Lecture notes on GL Mark III C

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Publisher's version / Version de l'éditeur:
https://doi.org/10.4224/21273954
PRA; no. PRA-50, 1942-06

[redacted]

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NATIONAL RESEARCH COUNCIL OF CANADA
RADIO BRANCH

LECTURE NOTES ON GL MARK III C

OTTAWA

JUNE, 1942

LECTURE NOTES ON GL MARK III C

I N D E X

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NOTE - The parts list, in every case, follows immediately the drawing to which it applies.

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LECTURE NOTES ON GL MARK III C

GENERAL OUTLINE

The Accurate Position Finder (APF) consists of a trailer carrying the transmitter, receiver and indicating apparatus; it also carries the final stages of the Zone Position Indicator (ZPI) receiver with its indicating equipment. It is towed by a Four Wheel Drive medium truck carrying the Diesel generator set, which is mounted on a wheeled carriage. The truck is equipped with a ramp for loading and unloading the Diesel unit.

The APF has three operating positions; facing the front of the panel, and in order left to right, these are: Elevation, Azimuth and Range, with ZPI to the right.

The ZPI furnishes range and azimuth information which appears on the Magslip dials in front of the corresponding APF operator. No elevation data is furnished. One receiver and one transmitter operator are needed.

The function of the APF is to take the information furnished by the ZPI and use it to determine the location of the target up to a maximum slant range of 17,000 yards, with an accuracy of ±25 yards for range, and 1/6° for elevation and for azimuth. This information is transmitted to the predictor by a Magslip. For range, a high speed Magslip with 2,000 yards per revolution, and a low speed Magslip with 34,000 yards per revolution, is provided. For elevation, the high speed Magslip gives 10° per revolution, and the low speed 90° per half-revolution. For azimuth the high speed Magslip reads 10° per revolution, and the low speed 360° per revolution. Provision is made to use Magslips calibrated in mils to provide information for a Sperry predictor.

APF INTRODUCTION

Block Diagrams

The switch marked "operate-calibrate" is used to select one of two sequences of operation: NRC-RB-1334 is a block diagram of the operate sequence, and NRC-RB-1335, of the calibrate sequence.

Operate Sequence

The recurrence frequency control (800-1200 c.p.s.) furnishes a positive wave of short duration which fires the modulator. The modulator sends out a negative square wave through a low capacity line to the cathode of the magnetron, causing the magnetron to oscillate. The 3000 Mc. R.F. is fed to a half-wave dipole and reflector rotating at 1200 r.p.m. at the focus of a 48-inch paraboloid. The magnetron is mounted on the frame of the paraboloid.

The modulator pulse is picked up by a small vertical antenna mounted on the modulator chassis. This is amplified and operates a Kipp relay in the sweep keying unit. The Kipp relay furnishes a negative square wave of sufficient time duration to allow for maximum range, and keys the sweep unit by causing the tube which short circuits the standard condenser in the sweep circuit to stop conducting. Separate sweep circuits and Kipp relays are provided for range and auxiliary cathode ray tubes. They are duplicated, except for voltage, since a long time base is not necessary on the auxiliary cathode ray tube. Both sweeps are controlled by the range operator through a motor drive which varies the standard capacity and sweep voltage with range.

The echo signal is received by a half-wave dipole which rotates in the same plane of polarization as the transmitting dipole, but which is offset by 7/8" from the central axis of the paraboloid. This causes the dipole to sweep in a circle and hence the receiving beam sweeps a solid angle in space. The signal is sent through a short coaxial line with triple stub matching to the crystal mixer. The local oscillator is a Sutton tube located in the main rack, the output being fed to the mixer on the roof through a coaxial cable. The resultant signal, at the intermediate frequency of 30 Mc. leaving the crystal, is then amplified by the preamplifier I.F. on the roof and is sent to the main receiver in the rack where it is fed in parallel to two I.F. amplifiers, one for range and one for elevation and azimuth. The output of the range I.F. is amplified by the range video, and transmitted to the range cathode ray tube. The elevation and azimuth I.F. feeds two video stages, one for the auxiliary cathode ray tube, and the other for the two integrators. Each integrator consists of two main parts, (a) an amplifier-pulse shaper stage, and (b) a comparator bridge circuit. Parts (a) and (b) are connected through opposite segments of the quadrant switch so that any differences in signal strength between the outputs of the two segments appear as an unbalance of the bridge circuit and are indicated on a meter. When the target is in line, both elevation and azimuth meters read zero. The integrators indicate signal level averaged over a short time interval, thereby smoothing out random fluctuations of the received signal. They are protected against the effect of extremely strong signals by the AVC with which the elevation and azimuth I.F. is provided.

Two positive square waves are provided by the strobe chassis which operates from the auxiliary sweep. The narrow strobe is sent to the integrators to ensure that only the signal at the centre of the range cathode ray tube acts on the meters. This avoids possible errors as to targets. The narrow strobe is available at the option of the range operator on both cathode ray tubes, as is also the wide strobe. The wide strobe is also sent to the main range I.F. in time to receive the signal returning from the target; in the absence of the strobe, the range I.F. is cut off to prevent direct pick-up from the transmitters from overloading subsequent circuits.

Calibrate Sequence

When the range operator desires to check the accuracy of his sweep, he turns the operate-calibrate switch to calibrate, putting the following sequence of operation into effect.

The transmitter is allowed to fire, but the sweep is now triggered by the recurrence frequency chassis in synchronism with the output of the pip generator. A crystal controlled oscillation at 655.71 Kc. (250 yards' range) from the pip oscillator is shaped by the calibration pip generator and then amplified. The oscillator runs continuously, but the generator operates only when calibration is desired. The amplified pips then appear on the sweep at 250-yard intervals.

The range main I.F. is cut off, removing any noise or signals from the cathode ray tube. The integrators and test cathode ray tube are left running normally.

OPERATING INSTRUCTIONS

Check line volts both sides of neutral. Note that all switches are in correct position for operation, also that variac is at zero and magnetron filament at "start".

Turn main circuit breaker on.

Check that light on resistor heater is on.

Note that over-voltage light is not on.

Turn on power switch. The "first" light should go on, and after 15 seconds, off. A click should then be heard, cathode ray tube spot should appear, and low voltage power supplies should give normal readings when metered. At this time also the "first" light goes out and the "second" light comes on and stays on until 15 seconds more have passed, when if the "stand-by" switch is closed, it goes out. Cathode ray tubes should be adjusted for brilliance, focus and centering.

Turn on "stand-by" switch.

Check magnet current meter.

Turn variac up slowly, watching modulator voltage and noticing that modulator current is well within the scale. Bring voltage up to about 10 kV. slowly.

After a few minutes, bring variac up until pulse current is 5 amps., watching power supply meters.

After a few minutes, bring pulse current up to final values (about 12 amps. at 15 kV.) This may mean re-adjustment of magnet current and variac.

Check crystal current and adjust it to above 600 µamps.

Centre elevation and azimuth meters.

Set range to 2,000 yards.

Tune local oscillator to give best signal on range tube (keeping gain low while doing this).

Turn on elevation and azimuth motor switches.

Find a good fixed echo at as great a range as possible.

Again tune local oscillator.

Re-adjust variac and magnet to give best signal. (May need to adjust local oscillator).

Check narrow strobe to see that it bears correct relationship to hairline.

Turn operate-calibrate switch to calibrate, and check calibration from 2,000 to 17,000 yards.

Set manual gain and AVC by observing signal on test cathode ray tube.

Notify ZPI that APF is ready.

RECURRENCE FREQUENCY CHASSIS (see NRC-RB-1351)

Provides triggering pulse for modulator and, when calibrating, for time-base.

Wobbulator - When the switch is thrown, condenser charges through a resistor to the firing voltage of the gas-discharge tube, which discharges the condenser. A choke in the plate lead tends to slow the condenser discharge rate. The resulting saw-tooth wave is applied to the multivibrator grids.

Multivibrator - Operates with or without the wobbulator. Frequency is controlled by varying the positive bias on the grids of the tube which can be varied between 800 and 1200 c.p.s. The higher frequency results from the more positive grids. Adjustments are provided for the amount of wobbulation voltage applied to the grids (modulation amplitude) and for frequency of wobbulation (charging time of condenser). The multi-vibrator output is essentially square with sloping extremes.

Multivibrator with Wobbulation - The wobbulator wave varies the multivibrator grid bias to produce frequency modulation of the output.

884 Thyratron - Firing voltage can be determined by the negative bias on the grid of the tube. Once the tube has fired, the grid

loses control. If a large resistor is in series with the plate supply, the tube will extinguish itself, if it fires at all, due to low plate voltage. By placing a condenser to ground from the plate, the tube fires, due to the condenser charge, and duration of firing will depend on the size of the condenser. The condenser recharges between pulses on the grid. If the grid remains positive for a lengthy period of time there may be a small series of firings of extremely low amplitude, since the condenser will discharge as soon as it has charged to the tube firing voltage. Thus there is only one main firing of the 884 for each positive swing of the multivibrator square wave.

Modulator Pulse - The 884 in the upper right hand corner of the diagram fires as described above. From the cathode a positive pulse of short duration and about 100 volts amplitude is sent to the modulator. From this same cathode a similar pulse of much lower amplitude is sent to the ZPI receiver, where it is used to blank any interference of the APF with the ZPI receiver.

Calibration - When calibrating, the sweep must be triggered by a calibration pip if the pips are to be motionless on the time base. If this triggering were done directly then the sweep would start and would last about 100 microseconds, at the end of which time the Kipp relay would remove the sweep. A calibration pip would at once re-trigger the sweep and so on. This would give about a 10,000-cycle sweep instead of the usual 1,000. Some means must be provided to synchronize triggering, by means of calibration pip, with the recurrence frequency.

Calibration pips at a frequency of 655.71 kc. enter at the point Z. These are fed to the cathode of an 1852 (impedance match) and come from the plate to the grid of the output tube at the lower right.

The calibration pips also go to the grid of an 1852 and the amplified negative pip shock excites a choke. The resulting damped train of oscillations is fed to the grid of the 884, together with the multivibrator wave. The first positive swing of one train of oscillations will fire the 884 a small interval of time ahead of its firing from the multivibrator. This only occurs when the multivibrator wave is positive and therefore can only occur once per 1,000 microseconds.

A positive pip is taken from the 884 cathode to the plate of a 6X5G, where it meets a negative voltage obtained from a bleeder from the -150Vpower supply. The diode will cut off any excess voltage possessed by the pip above the value of the negative voltage, and hence the voltage of the suppressor on the output tube is brought to ground for about two microseconds every 1,000 microseconds.

The delay through this circuit is so arranged that if one calibration pip brings the suppressor of the output tube to ground, the next following pip will be on the grid, will be amplified, and will come out as a negative pip. Only one such pip will be passed by the output tube every 1,000 microseconds, and is used to trigger the sweep when calibrating.

MODULATOR (see NRC-RB-1352)

This chassis provides a strong negative square wave at 1,000 c.p.s. which is used to provide plate voltage for the magnetron.

The input 884 is triggered by the positive pip from the 884 in the recurrence frequency chassis, and a damped train of oscillations is set up in the primary of the input transformer. The first positive swing from the damped oscillation in the secondary triggers the second 884.

The arrangement of chokes and condensers provides a means of timing the discharge. The output at the cathode is a flat top, positive wave.

The second 884, 807 and 813 are mounted on a specially insulated chassis with low capacity to ground. Since the cathodes are tied to this chassis, the chassis becomes positive with the cathodes. All tubes are biased to cut-off. The 807 conducts on the positive wave from the 884 and in turn this raises the potential of the whole chassis, and thus also raises the potential of the 884.

The 813 conducts on the positive wave from the 807, and again raises the chassis potential, which raises the potential of the 884 and 807. Thus power and voltage amplification are both obtained.

A diode is provided to remove any damped train of oscillations (these have a negative first swing) at the grid of the 304TH driver. The positive square wave from the 304TH cathode overcomes the -1500 volt fixed bias on the output 304TH's, allowing them to conduct. Their plate voltage drops from about 15 kV to about 500 volts, and the resulting negative square wave is sent to the pulse line and then to the magnetron cathode through a .06 µfd condenser.

The pulse current meter passes no current on the actual pulse, but reads on the flow of current to the condenser between pulses. The 1 µfd. condenser helps to keep the meter reading constant.

The pulse line consists of a large galvanized pipe with a bare #14 wire passing through its centre. This construction gives high insulation with low capacity.

MODULATOR BIAS SUPPLY (see NRC-RB-1353)

Provides +4,000 volts for the plates of the 813 and first 304TH, also -1,500 volts for output bias. This chassis also provides +1,000 volts for all the bleeders in the modulator.

MODULATOR HIGH VOLTAGE SUPPLY (see NRC-RB-1354)

This voltage doubler circuit provides +15 kV to the plates of the output tube. A variac is provided in the high voltage primary (30 second time delay) to allow gradual turning on of high voltage.

MAGNETRON

The magnetron consists of a copper block with a number of hollow chambers connected by slots to a central cavity containing the cathode. The case is kept at ground and the modulator pulse provides a negative potential for the cathode.

A magnetic field is applied by an electromagnet along the axis of the cathode. The resulting forces set up R.F. oscillations in the resonant chambers. The frequency is determined by the physical dimensions of the cavities and the output is taken by a loop in any of the cavities.

SWEEP KEYING UNIT (see NRC-RB-1345)

There are two possible inputs corresponding to two positions of the "operate-calibrate" switch,--one from a small pick-up aerial near the modulator, the other from the recurrence frequency chassis. Both inputs are negative and either can be applied to the first 1852 grid. The first tube amplifies, and its positive output is applied to the second tube, which is biased lower than the usual two volts (160 ohms in cathode). The negative amplified output is fed to the grid of the first tube in the Kipp relay.

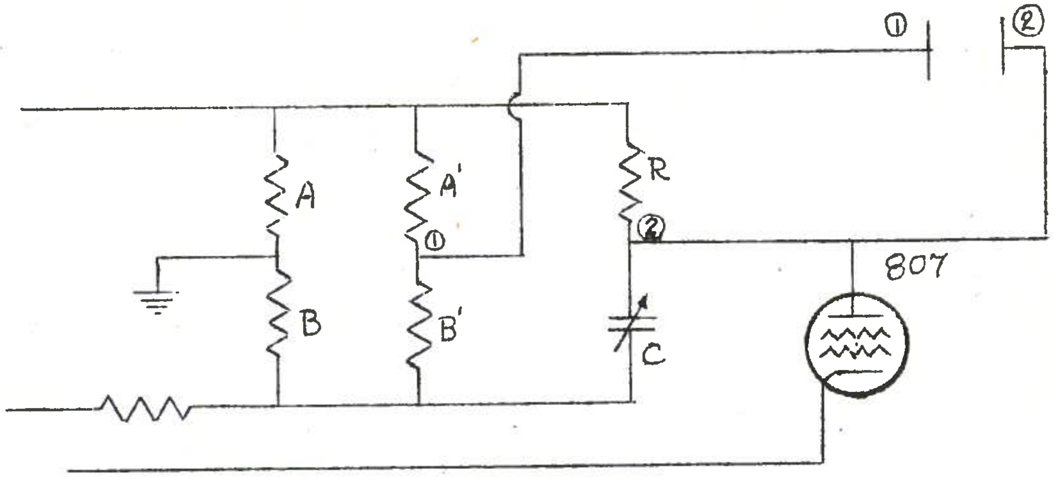
In this Kipp relay the first tube conducts heavily with no bias and its plate voltage is therefore low; the screen is fixed at 150 volts to avoid fluctuations in screen current and, therefore, in screen voltage, due to different conditions of conduction. The second tube is kept far below cut-off by the 105 volt positive cathode bias.

The grid of the second tube therefore has -105 volts bias from the cathode, and a positive voltage from the plate of the first tube. The plate resistor of this first tube is chosen so as to produce a voltage at the grid of the second tube that will keep it just below, but close to, cut-off.

If the negative pip is applied to the grid of the first tube, it conducts less heavily; its plate voltage rises; the second tube goes above cut-off; its plate voltage drops, and this decrease in voltage is applied to the grid of the first tube through the .0005 µfd condenser. driving the first tube to cut-off and the second goes to saturation. This condition lasts for a period of time determined by the RC constant of the .0005 µfd condenser and the resistors to ground from the first grid. The output taken from the second plate will therefore be a negative square wave which is used to trigger the sweep keying tube.

SWEEP CIRCUIT

Range is calibrated by measuring the time taken for a condenser to charge up to ground potential while a pulse is travelling to and returning from the target appearing at the centre of the cathode ray tube. If the condenser charges through a constant resistor R, then the time of charge will be a linear function of condenser capacity, and hence condenser capacity is a measure of range and can be so calibrated. The condenser is allowed to charge from a voltage -E to ground when the spot will be at the centre of the cathode ray tube. The charging curve of the condenser is fairly linear through this voltage, but brilliancy would vary with range, since the slope of the curve is different at different ranges. To overcome this effect the voltage -E is made to vary linearly with range, and brilliancy and expansion are kept constant.



In the simplified diagram above, point 1 will be at ground if

$$\frac{A}{B} : \frac{A'}{B'}$$

Plate 1 of the cathode ray tube is at ground. If the 807 sweep trigger tube is conducting heavily then point 2 is at -E, except for the voltage drop across the 807. If the 807 is suddenly cut off by the negative pulse from the sweep keying unit, the condenser starts to charge, and plate 2 of the cathode ray tube increases in potential from -E up through ground, producing the time-base. The rheostat provides compensation for the voltage drop across the tube.

Since R must be kept at its exact value, it is placed in a thermostatically controlled oven and is made up of a number of smaller resistors in series. A blower keeps the air temperature in the oven even throughout.

C is a precision type straight line capacity condenser varied by motor control.

The complete sweep circuits are in duplicate and the condensers are rotated by the same gearing controlled by range operator.

LOW VOLTAGE REGULATED POWER SUPPLY FOR SWEEP KEY CIRCUIT AND MAGNET (see NRC-RB-1349)

Since the Kipp relay is very critical and if the plate voltage should rise might fire itself, this supply is used.

Five 2A3's in parallel (60 mils each) are placed in series with the high voltage supply. The bias on the 2A3's is the plate voltage of the 1852 whose plate supply is the 300 volts output. The grid of the 1852 is connected to +150 volts on the bleeder at the output, and to -150 volts from the regulated power supply. For manual control the potentiometer can be set to give desired value of conduction in the 1852 and therefore bias on the 2A3's and hence desired output voltage.

If the output voltage should rise, the 1852 would conduct more heavily because of its more positive grid, its plate voltage would drop, the grids of the 2A3's would be less positive, the resistance of the 2A3's would increase, and the output voltage would be restored to its original lower value.

This supply provides current for the magnet also.

RANGE SWEEP POWER SUPPLY (see NRC-RB-1347)

Two 1616's are connected in a voltage doubler circuit to deliver 4,000 volts to the plate of the 304TH, of which only one half is used. The 304TH is in series with the high voltage output and its bias is obtained from the plate voltage of the 813 control tube. Automatic and manual regulation is obtained by controlling the bias on the grid of the 813.

The 6K potentiometer, towards the bottom of the diagram, is driven by the range sweep gearing to vary the output voltage to the sweep from 500 to 4,000 volts linearly with range.

To set these voltages range may be turned to maximum (6K control potentiometer towards bottom, or negative end). At this setting the 813 conducts least heavily, and output voltage should be maximum. The 100K potentiometer of the 813 grid is then set to produce the desired voltage.

If the sweep is then turned to minimum (6K potentiometer towards the top or least negative end) then the 6K "expansion" potentiometer is adjusted to give desired minimum voltage. This 6K potentiometer will have little effect at maximum range.

This power supply has no direct ground connections and the screen voltage for the 807 sweep keying tube is obtained from the output bleeder. Automatic voltage regulation is obtained in a fashion similar to that described above under the low voltage supply. Provision is made to substitute a tapped bleeder instead of the 6K motor-driven potentiometer to give an arbitrary output voltage for sweep contraction when searching. This bleeder is cut in by the sweep contractor switch.

TEST CATHODE RAY TUBE AND STROBE SWEEP SUPPLY (see NRC-RB-1348)

This supply is identical with the one described above, except as follows:--

The power supply is full-wave rectified and of about 2500 volts. There is no sweep contractor switch. Maximum and minimum voltages are about 300 - 2400 volts.

CATHODE RAY TUBE POWER SUPPLY (see NRC-RB-1344)

One supply is used for both tubes. The filament transformer has a spare winding and is highly insulated.

CATHODE RAY TUBE CONNECTIONS (see NRC-RB-1343)

Voltages to cathode are: grid -125 volts to nearly 0; focussing anode about +400 volts; anode 2 at about +2000 volts (ground).

For vertical centering two ganged potentiometers are connected across the -150 volt and +150 volt power supplies (note that the other sides of these supplies are at ground, and potential across potentiometers is 300 volts). This provides push-pull potentials for centering.

Since range is measured when the electron spot is at the centre of the tube, (the deflection plates are at the same potential) horizontal centering is necessary. To avoid possible interference with the sweep voltage the centering is obtained magnetically. A coil around the neck of the tube has one grounded end and the other end is connected to a potentiometer across the -150 volt and +150 volt supplies. Current can be sent in either direction through the coil. A switch (horizontal centering switch) is used to short the plates and the spot is centered with the horizontal centering potentiometer. If the video or pip amplifier is operating when this switch is used, a vertical line will appear on the cathode ray tube which can be easily aligned with the cross-hair.

It is desired to have the cathode ray tube show sweep when there is no strobe connected to the grid, and if the strobe is connected, to respond to its action. The diode and 10 megohm resistor are for this purpose. Turn the brilliancy to normal with no strobe connected. Now connect either strobe wave (the two cathode ray tube grids are in parallel and a switch selects the strobe wave desired). The condenser charges during strobe pulses through the 6H6 diode. After the pulse passes the charge from the condenser leaks off through the 10 megohm resistor, producing negative potential at the grid and extinguishing the sweep. This will last for 1/10 second if no further strobe waves appear, and the tube will respond to strobe pulses if they are present.

CRYSTAL MIXER

Crystal - By the usual equation for a non-linear mixer we can show that when the voltage applied to the crystal is made up of two sine wave oscillations, several different frequencies, among them the I.F. desired, and a D.C. are produced. Most of these pass to ground at the grid of the first tube in the pre I.F., the 30 megacycle I.F. alone passing through this tube, due to the tuned choke.

Crystal Current Meter - Reads the D.C. component of the mixer output and consists of two meters (one on the roof and the other on the rack) connected in series with the tuned choke on the first pre I.F. grid and by-passed by a condenser. These meters should read 600-1000 µamps. To obtain this reading two adjustments may be made. First the amplitude of the beat oscillation can be controlled by the voltage control potentiometer on the Sutton tube power supply (crystal current control), and secondly, by the beat oscillator injector on the transmission line. Note that the meter reading is mainly dependent on strength of beat oscillation reaching the mixer and the reading is practically independent of correctness of Sutton tube tuning.

To tune triple stubs, set all three to their centre position (1/2 wavelength) and try to locate a good fixed echo. Adjust them, one at a time, about the centre position, watching the picture on the range tube or on a special monitor receiver on the roof until the best signal is obtained. A voltmeter method may be used as an alternative.

LOCAL OSCILLATOR (see NRC-RB-1337)

The local oscillator is a Sutton tube. At a certain potential conditions are correct to return the electron stream, which has been bunched on its passage past the resonator, in phase to reinforce the original R.F. field which caused the bunching. This voltage is critical and once found, must be maintained by regulation.

A 2,000 volt power supply, full-wave rectified, has its negative side connected to one end of a bleeder and the positive side to ground through an 807 tube and a milliammeter. The Sutton tube has a resonator connected to ground and the cathode is strongly negative. The grid, which controls the flow of electrons, can be arranged at cathode potential or slightly negative. The first anode is tied to the cathode and the reflector can be varied from cathode potential to slightly positive with respect to it. The grid should be set to give about 7 milliamps on the meter and oscillation is indicated when a slight nick occurs in the meter reading. A bleeder, connected between a regulated +150 and a negative voltage from the bleeder, allows grid bias to be adjusted, and therefore the critical voltages for oscillation to be found. Any changes in the high voltage power supply will change this bias, and therefore the 807 resistance, to compensate for the change and maintain constant voltage.

The frequency of oscillation depends on the dimensions of the resonator. The amount of oscillation depends on the voltage, and since the Sutton tube output is largely responsible for the crystal current meter reading, the meter reading is, within limits, independent of whether tuning is correct or not. To obtain correct tuning to give an I.F. of 30 Mc., coarse and fine tuning stubs are provided, the fine one being the tuning control on the main panel. The R.F. is carried to the injector which enters the transmission line and is capacity coupled to it, just before the mixer. The pick-up loop is grounded inside the resonator cavity and must be disconnected if the line is to be tested for a short-circuit.

I.F. PRE-AMPLIFIER (see NRC-RB-1336)

If the signal as seen on the cathode ray tube is to have a build-up time of 1/10 microsecond, wide-band amplifiers must be used, since a wave front of this sharpness contains many components of high frequency. A bandwidth of 10 Mc. is desired.

The I.F. amplifier design which is similar throughout the pre I.F. and main I.F., obtains bandwidth at the expense of gain. This requires many stages to obtain the desired overall gain in the receiver of 20,000,000.

Tuned chokes with special metal cores are used for tuning. (These are the pressed iron dust type). About one-quarter of the signal voltage developed is fed back out of phase from the plate. This weakens the signal, but broadens the band. Condenser sizes are carefully chosen, and de-coupling filters are provided to keep R.F. out of the power supply.

