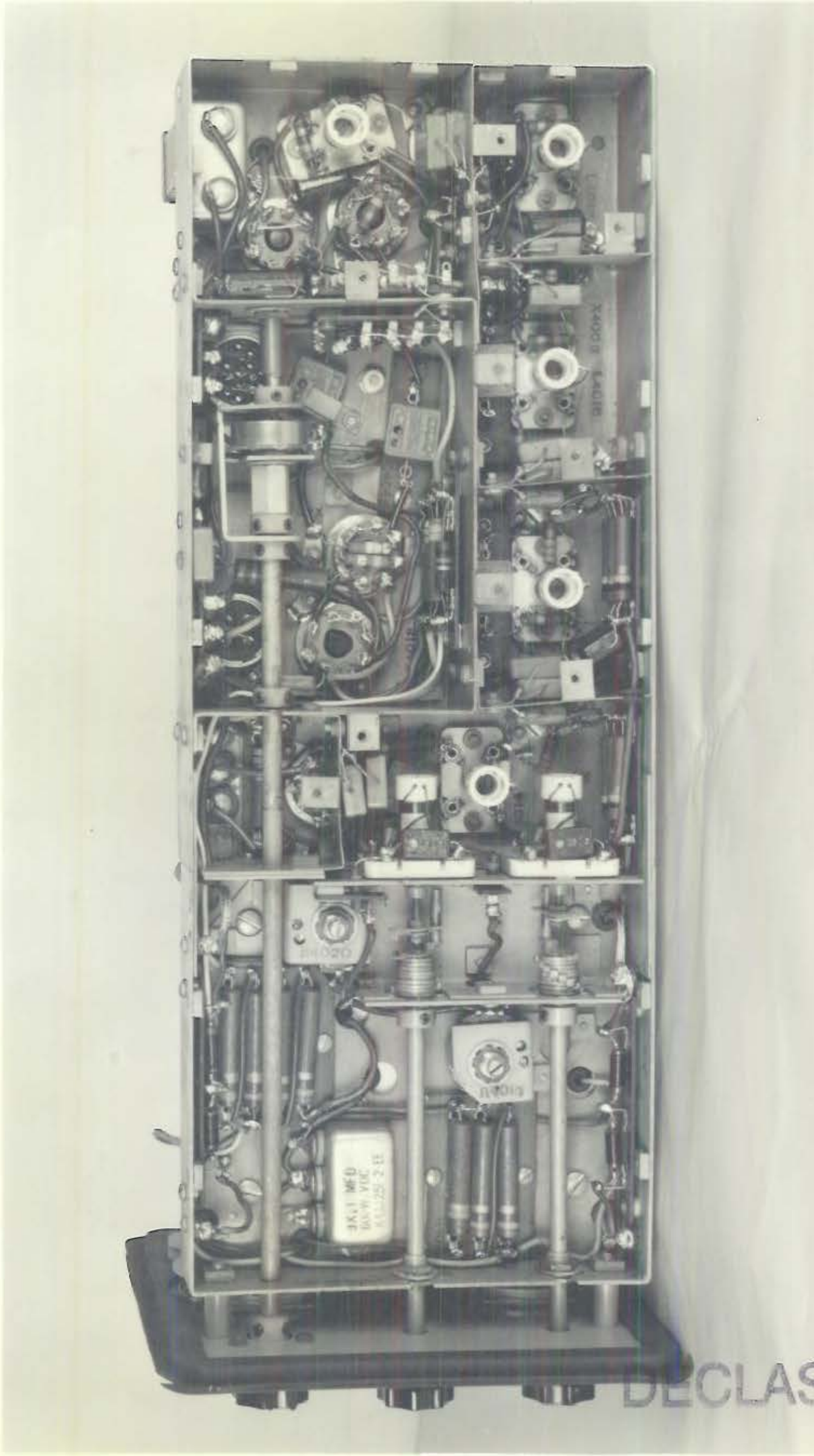
TYPE CG-46ACQ RECEIVER
FRONT VIEW

PLATE 2A



TYPE CG-46ACQ RECEIVER
TOP VIEW

PLATE 2B



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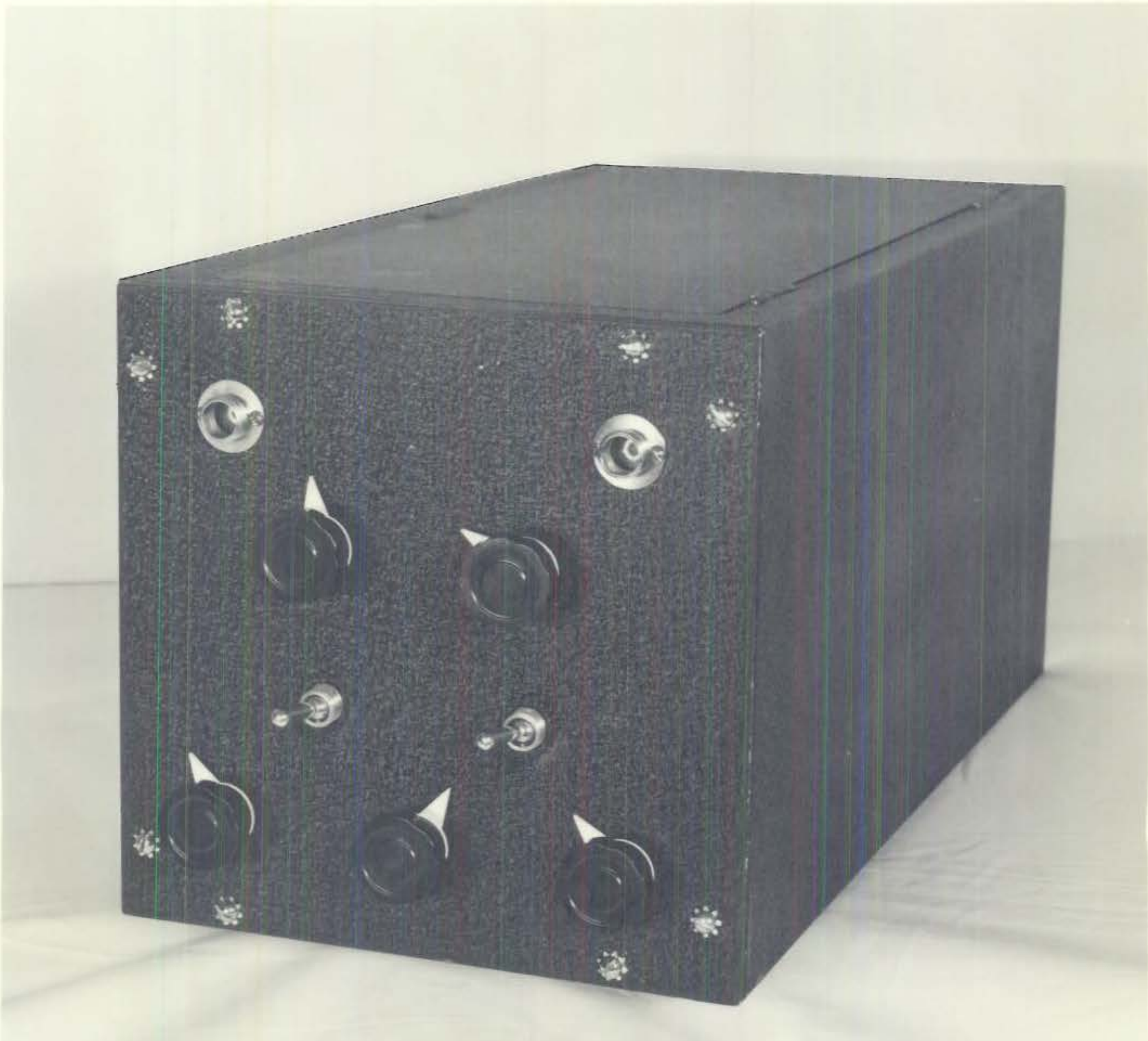
TYPE CG-46ACQ RECEIVER
BOTTOM VIEW

