Trainer for St. Hyacinthe school

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NATIONAL RESEARCH COUNCIL OF CANADA

RADIO BRANCH

TRAINER FOR ST. HYACINTHE SCHOOL

OTTAWA

SEPTEMBER, 1942

NATIONAL RESEARCH COUNCIL
RADIO BRANCH
OTTAWA CANADA

SECRET PRA-57 Copy No. 5

NAVY TRAINER
FOR ST. HYACINTHE R.D.F. SCHOOL

The Multivibrator.

When building a Resistance-Capacity coupled amplifier, the Radioman should endeavour to arrange the circuit so that a minimum of coupling occurs between output and input stages. This is accomplished by careful placement of circuit components, and by the use of decoupling resistors in the plate circuits so that coupling will not take place because of the internal resistance of the power supply.

If these precautions are not carried out, the amplifier will probably not be satisfactory. At least it will be unstable and if only a moderate degree of coupling between output and input exists, the amplifier will persist in a vicious form of oscillation sometimes spoken of as "motor boating".

The frequency of this oscillation may be changed by changing the value of the resistors, the condensers or both of these components. Therefore, we can see that the frequency is dependent on R and C.

Now if we construct a two-stage Resistance-Capacity coupled "amplifier", and deliberately couple the output back into the input, oscillation will occur. The action is as follows:

Let us say the grid of V_1 goes toward the positive. This causes a plate current increase in V_1, therefore a greater voltage drop occurs across R_1, and V_1 plate drops sharply to a less positive value. This sudden shift toward the negative is used to charge C_2 causing the grid of V_2 to go negative.

Less plate current is then drawn by V_2 which means that less voltage drop occurs across R_1 and V_2 plate rises sharply towards the positive, which charges condenser C_1 positive, thus forcing the grid of V_1 further positive. The above action will eventually drive V_1 to saturation while V_2 grid is driven to beyond cut-off. This action takes place in a few micro-seconds or less.

V_1 is now at zero voltage as it has drawn grid current and therefore accumulated negative electrons to neutralize its positive voltage. This is shown in Fig.2.

V_2 grid, however, is held negative beyond cut-off by the charge in C_2. C_2 is discharging slowly through R_4 along the line "Dis" as shown in Fig.3. The circuit then is blocked and nothing more can happen until C_2 discharges to cut-off, at point X on Fig.3. It will be seen that we can make this time any sensible length from a few microseconds to a few seconds by correct choice of values for C_2 and R_4.

At point X in Fig.3, V_2 plate starts to draw current, going towards negative, driving V_1 grid negative. V_1 plate then goes towards positive driving V_2 grid positive. Notice that this action is the same as the preceding alternation except that V_2 plate is now going negative where it was going positive before.

C_1 then becomes charged negatively holding V_1 grid negative until it discharges along line DiS in Fig.2 to point X. Thus one cycle is completed. The time taken for C_1 to discharge is of course dependent on its own size as well as the value of R_3, through which it is discharging.

The tubes are working between saturation and cut-off, going sharply from one extreme to the other.

If we use the same set of values for C_1, R_2 and R_3 as we do for R_1, C_2 and R_4 the wave-form will be found similar to that shown in Fig.4. We can, however, decrease one leg of the circuit, let us say, C_1, R_2 and R_3 to give us a wave-form as shown in Fig.5.

Furthermore, if we make R_3 a potentiometer, we can vary the wave shape from Fig. 4 to Fig.5, and any intermediate shape. Such a circuit is known as a multivibrator.

Item 2 - <u>Synchronizing Multivibrators.</u>

If a multivibrator is in operation and a sharp signal, such as that obtained from Thyratron (884 tube) is fed into one of the grids, the multivibrator will lock in with the frequency of the applied signals. This is because the synchronising signal serves to discharge the grid condenser to which it is connected, starting the multivibrator on its cycle.

Item 3 - Differentiating a wave shape by means of a Condenser and Resistor.

If a square wave form shown in Figs. 4 or 5 is applied to a circuit as shown in Fig.6 we have the following action as shown in Fig.7.

As the square wave goes towards the positive from the negative, point A will be driven positive, but only for an instant as C will discharge through R to ground. Then as the square wave goes towards the negative from the positive, point A will go instantaneously negative, returning quickly to zero as C discharges through R.

Thus, the square wave shape has been resolved into positive and negative pulses.

Item 4 - Moving the pulses in time.

Assume that we have two multivibrators operating in synchronism, and their outputs are differentiated. Let one of the multivibrators have a control to alter the wave shape between the limits shown in Fig. 4 and 5. Then the differentiated pulses from this multivibrator can be made to move further apart as in Fig.7 or closer together as in Fig.8.

If we disregard negative pulses, and use only the positive pulses to fire a Thyratron, we can obtain the following:

By moving the wave-form control of one multivibrator we can cause its positive pulses to fire its thyratron at the same time multivibrator #2 fires #2 thyratron, or any short time before or after.

In order to conserve tubes and space, the multivibrator is usually constructed around a single 6N7 tube, which contains the two necessary triodes in one envelope.

The Circuit.

V_1 is a multivibrator, which might be termed the Master Multivibrator as it determines the recurrence frequency of both the High Voltage sweep and the Low Voltage sweep. Its circuit constants are chosen so that its wave form on the plate is similar to that shown in Fig.4.

The wave is differentiated by a .001 mfd. coupling condenser, the negative pulses serving only to increase the bias on V_2, while the positive pulses are employed to overcome the bias and fire V_2. The plate condenser is discharged through the tube giving a short pulse of extreme amplitude. This is taken off at the cathode for both Sweep Controls.

The High Voltage Sweep.

The pulse from V_2 is fed into another 884 Thyratron (V_3) to control it in the same manner. V_3 is a sweep tube and also acts to control the transmission pulse. To ensure a very linear sweep it is necessary to take certain precautions at this point. In some commercial Cathode Ray Oscilloscopes, horizontal deflection voltage is taken off a condenser that is being charged through a resistor. The shape of the charge-discharge cycle is shown in Fig.9. Note that while the bottom portion of the charge is linear, the top portion certainly is not. Therefore, if this sweep were used for R.D.F., the latter part would move the electron beam in the Cathode Ray tube more slowly and thus place the calibration pips closer together towards the end of the sweep. This is an erroneous indication and cannot be tolerated.

In order to overcome this condition, V_3 and its sweep condenser bank in the plate circuit, is placed in series with a resistor bank of very high value, across 3000 volts.

We wish to use only the bottom portion of the curve, as shown in solid lines in Fig.10, but unless we do something about it the condenser bank will charge up to 3000 volts, along the dotted line in Fig.10, causing damage to circuit components. Therefore, a diode V_4 is placed in parallel with the condenser bank and V_3.

V_4 has its cathode connected to positive 300 volts. When the condenser is charged to 300 volts, then V_4 starts to conduct and as the charging resistor bank is of very high value, the remaining 2700 volts appear across it, and the condenser does not charge further. Thus, we use only the portion of the curve shown in solid lines in Fig.10 where it is most linear.