The actual bandwidth is about 16 Mc, with a gain of about 61 in the three amplification stages. The final stage is a coupler for the coaxial line to the main receiver in the rack. The pre I.F. is thus not a pre-amplifier in the usual sense, but is really part of the main I.F. channel. It is located on the antenna structure, immediately behind the receiving paraboloid, and is used to provide sufficient gain to overcome losses in the line down to the rack.

MAIN RECEIVER

The R.F. signal at 30 Mc. is fed in parallel to two I.F. channels. The main receiver comprises a range I.F. channel, an I.F. channel for azimuth and elevation, both second detectors, videos for integrators, test cathode ray tube, and AVC. Part of the first stage of the range video is also included.

Range Channel (see NRC-RB-1338) - This consists of five stages of I.F. amplification similar in construction to those in the pre-I.F. Gain is controlled manually by variation in the screen voltages of all tubes. Overall gain in this amplifier is about 5,000, and the gain at its input is about 40 (a loss of

20 occurs in the line from the pre I.F. to the main receiver). Gain is thus about 200,000 to the second detector. The range I.F. is strobed on the suppressor of the fourth tube to avoid overloading of the video by the ground pulse. When the switch is connected in top position, the suppressor is grounded and the tube would operate if the strobe was off. In the middle position of the switch a negative voltage is picked off the bleeder and applied to the suppressor which will then cut off the tube between the positive strobe pulses. In the lower position shown, the suppressor would be at -150 volts, cutting off the tube, since the strobe voltage would not be great enough to overcome it.

The negative output of the 6H6 second detector is fed to the grid of an 1852 video stage, whose plate load resistor is located in the range video and pip amplifier chassis. Discussion of the range video design will be undertaken when that chassis is studied.

Azimuth and Elevation Channel (See NRC-RB-1339) - The fundamental design of the I.F. portion of this channel is identical with the range channel, but no strobing is provided and the manual gain control regulates screen voltage on the first two tubes only. The suppressors of all tubes are connected to the AVC line (see below).

The negative output of the 6H6 detector is amplified by the 1852 video stage and sent in parallel to three different channels.

For the integrators, an 1852 tube provides an impedance match for the connecting cable. The middle tube on the right of the diagram provides voltage amplification for the signal to the test cathode ray tube. The AVC 1852 at the top receives a positive signal, and if bias on grid is correct will pass a negative amplified signal to the cathode of the diode. The magnitude of this signal can be adjusted by the 10K potentiometer on the -150 volt bleeder. The negative output of the diode is applied to the suppressors of the three middle tubes in the I.F. and due to the long time constant of the condenser and the resistor from the diode plate to ground, the output will be maintained as a slowly varying potential rather than a series of negative signals. These videos are of narrow bandwidth, since steepness in wave front is not necessary in this channel.

Careful adjustment of the AVC bias is necessary since the AVC operates as a signal limiter, and if set to operate on too weak a signal would prevent the desired increase in signal strength when direction finding. The usual procedure is to bias out the AVC action, set the manual gain on a strong signal to the desired level (observing the test cathode ray tube while doing this), then adjust AVC until it is seen to just take hold of the top of the signal. AVC action is necessary to prevent overloading of the integrator on sudden loud signals.

INTEGRATOR (see NRC-RB-1341)

If the antenna patterns of two different antennas have a common point of intersection, then by attaching two receivers and comparing their outputs we could find the azimuth (or elevation) of the target. Neither signal would necessarily be at maximum; it is their equality that determines the true direction. Unfortunately at 10 cm. the signals change amplitude between individual pulses so as to render this system impractical. Also as discussed below, this system would need four receiving aerials, and by the use of the quadrant switch and rotating dipole we now need only one receiving aerial. The function of the integrator is to average the two signals under comparison and compare the amplitudes of the averages. The transmitting and receiving dipoles are rotated about about 1200 r.p.m. and the receiving dipole is offset from the axis of the paraboloid. The receiving antenna pattern therefore is a continuously sweeping one, and if any two positions 180° apart are selected and at one instant the pattern is regarded as frozen, and a few moments later in the other position, it is again regarded as frozen, the result will be two inter-locking patterns corresponding to two separate aerials. A switch synchronized with the dipole rotation will perform this freezing action by connecting the receiver output for an instant when the dipole is in these positions. The opposite pair act as the other two aerials. The integrator averages and compares two signals fed to it and can be used on two separate aerials instead of the more economical single aerial and quadrant switch system.

The positive input from the video is applied to the grid of the first 1852 tube which is biased to -4 volts when the potentiometer is at the -150 end (the 2K and 75K bleeder does this) and the negative amplified output from the plate of the tube is applied to the .002 µfd condenser. The rates of charge and discharge of the condenser are quite different because of the relative resistances of the diode and the large resistors on the grid of the second tube. The result is a positive somewhat saw-toothed wave on the grid.

This signal is taken off the cathode at relatively low impedance to ground in case the switch should ever present a low impedance path. The positive signals will have a D.C. equivalent dependent on their area (height and width). The height is dependent on signal amplitude and is AVC'd, while the width depends on the setting of the "sensitivity" potentiometer. This D.C. component is allowed to charge the 2 µfd. condensers through resistors and the component itself will slowly rise and fall depending on the signals received, but individual signals will not have a great effect on it. In addition, due to the resistance in series with the condensers, fluctuations in the D.C. component will tend to be smoothed out. The result is a smooth average of voltage resulting from rapidly fluctuating signals. The resistor (25K "delay") can be set to produce delays of 0.2 - 0.6 seconds when we take into account the total R and C of the circuit and remember that the switch is only connected for 75° per quadrant or 1/5 of the time. Since it is desired that equal signals should charge the condensers to equal voltages, any differences in the R to each condenser would result in the condensers receiving their charges at different times if a change occurred. A 10K potentiometer ("Switch Compensation") is provided to equalize charging times.

The voltage difference between the condensers is measured by the balanced voltmeter V_4, V_5 which has a very high effective common cathode resistance (constant current tube V_6) which makes the voltmeter insensitive to differences in tube characteristics when the voltage of C_5 and C_6 vary in unison (varying signal intensity).

A switch is provided on the grids of the two 6F6's which, when closed, places the grids at equal potential to allow adjustment of the 1K "Set Zero" potentiometer for zero reading on the meter.

On the grid of the first tube a mock signal potentiometer is arranged which, if turned towards ground, sends a positive-going voltage on the first grid. This will test for equal delays on both sides of the quadrant switch and allow for necessary adjustment.

Selenium cells are provided to produce a logarithmic loss of sensitivity in the meter as relative cathode potentials increase. This means that 1/4° error in angle produces 1/2-scale deflection, while full-scale deflection may mean several degrees.

One integrator is provided for each of azimuth and elevation. The signal for range does not pass through the quadrant switch. The quadrant switch is gear driven by the same drive that rotates the dipoles and the same cam controls all four contacts. Adjustment is provided for the length of time contacts are closed during a revolution. Use an ohmeter -- a correct adjustment for 75° (1/5 revolution) would be indicated by a reading of 20% of the scale.

RANGE VIDEO AMPLIFIER (see NRC-RB-1340)

This four-stage amplifier (first tube is in the main receiver) is designed for a band pass of from 40 c.p.s. to 8 Mc. Chokes in plate leads maintain impedance at high frequencies. Fixed bias on the grids is used. Negative output to the cathode ray tube is kept at low capacity to ground to avoid distortion of signal. The gain is about 100.

STROBE (see NRC-RB-1346)

Since the azimuth and elevation operators follow meter indications when direction finding, and have no knowledge of possible interfering echoes except on the test cathode ray tube, some means must be provided to prevent either or both following a different target than that selected by the range operator. It would be desirable if the range operator could select the target, note the time after the firing of the transmitter (range), turn on the azimuth and elevation receiver a few microseconds before this time, and turn it off a few microseconds after this time. This would obviate the following of wrong targets since only the echo from that target selected by the range operator would reach the angle indicating meters. This turning off and on is done by a positive square wave which occurs just before and lasts until just after the electron beam has crossed the hair-line on the range cathode ray tube since the time taken for the spot to reach this point (sweep at ground) is controlled by the range operator. Then if the square wave can be formed from the sweep voltage, and is symmetrical around the ground point on the sweep, the switching process can be carried on.

The sweep voltage is applied to a voltage divider (one twentieth) to the grid of the first 1852 tube. A 5 µµF condenser preserves wave shape since the lower part of the bleeder is by-passed by tube capacity. The plate voltage of the tube, which was at cutoff until the sweep voltage reached the cutoff value of the tube, falls until the tube reaches saturation at a little above zero (ground) on the sweep, and rides at its lowest value while the sweep voltage goes on up. The small time constant of the .0005 µfd. condenser and the 10,400 ohm resistance causes the voltage wave to be restored to its original value. At the grid of the second tube we have an approximately V-shaped negative wave reduced in voltage by the bleeder effect of the 10K and 400 ohm resistors. The output of the second tube is a positive V-shaped wave of fairly high amplitude.

The input to the wide strobe (top two tubes in the diagram) is positive V-shaped wave. If the negative bias on the grid of the 1852 tube is high, then the input voltage must rise to near the top of the wave before the tube starts to conduct, will rise several volts more when the tube goes to saturation, and it stays there until the input wave rises to maximum and falls back to cut-off. The resulting plate voltage wave will be a negative, flat-topped "square" wave whose central point corresponds to the point at which the first tube in the chassis went to saturation, which was a little after the sweep was at ground. Bias adjustment is provided on this first tube to vary the central point and therefore centre the strobe wave. The negative output of the first wide strobe tube is amplified by the 807 (used because of its large grid swing) and the positive amplified square wave is applied to the cathode ray tube grid switch and the range main I.F. The width of the pulse will depend on the bias on the first wide strobe tube since this bias determines the place on the V-shape wave at which the tube is driven to saturation.

The first tube in the narrow strobe is arranged exactly as described above except that positive bias is applied to the cathode. It is usually biased to produce a much narrower wave than in the wide strobe. The negative output of this tube is amplified by the 807 and its positive output is applied to a pair of 807's in parallel, with fixed bias, which provide low impedance power amplified positive output. The entire voltage is sent to the screens of the first tubes in the two integrators, and the screens of the AVC and test video 1852's. A portion of the voltage is provided for the cathode ray tube grid switch.

PIP OSCILLATOR AND GENERATOR (see NRC-RB-1350

Some means must be provided for checking the accuracy of the range indications, since if any components have changed value since the original calibration, errors will be introduced. If the time-base were only five inches long, this calibration could take the form of some kind of a cursor, but due to the length of the time-base some electrical method is necessary.

The first tube is arranged as a crystal controlled sine wave oscillator of high accuracy with a frequency of 655.7 Kc. The time of one complete oscillation corresponds to a range of 250 yards, or a total travel of the R.F. of 500 yards. The 95 microhenry choke in the plate lead is tuned to approximately 655 Kc. by condensers, one of which has a negative temperature coefficient. The shock excited oscillations of this coil are fed back through tube capacities to the grid and cause oscillations of the 655.7 Kc. crystal. The oscillations of the crystal are then amplified by the tube and control the exact frequency of the output.

Since the output of the first tube exceeds the grid swing of the second stage, it is squared top and bottom by the second stage, and again by the third stage. These successive clippings of the original since wave mean that the output of the third tube is fairly square since it represents a very small slice of the sine wave near its centre, much amplified. This square wave is applied to an RC of small size, and the resulting pair of pips, both positive and negative, have steeply rising fronts and exponential tails. The third tube is supplied with positive bias on the cathode and hence passes only the positive pips; at high values of bias it passes only the tips of the positive pips. The negative output is fed to an 807 and the final output is an amplified series of positive pips spaced 250 yards apart in range. This output is supplied to both the recurrence frequency chassis and the pip amplifier.

One gang of the "Operate-Calibrate" switch is so connected to the bias bleeder on the fourth tube as to bias the tube below cutoff (cathode is placed farther up the bleeder) when operating; or when calibrating, part of the bleeder is shorted to ground, reducing the bias to a desirable level.

<u>PIP AMPLIFIER</u> (see NRC-RB-1340)

A pair of 1852's are connected in parallel to form an amplifier with wideband characteristics. The suppressors when operating are at -150 volts and when calibrating are grounded through either a manual switch to ground ("continuous") or a mechanical switch geared to the range motor control which grounds the suppressor whenever a calibration pip is in the neighbourhood of the cross-hair on the range tube ("flash"). This flashing of the calibration pips is to make the process of counting pips, when calibrating, much easier.

When calibrating, the range is set at 2,000 yards and the 2,000-yard pip is located by turning off the "stand-by" switch which allows the sweep to collapse. The range is then advanced to maximum and the pips counted. If errors are found they are corrected by trimmers on the standard condensers and by small variations in the value of the standard resistors. For exact procedure consult Instructions for GL Mark IIIC.

<u>POWER SUPPLIES</u>

The Modulator High Voltage and Bias Supplies, the Range and Test Sweep Supplies, the Regulated Low Voltage Supply for the sweep keying unit, the Sutton Tube Supply and the Cathode ray Tube Power Supply have all been described above.

In addition to these, two Low Voltage and Bias Supplies (+300 +150 and -150 with outputs paralleled) are provided for general supply of those voltages to all chasses using them. (See NRC-RB-1342.)

The Thyratron Motor Control chassis has a +250 volt power supply for motor fields and chassis supply, as well as the -250 volt supply.

RANGE MOTOR CONTROL (see NRC-RB-1355)

To provide smooth control over wide limits of speed of the rotation of the standard condenser in the sweeps and to provide accurate maintenance of any given speed, this circuit is used.

A series field A.C. motor is connected in series with the primary of a step-up transformer; mechanical switches are provided to reverse the field and hence the motor. Any changes in the impedance of the transformer secondary will be reflected into the primary and hence will change the impedance in series with the motor.

A pair of 2A3's are connected across the secondary, and the plate current of whichever tube is conducting on the A.C. swings, will flow through the transformer secondary. An 1852 tube, whose bias is controlled by the operator's slow speed motor control on the panel, has its plate tied to the 2A3 grids and hence controls their bias. For high motor speed (low impedance in transformer) the 1852 tube must be conducting very little. Under these conditions 1852 plate voltage is high, and 2A3's conduct heavily. The current is high in the transformer and impedance is low, hence motor speed is high.

To maintain a constant rate of speed a small alternator is connected to the motor shaft and its output fed back to the 1852 grid. The positive swings have more influence on the 1852 tube than the negative one, due to bias conditions. If for any given bias the motor should speed up, the 1852 tube would conduct more heavily, which would decrease the current through the 2A3's, increasing the transformer impedance and slowing the motor down again.

Limit switches are provided to prevent over-running the condenser maximum and minimum limits. The switch for reversing the field is ganged to the operator's control.

A high speed motor is provided without speed control to allow quick changes in range.

THYRATRON MOTOR CONTROL (see NRC-RB-1356)

If the Thyratron gas discharge tube is supplied with A.C. plate voltage and the grid bias is sufficient to allow the tube to fire, the output will be a series of "bumps" of current. A D.C. motor can be run on the average value of these and its speed will be dependent upon the area of the tube output curve. The motors used for rotation of the hut for azimuth, and the control of the antenna structure for elevation, are each provided with this type of control.

The plates of the Thyratron are fed several hundred volts A.C., 60-cycle, and two Thyratrons are used to provide both directions of motor rotation. The tubes used are FG57's or FG27's, which have identical characteristics except that the FG27 tube has a warm-up time of only one minute.

The grids of the Thyratrons have three different voltages applied. First, a fixed D.C. bias of about -70 volts, second an A.C. out of phase with the A.C. on the plate, and third a 5 Kc. oscillation. The only voltage that can bring the grid up to the firing point is a positive swing of the 5 Kc. oscillation. If the 5 Kc. is of high amplitude, the grid will be at firing voltage early in the positive swing of the plate voltage and much current will be passed by the Thyratron. If the 5 Kc. amplitude is medium, then the Thyratron will fire towards the mid-point of the plate cycle, and a medium speed will result. If the 5 Kc. amplitude is extremely small, then the Thyratron may not fire at all. By this system minute differences in motor speed can be obtained. Since the whole circuit is in duplicate to allow both directions of rotation for the motor, we shall discuss only one part of the circuit.

The fixed D.C. bias is obtained from a power supply whose positive side goes to the Thyratron cathode, and which is voltage regulated at 105 volts. The 15K potentiometer enables the grid bias to be accurately adjusted.

The A.C. is fed onto the grid circuit through a transformer which is fed through a phase shift from the 60 cycle A.C. under control of the 20K potentiometer.

The 5 Kc. oscillation reaches the grid line through an audio transformer from the plate of the 6L7. A 6N7 multivibrator of usual design is fed to the mixer grid of two 6L7's in parallel, and necessary bias for these grids is obtained from a bleeder from the -250 volt supply. The right hand 6SF5 has its bias control by the operator's control which can move towards +250 or -250. The two 6SF5's have a common cathode resistor and hence can effect each other's bias conditions. Suppose the operator's potentiometer is moved up (more positive); the right hand 6SF5 will conduct more heavily, its plate voltage will drop, the 6L7 control grid will become less positive and no 5 Kc. oscillation can pass through it, and therefore the right hand Thyratron cannot fire. At the same time, as the right hand 6SF5 conducts more heavily this will cause an increase of the positive potential on the cathode of the left hand 6SF5, which will cause it to conduct less heavily. Its plate voltage will increase, causing the left hand 6L7 to conduct more heavily, allowing more 5Kc. oscillation to pass through it, and causing the left hand Thyratron to fire. The motor then will run in a certain direction, and its speed will be dependent on the amplitude of the 5 Kc. and hence on how positive the right hand 6SF5 grid is made. The control grids on the 6L7's must be biased by means of the 100K potentiometers so that when the operator's control is at ground, neither Thyratron fires and the motor is stopped.

To provide maintenance of constant speed at any control setting, the cathode of the left hand Thyratron goes to ground through a bleeder to which is connected the grid of the left hand 6SF5. Since back e.m.f. of the motor is greater at higher speeds, this feed back of voltage acts to correct any changes in motor speed by applying a corrective bias which opposes the change in speed.

The power supplies, both +250 and -250, are regulated by VR tubes in series. The +250 supply also looks after the motor field.(See NRC-RB-1357).

Adjustments are provided for bias, phase, 6L7 control grid bias, cathode bias to equalize 6SF5 characteristics and mixer grid bias on the 6L7's.

PRIMARY A.C. CIRCUITS

The A.C. supply consists of a three-wire 230 volt supply (115 each side of neutral) provided by a Diesel.

The A.C. distribution is divided into three sequences - instantaneous, or first line, second line, and third line. Power supply diagrams show that in general, when the power switch is closed filaments are connected at once. After 15 seconds the second line relay closes, applying plate voltage to all rectifiers except the modulator high voltage power supply and the sweep power supplies. These latter three supplies are delayed 15 seconds after the second line is connected and come on only when the stand-by switch is closed.

The over voltage, first and second relay lights, when on indicate open relays.

No fuses are included in the main primary circuit since an over load circuit breaker is used both for protection and as main power switch.

FILAMENT AND +300 +150 AND -150 DISTRIBUTION

Except in a few cases where due to the necessity of low capacity filament transformers or for special insulation of the filaments, all 6.3 volt filaments are supplied from a common transformer.

Similarly all chasses using +300 +150 or -150 volts are provided with these voltages from a common source.

Fuses are provided in all leads to the chassis from the common supplies.

ZPI INTRODUCTION (see NRC-RI-2-1)

ZPI stands for Zone Position Indicator. It gives approximate range and azimuth to the operators of the APF equipment by means of Selsyn drives which move special pointers on the APF azimuth and range indicating dials. Azimuth can be measured to ± 2°, range can be measured to ± 1,000 yards, and the maximum range is 60,000 yards. There is a 360° coverage in azimuth, and target indications appear on a 9-inch cathode ray tube which has a revolving radial trace.

The transmitter and monitor receiver are carried in one trailer, known as the ZPI trailer. On top of this trailer is mounted a rotating collinear array which is collapsible for stowage when travelling. The trailer is towed by a 3-ton truck which carries, when in transit, the top section of the array and the reels of the power and intelligence cables.

The ZPI display unit is carried in the APF trailer along with the complete APF equipment.

The main ZPI rack in the APF trailer contains a scanning chassis with a 6N7 multivibrator of variable frequency. Its output controls the firing of the transmitter through a variable delay circuit and controls the start of the time-base on the main cathode ray tube. This radial time-base rotates in synchronism with the antenna array. A calibrator circuit fed from the time-base circuit can be seen on the cathode ray tube by use of the cathode ray tube input switch. The firing pulse for the transmitter is fed over a coaxial cable to the APF trailer where it trips the sweep of the monitor receiver at the same time that it pulses the modulator of the transmitter. The modulator causes the transmitter to give an R.F. pulse of about 100 kW peak.

The same aerial is used for transmitting and receiving using a spark gap system for protection of the receiver. The returning signals are fed to the monitor receiver which has the conventional time-base that indicates range by horizontal deflection and signal amplitude by vertical deflection. An I.F. signal is taken from this receiver and fed to the receiver in the APF trailer. After amplification and detection, the signal, limited in voltage, is fed through the cathode ray tube input switch to the main cathode ray tube where it is applied as beam intensity modulation and appears as a bright spot on the tube's screen. These spots will lie side by side, forming an arc whose width is the same as the angular width of the antenna pattern, whose position in azimuth is that of the target, and whose distance from the centre is proportional to the range. A cursor, when rotated to bisect the arc, moves the Selsyn which provides azimuth information to the APF, and a separate calibrated dial is turned to transmit the range information.

TRANSMITTER

The oscillator consists of a pair of Number 5 tubes arranged in a self-squegging circuit. The transmitter design is quite similar to the

British 300 Mc. CHL transmitter with a few necessary changes.

The modulator (see Fig.30) is arranged to provide three possible methods of triggering. A four-gang switch, with three positions per gang controls this. In the top position, arranged for internal triggering, the input is shorted and the output of the first 1852 plate is fed back through a phase shifting network in phase with the grid. A control is provided to allow adjustment of the phase shift. The output goes to a 6SJ7 which squares it, thence from the plate through 50 μμF with 68 K resistance to ground, which causes positive and negative pips to be formed, which go to the grid of the 1852. If triggering from a positive pip is desired, the switch is put in the bottom position and the negative output of the first 1852 tube passes through the small time constant circuit to the grid of the second 1852. For a negative input, which is normally used since it is provided by the transmitter pulse circuit in the ZPI display rack, the switch is placed in the middle position. The positive output of the first 1852 is applied directly to the second 1852 grid. This tube is biased to accept only positive signals which, in the case of the positive input and internal oscillation positions of the switch, is provided by the small R C time constant and with negative input directly by the first 1852 tube. In every case the 1852 receives a positive input and provides a negative amplified output.

The rest of the modulator works between ground and 1000 volts below ground, the latter is the usual voltage of the oscillator grids between pulses. When the negative output of the second 1852 tube in the modulator reaches the first 807, it is amplified and goes to the grids of the four 807's in parallel, causing a power and voltage amplified positive wave to be fed to the oscillator grid. This raises the grids from their normal -1000 volts up to a point where oscillation is possible. The duration of the oscillation is controlled by the time constant of the grid squegg circuit. Diodes are provided to prevent flash arcs in the modulator and positive grids on the oscillator tubes.

The oscillator (see Fig.32) which is fed 25 kV on the plates, has plate, grid and filament tuning. Included in the plate circuit of the power supply is a large resistor and in the oscillator circuit from the plates to ground are condensers of small capacity. When the tubes draw current, the plate voltage is supplied by the condensers since the series resistor is large and oscillations would cease in a short time when the condensers discharge if, for any reason, the grids remained at a potential where oscillations were possible. This guards against CW operation or double pulsing.

To allow examination of the R.F. or modulator wave shapes (see Fig.29) a transmitter monitor is provided built in to the transmitter rack. This consists of a 5-inch cathode ray tube with a linear short duration time-base. The 6SK7 in the modulator receives the negative pulse from the

1852 tube and the positive output charges a condenser through a resistor (in the monitor) providing a linear time-base of 14 microseconds' duration, which is triggered in synchronism with the modulated pulse. A small portion of the positive modulator output is used to modulate the cathode ray tube beam intensity, preventing electron flow in the cathode ray tube between transmitter pulses.

A small receiver (lock unit) is provided in case it is desired to trigger a time-base from the transmitter output, when the modulator is being triggered internally.

Power supplies are provided for the oscillator, squarer and pipper in the modulator (+300 volts), a separate +300 volt supply for the lock unit, a -1000 volt supply for the mod lator, a 25 kV supply for the R.F. oscillator tubes, and a 2000 volt supply for the monitor cathode ray tube.

MONITOR RECEIVER (see #130 and #131)

Since the same aerial is used for both transmitting and receiving, the receiver, or at least the I.F. portion, must be located in the ZPI trailer. It consists of a matching circuit for the antenna feeders, two stages of R.F. amplification using 956 acorn tubes, a 956 mixer, a 955 local oscillator inductively coupled to the mixer, and an inductive coupling from the mixer to an I.F. amplifier. Two R.F. channels are provided to allow use of two different bands (96 - 108 Mc. and 155 - 165 Mc, whichever is desired). The I.F. amplifier (30 Mc.) consists of four stages and has a bandwidth of about 500 Kc. An output is taken from the third stage and fed through a coaxial line to the receiver in the APF trailer. To allow examination of the received signals by the transmitter operator, a second detector and video is provided in this receiver, whose positive output is fed to the deflection plates of a 5 inch cathode ray tube. The monitor receiver then, is really the main receiver down to the third stage of the I.F., and the cathode ray tube provided must be distinguished from the transmitter monitor which is in the same trailer.