PLATE 2C



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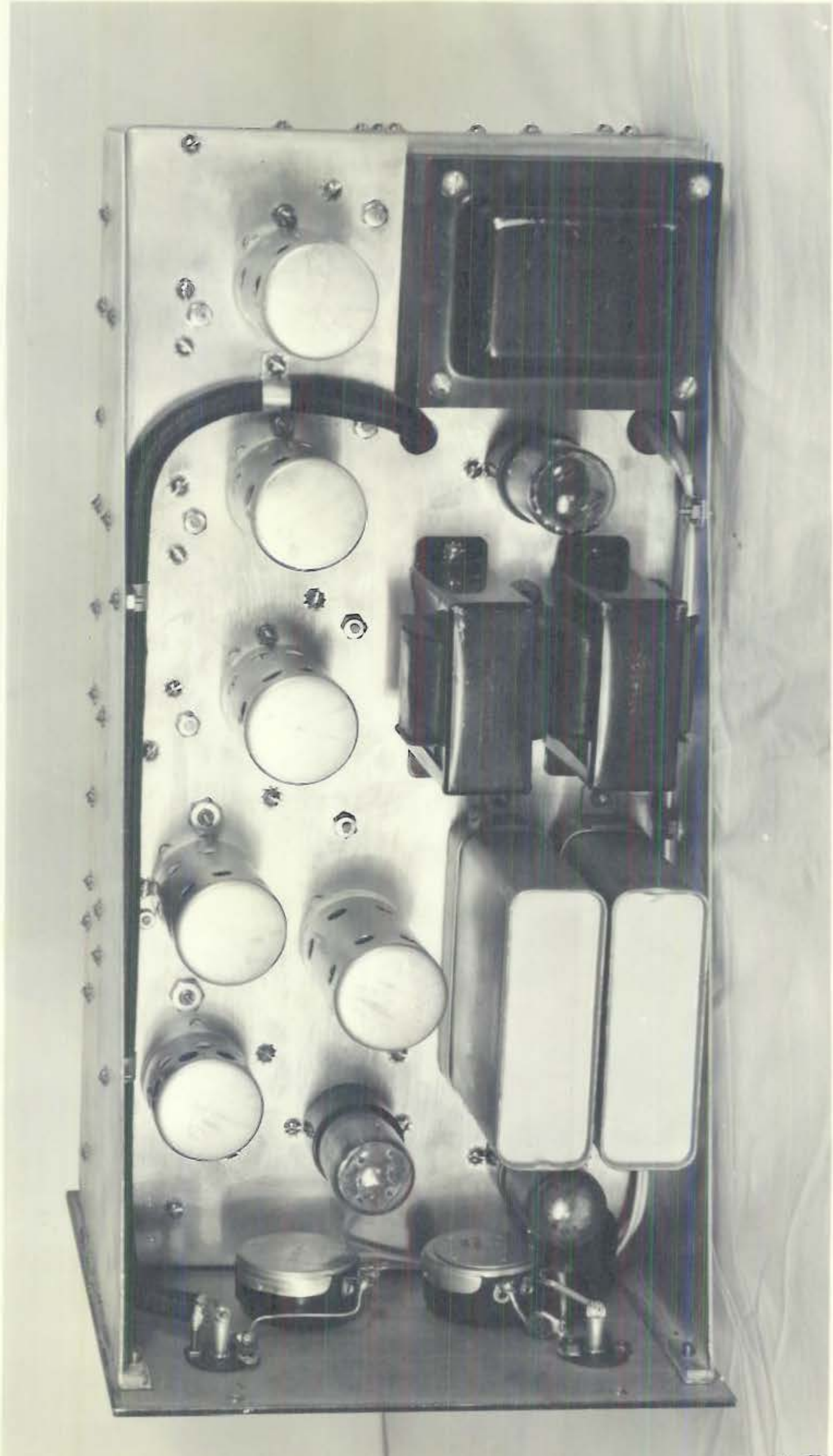
AJ ADAPTER
FRONT VIEW

PLATE 3A



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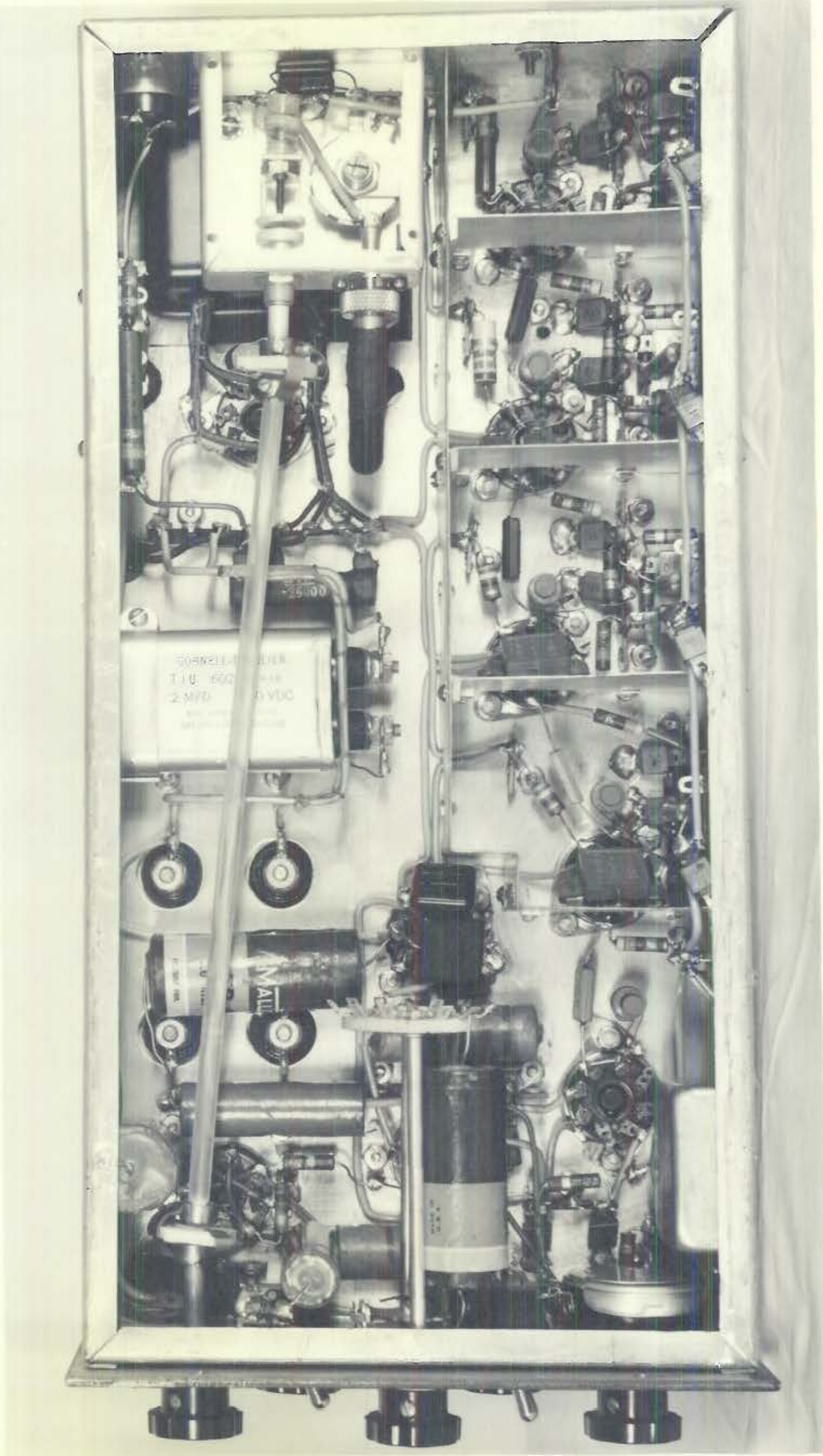
AJ ADAPTER
TOP VIEW

PLATE 3B



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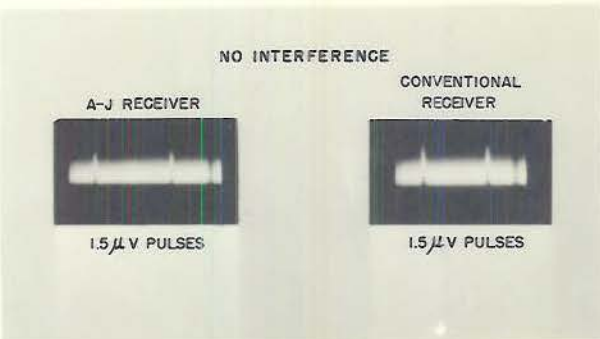
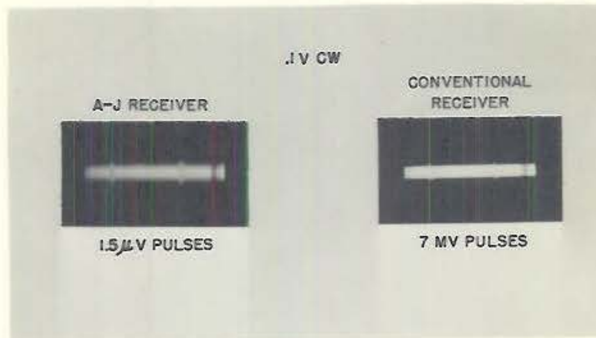
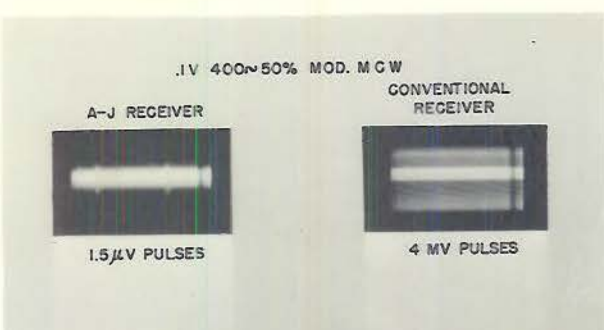
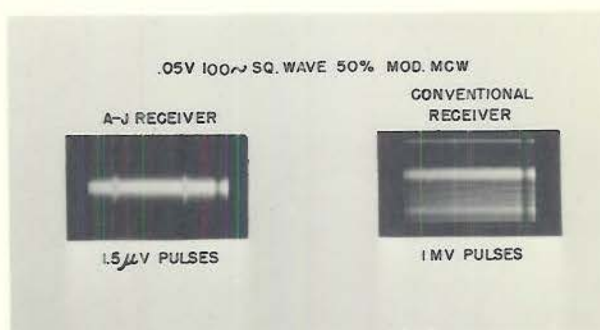
AJ ADAPTER
BOTTOM VIEW