In order to obtain a balanced sweep, tube V_5 is included. Its output is 180° out of phase with its input, thus giving a push-pull effect at H_1 and H_2 which connect to the Cathode Ray horizontal deflection plates. By adjustment of the bias on V_5 so that the voltages at H_1 and H_2 are equal, a very linear sweep is achieved. V_5 grid is excited by an appropriate value of voltage taken from the sweep condenser bank, which is arranged in the form of a voltage divider using condensers instead of resistors.

A suitable value of voltage is also taken from this condenser-divider and amplified by V_6. This tube is a 6N7 of which only one half is used.

The output of V_6 is used to fire a Thyratron V_7. The pulse taken from the cathode is used to fire a transmitter in R.D.F. practice.

A sweep change plug, mounted on the charging bank can be removed to show the effect on the sweep.

The Low Voltage Sweep.

The Low Voltage Sweep is divided into two sections: one for the generation of sweep voltage, the other to furnish calibration pips. Both sections are actuated by pulses taken from the cathode of V_2 which is controlled by the Master-multivibrator, V_1, each section being fed through a small condenser.

V_8 is the sweep multivibrator which has a positive pulse from V_2 applied to its grid for the purpose of synchronizing. One leg of V_8 has a long time constant, the other leg a short time constant thus giving a wave-form similar to Fig.5.

This is differentiated by the coupling condenser and the grid resistor of V_9. V_9 is biased so that only the positive pulse is used to synchronize a multivibrator circuit using the other half of V_9 as one triode; and the cathode, grid and screen grid of V_{10} as the other triode. The wave-form on V_9 plate is a square wave towards the negative, thus driving V_{10} grid negative.

Therefore, on V_{10} screen grid, which is acting as the plate of one multivibrator triode, there appears a square wave towards the positive. This is used to cancel part of the bias on the Cathode Ray tube, which is normally biased for a dark screen condition, and will brighten the screen for the duration of the sweep. If this is not done, the electron beam will remain at one end of its scan between sweeps causing a bright spot which persists during sweeps and which may damage the fluorescent coating in the Cathode Ray tube.

As V_{10} grid goes negative, the plate cannot rise instantaneously to a full positive value, as the .003 mfd. condenser between plate and ground must be charged through the 5 megohm plate resistor. These constants are chosen so that the linear portion of the charge is used as the sweep. The V_{10} plate coming down towards negative again, as the negative pulse on the grid ends, discharges the condenser, and the brightening pulse ends, darkening the screen.

The output of V_{10} is coupled into a phase inverter tube, V_{11}, to obtain a balanced sweep at H_1 and H_2.

Obtaining Calibration Pips.

V_2, in addition to furnishing synchronizing voltage to High and Low Voltage sweeps, also is employed to synchronize the pip generator circuit through a small condenser into V_{12}.

The first half of V_{12} is used as a buffer tube with the second half, in conjunction with the following tube V_{13} connected in a multivibrator circuit. The method of connection between these two tubes somewhat resembles the circuit of V_9 and V_{10}, except that in the former, the plate is used as the anode of one of the multivibrator tubes. R_6 is used to vary the wave shape as shown in Figs. 7 and 8.

The output is taken from the plate of V_{12} and differentiated through a condenser bank consisting of .001 and .0001 microfarads in series. The differentiated pulses may therefore be moved in time by adjustment of R_6 (See Figs. 7 and 8).

The positive pulse fires V_{14}, a Thyratron, the negative pulse serving only to increase V_{14} bias may be disregarded.

The circuit about the next two tubes, V_{15} and V_{16} is rather novel. The two tubes have their plates in parallel and a tuned circuit is placed in this common plate circuit.

A positive pulse from V_{14} cathode is applied through a 50 mmfd. condenser to V_{15} grid circuit. This condenser differentiates the pulse, the resulting positive pulse is killed because of grid current in the unbiased V_{15} while the resulting negative pulse causes the common plate circuit to rise very sharply towards the positive.

A series of actions result -

1. The sharp change in plate ~~circuit~~ VOLTAGE shocks the tuned plate circuit into oscillation. This would normally be damped.

2. The presence of a grid coil in V_{16}, with a .0005 condenser to assist the tube capacity causes the circuit to oscillate as a tuned plate - untuned grid (T.N.T.) circuit. Oscillation would persist were it not for an un-bypassed cathode resistor which is such a value that a critical amount of degeneration is introduced.

3. The rapid vanishing of the negative pulse on the grid, resulting in the sharp trend of the plate potential towards the negative acts to quickly and effectively quench the oscillations.

The result is a succession of trains of oscillations, the beginning of each train being synchronised with the beginning of the sweep, and capable of being moved in time with respect to the sweep, as detailed in Item 4.

V_{17} and V_{18} are included to convert these trains of oscillations to calibration pips. V_{17} is employed to amplify the train to a very high level, so that while the relative amplitude of any two successive cycles is not changed, the VOLTAGE DIFFERENCE between two adjacent cycles is made greater. This enables the following amplifier to discriminate against cycles having low amplitude and confine its action to a section of the wave train where only slight differences in amplitude exists.

Also, there is inserted in the plate circuit of V_{17} a pulse sharpener circuit. This consists of a small R.F. choke, critically damped so that it will oscillate for one alternation only at its resonant frequency when it is shocked by an alternation of the wave train.

V_{18}, the final tube, is biased class C, so that only the extreme tips of the positive alternations are effective in causing the tube to draw plate current. This gives extremely short pips, probably less than a microsecond in length. However, the pips are not all of equal amplitude due to the damping of the wave train from which they are derived.

The leading pips are brought up to a level with the others by placing a precise value of capacitance across the cathode resistor of V_{18}. This permits the grid bias to rise at a limited rate, so that each following pip must overcome a greater value of bias than the one preceding it. This corrects the leading pips for amplitude.

The rear pips are not corrected, therefore, it is possible to observe the same condition to which the leading pips were subject before correction.

As these pips are derived from the wave train from V_{15} and V_{16}, they also may be moved in time with respect to the sweep by adjusting the time constant on the pip multivibrator, V_{13}, as per Item 4.

Operation.

Two small snap switches will be found on the left side of the frame. The switch nearest the front panel controls the Low Voltage circuit which lights the tubes, furnishes -150 volts for bias purposes and + 300 volts for plate voltage on the tubes. The rear switch controls the High Voltage circuit which furnishes 3000 volts for the Cathode Ray tube and the High Voltage sweep.

The Low Voltage circuit should be turned on first, and the tubes should be allowed a minute or two to reach operating conditions before turning on the High Voltage.

CAUTION: No adjustments or connections should be made at the rear of the panel when the High Voltage switch is on (in the "up" position) as there is then 3000 volts applied to various circuits.

1. Always make sure the High Voltage switch is "off", in a "down" position before making any changes at the rear of the panel, as accidental contact with 3000 volts will probably prove fatal.

2. Always turn on the Low Voltage supply first. Until diode V_4 reaches operating temperature, there is no protection offered the sweep condenser bank from the High Voltage.

The firing of the Master Thyratron V_2, is first adjusted. This is accomplished by turning R_1, which controls the bias in a counter-clockwise direction until V_2 just fires, then advancing R_1 a bit more to ensure stable firing.