CIRCUITS IN ZPI RACK

RECEIVER CHASSIS

I.F. Amplifier (see NRC-RI-16-3) - The signals from the receiver I.F. in the ZPI trailer are received at 32 Mc. through a coaxial line to the main receiver. Here there are three stages of I.F. amplification followed by a 6H6 second detector. The output is sent to the video amplifier.

Since the signal from the ZPI receiver acts to overcome the negative bias on the cathode ray tube grid, care must be taken to avoid spurious signals from turning on the electron beam. Since the

APF modulator pulse would have this effect, the suppressor on the second tube is provided with a negative pulse which turns off the receiver while the APF modulator is firing. To remove possible signals on the back trace of the sweep, a blanking pulse is fed from the sweep circuit to the suppressor of the first 1852 tube, turning off the receiver during the back trace. Gain is controlled by a bleeder on the screen voltage of all three stages.

Note that the +300 volts for this chassis are obtained from the +400 volt supply by a bleeder shown on the video diagram.

Video Amplifier (see NRC-RI-16-9) - The negative output of the diode goes to the grid of V_8 which is operating at saturation. The tube is driven to cut-off by a strong signal and hence acts as a limiter. V_9 is connected as cathode follower to provide a low impedance output to the cathode ray tube because of the capacity of the cathode ray tube input switch, etc. The grid return is connected at the midpoint of the cathode resistor to provide greater plate current in V_9 than otherwise would be the case.

APF Suppressor (see NRC-RI-16-4)- The positive pip received from the APF recurrence frequency chassis is amplified and inverted by the first tube. The small time constant circuit causes a negative followed by a positive pip to be fed from the grid of the second tube; the width of the pip is controlled by the 10K potentiometer. A second tube amplifies these pips, they are fed to the grid of the third tube which has positive bias on its cathode, and hence responds to the positive signal only. The negative output goes to the suppressor of the first tube in the I.F. amplifier. The plate supply for this circuit is shown on the video diagram.

SCANNING CHASSIS

Time Base Circuit (see NRC-RI-8-1) - A 6N7 multivibrator produces square waves which are distorted by the small time constant to ground, and fire an 884 gas discharge tube whose firing time is limited by the choke in the plate circuit and which is biased on the grid from the -150 volt supply. When the 884 fires, a .001 µfdcondenser on its cathode charges, and when the 884 ceases to fire the condenser can discharge to ground through the 6SJ7, whose resistance will control the time of discharge. The 6SJ7 is connected as a constant current tube (current flow and therefore resistance substantially independent of plate voltage). The resistance of the 6SJ7 is under control of the screen voltage which is, in turn, provided with operator's controls. The resulting wave at the cathode of the 884, the plate of the 6SJ7 and the grid of the 807 is a positive saw-tooth. The slope of this is controlled by the resistance of the 6SJ7 and therefore by the setting of the potentiometer on its screen voltage. The range switch enables two potentiometers to be pre-set for 30,000 or 60,000 yard ranges and selected by the switch. All plate voltages as well as filament voltages are carefully regulated to ensure stability.

The 807 and the sweep deflection coils are connected in parallel with a current regulated supply. When the 807 receives the positive saw-tooth on its grid, it suddenly starts to conduct, and requires all the current available and in addition to this, draws current from a voltage regulated supply through the sweep coil in the reverse direction to the usual current through that coil. As the 807 conducts less and less as the grid goes down the slope of the saw-tooth, more and more current is available for the deflection coil, until finally, when the saw-tooth has passed, all the current from the regulated supply passes through the coil. This current passing the the 807 cathode resistor biases it to cut-off. The coil thus carries a high current between pulses and the spot will be held at the outside of the tube. When the 807 suddenly starts to conduct, the current through the coil not only stops, but actually reverses and the spot snaps to the centre and over-shoots slightly. The degree of over-shoot will depend on the current available from the regulator.

As the 807 begins conducting less and less heavily down the slope of the saw-tooth, the current through the coil will steadily increase, drawing the spot towards the outside of the tube forming the time base. The slope of the saw-tooth, although formed by the discharge of a condenser through a resistor, is substantially linear because of the constant current characteristics of the 6SJ7.

Transmitter Pulse Circuit (see NRC-RI-8-1) - A Kipp relay (V_6 and V_7), in which V_7 is conducting very heavily and V_6 is biased to cut-off by the common cathode resistor, is triggered by the grid swing of the 884 sweep tube at the instant it fires. The tube V_6 is actually biased much below cut-off by the current through V_7 and a positive bias is placed on its grid to bring it to just below cut-off. The time constant of the Kipp relay is controlled by the .0005 µfd condenser and .1 megohm resistor.

When the positive pip triggers the Kipp relay, the negative square wave is taken from the screen of V_6. (When V6 suddenly starts to conduct its screen voltage drops). The negative square wave is passed through the small RC circuit and the resulting distorted pips are fed to the grid of V_8. This tube is biased to pass only the tip of the positive swings and the output from its plate is a negative amplified pip. Since this output represents a trailing edge of the Kipp relay wave, it is delayed after the start of the sweep by an amount equal to the width of this wave. Thus the firing of the transmitter can be phased in relation to the sweep as desired.

Calibrator (see NRC-RI-7-1) - The positive saw-tooth sweep voltage is applied to a tank circuit tuned to 16.39 Kc. The time of a complete oscillation corresponds to a range of 10,000 yards. The damped train of oscillations that results from the shocking of the circuit is amplified by V_9 to a peak of about 27 volts. This damped train of oscillations is applied to the grid of V_{10} through a 100K resistor in series with the grid. This levels off the tops of the first eight or nine swings due to grid current. The screen of V_{10} receives its voltage mainly from the 50 µµF condenser, which also tends to level off the oscillations to a constant amplitude. The output at the plate of V_{10} consists of largely negative signals of equal amplitude. These are passed through a small RC circuit to the grid of V_{11} which is operating at saturation and responds to the sharp negative swings. The amplified positive pips are then sent to the grid of the cathode ray tube through the cathode ray tube input switch. These pips modulate the intensity of the cathode ray tube beam and appear as a series of circles of light, spaced 10,000 yards apart.

LOW VOLTAGE POWER SUPPLIES (see NRC-RI-4-1)

Two supplies, both full wave rectified and unregulated, are provided. One of these provides +600 volts to the regulators for the scanning chassis, the other provides +400 volts for the receiver. A regulated -150 volt supply is also provided for the scanning chassis.

REGULATOR CHASSIS (see NRC-RI-6-1)

Voltage Regulator - The high voltage (+600) from the low voltage power supply is fed to the plates of a pair of 2A3's in parallel in the top part of the diagram. The bias for these 2A3's is provided by the plate voltage of an 1852 whose plate load resistor is the 1 megohm resistor, R_{18}. The high voltage output is taken from the centre tap of the filament transformer of the 2A3's, which are thus placed in series with the high voltage output. The 1852 is maintained at a fixed bias of 150 volts on the cathode (note the 20K resistor, R_5, which provides current for the regulator tube, V_1). The grid of the 1852 is on a bleeder between the positive high voltage and ground, with a potentiometer as part of the bleeder for adjustment of bias. If the high voltage output should increase, the grid will go more positive, the 1852 would conduct more heavily and its plate voltage would drop; the 2A3's would conduct less heavily, their resistance would increase, and the output voltage would be reduced to its original value. The output is fed to the calibrator and sweep chassis. Across the output are two bleeders, one of which is adjustable, connecting to a coil around the cathode ray tube providing transverse centering. Direction of current flow in this coil will depend on which side of centre R_2 is placed. Magnetic focussing coils are also connected in the bleeder.

Current Regulator Circuit - The +600 volts from the low voltage power supply also goes to the plates of V_6 and V_7 in parallel. The high voltage output is taken from the centre tap of the filament transformer and then in series to the 500 ohm resistor and a choke to the 807 in the scanning circuit. A VR-150 is connected with its plate to the left of the 500 ohm resistor, and its cathode to one end of a potentiometer to ground and to the grid of the 1852. A VR-105 is connected with its plate to the right of the 500 ohm resistor, and its cathode to ground and to the cathode of the 1852. Suppose the output current should increase, greater voltage drop would develop across the 500 ohms which would change the bias on the 1852, causing an increase in current and therefore a higher resistance in V_6 and V_7 which would lower the current and restore the original potential drop across the 500 ohms. Two potentiometers in parallel are provided to allow adjustment of the 1852 bias; these are pre-set to give current desired for the two ranges mentioned under the scanning chassis, and the switch is ganged with the switch from that chassis.

The return trace on the sweep really occurs just before the time base portion of the deflecting wave. The first calibration pip occurs on the back trace. In operation we desire to align the second calibration pip with the centre spot engraved on the tube, and also to align the transmitter pulse with this same marker which will act as zero range marker. The slope of the trace will be different for different resistances of the 6SJ7, and therefore the second calibration pip will not be in line with the centre mark when the range scale is changed. To produce this alignment the current provided to the 807 and deflection coil is kept below the maximum requirements of the 807, and over-shoot results. The amount of this over-shoot is controlled by the 100K potentiometer in the current regulator. This is why two potentiometers are used to correspond to the two ranges provided; the correct one being selected by the switch.

The voltage regulator tubes are provided with jumpers between a pair of pins. These jumpers (marked switches 2, 3, 4) are placed in series with the +600 volt input. If any VR tube is removed, the voltage is disconnected, preventing a sudden increase in output that would result when regulation was removed.

<u>CATHODE RAY TUBE CONNECTIONS AND POWER SUPPLY</u> (see NRC-RI-8-1)
(10-1)

The power supply, bleeder and electrode connections are conventional, with control provided for brilliance. The tube is magnetically focussed and the sweep is also produced magnetically. A diode is provided on the grid to restore the D.C. bias conditions at the grid between signals in order to prevent changes in brilliance with recurrence frequency or signal strength.

Ottawa,
June, 1942 R. G. Campbell

HP

S E C R E T
PRA-50

Correction Sheet No.1

The following additions and changes have been made in the drawings included in this report.

1. I.F. Pre-amplifier, RB.1336

   Feedback Resistor 3rd tube unmarked should be 500.
   Screen bypass 4th tube unmarked should be .01.

2. Heterodyne Oscillator, RB.1337

   Bleeder in parallel with 4 µf unmarked should be 2 meg.

3. Main Receiver - Range Channel, RB.1338

   Coupling condenser to grid of last tube marked 1.0 should be 0.1 µf.

4. Main Receiver - Az.- El. Channel, RB.1339

   Volume Control resistor from 300+ should be 14K not 10K and pot. should be 25 K not 50 K.
   In the A.V.C. 1852: Add 10 K in series with grid (Par.Suppl) and change 5 K plate load to 50 K.
   In the A.V.C. 6H6: Change filter condenser 0.1 to 0.5 µf.

5. Video-Amplifier & Pip Amplifier, RB.1340

   Blocking condenser in grid of first tube marked 1.0 should be 0.1.
   Suppressor grids in Pip Amplifier bypassed at both ends by .01 µf.
   Cathode bypass in Pip Amplifier marked 1.0 should be 0.1.

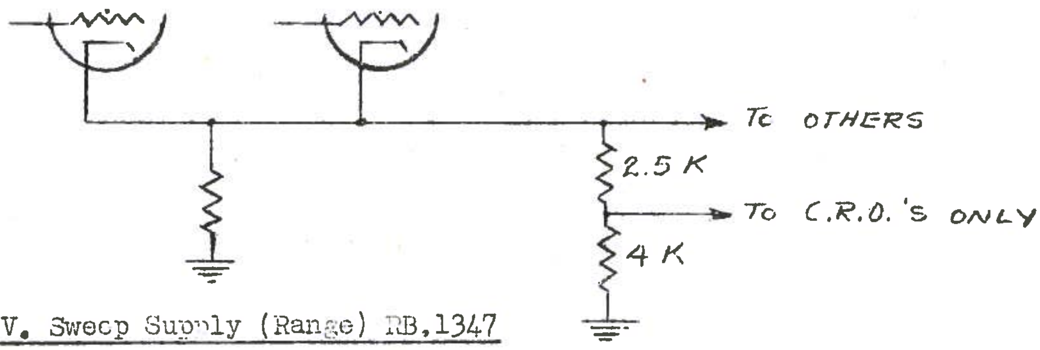
6. Sweep Keying Unit, RB.1345

   Cathode bypass condensers in grid of first and second tubes marked 1.0 should be 0.1.
   Screen bypass of output 807 should be Screen to Cathode, not Screen to Ground.
   Only VR.150 is common to both sweeps.

Correction Sheet No.2

7. Strobe, RB.1346

Add series grid resistor 10 K to first tube (Par. Supp.).
Three bypass condensers second tube marked 1.0 should be 0.1.
Screen bypass of wide output 1852 marked 0.1 should be 1.0.
Blocking condenser to grids of narrow output 807's (last stage) marked .05 should be 0.5.
Change 150 K in grid voltage divider of 807's (last stage, narrow output) to 65 K.
Add voltage divider as shown in parallel with 1 K output load of narrow strobe.



8. H.V. Sweep Supply (Range) RB.1347

Value of bleeder in parallel with 2 μf not shown should be 1080 ohms.

9. Oscillator and Pip Generator, RB.1350

Decoupling Resistor 1st tube marked 5 K should be 75 K.
Screen bypass 3rd tube not marked should be .01.

10. Recurrence Frequency Control, RB.1351

Primary Frequency Pot. (50 K) in series with 250 K.
Plate resistors 6N7 are 20 K each.
Bypass on slider of Mod. Amp. Control unmarked is 0.25.
Bypass in cathode circuit of 884 (output to modulator and ZPI) marked 25 should be .25.
Cathode resistor of 1852 marked 150 K should be 150 ohms.

S E C R E T
PRA-50

Correction Sheet No.3

11. Modulator, RB.1352

Choke values are:

L_1	20 mh	L_6	20 mh
L_2	100 µh	L_7	40 mh
L_3	20 mh	L_8	20 mh
L_4	20 mh	L_9	40 mh
L_5	20 mh	L_{10}	40 mh

12. Range Motor Control, RB.1355

Bypass in grid of 1352 unmarked should be 1.0 µf.

13. Thyratron Control, RB.1356

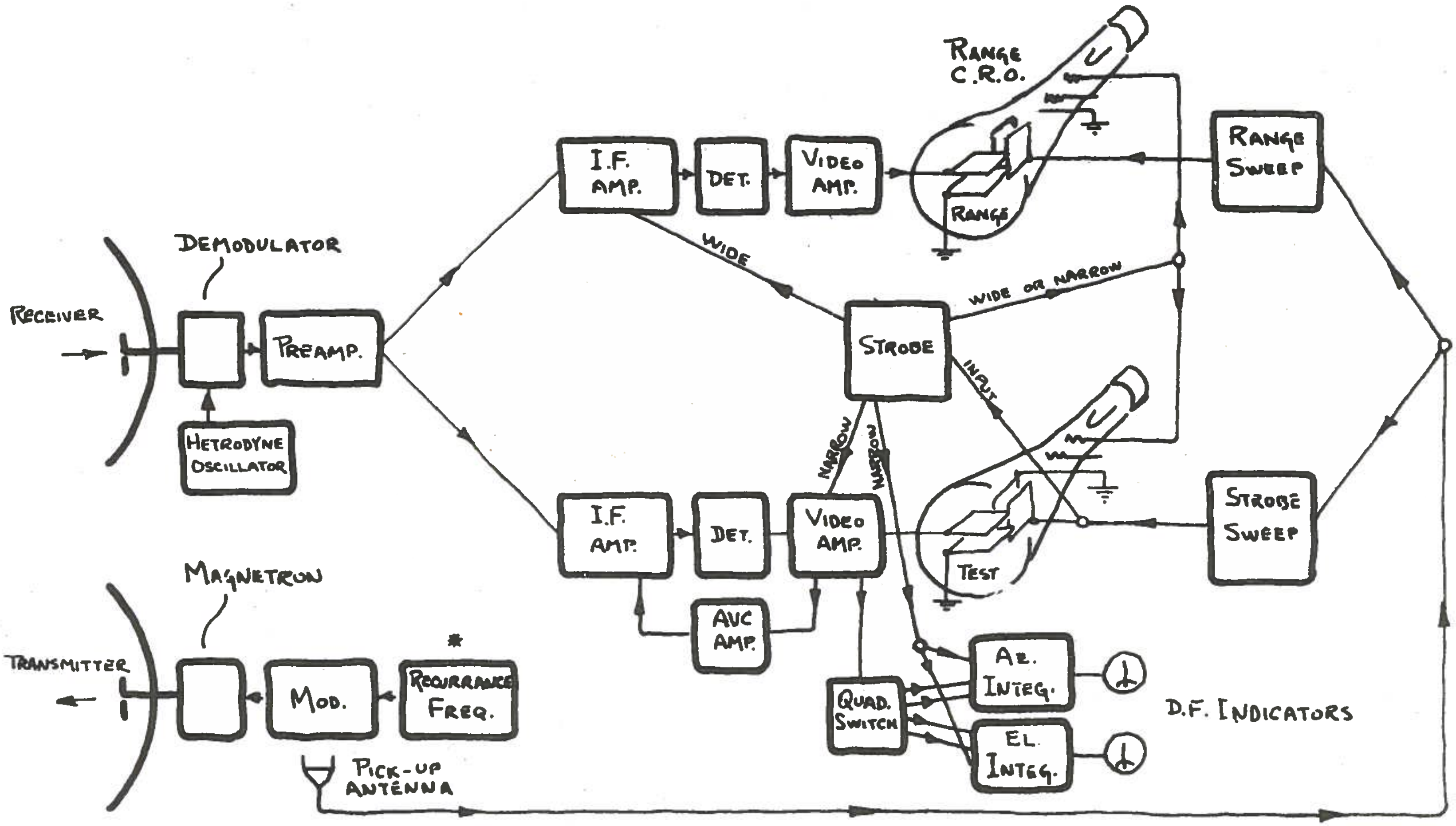
In the grid bias supply the VR.105 is upside down
The VR.105 and VR.150 on the 250+ are upside down
The phase shifting potentiometer in leg "C" is a 20 K potentiometer in series with 5 K.
The grid bypass on 6SF5 unmarked should be 0.1.
The bleeder across 250+ unmarked should be 50 K, 6 K pot. and 50 K.
Grid voltage dividers of 6L7's consist of 250 K, 100 K, 500 K, not 100 K, 100 K, 500 K as marked.

14. Thyratron Control Supply, RB.1357

Motor Field control is 1 K.
Unmarked chokes (2) are 30 h.
Add VR.105 and VR.150 to 250- line (to ground).

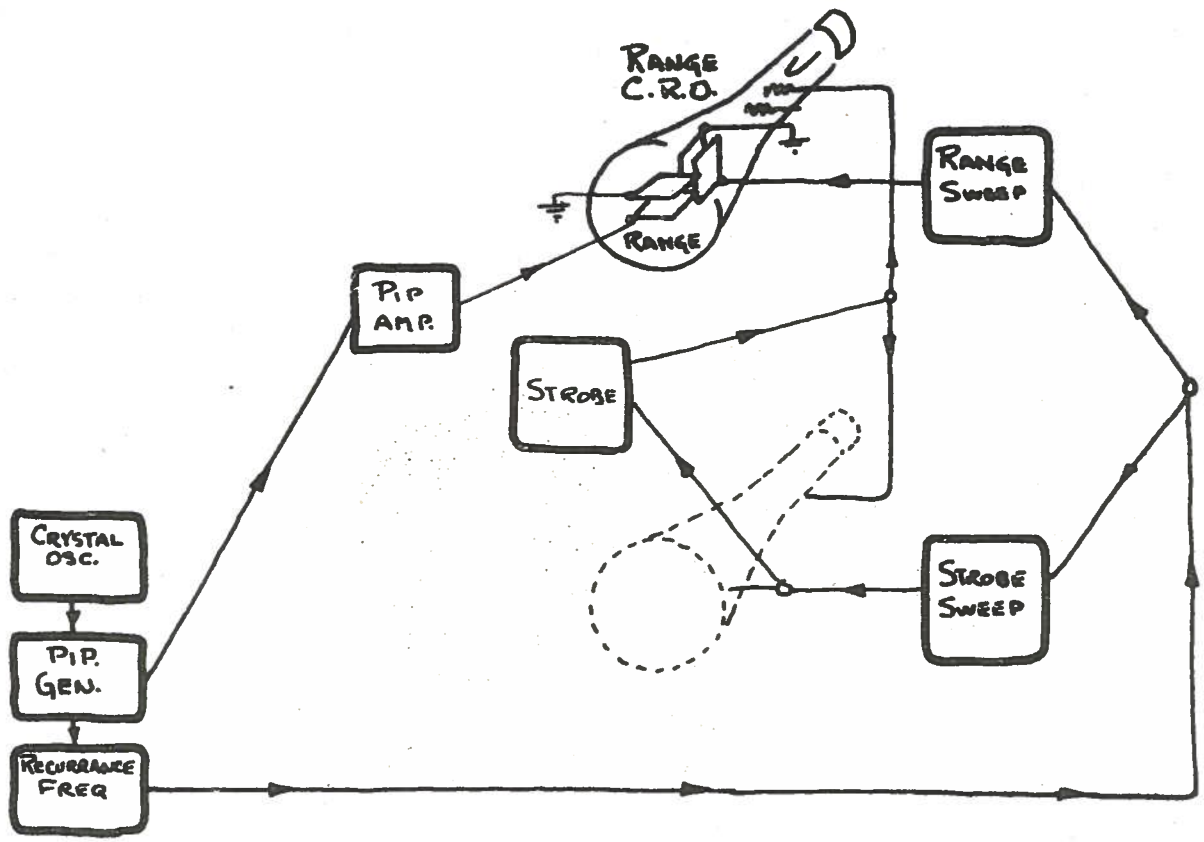
15. NRC-RI-6-1: Change R_5 from 2K to 20K
Change R_3 and R_4 from 100K to 50 K
Add R61 (250K) between R3, R4 and Terminal 24.