PLATE 3C


NO INTERFERENCE
A-J RECEIVER
CONVENTIONAL RECEIVER
1.5μV PULSES
1.5μV PULSES


.1V CW
A-J RECEIVER
CONVENTIONAL RECEIVER
1.5μV PULSES
7 MV PULSES


.1V 400~ 50% MOD. MCW
A-J RECEIVER
CONVENTIONAL RECEIVER
1.5μV PULSES
4 MV PULSES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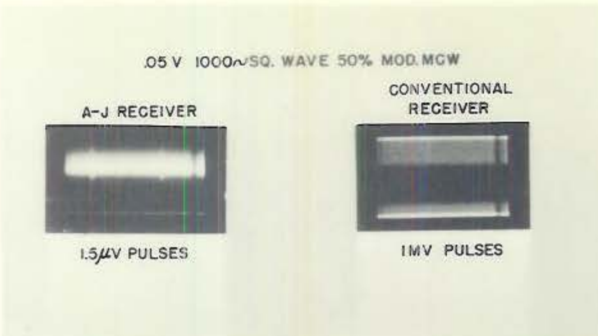
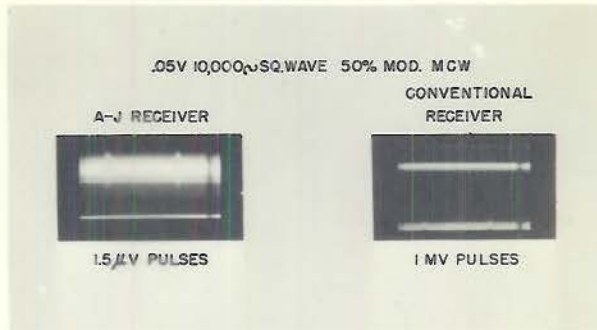
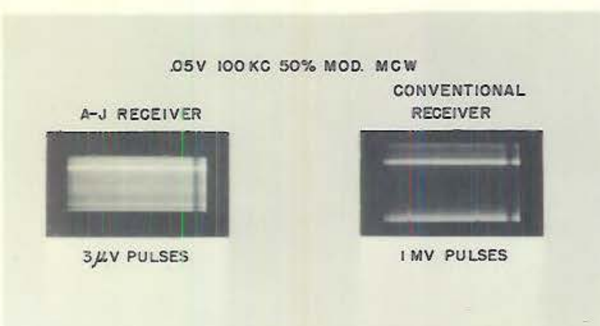
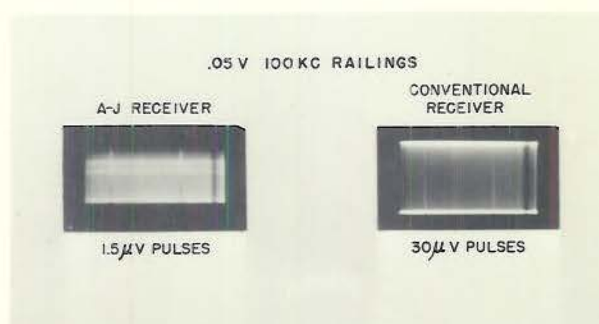
A-J RECEIVER
CONVENTIONAL RECEIVER
1.5μV PULSES
1 MV PULSES