If an external Cathode Ray Oscilloscope is connected to V_2 cathode (Test point #6) - H.V. SWITCH OFF while connecting - "mush" can be seen at the base of the pulse when R_1 is turned too far in a counter-clockwise direction. The correct adjustment of R_1 will be seen to give the cleanest pulse.

For ordinary purposes, the adjustment may be made from the front of the panel, with the High Voltage on the built in Cathode Ray tube, and R_1 adjusted in a counter-clockwise direction until the sweep on the tube ceases to flicker, then advancing R_1 a trifle more.

The H.V. Sweep Thyratron V_3, is then adjusted for a stable firing condition by means of R_2. This adjustment should be made from the front of the panel with the High Voltage on.

To facilitate adjustments a Cathode Ray Oscilloscope may be connected to the H_1 terminal of the H.V. sweep, BEFORE the High Voltage is turned on. (Test point #7).

The Sweep Amplifier is next adjusted. Connect the Cathode Ray Oscilloscope to the H_2 terminal of the H.V. Sweep BEFORE the High Voltage is turned on. The bias on V_5 is then adjusted by R_3 until the amplitude of the pulse on the C.R. Oscilloscope screen is exactly the same as it was when the scope was connected to V_3. The V-gain control on the scope should not be adjusted during this test.

Alternative method of adjusting V_5 - The scope should then be disconnected and, with all switches in the "off" position, one H plate of the built in Cathode Ray tube connected H_1, while one V plate should be connected to H_2. Power is then applied.

The trace on the C.R. tube will be defocussed and will have a bright spot at one end. R_3 should be adjusted until the trace approximates Fig.11.

Fig.12 indicates that V_5 is not contributing enough sweep voltage, while Fig.13 indicates that V_5 is overloaded.

R_3 then, is adjusted to a point just before the trace tends to show a flat upper portion. The built in C.R. tube may then be connected to the right-hand group of the Cathode Ray connection strip. V_7 is then adjusted until it fires in a stable manner by means of R_4. This adjustment may be made from the front of the panel, the transmission pip will appear on the sweep of the built-in Cathode Ray tube when V_7 is firing.

Adjusting the Low Voltage Sweep.

The built-in Cathode Ray tube is connected to the left hand terminal group. No high voltage is necessary for adjusting or for the demonstration of the various Low Voltage sweep circuits on an external C.R. Oscilloscope, only when observing the pips on the built in Cathode Ray tube.

Adjusting is simple. R_5 controls the position of the sweep in time (see Item 4) and should be turned as far as possible in a counter-clockwise direction and left there.

R_6 controls the position of the pips in time (see Item 4), and by moving it slowly the pips may be made to move slowly along the sweep.

Demonstration.

By employing an auxiliary Cathode Ray Oscilloscope, the operator may demonstrate the various wave-forms peculiar to the different circuits. An insulating strip, on which are mounted 24 test points, will be found on the rear of the rack. Read this 1 to 24 starting from the left. The C.R. Oscilloscope Vertical amplifier lead is connected to the test point indicated. A condenser of .1 mfd. should be inserted in series with the V-lead. The ground lead from the scope is connected to the metal rack of the trainer.

Test 1 - Master Multivibrator grid #1, trace similar to Fig.2.

Test 2 - Master Multivibrator grid #2, trace similar to Fig.3.

Test 3 - Master Multivibrator plate, trace similar to Fig.4. but with corners slightly rounded.

Test 4 - V_2 grid showing differentiated wave because of coupling condenser and grid resistor.

Test 5 - V_2 plate, a typical thyratron discharge showing the plate going towards the negative.

Test 6 - V_2 cathode, a thyratron discharge showing the cathode going towards the positive owing to I.R. drop across cathode resistor when the tube fires. This is the pulse used to fire V_3 of the High Voltage sweep, also to synchronize V_8 and V_{12} of the Low Voltage sweep.

Test 7a - Shows the portion of the sweep furnished by V_3. This test point connects to the plate of V_3 and the plate of the limiting diode, V_4. The trace should be the usual sawtooth sweep with the charge line very linear and in a negative direction.
H.V.ON CAUTION

Test 7b - Expand one sweep cycle on C.R. Scope screen and pull the sweep-change plug on resistor bank to show how a larger value of charging resistor lengthens the sweep time.

Test 8 - V_5 sweep inverter plate, showing the sweep trace in a positive direction.
H.V.ON CAUTION

Test 9 - Pip amplifier plate. Saw-tooth wave from V_3 plate amplified and inverted to fire V_7.
H.V.ON CAUTION

Test 10- V_7 cathode. Shows thyratron discharge towards the positive. It is from this point that the transmitter keying pulse is taken in R.D.F. work.
H.V.ON CAUTION

Test 11- V_8 grid. Trace showing some of the characteristics of Figs.2 and 3, modified by synchronizing pulse.

Test 12- V_8 plate. Modified square wave on account of synchronizing pulse on V_8 grid.

Test 13- V_9 plate. Modified square wave.

Test 14- V_{10} screen. Modified square wave. A portion of this taken from a tap on the screen resistor is used as a brightening pulse on the Cathode Ray grid.

Test 15- V_{10} plate. A modified saw-tooth wave. Attention should be directed to the fact that the charge portion is very linear.

Test 16 - V_{11} plate #1 - the amplified sweep in a positive direction.

Test 17 - V_{11} plate #2 - the amplified and inverted sweep. Same trace as in test 16, but in a negative direction.

Test 18 - V_{12} plates. A typical multivibrator square wave towards the negative. Adjusting R_6 will vary the wave shape. See Figs.7 and 8.

Test 19 - V_{13} plate. A square wave going towards the positive. This is because V_{13}, and one half of V_{12} are connected in a multivibrator circuit, with the first half of V_{12} acting as a buffer tube. Therefore, adjustment of R_6 will also vary this wave shape.

Test 20 - V_{14} grid. Pulses due to the differentiation of the square wave from V_{12} plate. The positive pulse fires V_{14}. Motion of positive and negative pulses with respect to one another is accomplished by manipulating R_6.

Test 21 - V_{14} cathode. Characteristic Thyratron discharge. Two peculiarities observable on the C.R. screen serve to emphasize the extremely short duration of this pulse.
(1) The pulse appears almost as a vertical line, which shows that during the time taken to complete the discharge, the Horizontal Sweep of the Oscilloscope has not had time to move the electron beam to any extent.
(2) The pulse appears dim with respect to the brilliancy of the sweep line, indicating that the C.R. electron beam is moving so fast that it does not have time to furnish the required number of electrons to any part of the line, during the pulse, to fully excite the C.R. tube screen.

Test 22a- V_{15} and V_{16} plates. Showing the trains of oscillations obtained from V_{16}. V_{16} is the control tube.

Test 22b- V_{15} and V_{16} plates. Expand one train of oscillation on the C.R. screen to show shape of individual cycles.