16. NRC-RI-16-3)
16-9) Note that detector V_4 is shown in both drawings.



DURING OPERATION

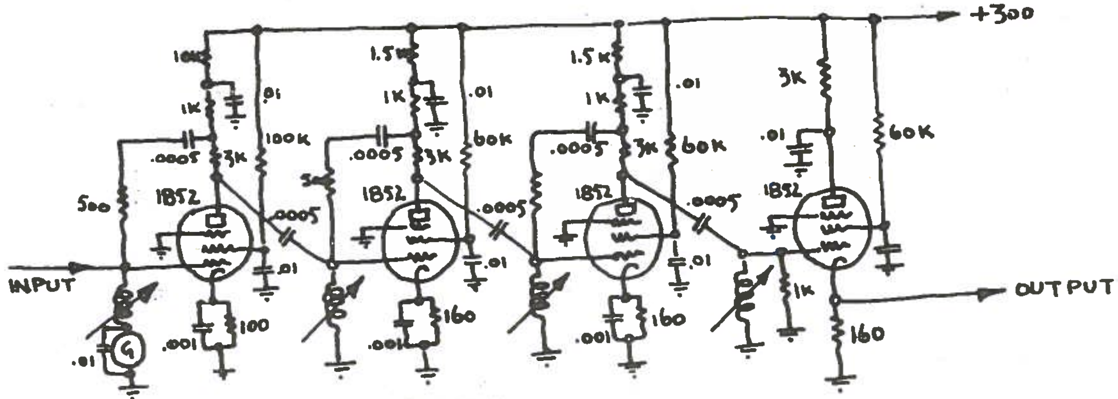
NRC-RB-1334
DEC. 1941
WH



DURING CALIBRATION

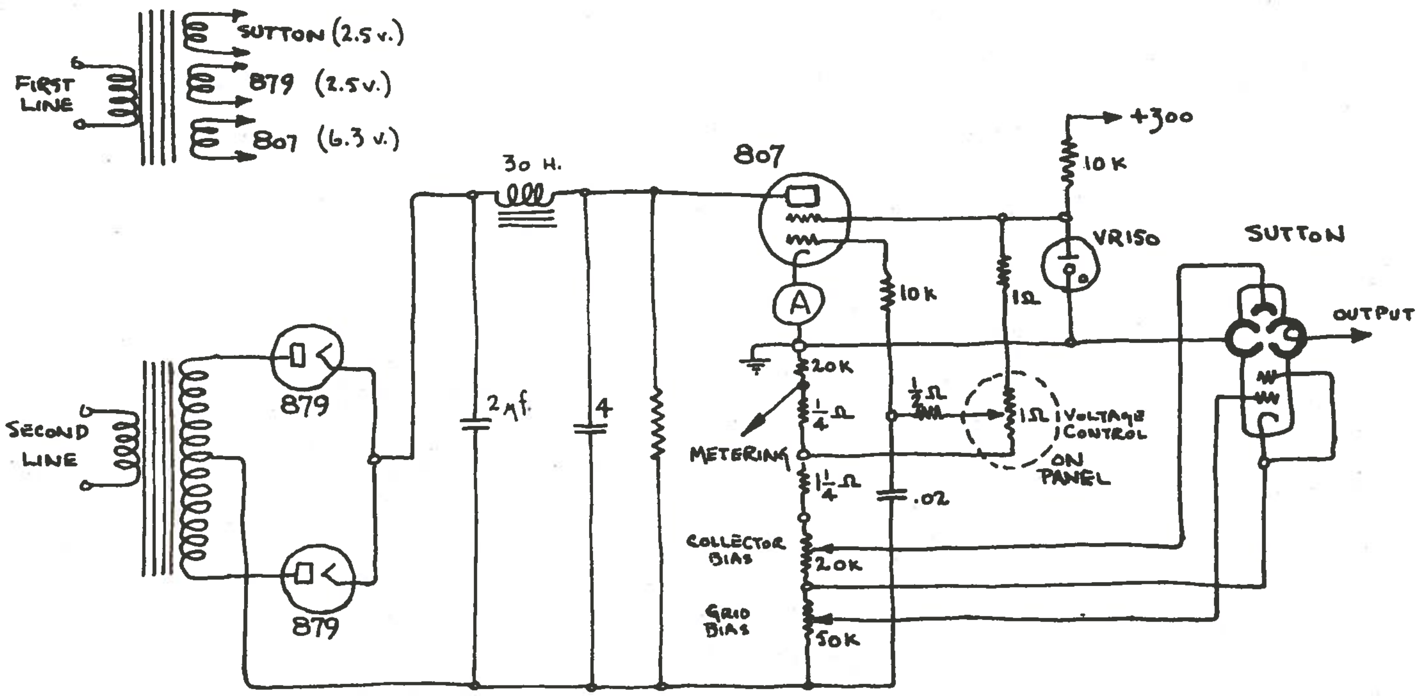
NRC-RB-1355

WH DEC. 1941



I.F. PREAMPLIFIER

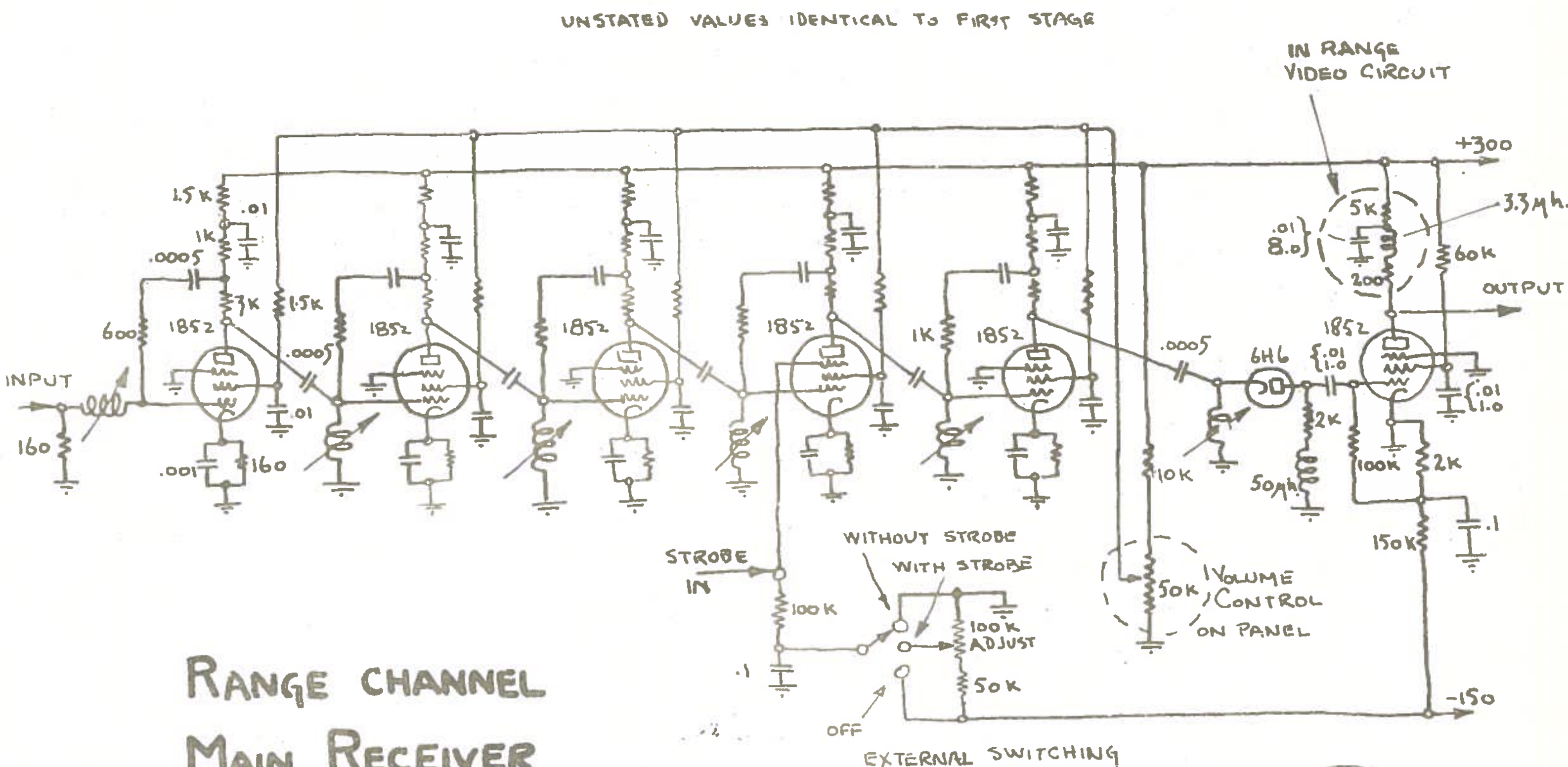
NRC-RB-1336
DEC. 1941



HETERODYNE OSCILLATOR

WH DEC. 1941

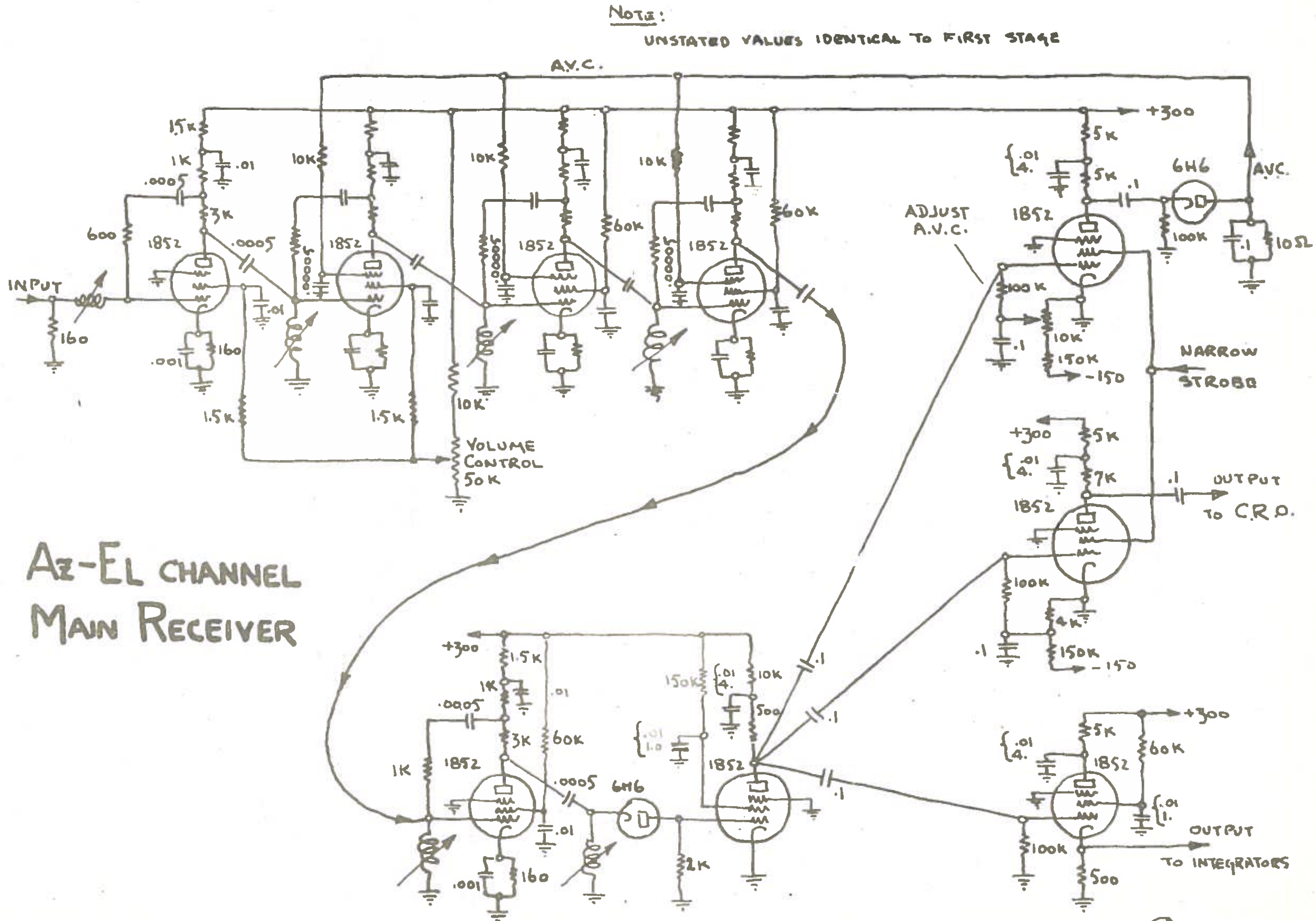
NRC-RB-1337



RANGE CHANNEL
MAIN RECEIVER

DEC. 1941

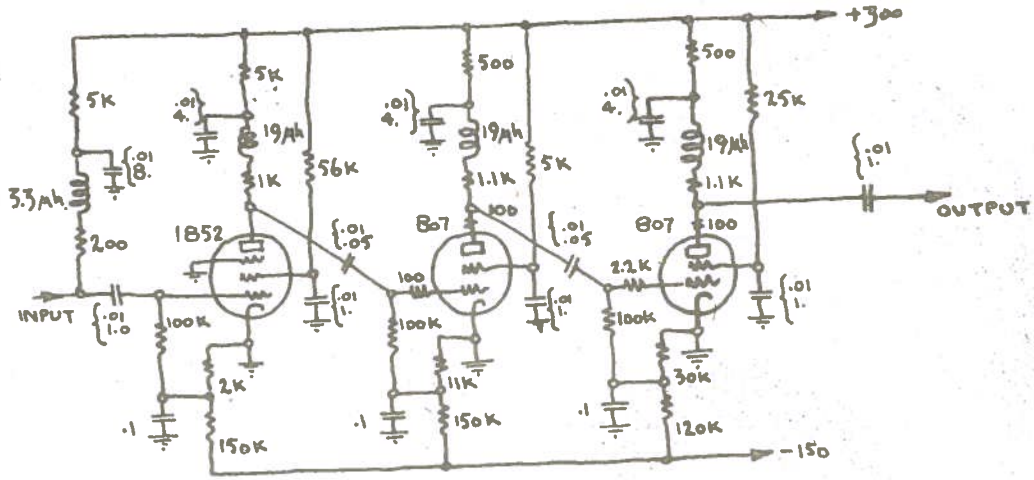
NRC-RB-1338



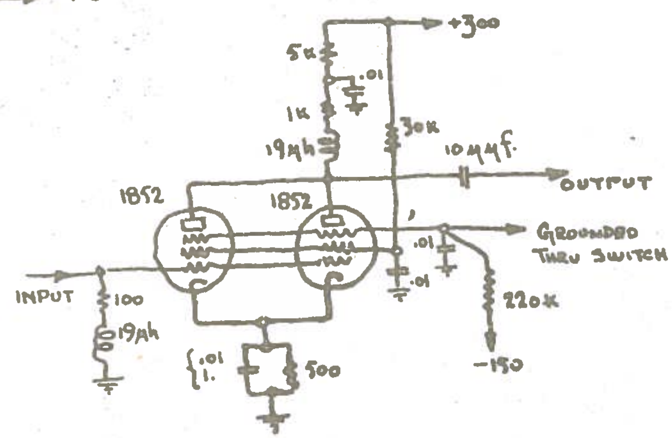
Az-El CHANNEL MAIN RECEIVER

WH DEC. 1941

NRC-RB-1339



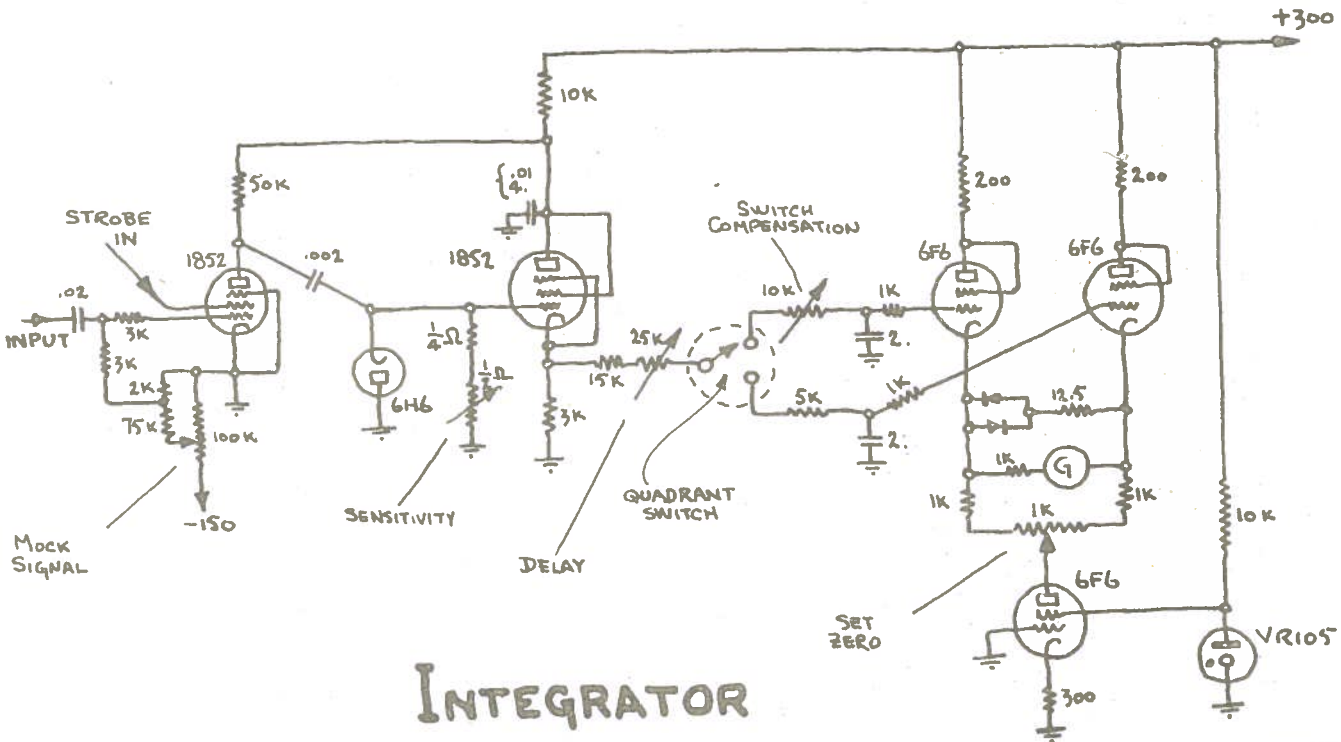
VIDEO AMPLIFIER



PIP AMPLIFIER

NRC-RB-134-0

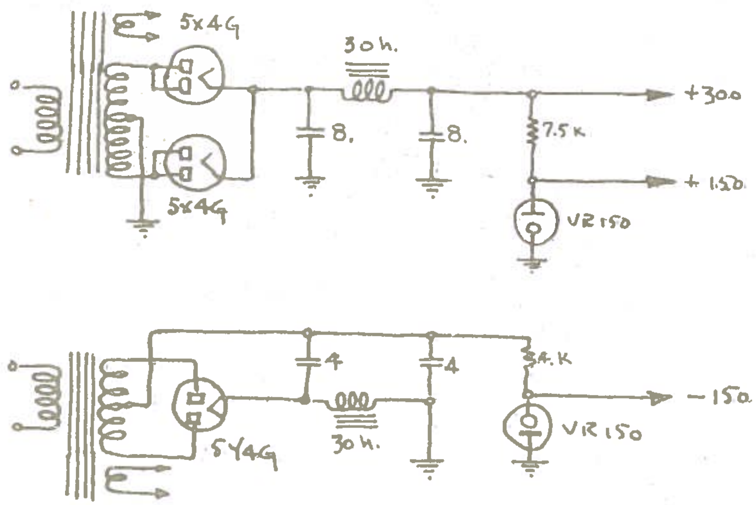
(WH) DEC. 1941



INTEGRATOR

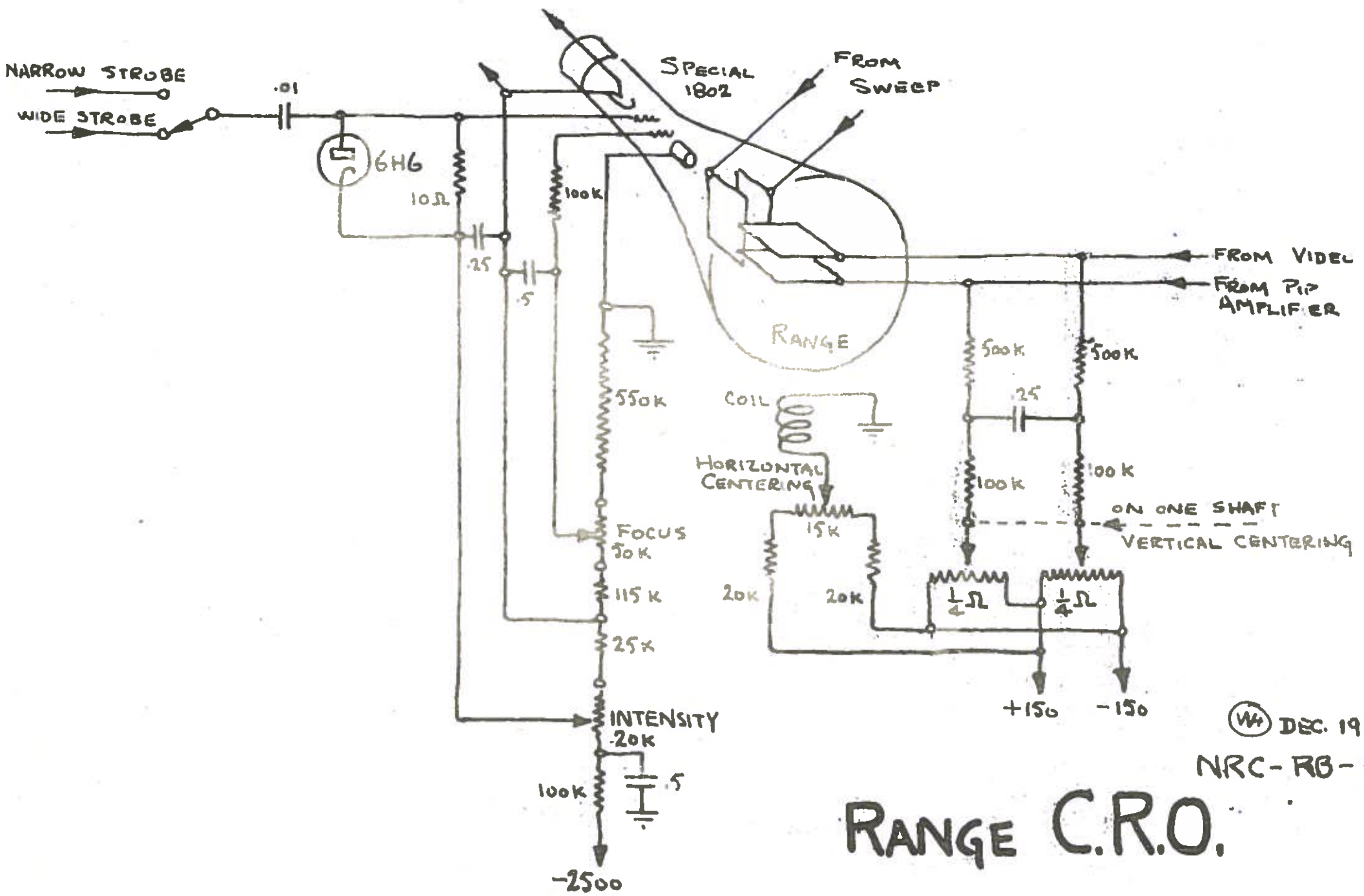
DEC. 1941

NRC-RB-1341



DEC. 1941
NRC-RB-1342

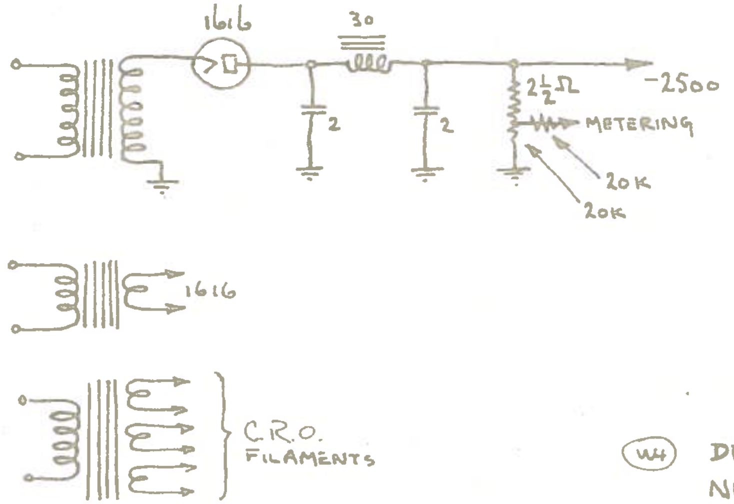
Low Voltage and Bias Supply



WH DEC. 1941

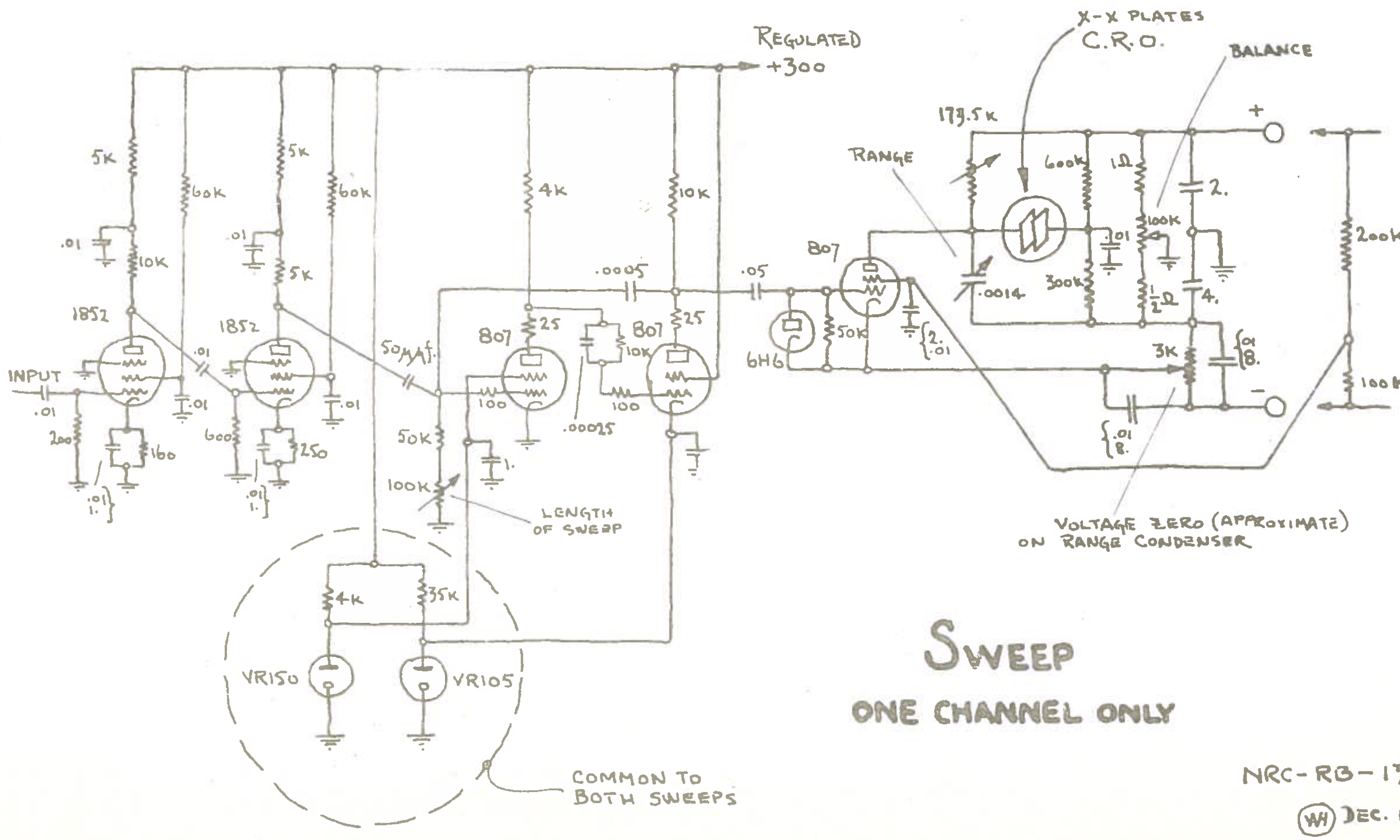
NRC-RB-1343

RANGE C.R.O.