DECLASSIFIED

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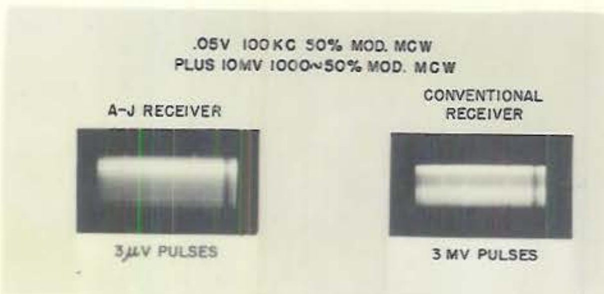
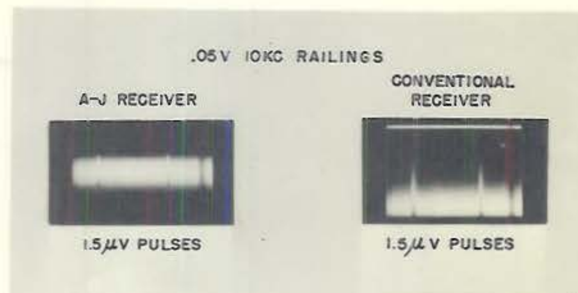
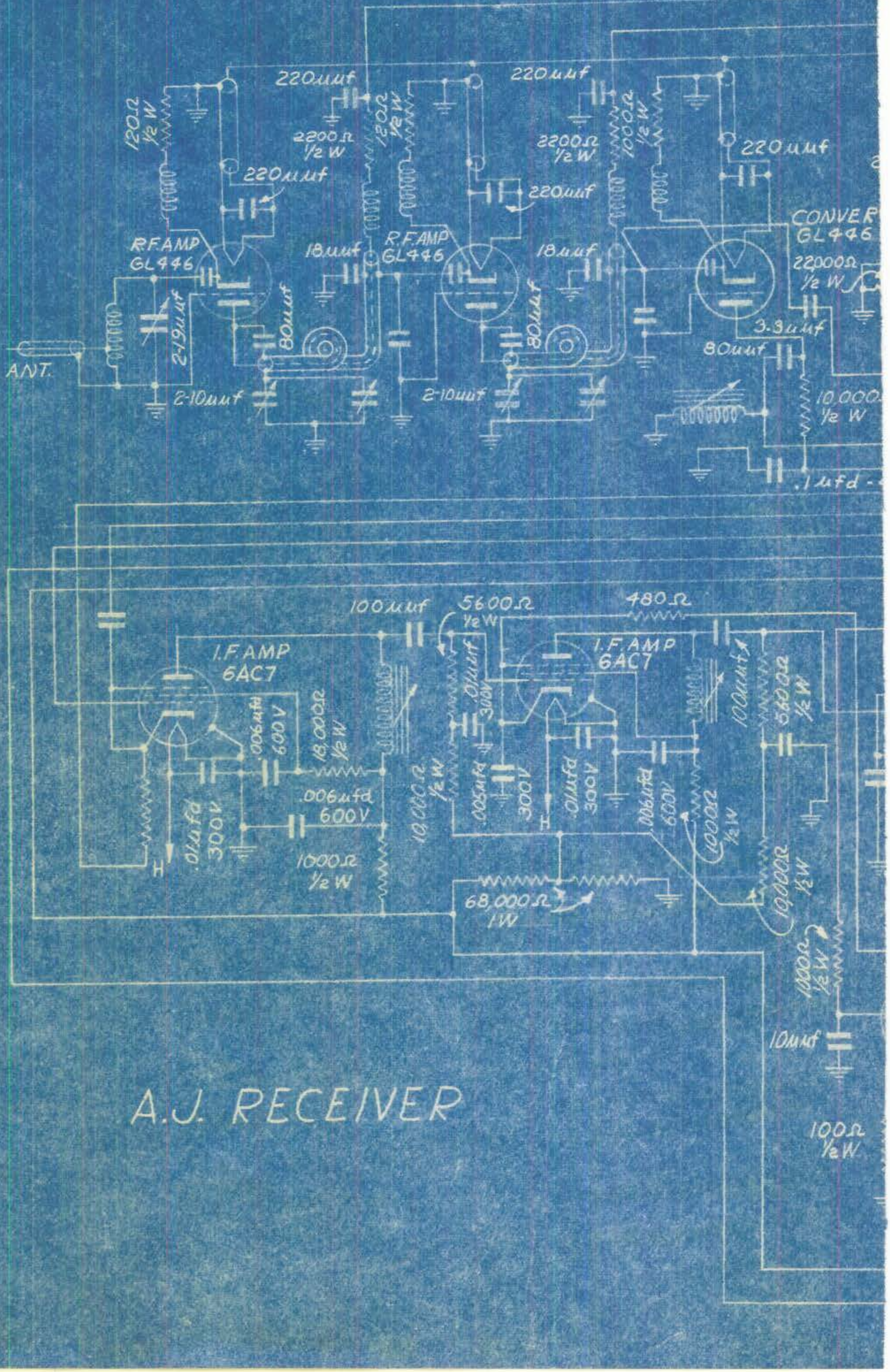
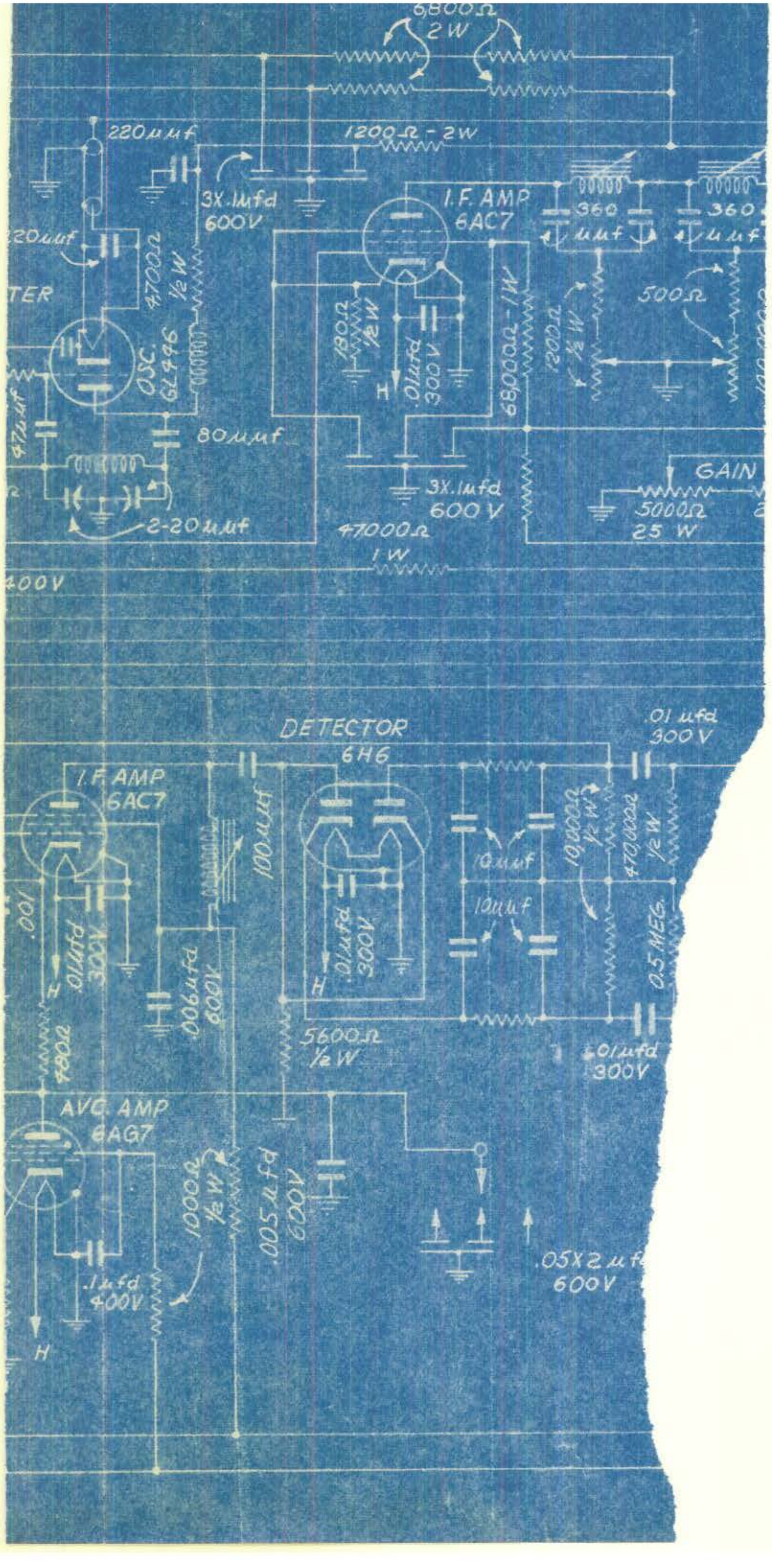

.05V 100KC 50% MOD. MCW
PLUS 10MV 1000~50% MOD. MCW
A-J RECEIVER
CONVENTIONAL RECEIVER
3μV PULSES
3 MV PULSES


.05V 10KC RAILINGS
A-J RECEIVER
CONVENTIONAL RECEIVER
1.5μV PULSES
1.5μV PULSES



R.F. AMP
GL446
R.F. AMP
GL446
CONVER
GL446
ANT.
I.F. AMP
6AC7
I.F. AMP
6AC7

A.J. RECEIVER


6,800Ω
2W
220μμf
1200Ω - 2W
3X.1μfd
600V
I.F. AMP
6AC7
360
μμf
360
μμf
220μμf
47000Ω
½W
TER
OSC.
6L996
180Ω
½W
.01μfd
300V
H
68,000Ω - 1W
1200Ω
½W
500Ω
47μμf
80μμf
3X.1μfd
600V
GAIN
5000Ω
25 W
2-20μμf
47000Ω
1W
400V
DETECTOR
6H6
.01 μfd
300V
I.F. AMP
6AC7
100μμf
10μμf
10,000Ω
½W
470,000Ω
½W
10μμf
.001
.01μfd
300V
H
.006μfd
600V
.01μfd
300V
H
0.5 MEG.
5600Ω
½W
.01μfd
300V
180Ω
AVC. AMP
6AG7
1000Ω
½W
.005μfd
600V
.05X2μf
600V
.1μfd
400V
H