Test 23 - V_{17} plate. Leave Cathode Ray scope set as in test 22b. Amplification will be indicated by greater amplitude on the Cathode Ray screen. Attention should be directed to the sharpness of the individual alternations resulting from the sharpener circuit in V_{17} plate.

Test 24 - V_{18} plate. Shows the tops of the positive alternations from V_{17} plate cut off to form calibration pips. Some Cathode Ray scopes show over-correction of the first pip.

An insulating strip, carrying two groups of five terminals is mounted at the rear of the rack for connections to the built in Cathode Ray tube.

The group of terminals to the right (looking from the rear) is the High Voltage sweep connections; the group at the left for the Low Voltage sweep.

The connections are as follows: The two right hand terminals are V_1 and V_2. The centre terminal is Cathode Ray grid and the two left hand terminals are H_1 and H_2.

The same order of connection also applies to the plug-in Cathode Ray connection on the top panel. Condensers are built into the plugs.

Tests 1 to 6 inclusive take in the Control Section.
Tests 7 to 10 inclusive show the High Voltage sweep.
Tests 11 to 17 inclusive show the Low Voltage sweep.
Tests 18 to 24 inclusive show the pip generating section of the Low Voltage sweep.

1. Master multi grid #1
2. Master multi grid #2
3. Master multi plate
4. V_2 Thyratron grid
5. V_2 Thyratron plate
6. V_2 Thyratron cathode synchronizing output (to grids of V_3, V_8 and V_{12})
7. V_3 sweep Thyratron plate and diode plate) Sweep H.V.
8. V_5 sweep amplifier plate)
9. V_6 pip amplifier plate.
10. V_7 thyratron cathode (pip output)
11. V_8 grid
12. V_8 plate
13. V_9 plate
14. V_{10} screen
15. V_{10} plate
16. + V_{11} plate #1) Sweep L.V.
17. - V_{11} plate #2)
18. V_{12} plate
19. V_{13} plate
20. V_{14} grid
21. V_{14} cathode
22. V_{15} and V_{16} plates
23. V_{17} plate
24. V_{18} plate - pips