W4 DEC. 1941
NRC-RB-1344

C.R.O. Supply



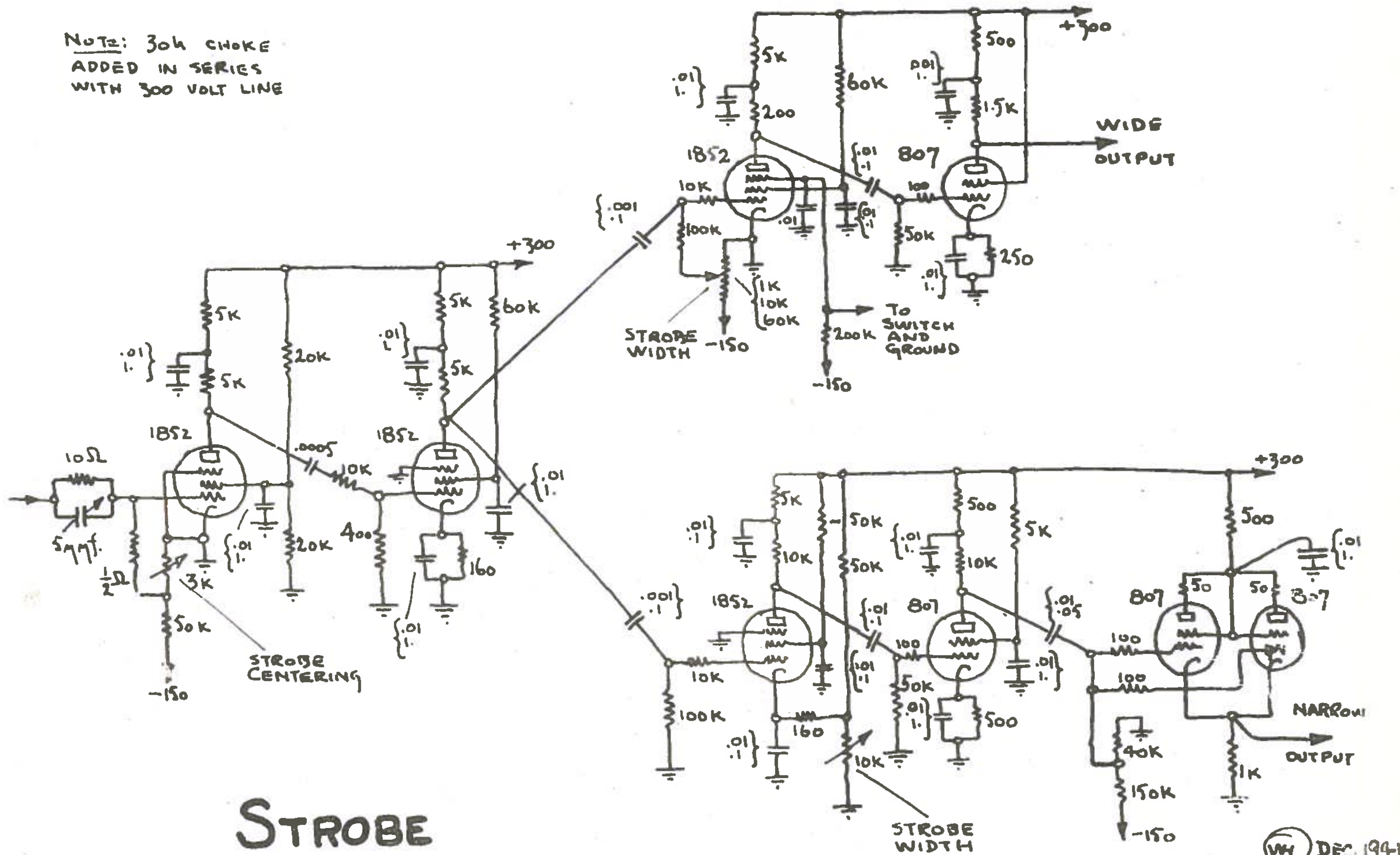
SWEEP

ONE CHANNEL ONLY

NRC-RB-1345

(WH) DEC. 1941

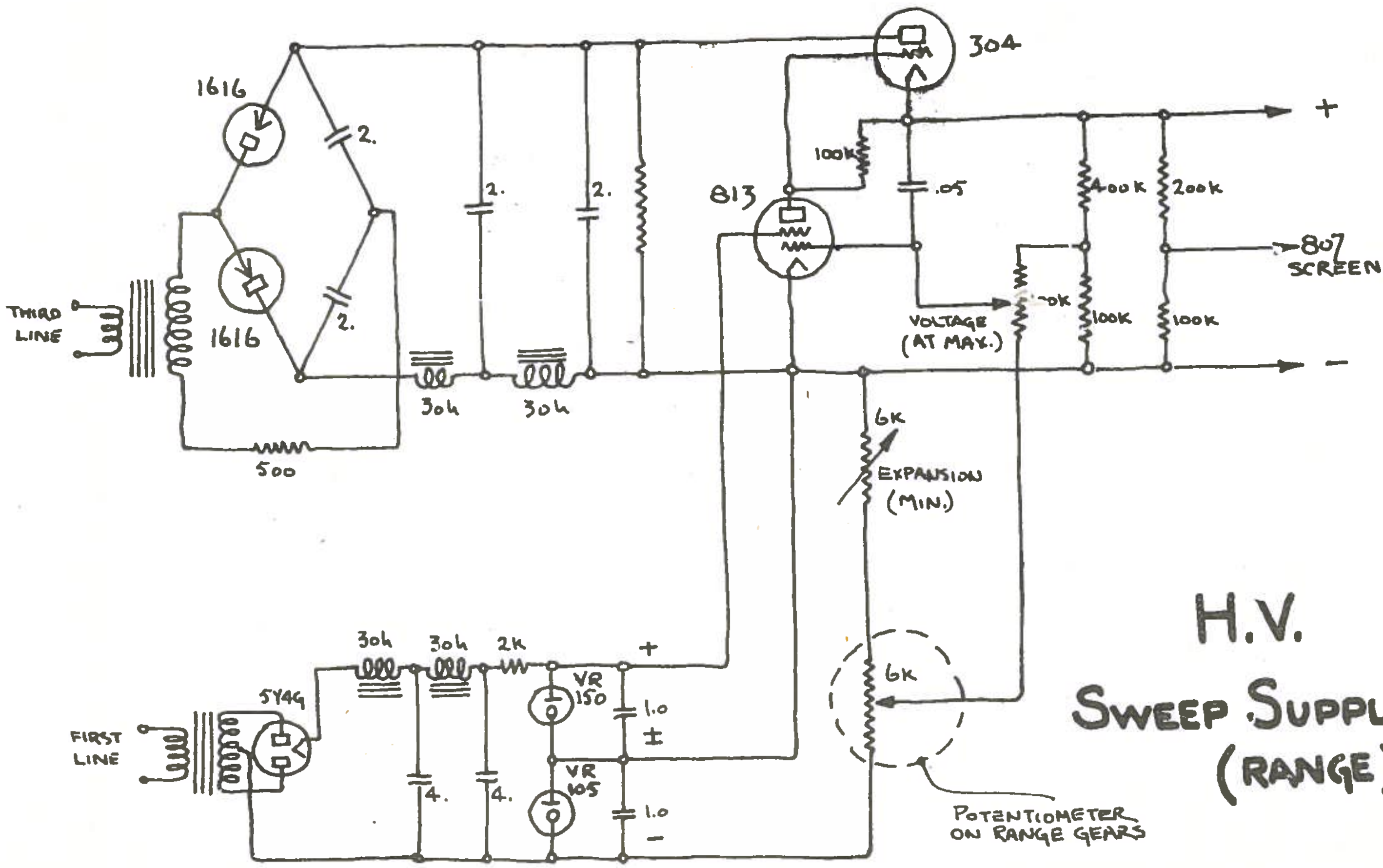
NOTE: 30h CHOKE ADDED IN SERIES WITH 300 VOLT LINE



STROBE

(VH) DEC. 1941

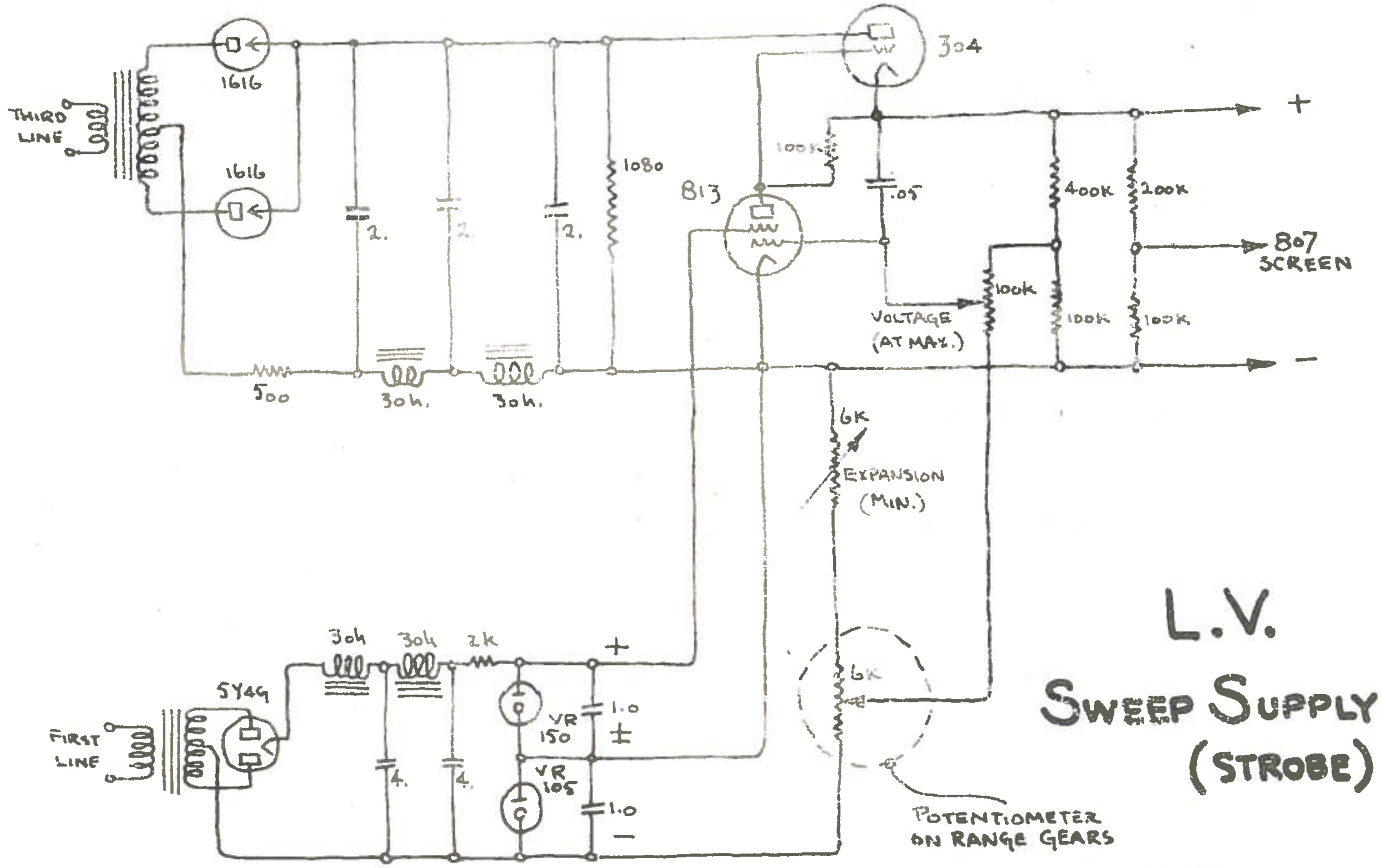
NRC-RB-1346



H.V. Sweep Supply (Range)

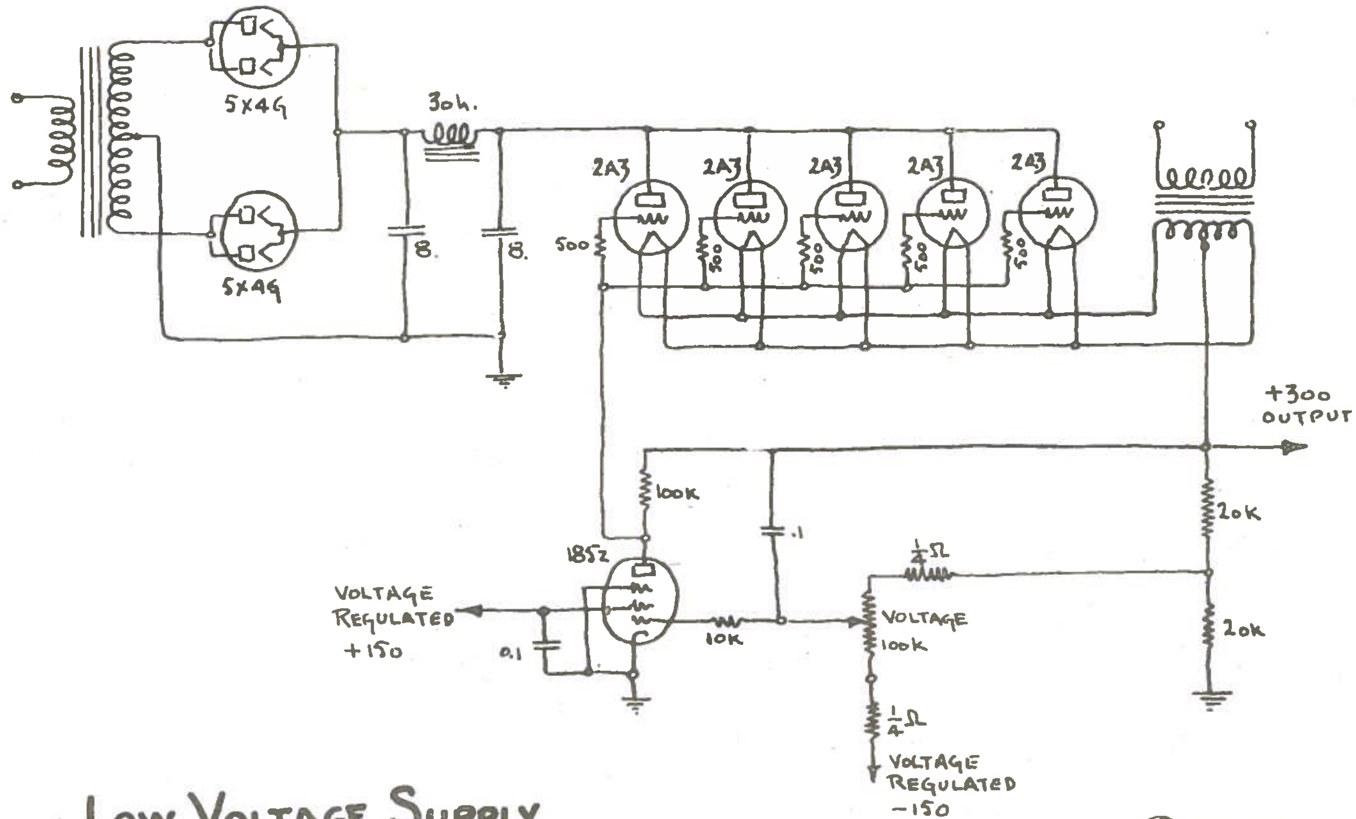
NRC-RB-1347

(WH) DEC. 1941



L.V.
Sweep Supply
(Strobe)