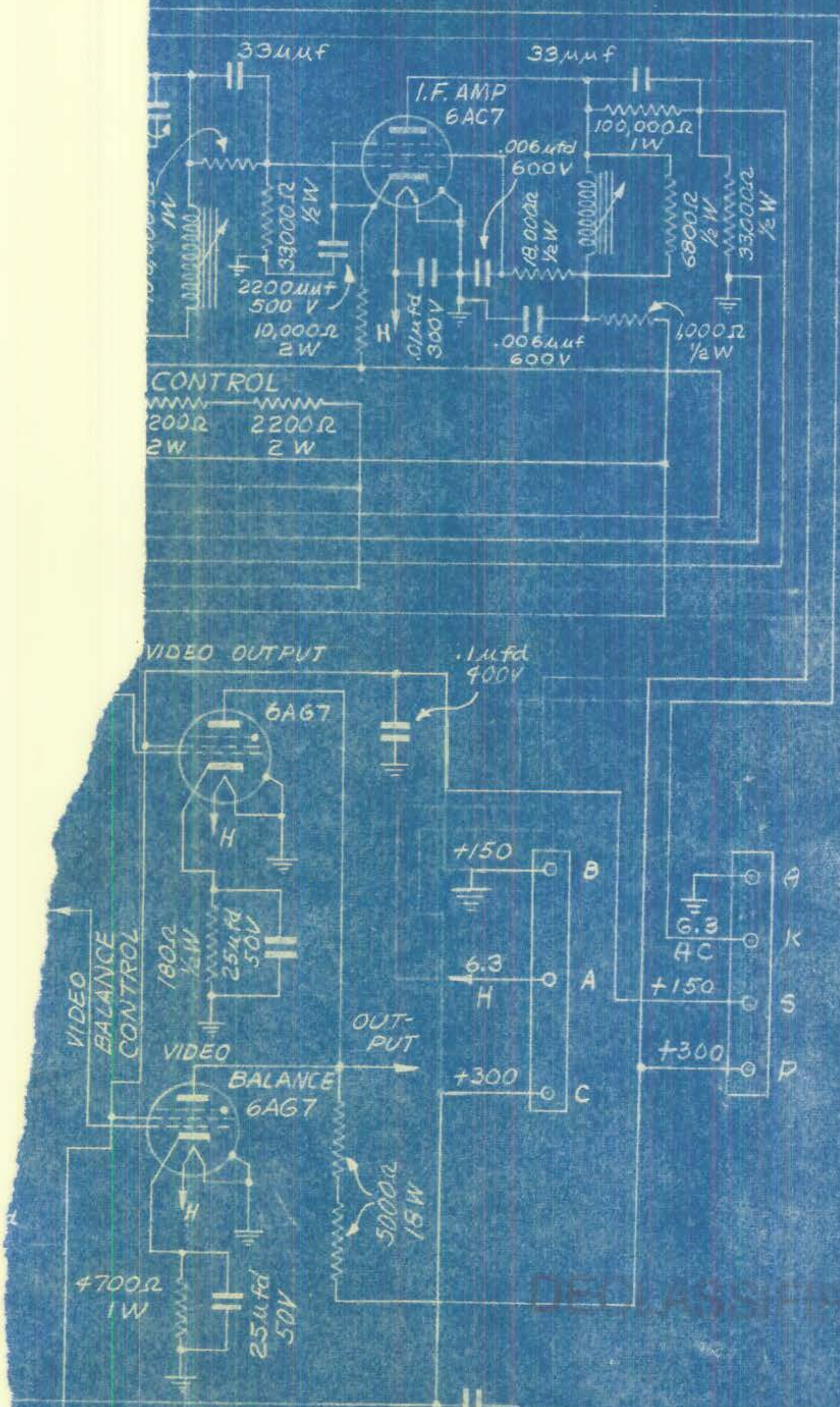
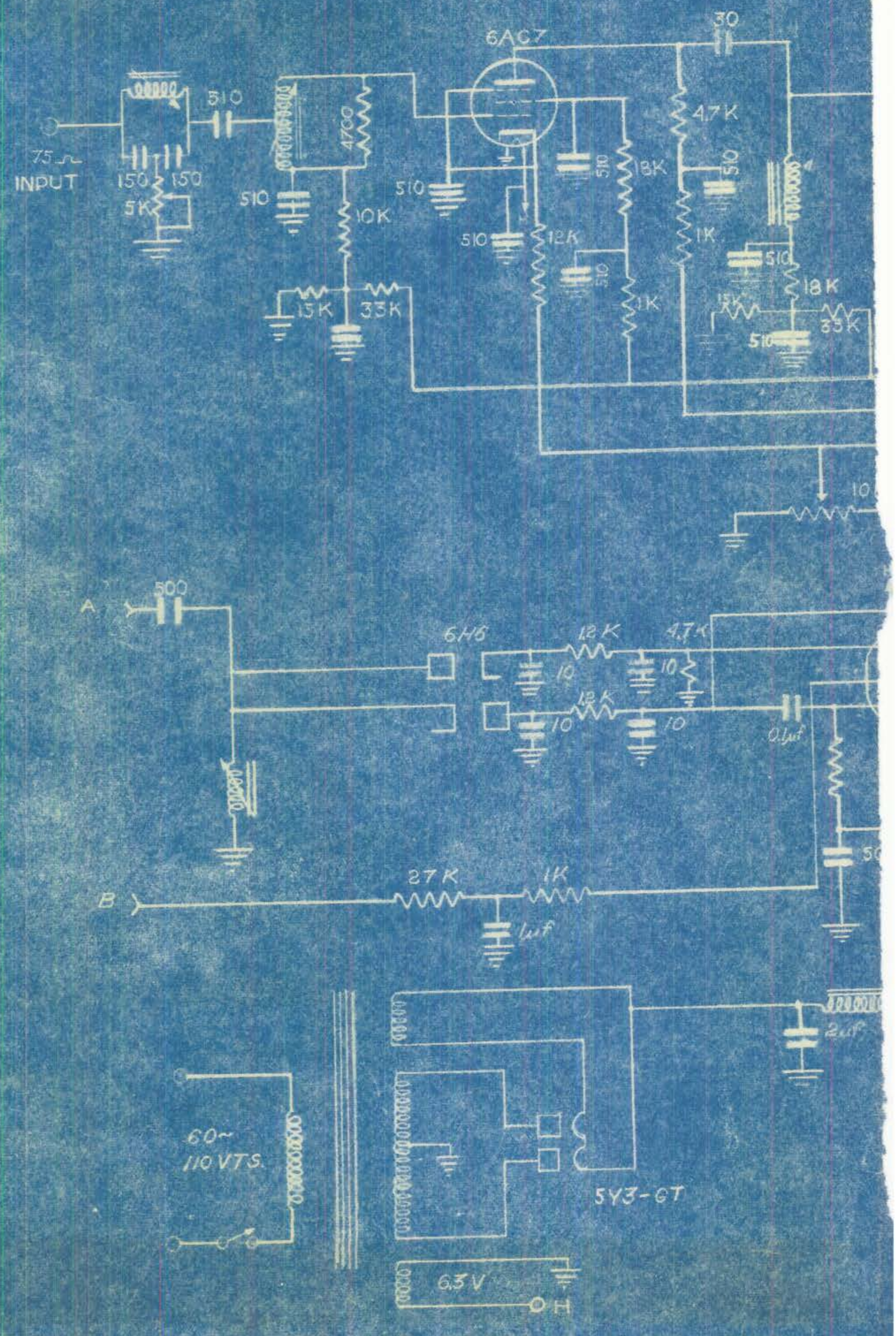
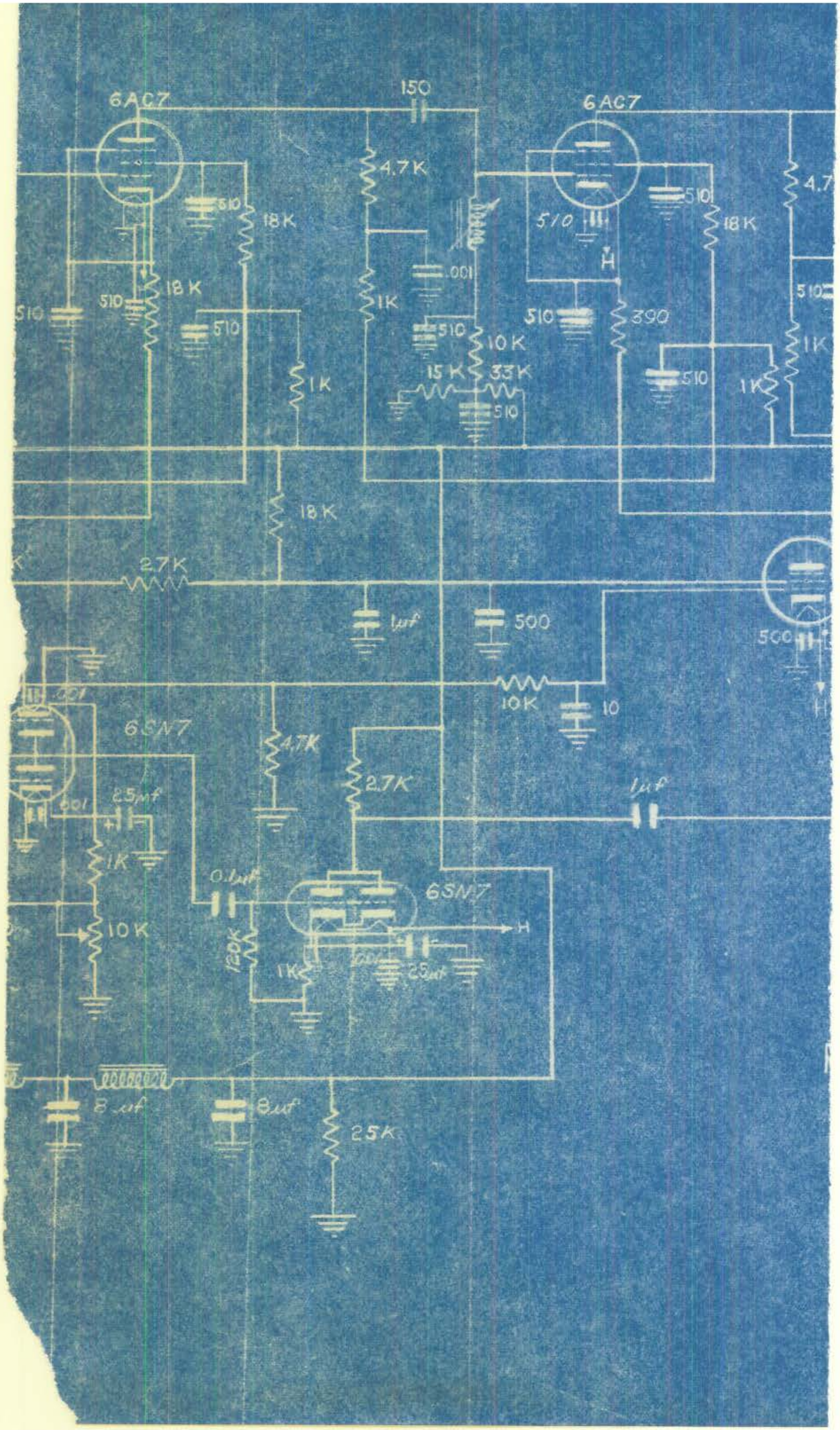