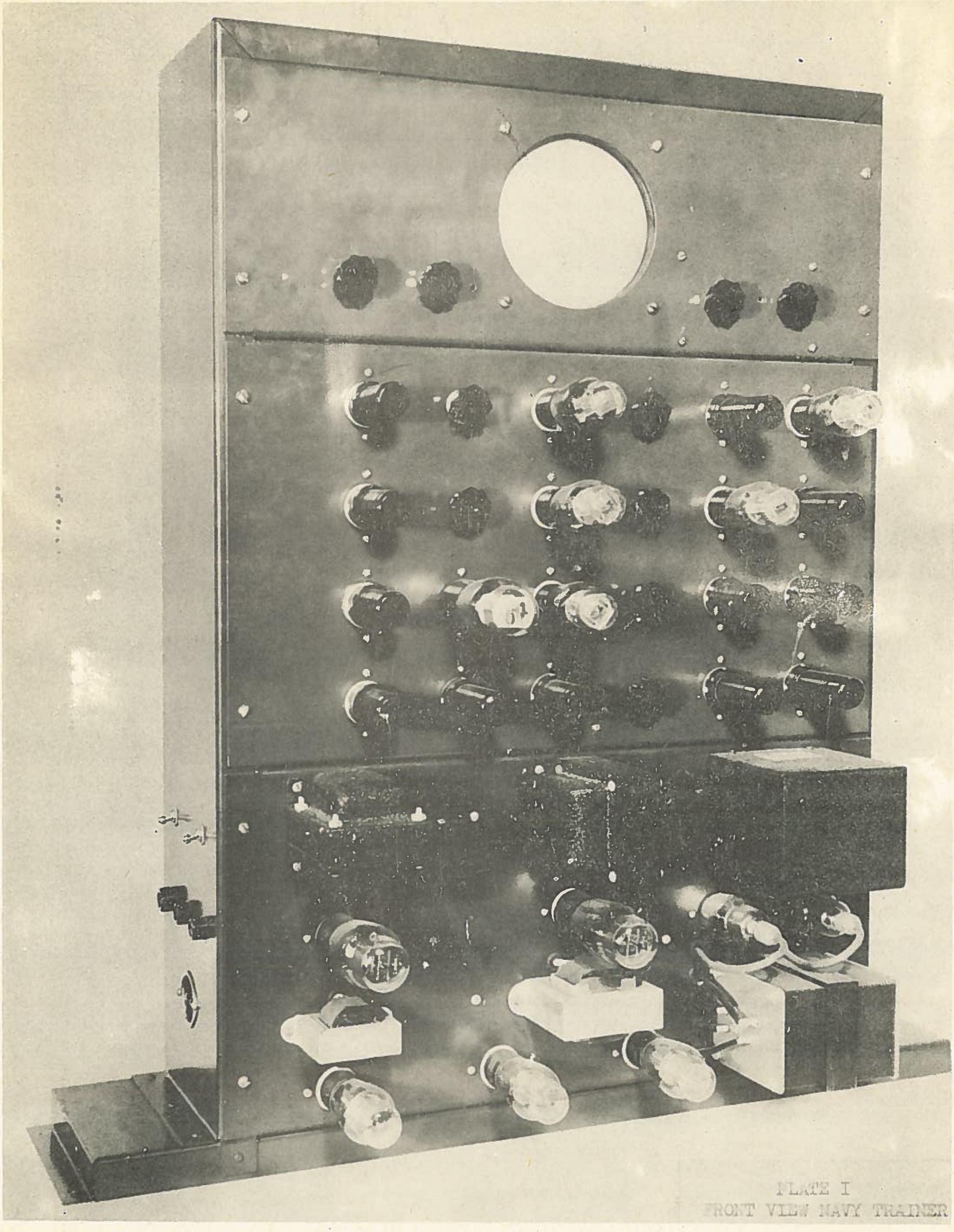


PLATE I
FRONT VIEW NAVY TRAINER

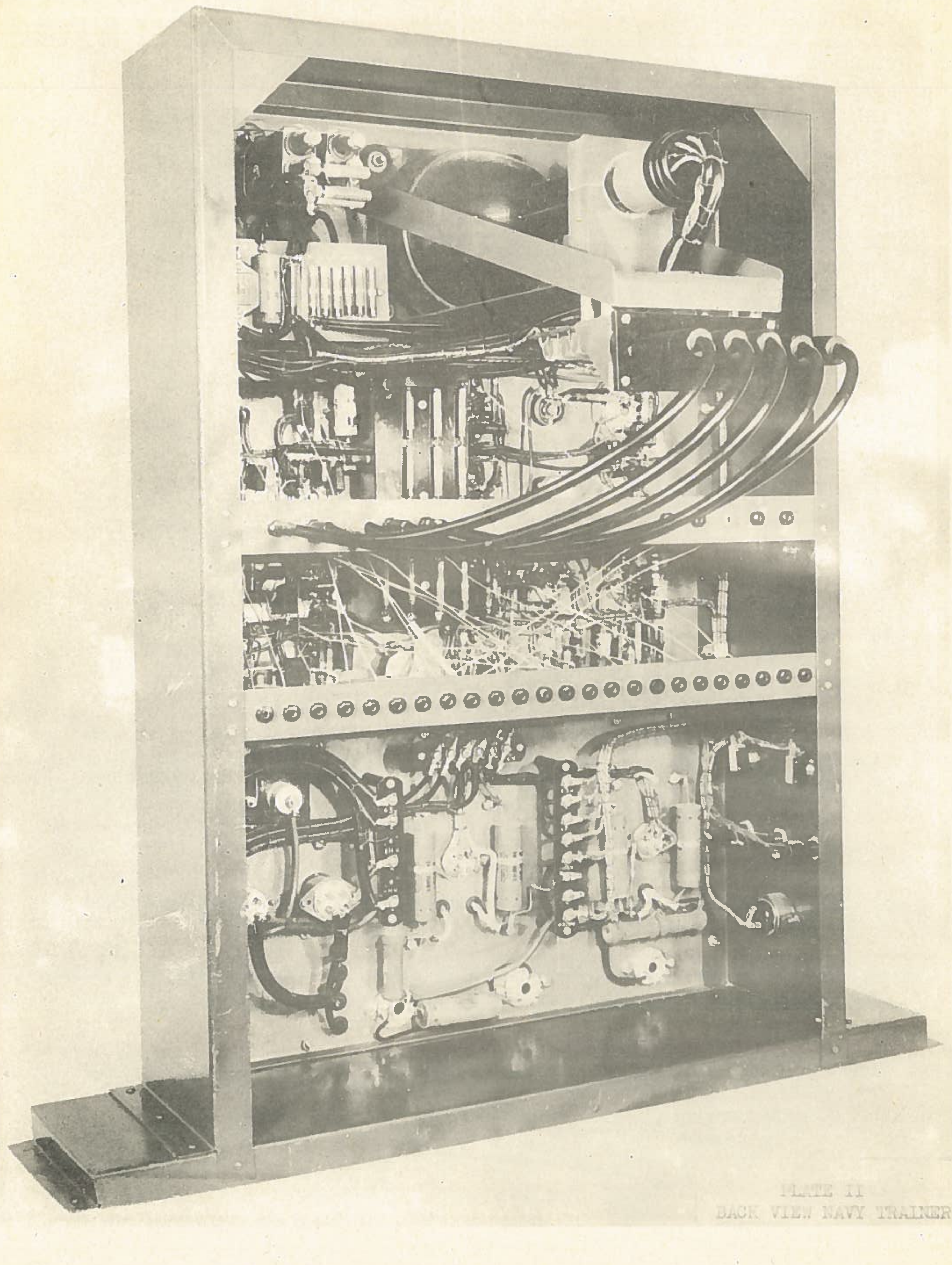


PLATE II
BACK VIEW NAVY TRAINER

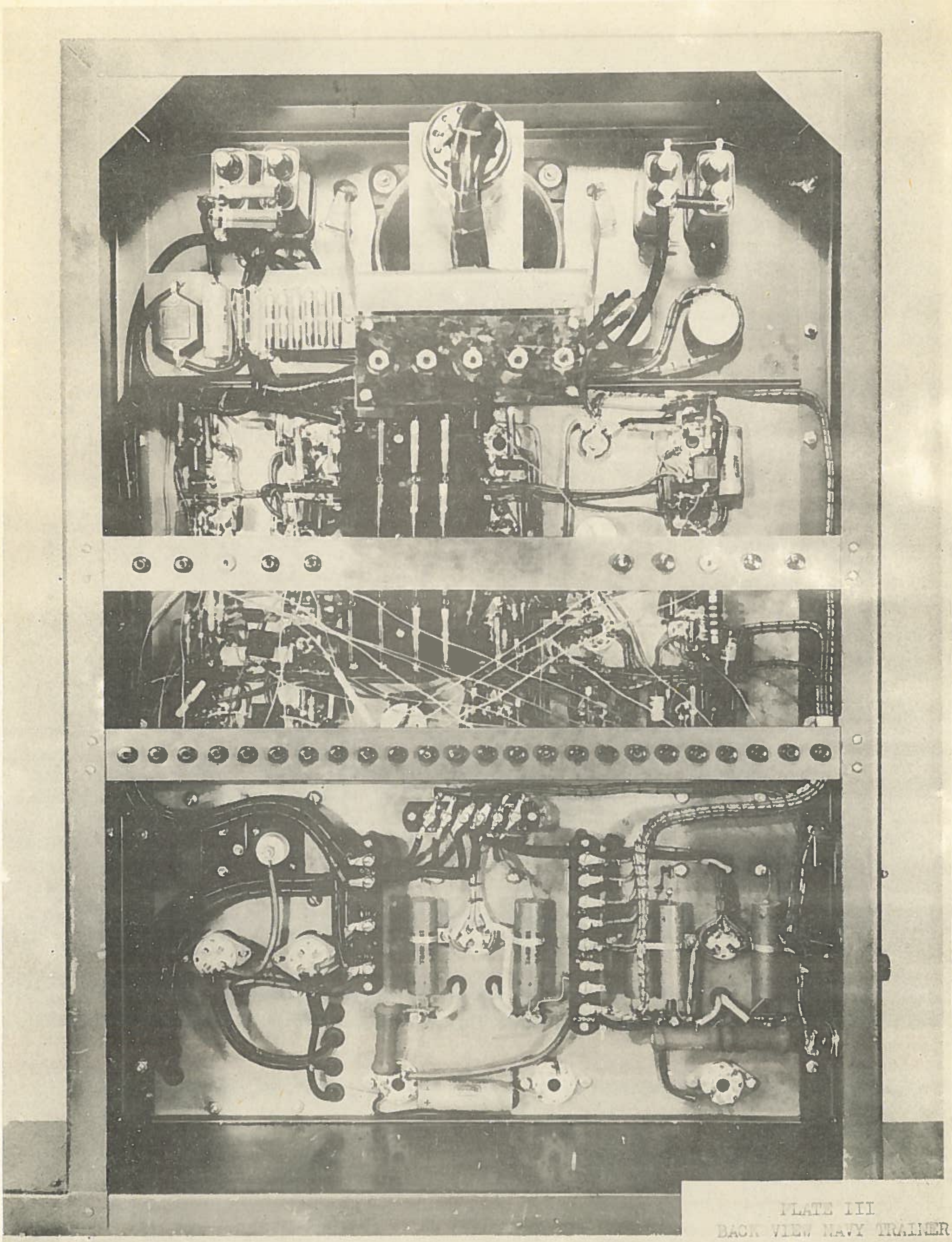
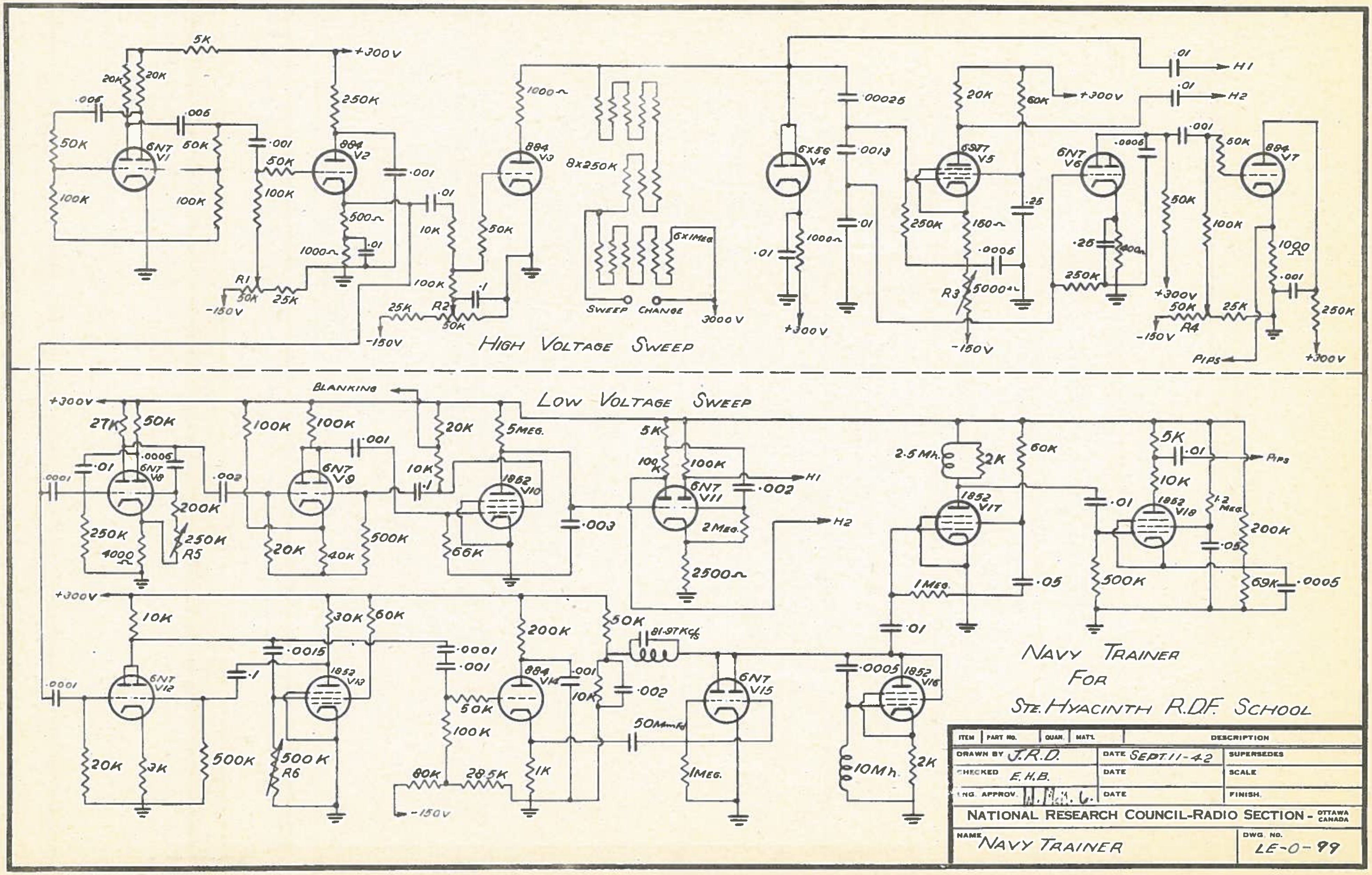
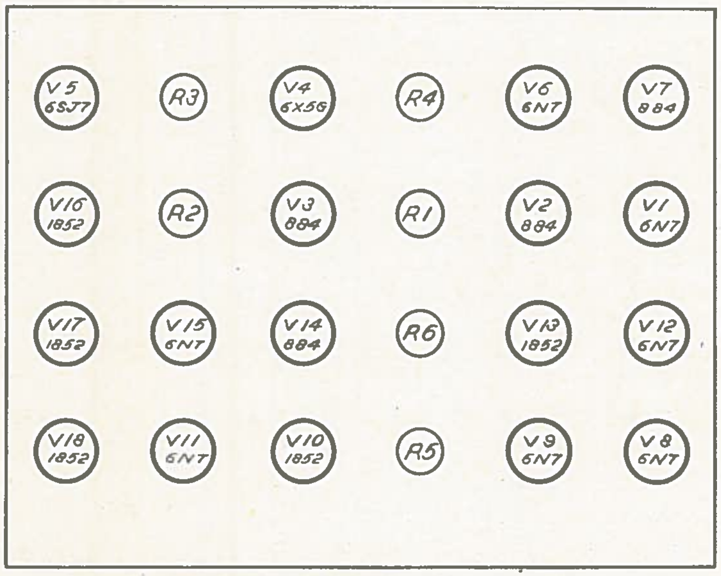


PLATE III
BACK VIEW NAVY TRAINER


High Voltage Sweep
Low Voltage Sweep
Navy Trainer
For
Ste. Hyacinth R.D.F. School
ITEM | PART NO. | QUAN. | MAT'L | DESCRIPTION
DRAWN BY J.R.D.
DATE SEPT. 11-42
SUPERSEDES
CHECKED E.H.B.
DATE
SCALE
ENG. APPROV.
DATE
FINISH
NATIONAL RESEARCH COUNCIL-RADIO SECTION - OTTAWA CANADA
NAME NAVY TRAINER
DWG. NO. LE-0-99



Front View Of Panel

C.R. Connection

RESISTORS

R1- Adjust Master Thyratron
R2 Adjust H.V. Sweep Thyratron
R3-Adust H.V. Sweep Amplifier
R4-Adjust H.V. Sweep Pip Thyratron
R5-Adjust L.V. Sweep Multi-Vibrator
R6-Adjust L.V. Sweep Pip Multi-Vibrator

Tubes

V1- Master Multi-Vibrator
V2- Master Thyratron
V3- Sweep 884
V4- Limiting Diode H.V. Sweep
V5- Sweep Amplifier H2
V6- Pip Amplifier
V7- Pip 884
V8- L.V. Sweep Multi-Vibrator
V9- Buffer & Multi-Vibrator
V10- Sweep Multi-Vibrator
V11- Sweep Phase Inverter
V12- Pip Multi-Vibrator & Buffer
V13- Multi-Vibrator
V14- Pip 884
V15- Pip Control
V16- Pip Oscillator
V17- Amplifier & Sharpener (Pip)
V18- Rectifier & Corrector

ITEM	PART NO.	QUAN.	MAT'L	DESCRIPTION
DRAWN BY J.R.D		DATE 9-14-42		SUPERSEDES
CHECKED E.H.B.		DATE		SCALE
ENG. APPROV. W. McM.		DATE		FINISH.