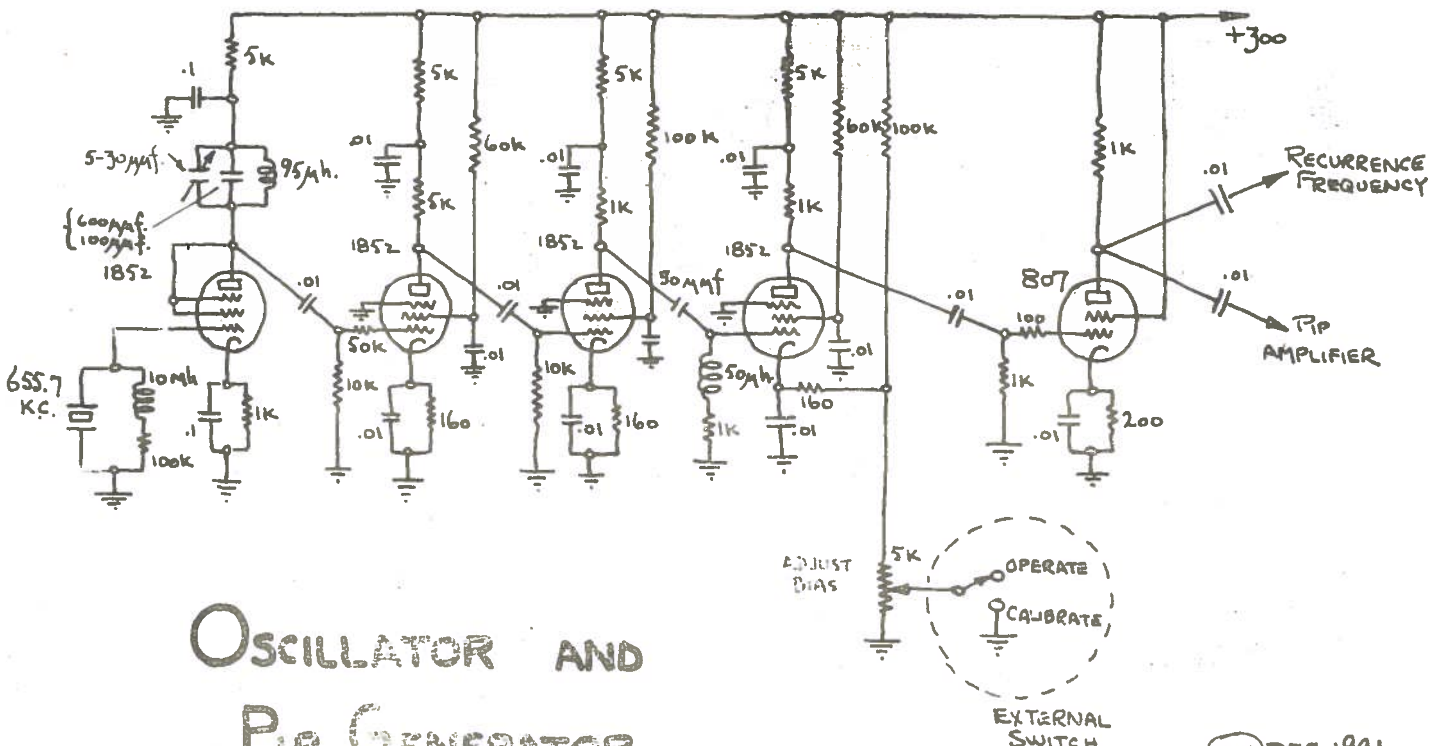
(VH) NRC-RB-134B
DEC. 1941



Low Voltage Supply and Regulator

WH DEC. 1941

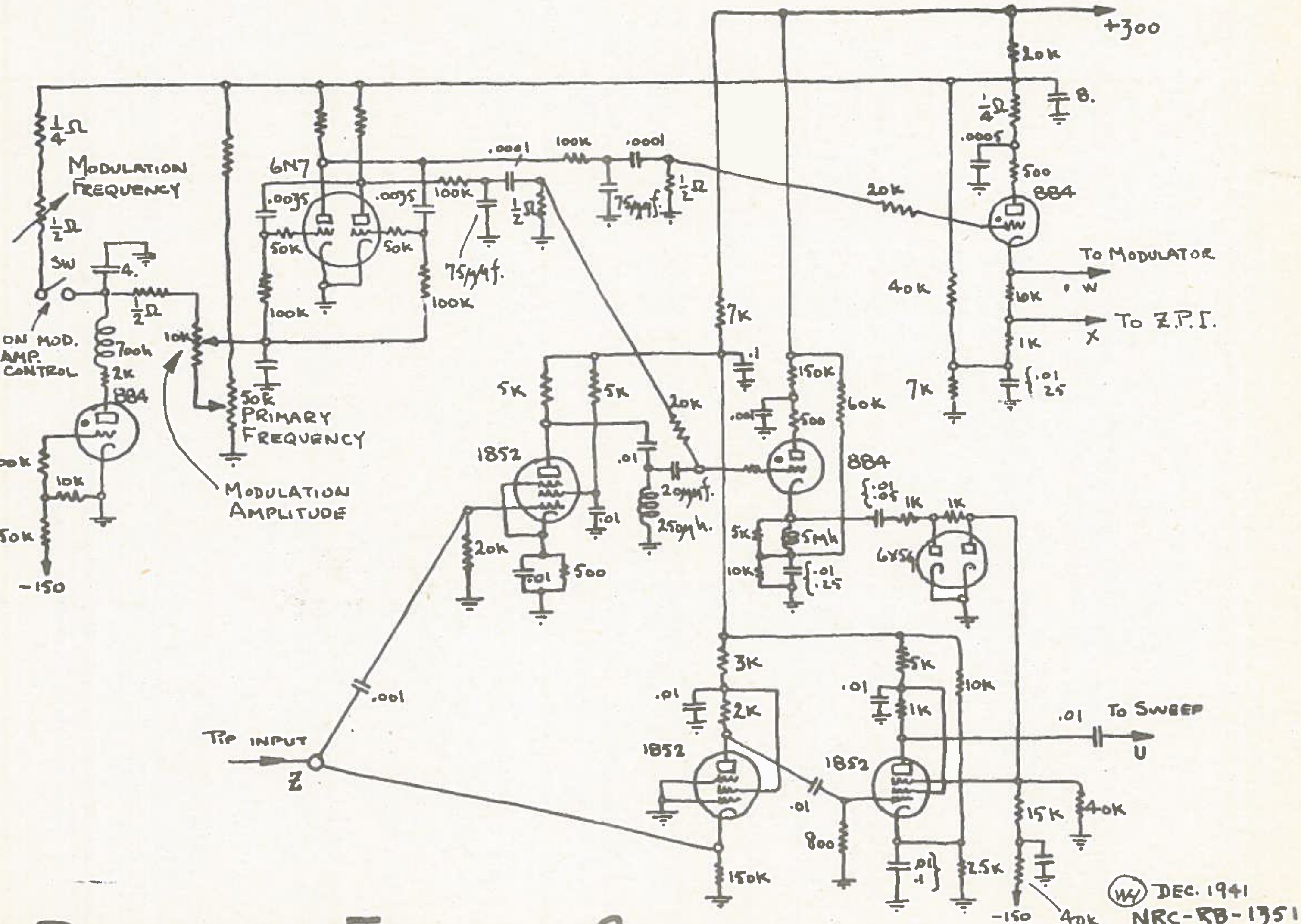
NRC-RB-1949



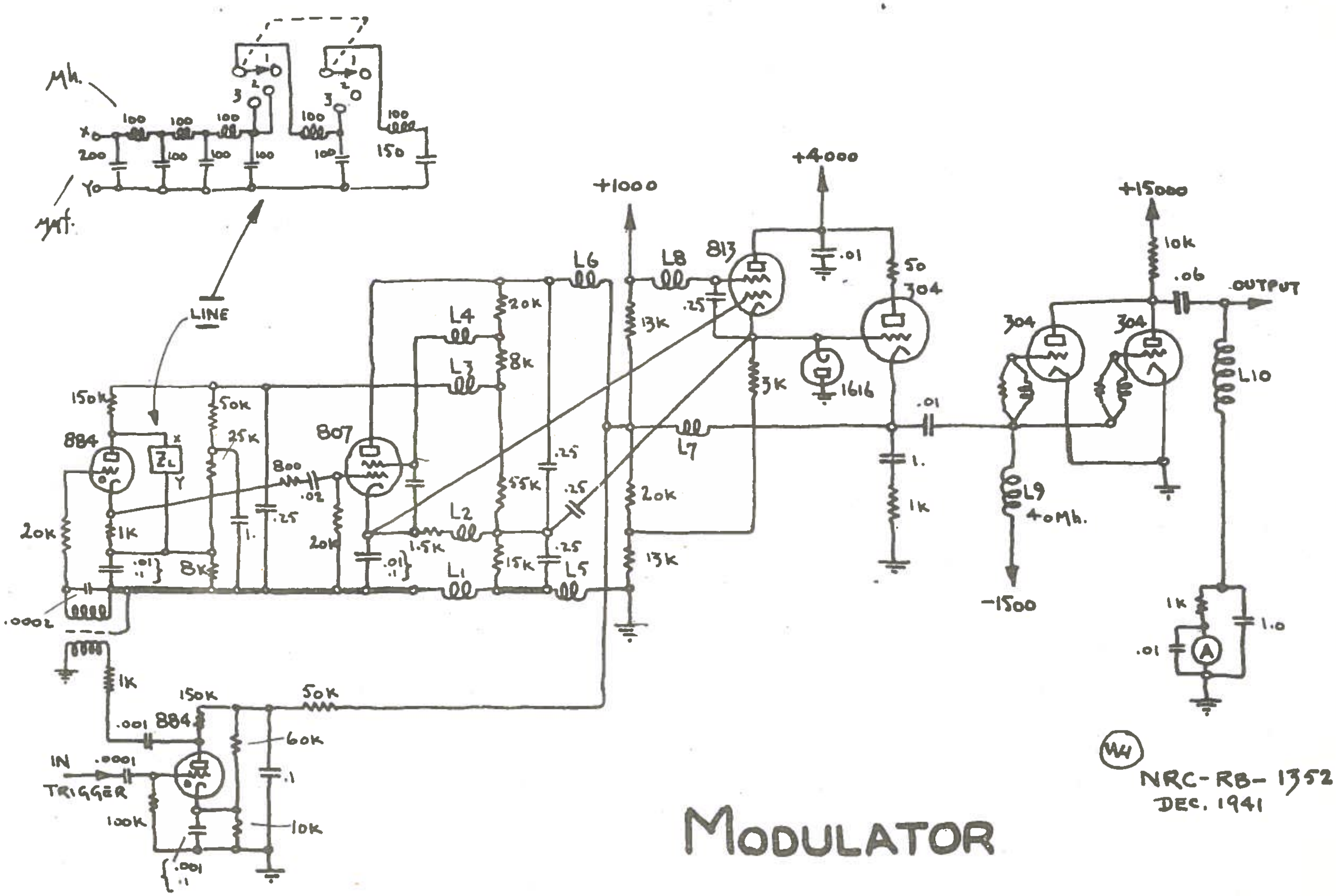
OSCILLATOR AND PIP GENERATOR

(WH) DEC. 1941

NRC-RB-1350

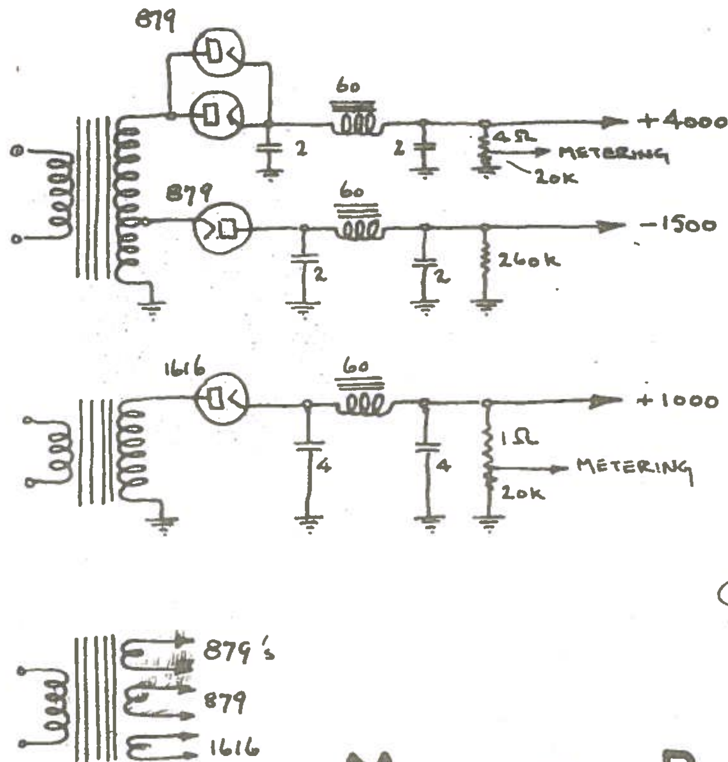


RECURRENCE FREQUENCY CONTROL



MODULATOR

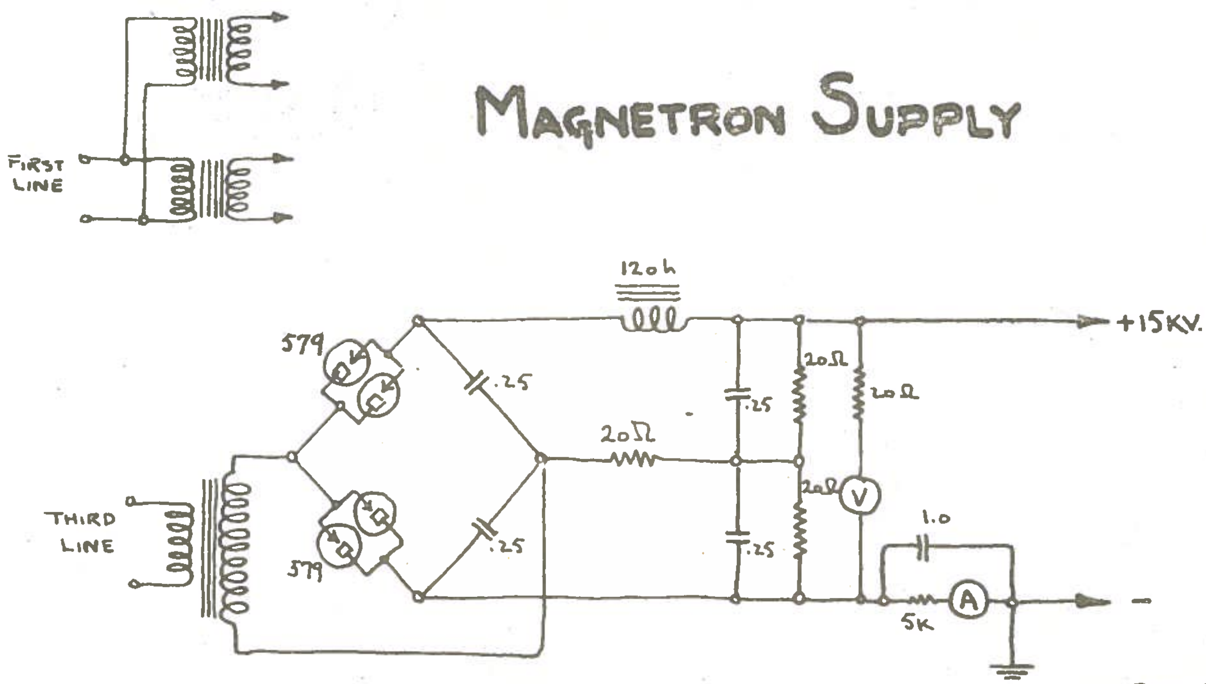
NRC-RB-1352
DEC. 1941



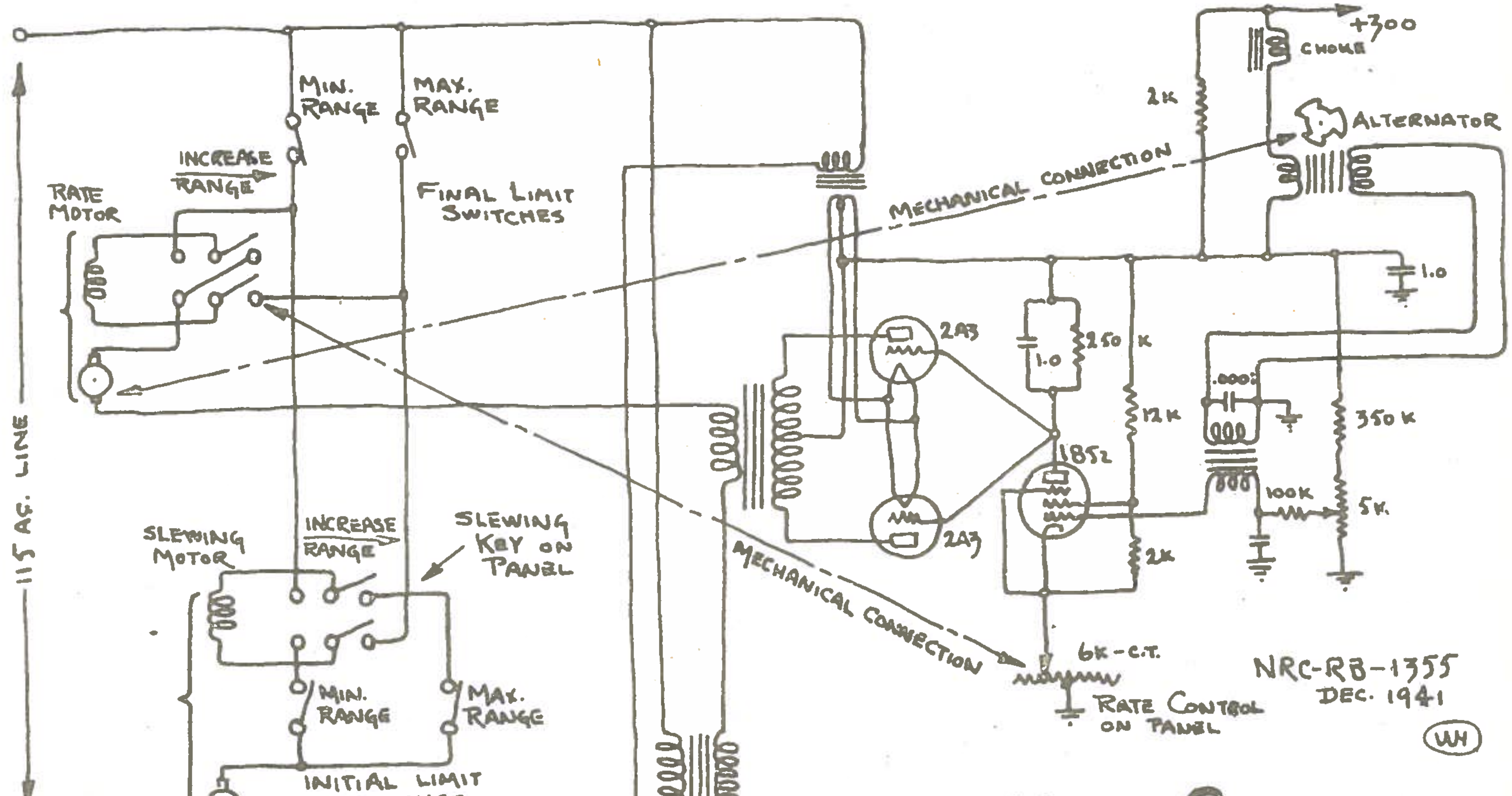
WH NRC-RB-1353
DEC. 1941

MODULATOR BIAS SUPPLY

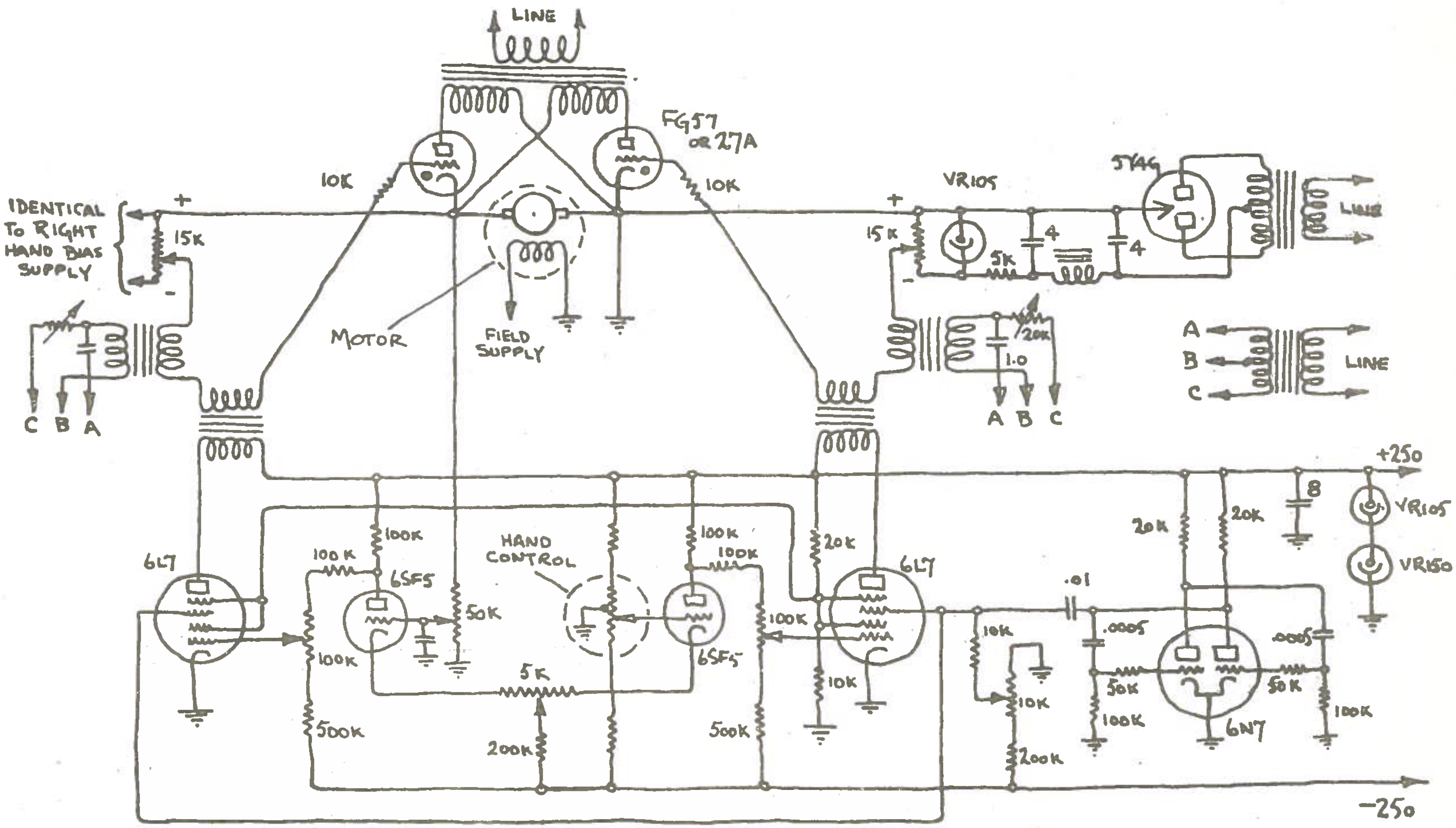
MAGNETRON SUPPLY



DEC. 1941
NRC-RB- 1354

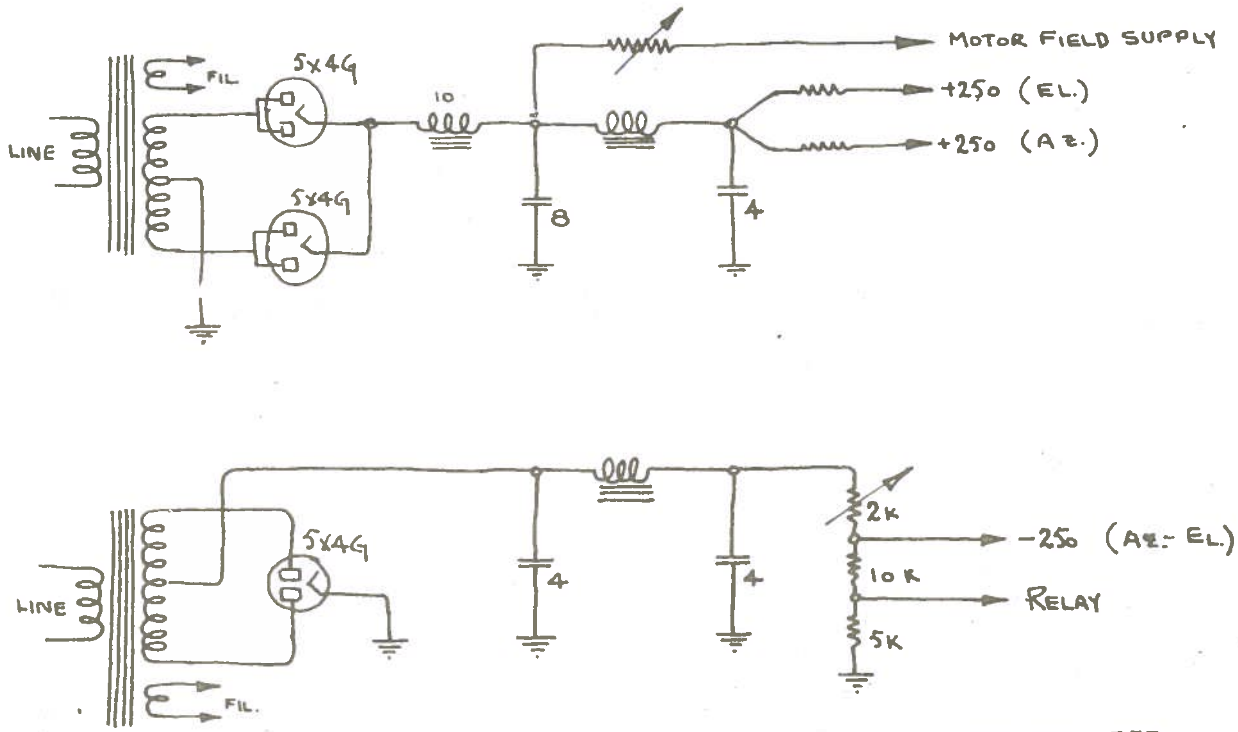


RANGE MOTOR CONTROL



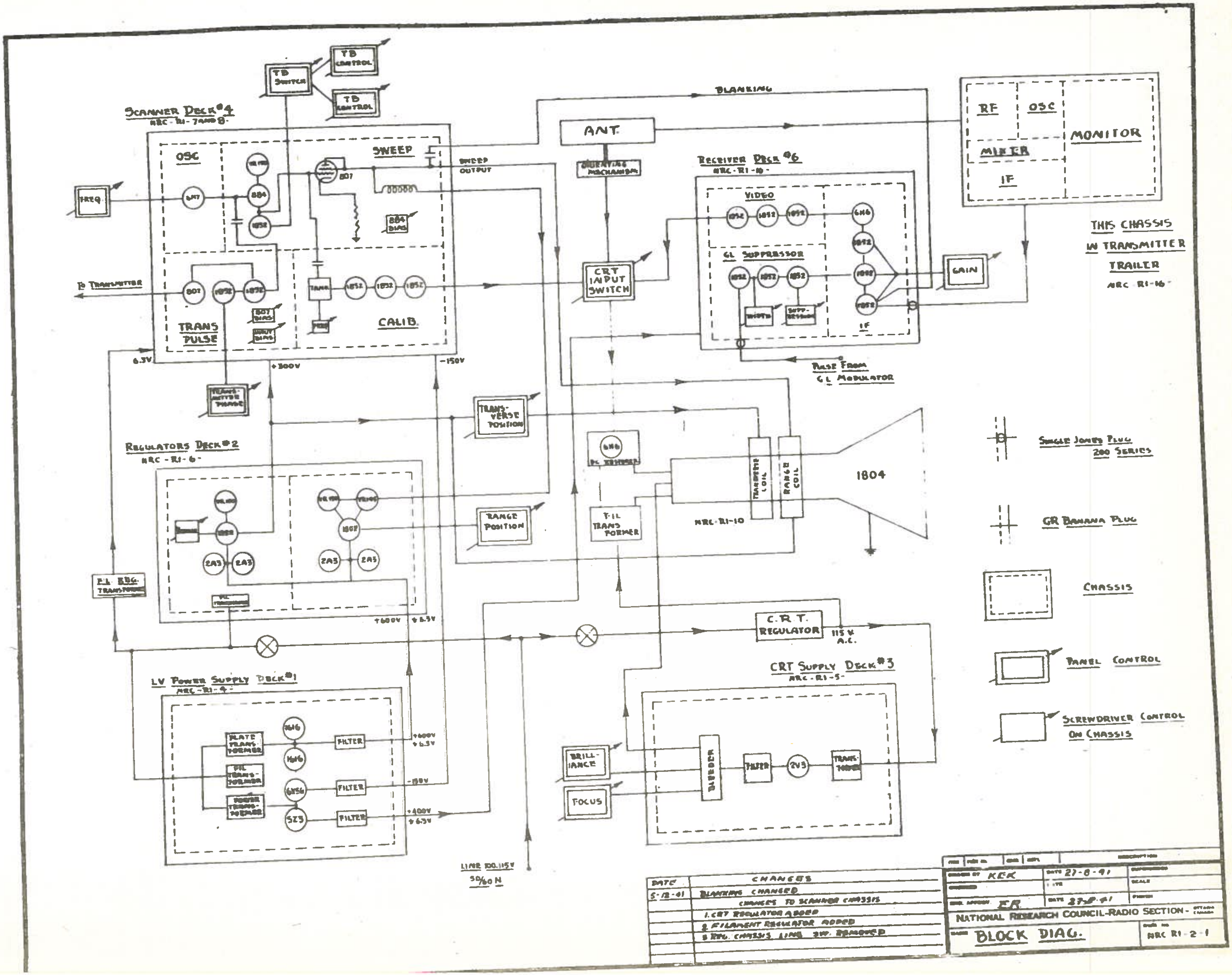
NRC-RB-1356
DEC. 1941
(WH)

THYRATRON CONTROL

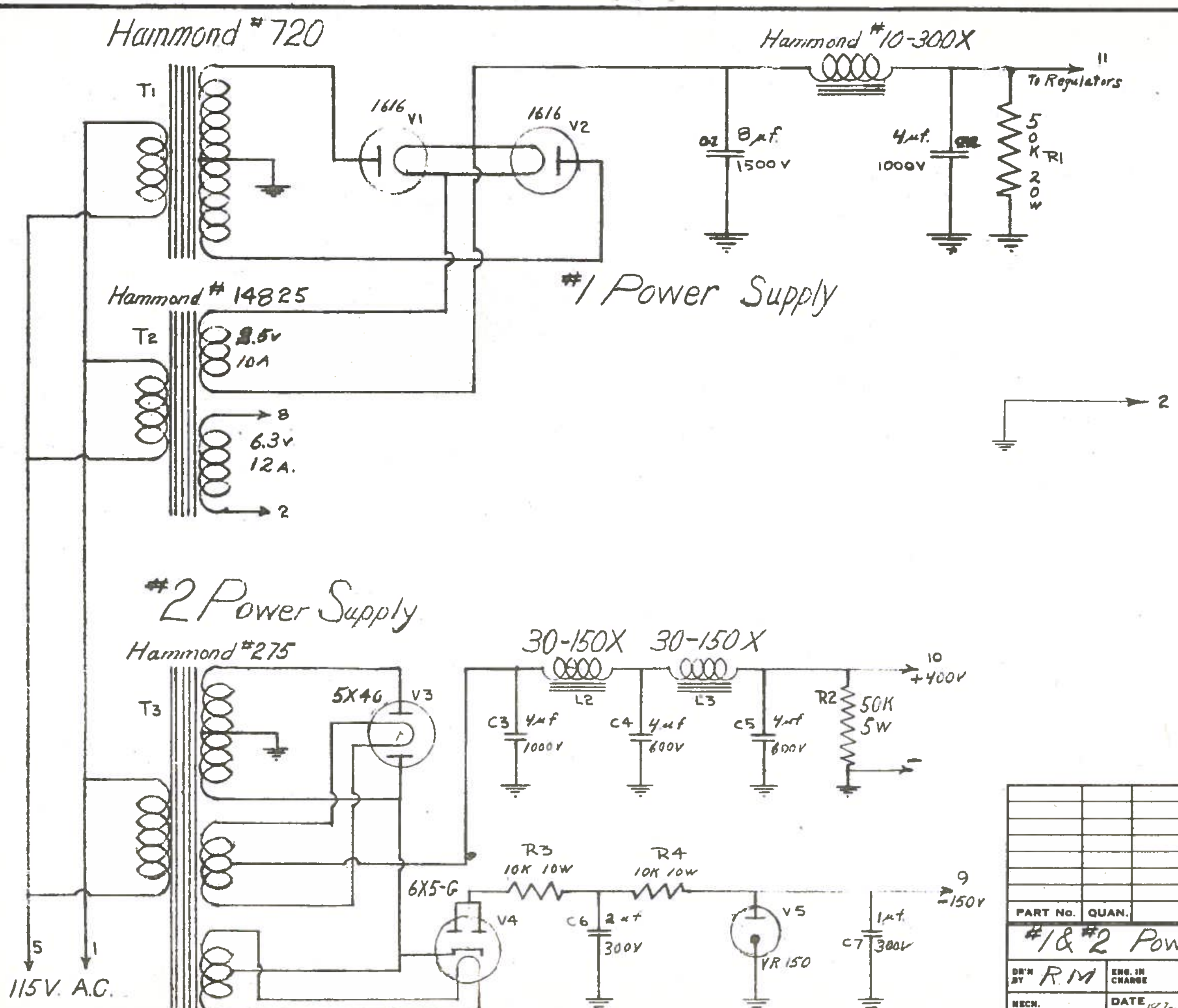


NRC-RB-1357
DEC 1941
WH

THYRATRON CONTROL SUPPLY



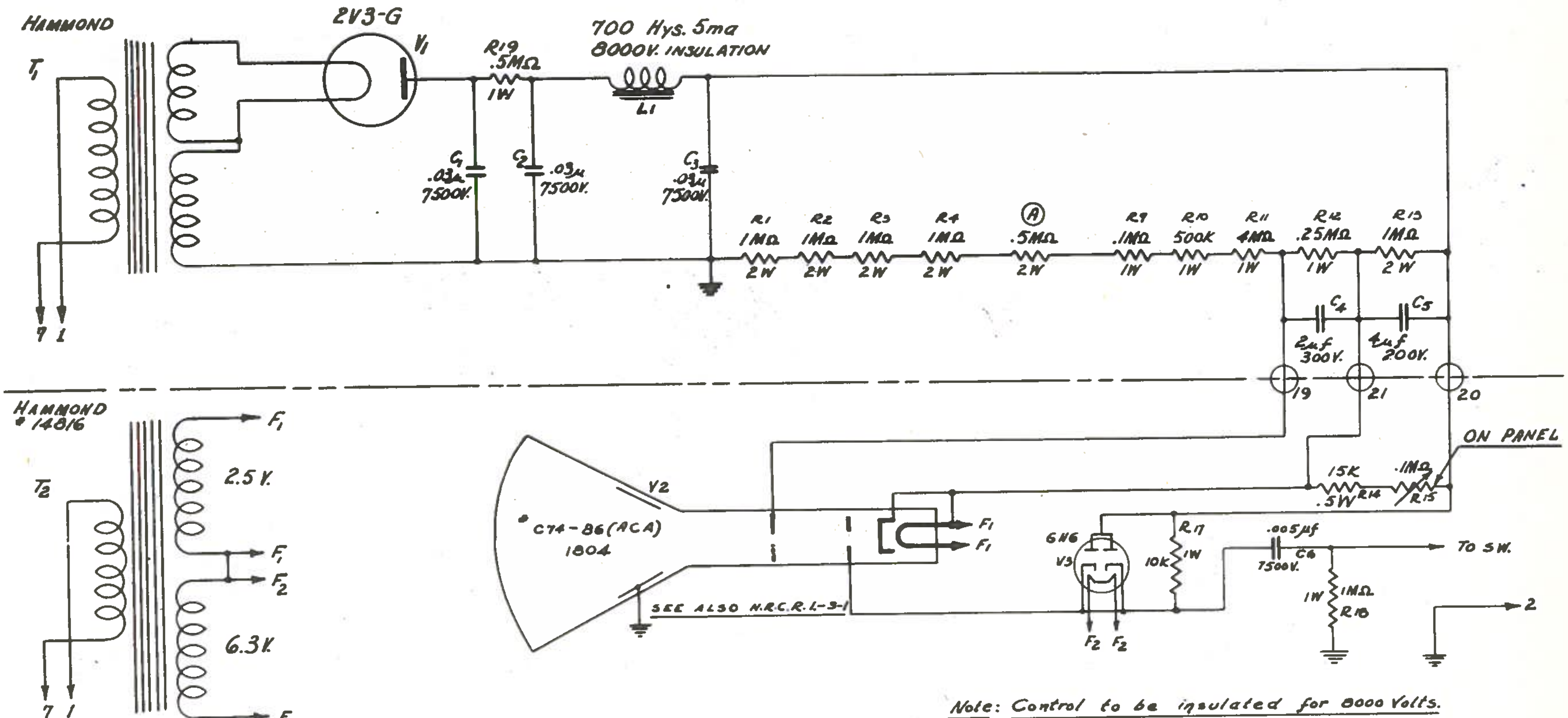
SCANNER DECK #4
NRC-RI-7 AND 8-
OSC
SWEEP
SWEEP OUTPUT
TB SWITCH
TB CONTROL
TB CONTROL
FREQ.
884 BIAS
TO TRANSMITTER
TRANS PULSE
CALIB.
807 BIAS
TRANSMITTER PHASE
6.3V
+300V
-150V
BLANKING
ANT.
CRT INPUT SWITCH
RECEIVER DECK #6
NRC-RI-10-
VIDEO
GL SUPPRESSOR
IF
GAIN
PULSE FROM GL MODULATOR
RF
OSC
MIXER
IF
MONITOR
THIS CHASSIS IN TRANSMITTER TRAILER
NRC RI-16-
TRANS-VERSE POSITION
RANGE POSITION
REGULATORS DECK #2
NRC-RI-6-
2A3
2A3
2A5
2A5
FIL. REG. TRANSFORMER
6H6
FIL TRANS FORMER
TRANSVERSE COIL
RANGE COIL
1804
NRC-RI-10
SINGLE JONES PLUG 200 SERIES
GR BANANA PLUG
CHASSIS
PANEL CONTROL
SCREWDRIVER CONTROL ON CHASSIS
C.R.T. REGULATOR
115 V. A.C.
+600V +6.3V
LV POWER SUPPLY DECK #1
NRC-RI-4-
PLATE TRANS-FORMER
FIL TRANS-FORMER
POWER TRANS-FORMER
FILTER
FILTER
FILTER
5Z3
+600V +6.3V
-150V
+400V +6.3V
LINE 100-115V 50/60 N
CRT SUPPLY DECK #3
NRC-RI-5-
BLEEDER
FILTER
2V3
TRANS-FORMER
BRILL-IANCE
FOCUS
DATE
CHANGES
5-12-41 BLANKING CHANGED
CHANGES TO SCANNER CHASSIS
1. CRT REGULATOR ADDED
2. FILAMENT REGULATOR ADDED
3. REG. CHASSIS LINE SW. REMOVED
KEK
DATE 27-8-41
ER
DATE 27-8-41
NATIONAL RESEARCH COUNCIL-RADIO SECTION-
BLOCK DIAG.
NRC RI-2-1



No.	DATE	CHANGE
	4/11/41	5Z3 CHANGED TO 5X4G

PART No.	QUAN.	DESCRIPTION
		#1 & #2 Power Supplies Z.P.I.