33μμf
33μμf
I.F. AMP
6AC7
100,000Ω
1W
.006μfd
600V
3300Ω
½W
18,000Ω
½W
6800Ω
½W
3300Ω
½W
2200μμf
500 V
10,000Ω
2W
H
.01μfd
300V
.006μμf
600V
1,000Ω
½W
CONTROL
2200Ω
2W
2200Ω
2W
VIDEO OUTPUT
.1μfd
400V
6AG7
H
+150
B
6.3
H
A
+300
C
180Ω
½W
25μfd
50V
VIDEO
BALANCE
CONTROL
OUT-
PUT
VIDEO
BALANCE
6AG7
H
5000Ω
15W
4700Ω
1W
25μfd
50V
6.3
AC
K
+150
S
+300
P

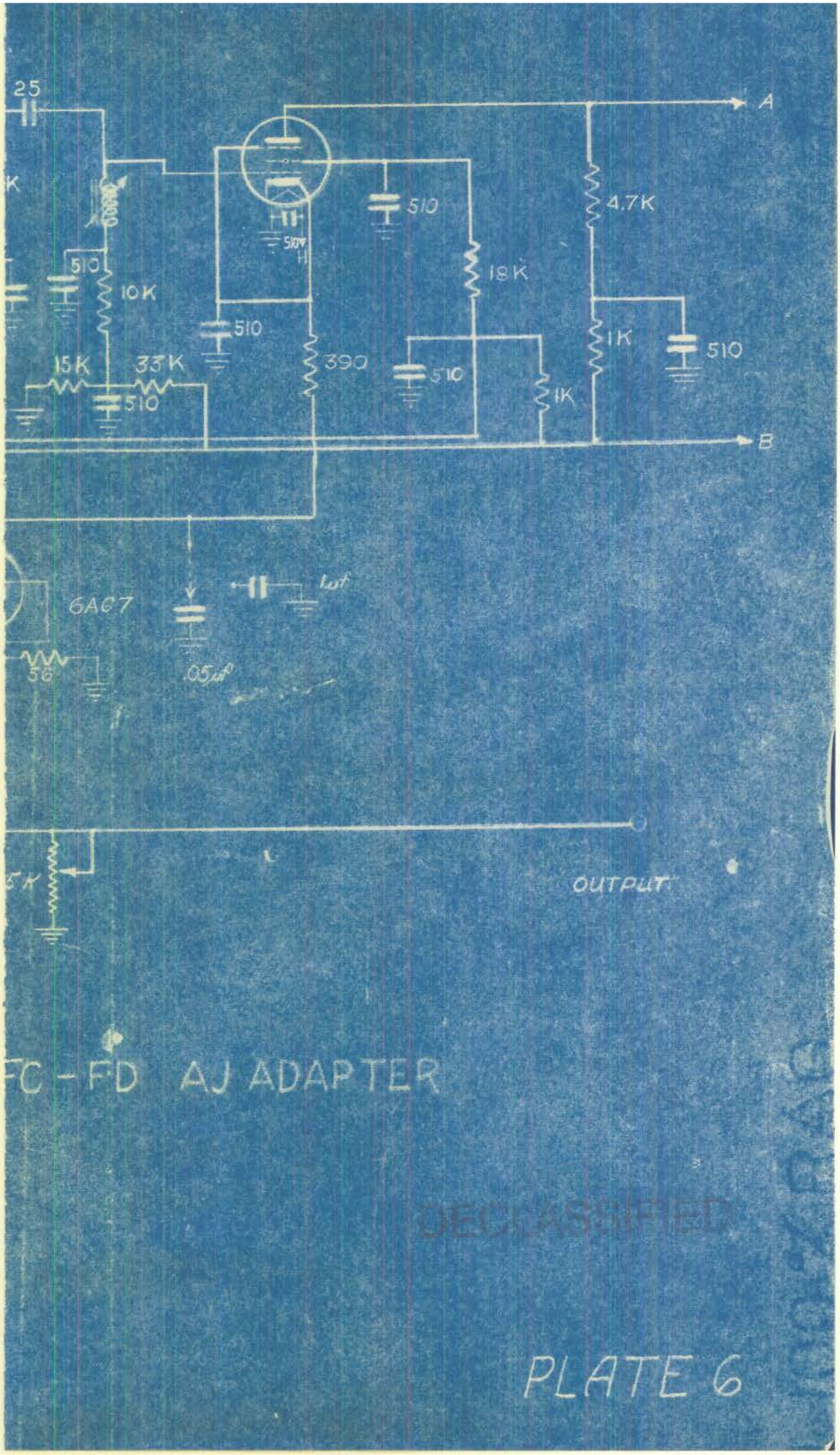
PLATE 5



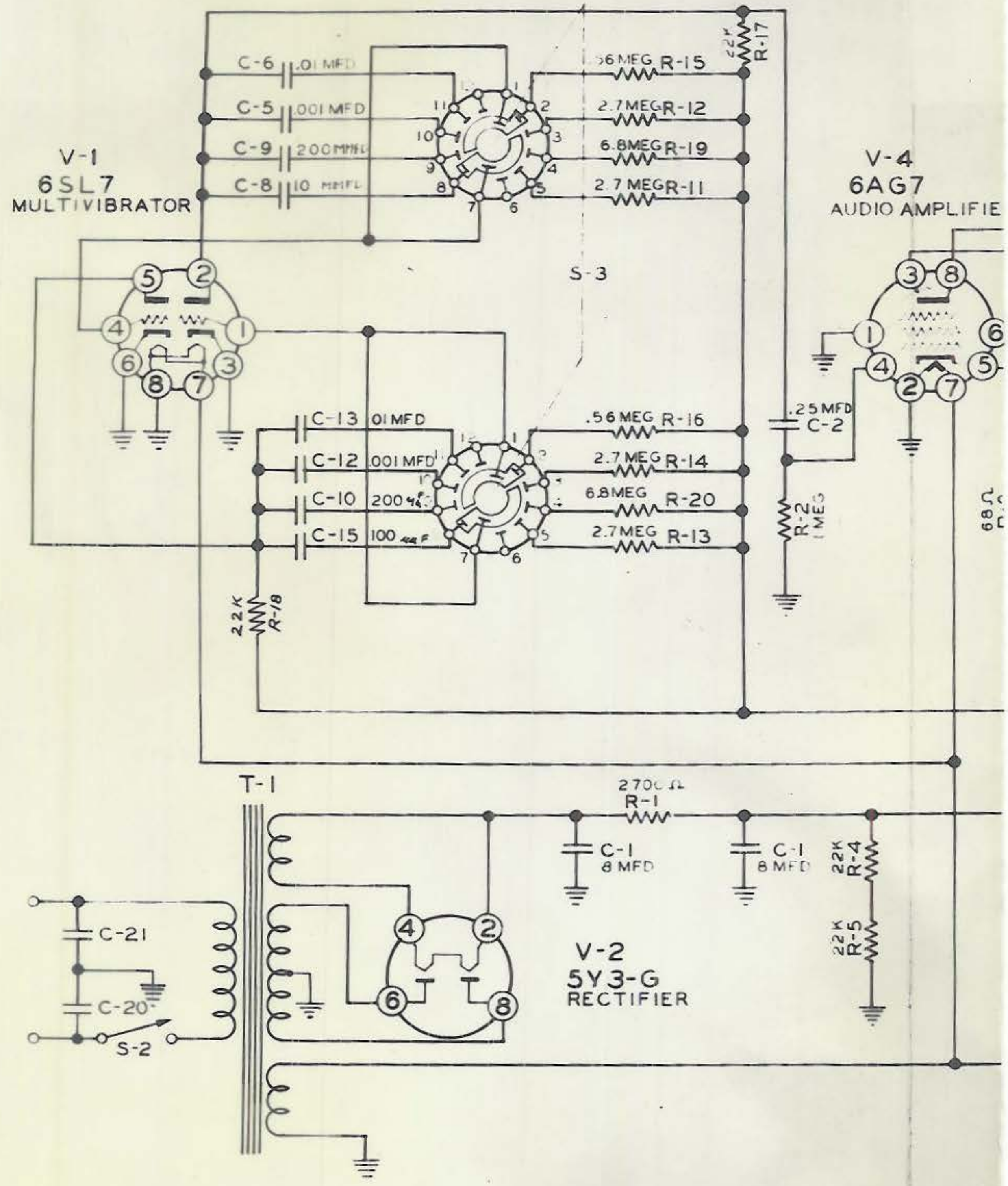
6AC7
30
510
75 ⎍
INPUT
150
150
5K
4700
510
10K
13K
33K
510
510
510
12K
510
18K
4.7K
510
1K
1K
510
18K
33K
510
A
500
6H6
12K
4.7K
10
10
10
12K
10
10
0.1μf
B
27K
1K
1μf
2μf
60~
110 VTS.
5Y3-GT
6.3V
H