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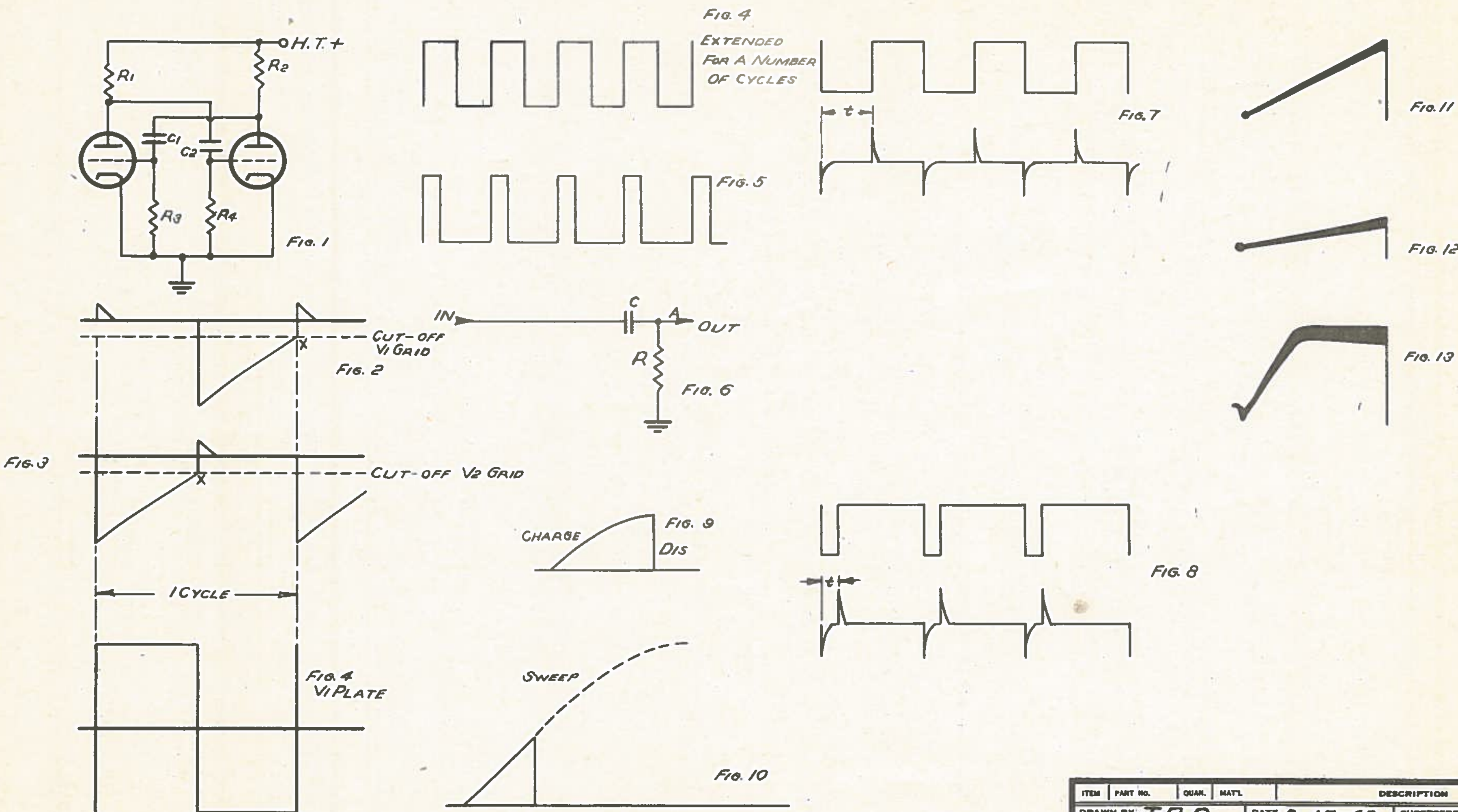
NAME NAVY TRAINER FRONT PANEL

DWG. NO. LE-0-100



ITEM	PART NO.	QUAN.	MAT'L	DESCRIPTION
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ENG. APPROV. W. McK. J.		DATE		FINISH.

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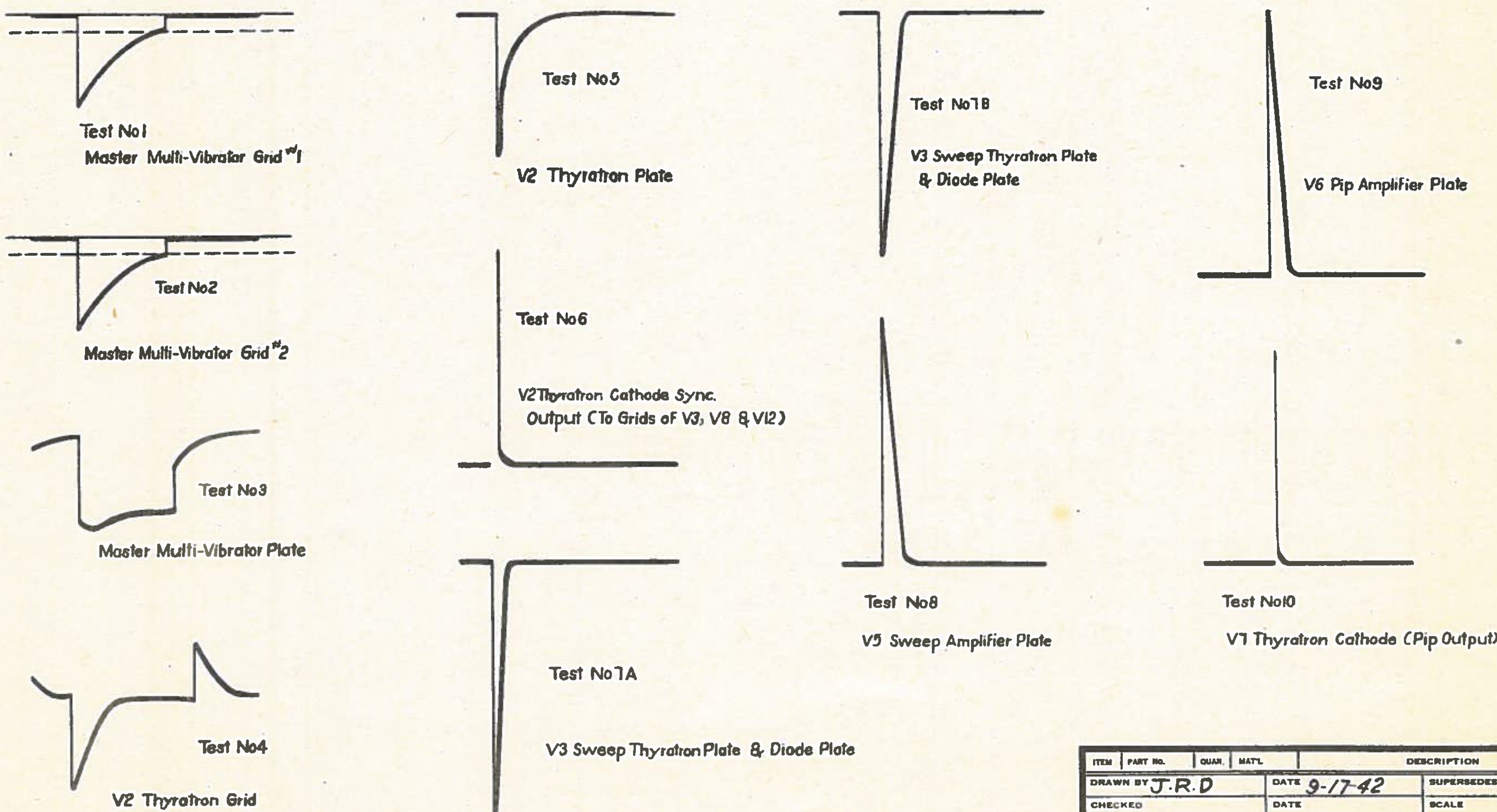