DR'N BY R.M	ENG. IN CHARGE	MAT.	
MECH. CH'K	DATE 18/8/41	FIN.	
DESIGN ENG.	SCALE	TOLERANCE UNLESS OTHERWISE STATED	NRC-R1-4-1



REVISIONS

4-11-41 RESISTANCE VALUES OF BLEEDER CHANGED - FILTER INPUT AND OUTPUT RESISTORS OMITTED. R16 CHANGED FROM 250 K.

Ⓐ 31-1-42 FOCUSING ANODE AND R5 TO R8 AND POT. REMOVED NEW R ADDED Ⓐ

28-2-42 - ADDITION - INFORMATION ON C.R. TUBE

ITEM	PART NO.	QUAN.	MAT'L	DESCRIPTION

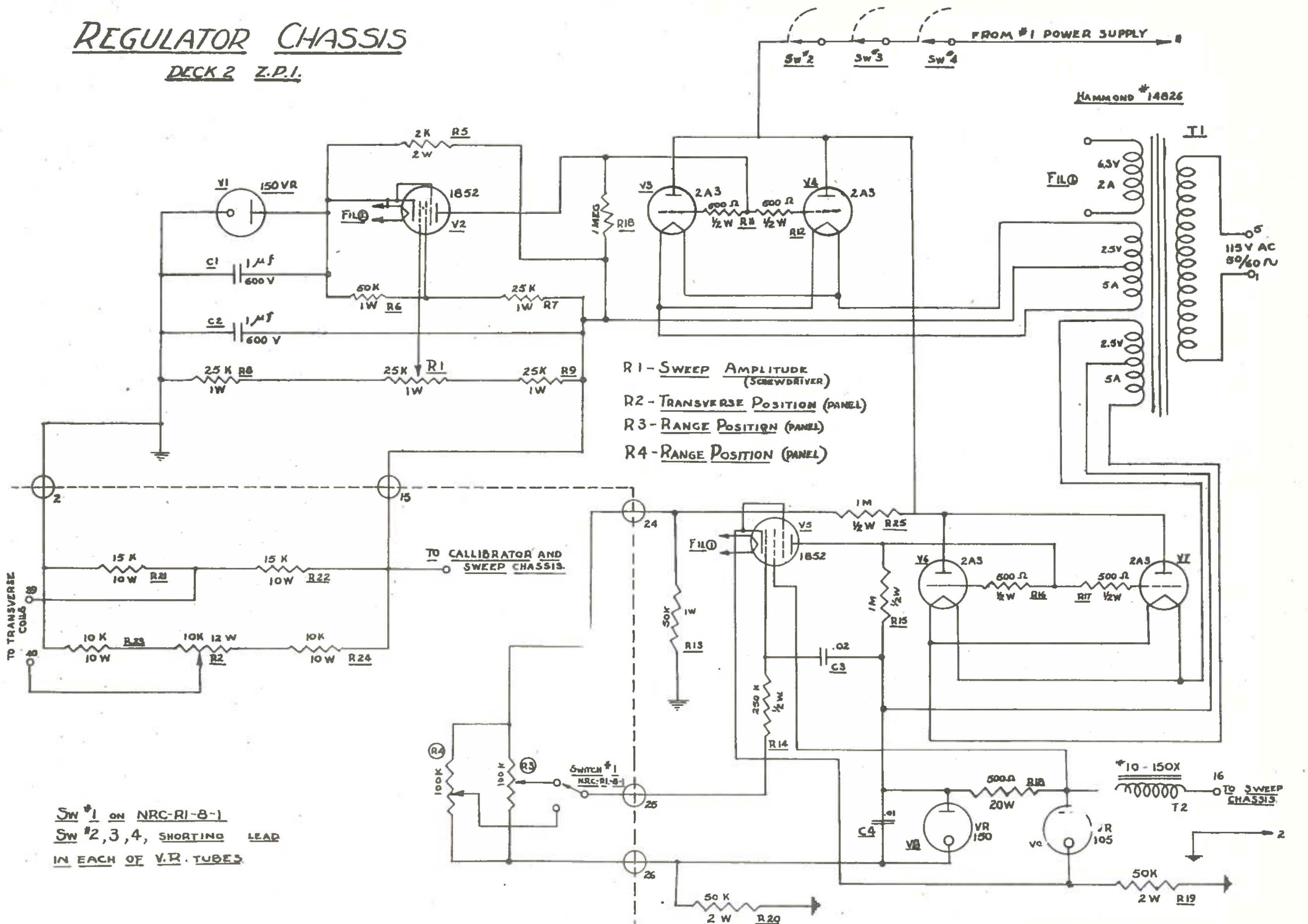
DRAWN BY R.M.	DATE 18-8-41	SUPERSEDES
[redacted] REDRAWN W.H.P. TRACED B.A.R.	DATE 28-2-42 3-7-42	SCALE
ENG. APPROV.	DATE	FINISH.

NATIONAL RESEARCH COUNCIL-RADIO SECTION - OTTAWA CANADA

NAME	DWG. NO.
C.R.T. POWER SUPPLY	N.R.C.R.I. - 5-1 / 10-1

REGULATOR CHASSIS

DECK 2 Z.P.I.



R1 - Sweep Amplitude (screwdriver)
R2 - Transverse Position (panel)
R3 - Range Position (panel)
R4 - Range Position (panel)

Sw #1 on NRC-RI-8-1
Sw #2, 3, 4, shorting lead in each of V.R. tubes

Change	Date			Change	By	Date
VR tubes wired in to cut				R21, 22 from 7500 Ω 20W; R23 24.		
H.V. when VR tube is removed	10/9/41			from 2500 Ω 20W; R2 from 500-Ω W.W.	F.W.	13-11-41
Numbered components C3 changed				# 15 changed to # 16.	K.W.	15-11-41
from .01	18/9/41					
C4 added	4/11/41					

Item	Part No.	Quan.	Mat'l.	Description

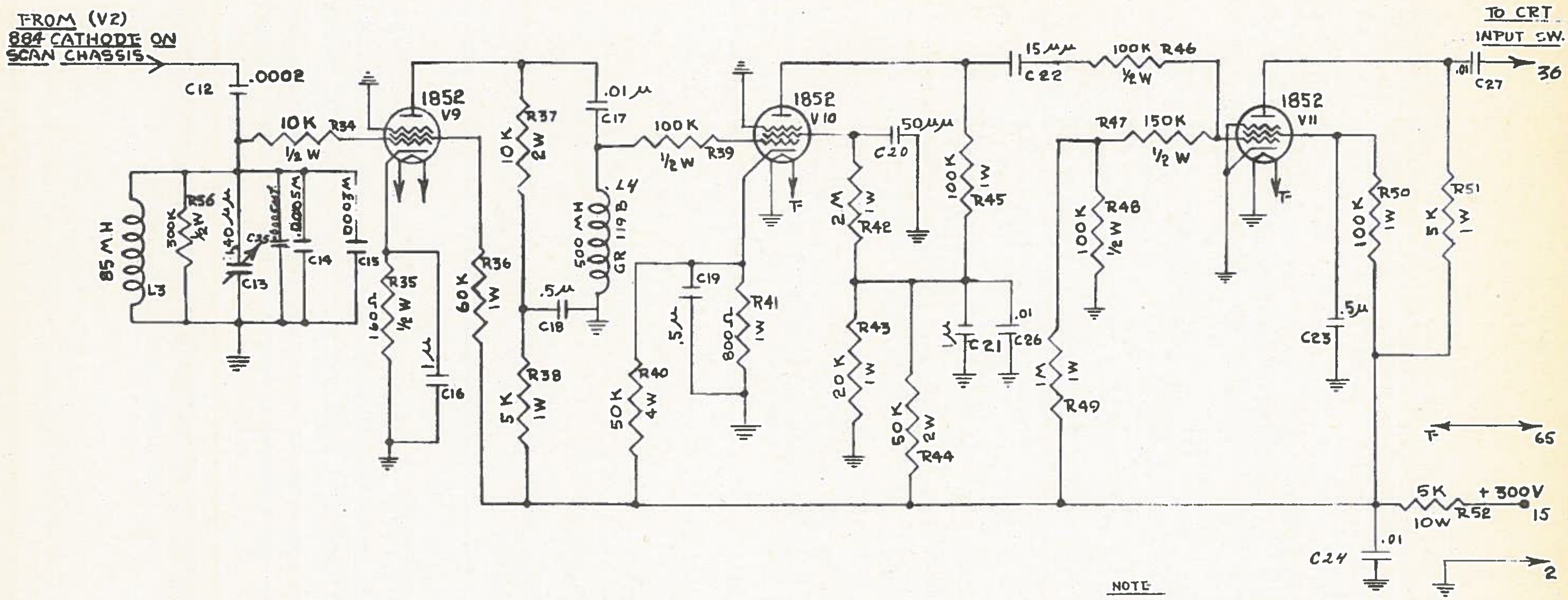
Drawn by KEK	Date 18-8-41	Supersedes
Checked	Date	Scale
Eng. Approv.	Date	Finish.

NATIONAL RESEARCH COUNCIL-RADIO SECTION - OTTAWA CANADA

Name: REGULATORS — Dwg. No. NRC:R.I.-6-1

No.	DATE	CHANGE
	26-4-41	CHANGED WORDING ON INPUT AND OUTPUT
	1-12-41	R54 CHANGED TO R56

No.	DATE	CHANGE
	4/11/41	C27 .01 ADDED
		R51 CHANGED FROM 10K
	10/11/41	R56 ADDED
	15/11/41	Input no. from 16 to 15



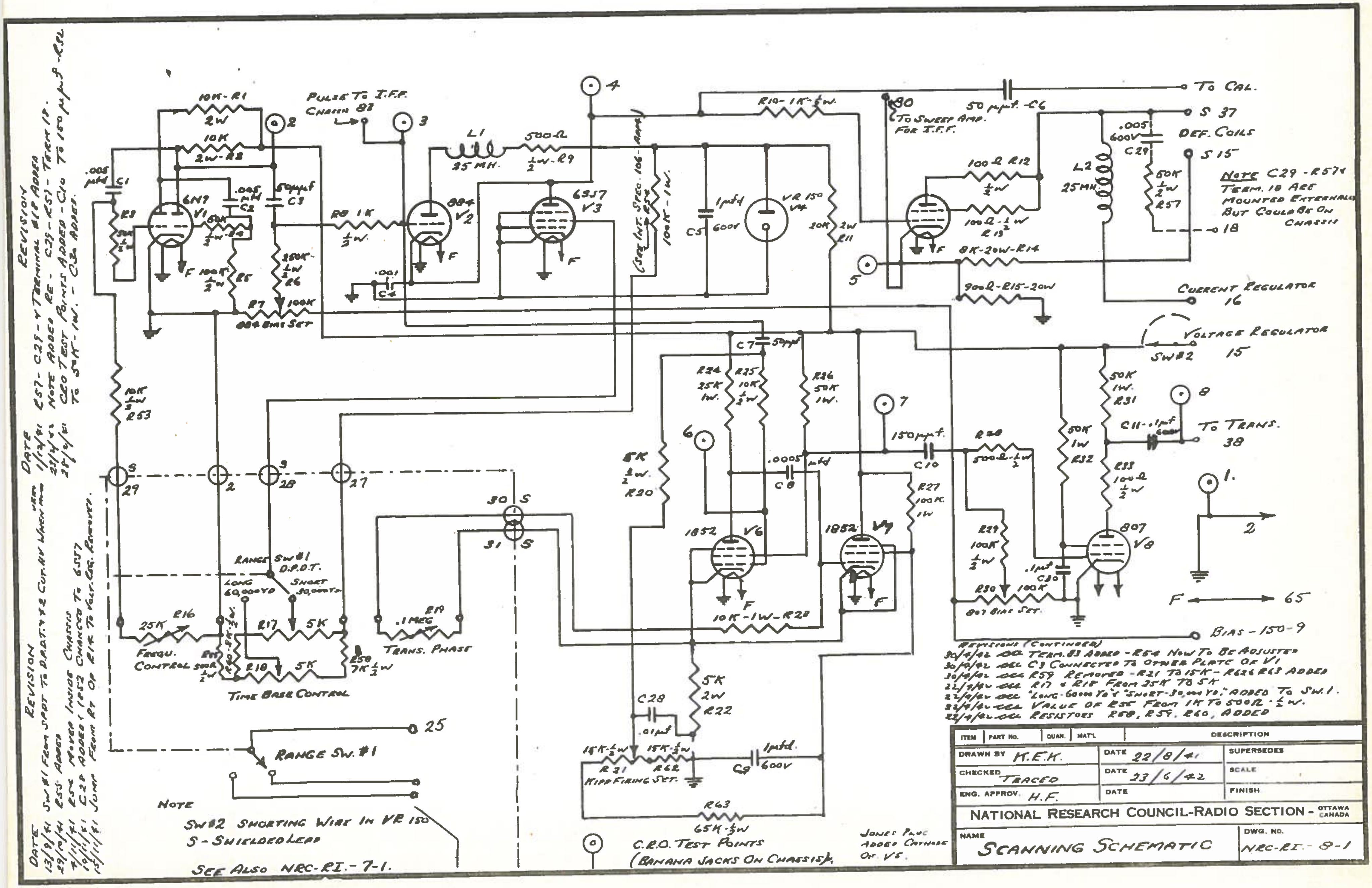
NOTE

ON SCANNING CHASSIS NCR-R1-8-2

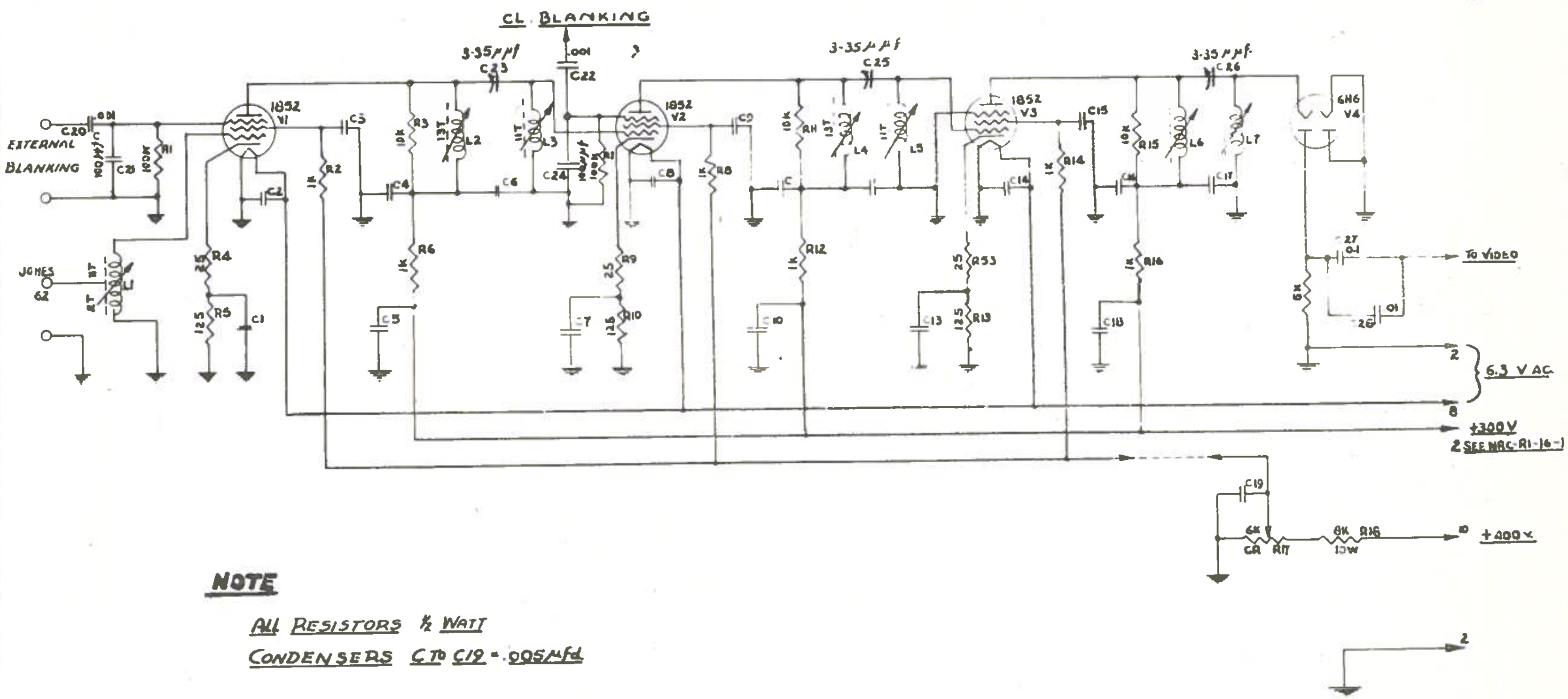
PART No.	QUAN.	DESCRIPTION

CALLIBRATOR 16.4 KC (10,000 YDS)

DR'N BY KEK	ENG. IN CHARGE	MAT.
MECH. CH'K	DATE 22/8/41	FIN.
DESIGN ENG. GM	SCALE	TOLERANCE UNLESS OTHERWISE STATED — NRC-R1-7-1



10K-R1 2W
10K 2W-R2
PULSE TO I.F.F. CHASSIS 83
L1 25 MH.
500Ω ½W-R9
To CAL.
50 μμf. -C6
R10-1K-½W.
S 37
DEF. COILS
S 15
To SWEEP AMP. FOR I.F.F.
6N7 V1
884 V2
6J57 V3
VR 150 V4
R8 1K ½W.
C5 1μfd 600V
20K 2W R11
100Ω R12 ½W
100Ω-½W R13
8K-20W-R14
900Ω-R15-20W
L2 25 MH
.005 600V C29
50K ½W R57
NOTE C29 - R57 TERM. 18 ARE MOUNTED EXTERNALLY BUT COULD BE ON CHASSIS
CURRENT REGULATOR 16
VOLTAGE REGULATOR 15
SW#2
884 BIAS SET
R7 100K
C7 50μμf
R24 25K 1W.
R25 10K ½W
R26 50K 1W.
10K ½W R53
150μμf. C10
R28 500Ω-½W
50K 1W R31
50K 1W R32
R33 100Ω ½W
C11-.1μf 600V
To TRANS. 38
.0005 μfd C8
R27 100K. 1W
1852 V6
1852 V7
807 V8
R29 100K ½W
R30 100K
807 BIAS SET
F ← → 65
BIAS - 150-9
5K ½W R20
10K-1W-R23
5K 2W R22
C28 .01μf
15K-½W R21
15K-½W R62
KIPP FIRING SET.
1μfd. 600V C9
R63 65K-½W
RANGE SW#1 D.P.D.T.
LONG 60,000YD
SHORT 30,000YD
25K R16
FREQU. CONTROL
R17 5K
R18 5K
R58 7K ½W
TIME BASE CONTROL
R19 .1MEG
TRANS. PHASE
RANGE SW. #1
NOTE
SW#2 SHORTING WIRE IN VR 150
S - SHIELDED LEAD
SEE ALSO NRC-RI.-7-1.
C.R.O. TEST POINTS (BANANA JACKS ON CHASSIS).
JONES PLUG ADDED CATHODE OF V5.
REVISIONS (CONTINUED)
30/4/42 Term. 83 Added - R54 Now To Be Adjusted
30/4/42 C3 Connected To Other Plate Of V1
30/4/42 R59 Removed - R21 To 15K - R62 & R63 Added
22/4/42 R17 & R18 From 25K To 5K
22/4/42 "Long-60000 Yd" & "Short-30,000 Yd." Added To Sw. 1.
22/4/42 Value Of R55 From 1K To 500Ω-½W.
22/4/42 Resistors R58, R59, R60, Added
ITEM | PART NO. | QUAN. | MAT'L | DESCRIPTION
DRAWN BY K.E.K. DATE 22/8/41
CHECKED TRACED DATE 23/6/42
ENG. APPROV. H.F.
SUPERSEDES
SCALE
FINISH
NATIONAL RESEARCH COUNCIL-RADIO SECTION - OTTAWA CANADA
NAME SCANNING SCHEMATIC
DWG. NO. NRC-RI.-8-1



NOTE

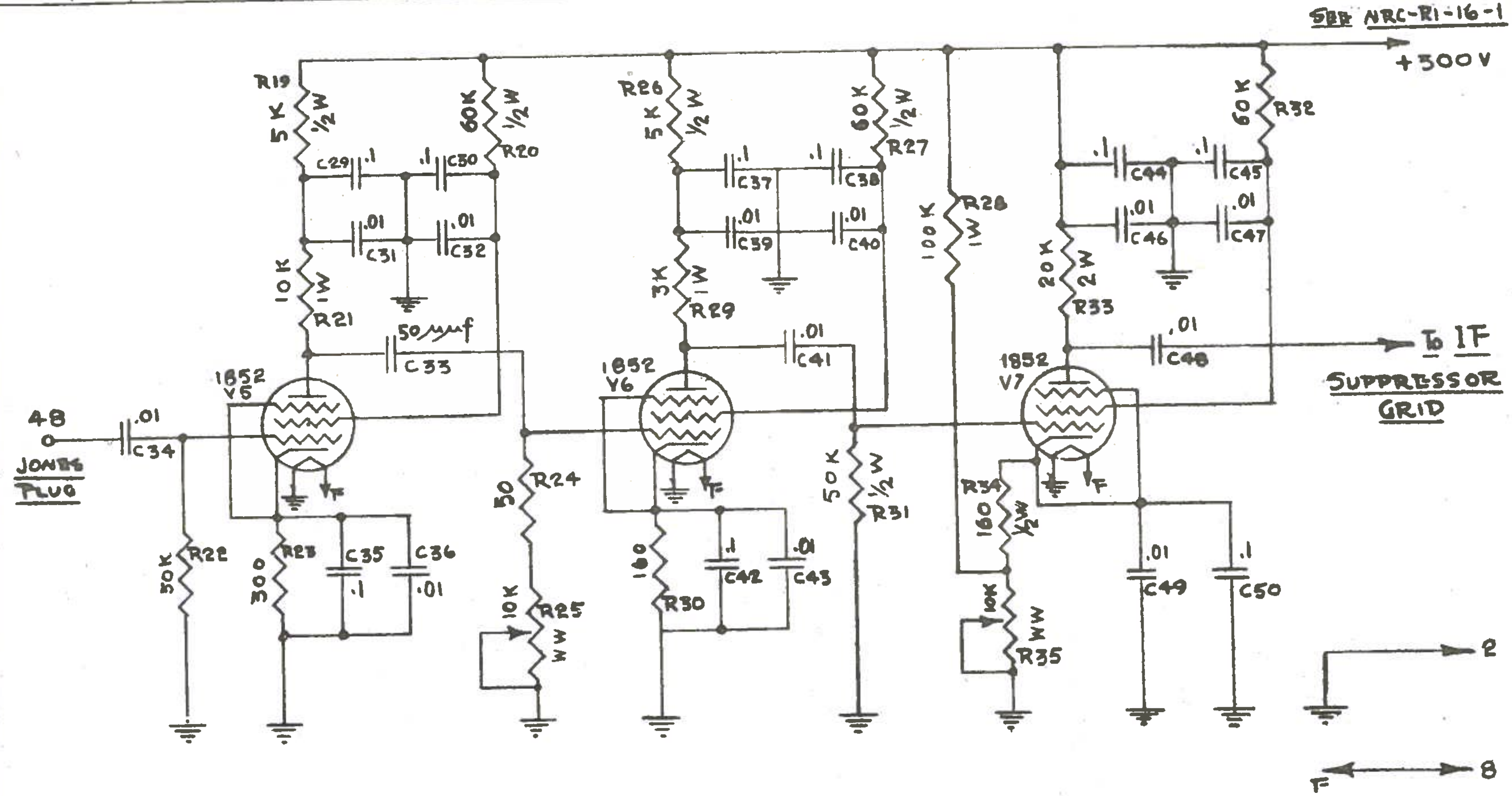
All Resistors ½ Watt

Condensers C To C19 = .005 Mfd

Resistor Values Changed H.D. 5/10/41

Drawn by K.E.K.	Date 25-9-41	Superseded	
Checked	Date	Scale	
Eng. Approv. H.H.A.D.	Date	Finish	
National Research Council-Radio Section- Ottawa Canada			
Name: Receiver Second I.F.		Dwg. No. NRC-R1-16-3	

NUMBER	LTR	CHANGE	BY	DATE	CHECK	NUMBER	LTR	CHANGE	BY	DATE	CHECK	PART NUMBER



DO NOT SCALE — USE STANDARD TOLERANCES UNLESS OTHERWISE SPECIFIED   USED ON

FINISH

STANDARD TOLERANCES ON DIMENSIONS

INCHES	FRACTIONAL	DECIMAL
0-1/4	±1/128	±.005
1/4-6	±1/64	±.005
6-24	±1/32	±.010
OVER 24	±1/16	±.015

MATERIAL

RAW MATERIAL

PER M PIECES

EXPERIMENTAL NO.