6AC7
150
6AC7
4.7K
510
18K
.001
18K
510
510
1K
510
1K
10K
15K
33K
510
390
510
18K
510
1K
1K
18K
2.7K
1uf
500
500
H
10K
10
.001
6SN7
4.7K
2.7K
.001
2.5mf
1uf
1K
0.1uf
6SN7
10K
120K
1K
.001
2.5uf
8uf
8uf
25K

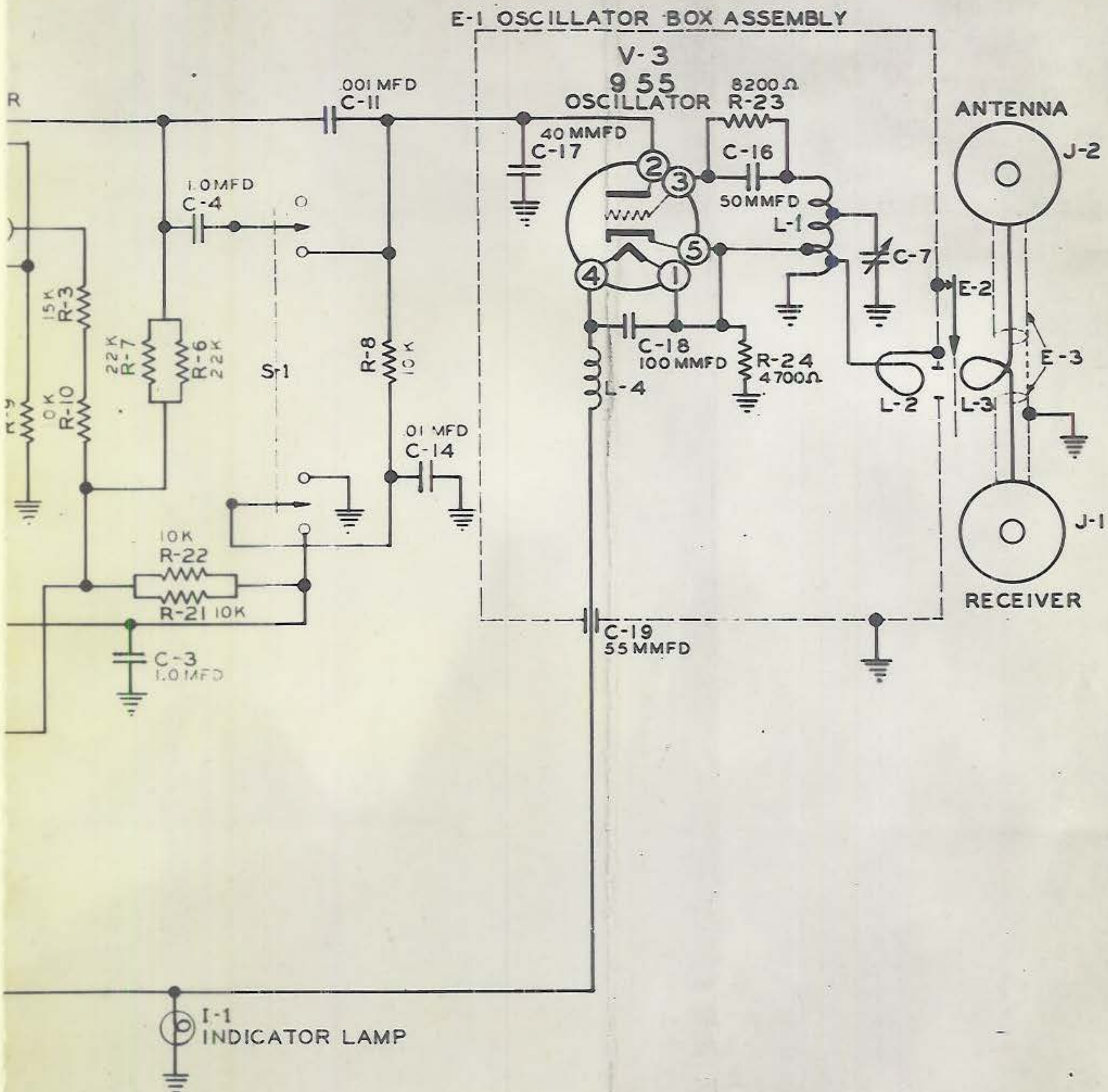

25
A
510
4.7K
18K
10K
510
1K
510
15K
33K
390
510
510
1K
B
6AC7
1uf
56
.05uf
OUTPUT
FC - FD AJ ADAPTER
DECLASSIFIED
PLATE 6