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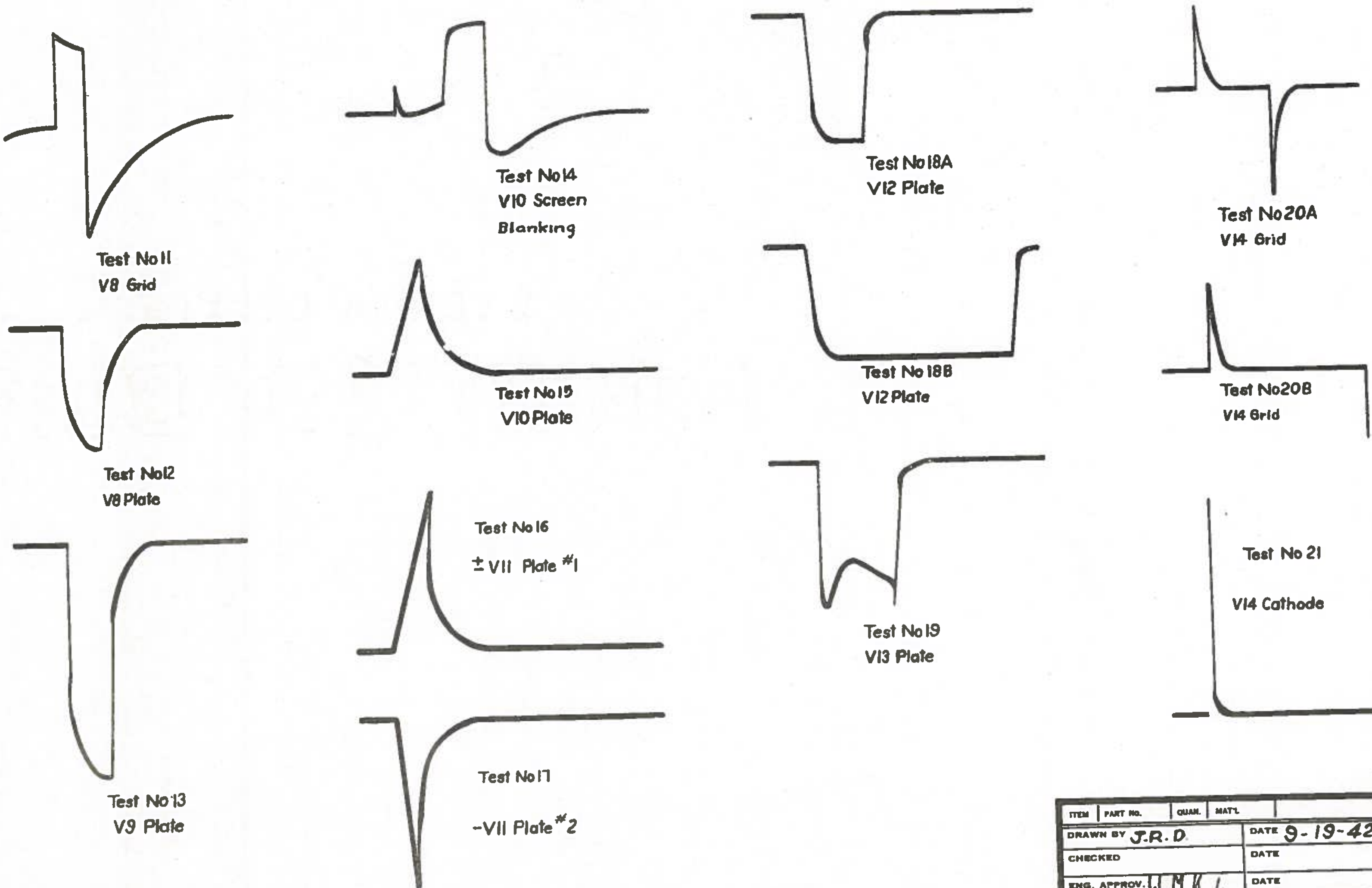
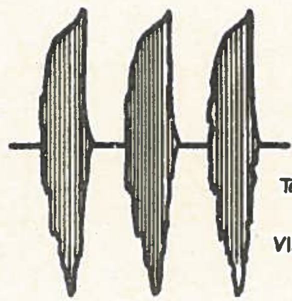
ENG. APPROV.		DATE		FINISH.	

NATIONAL RESEARCH COUNCIL-RADIO SECTION - OTTAWA CANADA

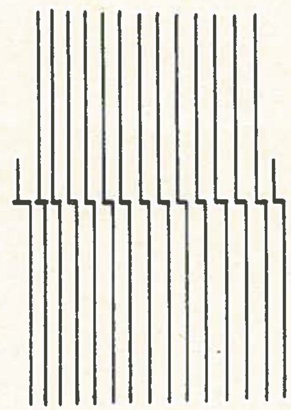
NAME NAVY TRAINER TEST	DWG. NO. LE-O-102



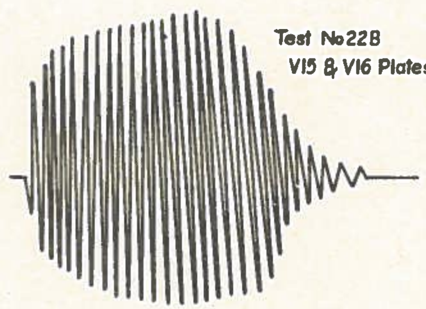
ITEM	PART NO.	QUAN.	MAT'L	DESCRIPTION
DRAWN BY J.R.D		DATE 9-19-42		SUPERSEDES
CHECKED		DATE		SCALE
ENG. APPROV. W.McK.C.		DATE		FINISH.
NATIONAL RESEARCH COUNCIL-RADIO SECTION - OTTAWA CANADA				
NAME NAVY TRAINER TEST				DWG. NO. LE-0-103



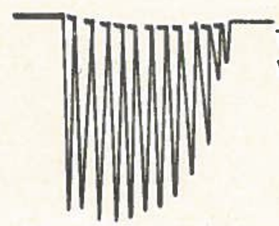
Test No22
V15 & V16 Plates



Test No23
V17 Plate



Test No22B
V15 & V16 Plates



Test No24
V18 Plate – Pips

ITEM	PART No.	QUAN.	MAT'L	DESCRIPTION
DRAWN BY J. R. D.	DATE 9-19-42	SUPERSEDES		
CHECKED	DATE	SCALE		
ENG. APPROV. W. McK. G.	DATE	FINISH.		
NATIONAL RESEARCH COUNCIL-RADIO SECTION - OTTAWA CANADA				
NAME NAVY TRAINER TEST		DWG. NO. LE-0-104		