#7



TEST GENERATOR

DWG #242



CDL-60 ABY OF OAV

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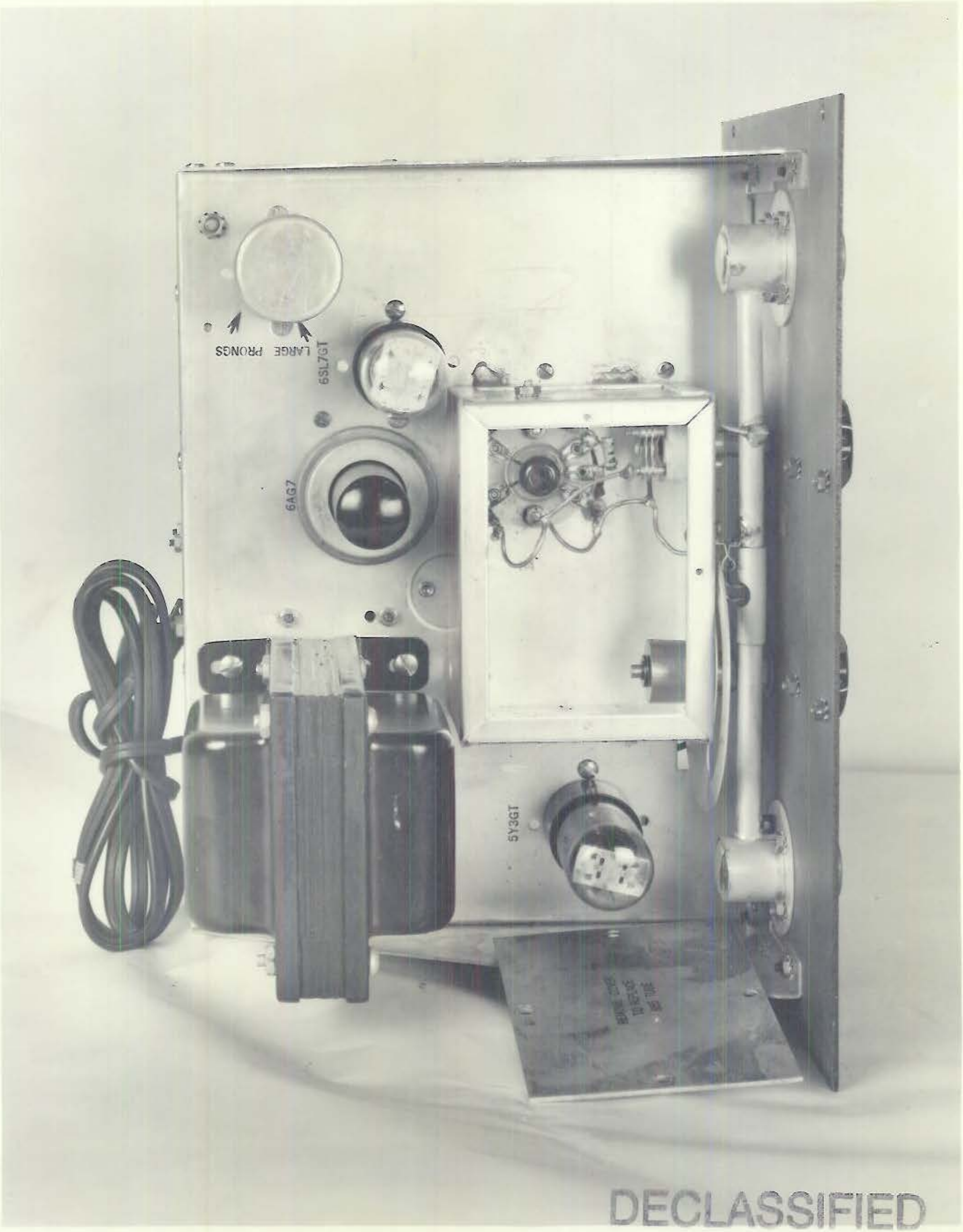
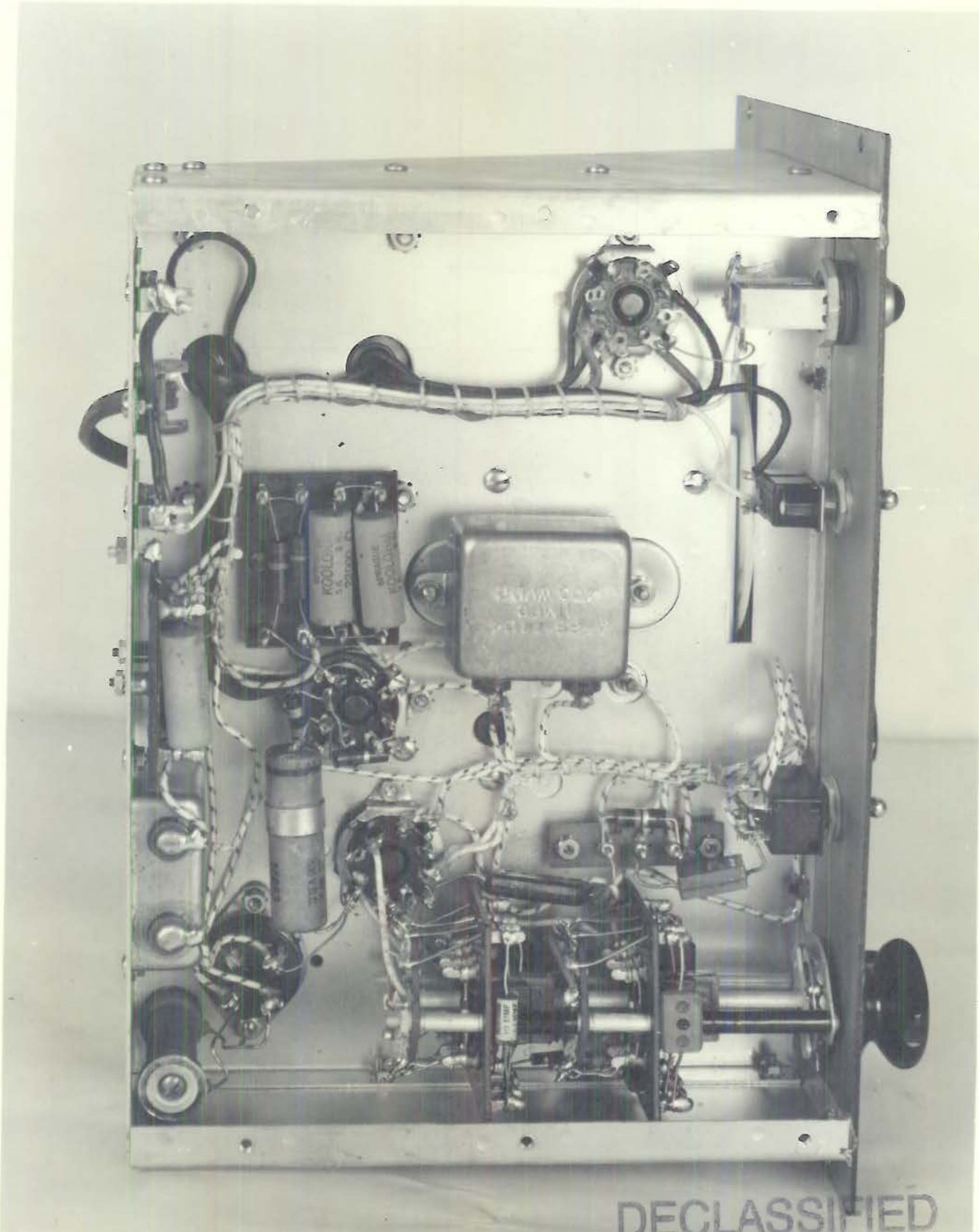
PLATE 7.


TEST GENERATOR
CDL-60ABY OF OAV
SUPPLY: 117V 1φ 60~
NXSS-27821
101
RECEIVER
FREQUENCY
MEGACYCLES
ATTENUATOR
PULSE
MODULATION
MILLIVOLTS
ANTENNA
K.C.
MOD.-PUL. FREQ.
OFF
10
100
MODULATION
PULSE
ON
OFF
POWER

PLATE 8A


LARGE PRONGS
6SL7GT
6AG7
5Y3GT



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RESTRICTED

PLATE 8C

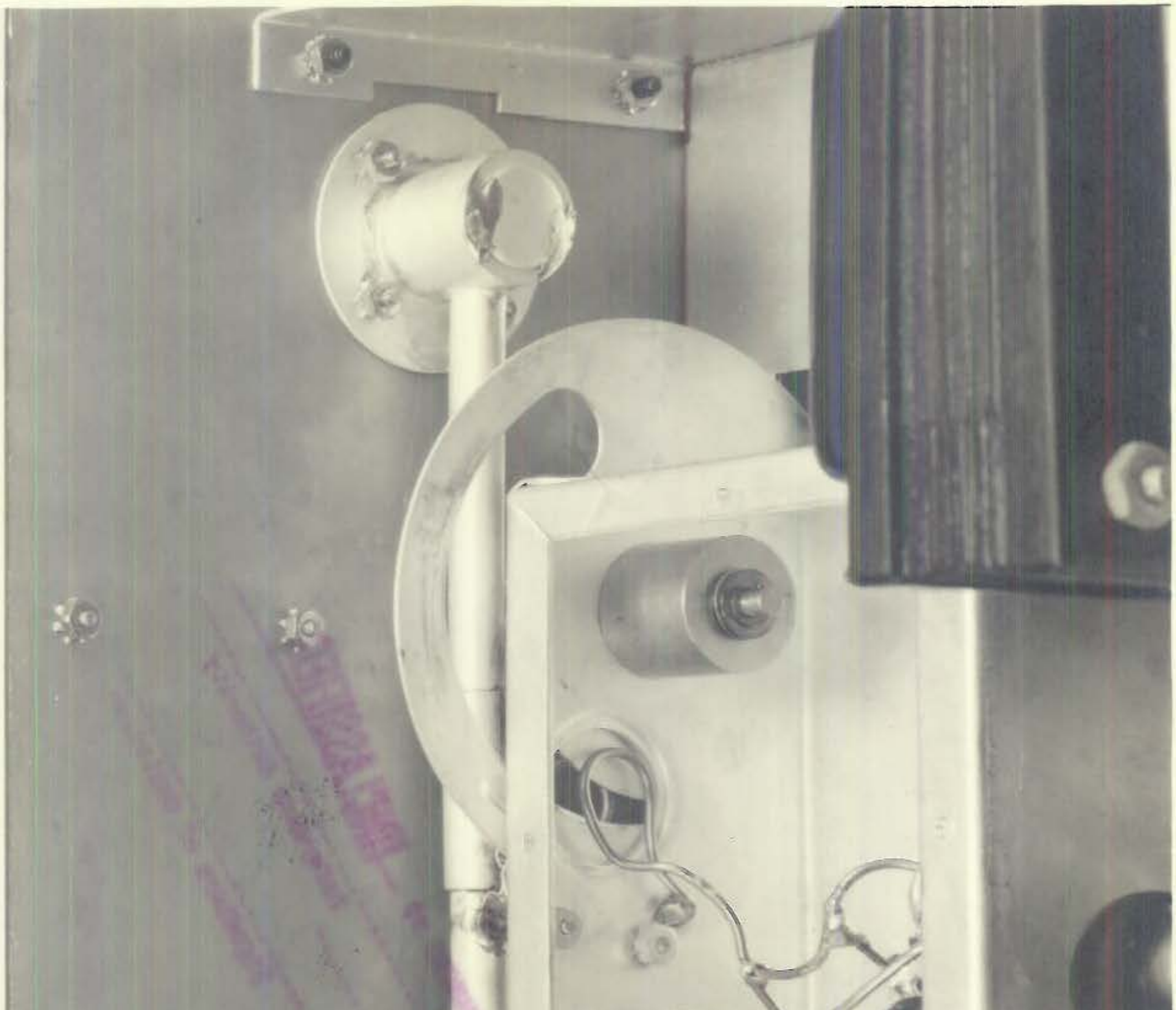

PLATE 8D