SCALE

SUPERSEDES

DRAWN DATE KEK 30/9/41

ENG. APPROVAL HHAD

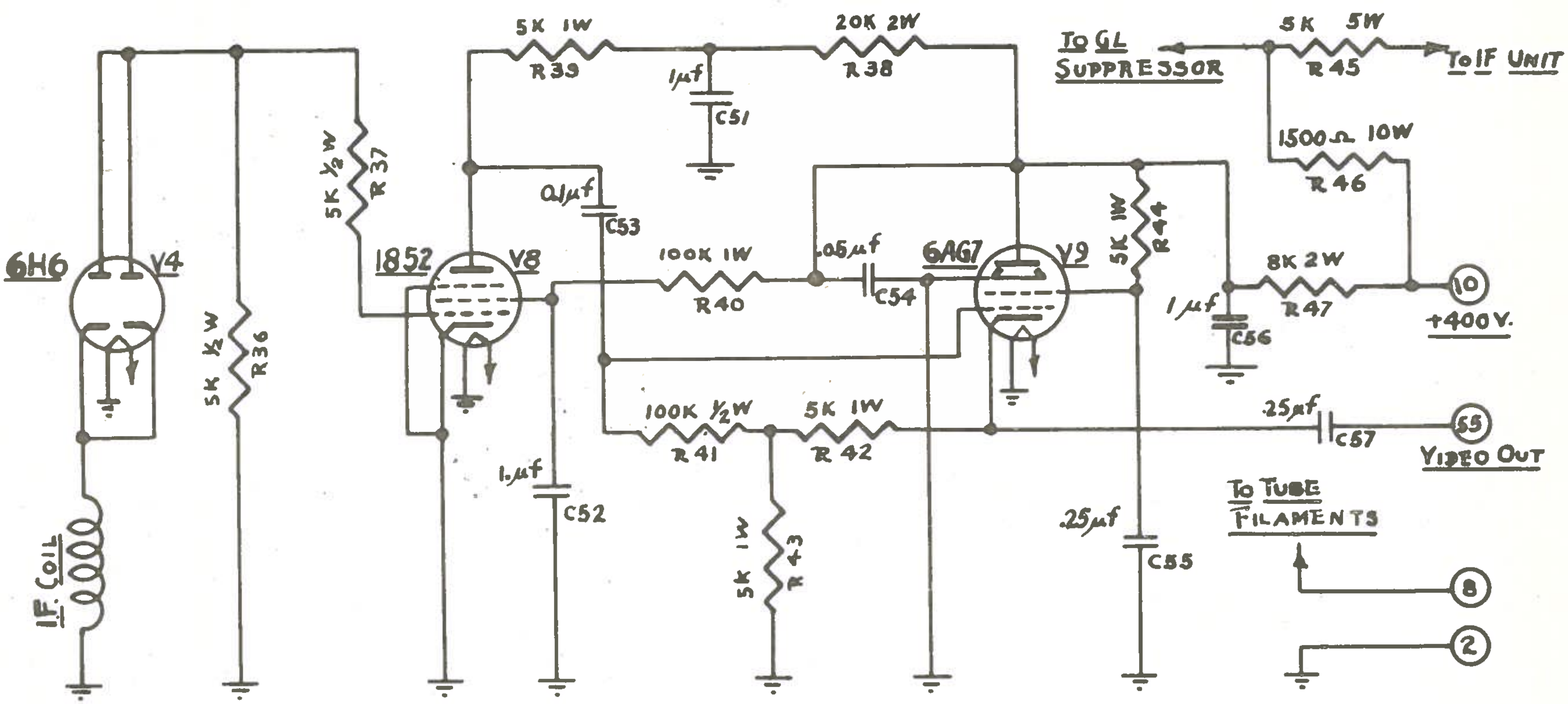
CHECKED DATE

DR. OFFICE APPROVAL

[redacted]

NAME GL SUPPRESSOR FOR Z.P.I.

NO. NRC-R1-16-4



ITEM	PART NO.	QUAN.	MAT'L	DESCRIPTION

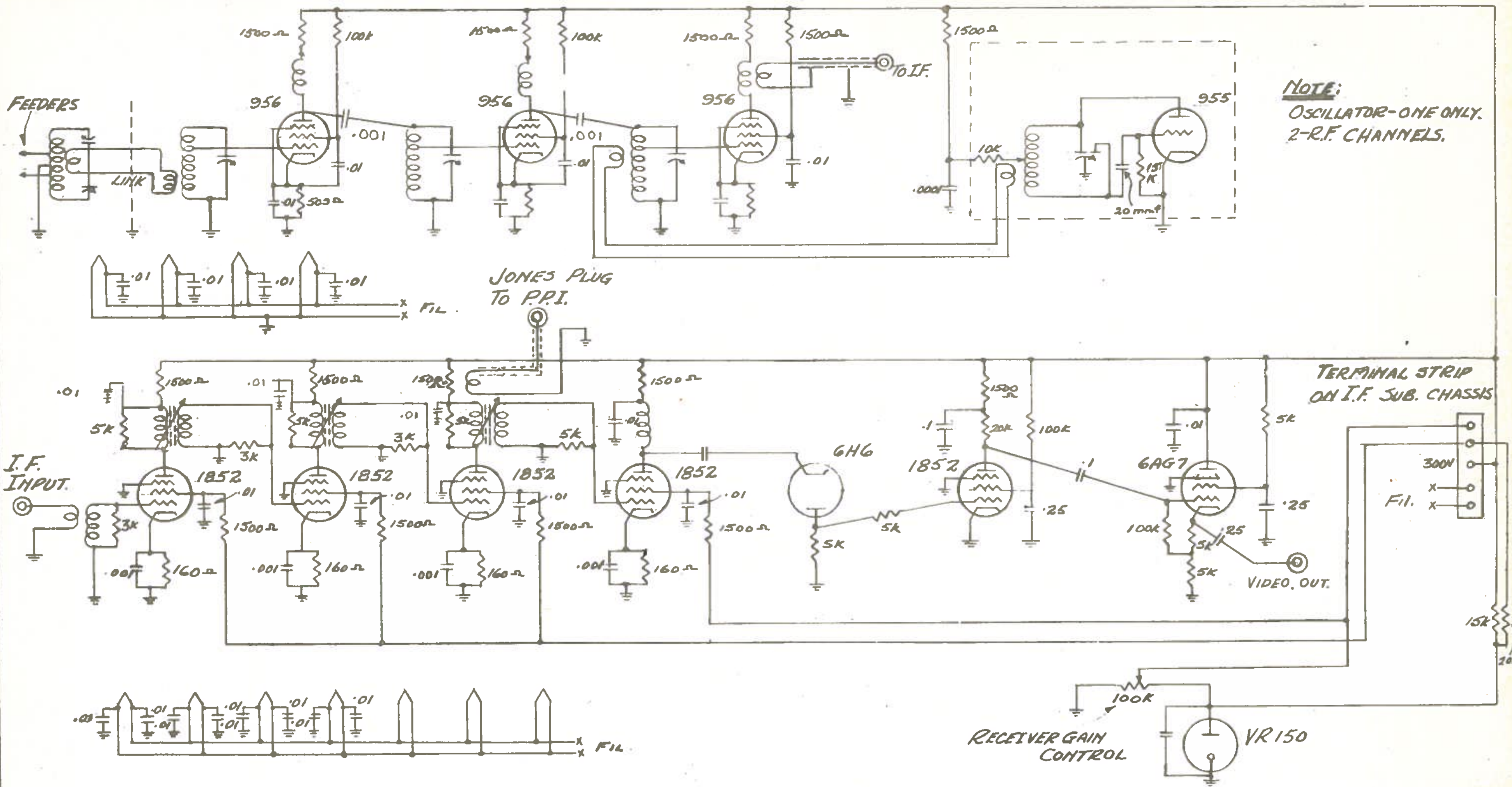
DRAWN BY KEK DATE 19-12-41 SUPERSEDES

CHECKED ER DATE [redacted] TRACED GM 29/6/42

ENG. APPROV. GRM DATE FINISH.

NATIONAL RESEARCH COUNCIL-RADIO SECTION - OTTAWA CANADA

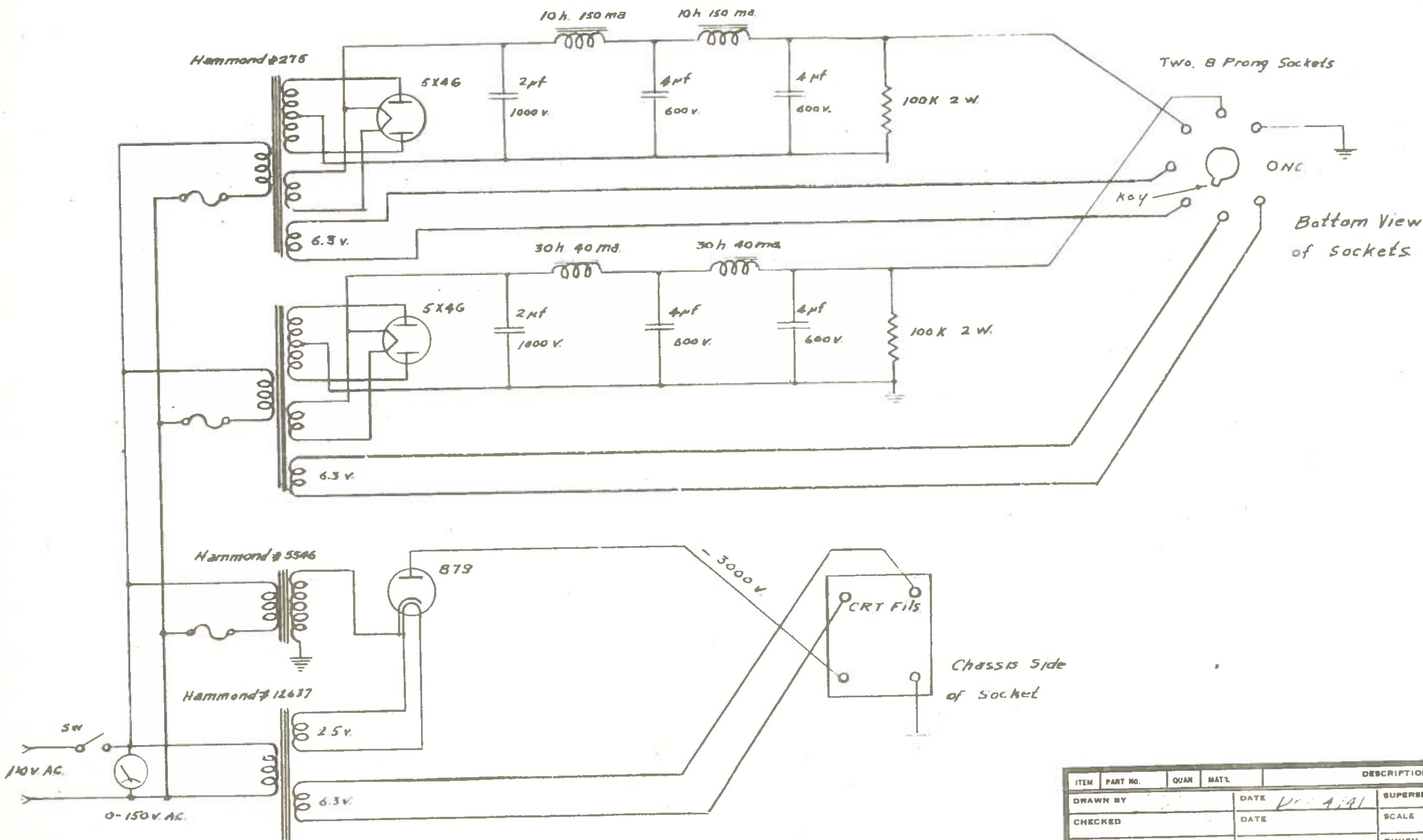
NAME INDICATOR VIDEO SCHEMATIC DWG. NO. NRC-RI-16-9



ITEM	PART NO.	QUAN.	MAT'L	DESCRIPTION
DRAWN BY - W. Johnson		DATE DEC-5-41		SUPERSEDES
CHECKED		DATE		SCALE
ENG. APPROV.		DATE		FINISH.

NATIONAL RESEARCH COUNCIL-RADIO SECTION - OTTAWA CANADA

NAME R.F. CIRCUIT OF ZPI MONITOR RECEIVER. — DWG. NO. # 130



ITEM	PART NO.	QUAN.	MAT'L	DESCRIPTION

DRAWN BY	DATE [illegible] 4/41	SUPERSEDES
CHECKED	DATE	SCALE
ENG. APPROV.	DATE	FINISH.

NATIONAL RESEARCH COUNCIL-RADIO SECTION - OTTAWA CANADA

NAME *Power Supplies for ZPI Monitor Receiver* DWG. NO. 131

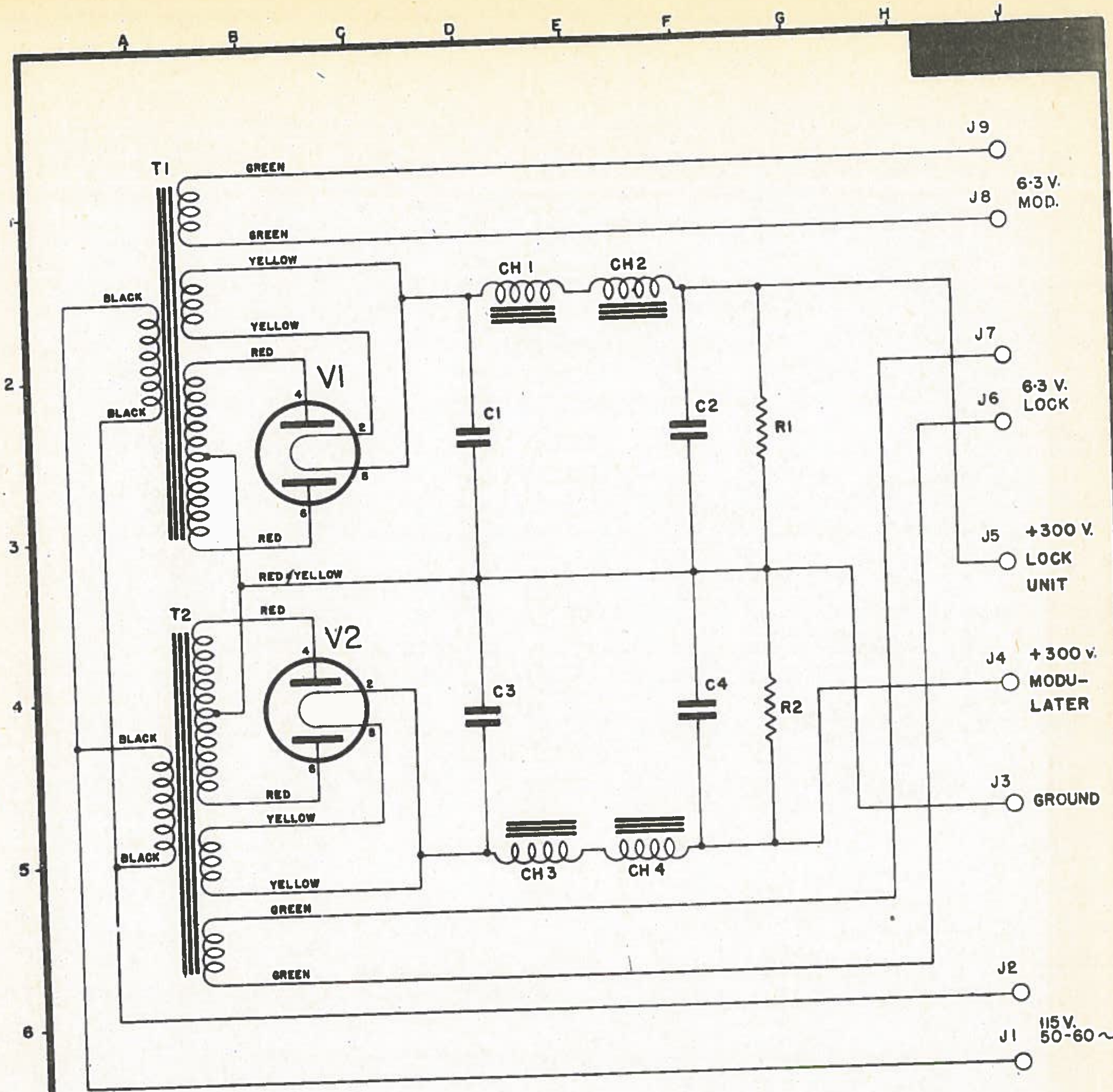


FIG. 27

SECRET

FIG. 27

PARTS LIST

CONDENSERS

ITEM	POS	VALUE	DESCRIPTION		MFGR'S NO.	REF. NO.
C1	D2	10 MFD.	600 V. OIL FILLED			
C2	F2	10 MFD.	600 V. " "			
C3	D4	10 MFD.	600 V. " "			
C4	E4	10 MFD.	600 V. " "			

FILTER CHOKES

ITEM	POS	VALUE	DESCRIPTION		MFGR'S NO.	REF. NO.
CH1	E1	30 H	65 M.A.			
CH2	E1	30 H	65 M.A.			
CH3	E5	30 H	65 M.A.			
CH4	E5	30 H	65 M.A.			

RESISTORS

ITEM	POS	VALUE	DESCRIPTION		MFGR'S NO.	REF. NO.
R1	G2	250,000Ω	2 W ±10%			
R2	G4	250,000Ω	2 W ±10%			

TUBES

ITEM	POS	DESCRIPTION		MFGR'S NO.	REF. NO.
V1	B2	5U4G			
V2	B4	5U4G			

TRANSFORMERS

ITEM	POS	DESCRIPTION		MFGR'S NO.	REF. NO.
T1	A2	POWER			
T2	A4	POWER			

CONNECTORS

ITEM	POS	DESCRIPTION		MFGR'S NO.	REF. NO.
J1	J1	BANANA PLUG JACK			
J2	J1	BANANA PLUG JACK			
J3	J2	BANANA PLUG JACK			
J4	J2	BANANA PLUG JACK			
J5	J3	BANANA PLUG JACK			
J6	J4	BANANA PLUG JACK			
J7	J5	BANANA PLUG JACK			
J8	J6	BANANA PLUG JACK			
J9	J [illegible]	BANANA PLUG JACK			

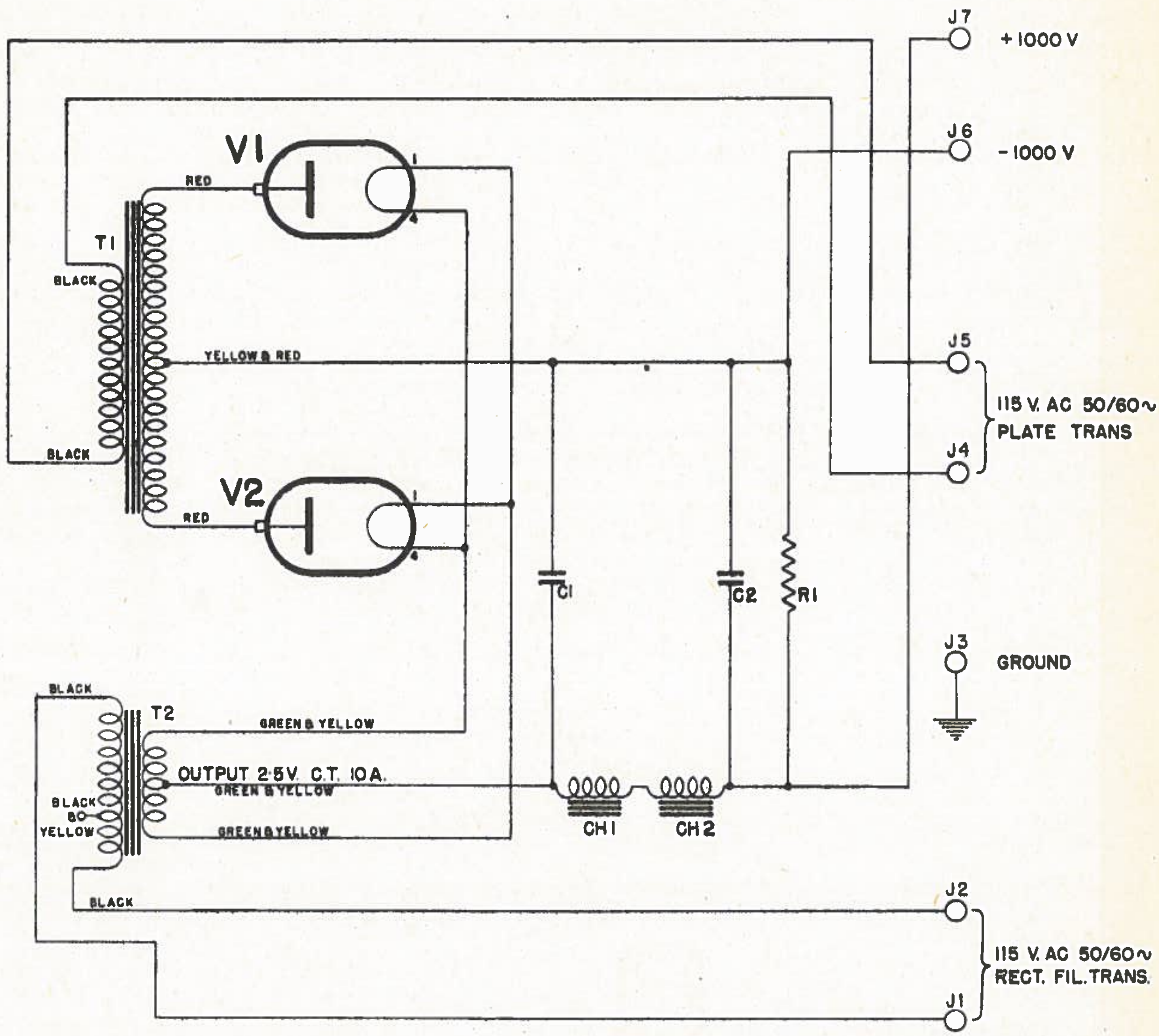


FIG. 28

SECRET

FIG. 28

PARTS LIST

TUBES

ITEM	POS.	DESCRIPTION		MFGRS NO.	REF. NO.
V1	C 2	1616			
V2	C 4	1616			

CONDENSERS

ITEM	POS.	VALUE	DESCRIPTION		MFGRS NO.	REF. NO.
C1	E 4	8 MFD.	1500 V. OIL FILLED			
C2	F 4	8 MFD.	1500 V. " "			

TRANSFORMERS

ITEM	POS.	DESCRIPTION		MFGRS NO.	REF. NO.
T1	A 3	H 728 50-60 CYCLE			
T2	A 5	1166 50-60 CYCLE			

CHOKES

ITEM	POS.	DESCRIPTION		MFGRS NO.	REF. NO.
CH1	E 6	HAMMOND 10-200			
CH2	F 7	HAMMOND 10-200			

RESISTORS

ITEM	POS.	VALUE	DESCRIPTION	R.E.L. NO.	MFGRS NO.	REF. NO.
R1	G 5	1 MEGΩ	2 W ±10%	132-081		

CONNECTORS

ITEM	POS.	DESCRIPTION		MFGRS NO	REF. NO.
J1	H 6	BANANA PLUG JACK			
J2	H 6	BANANA PLUG JACK			
J3	H 6	BANANA PLUG JACK			
J4	H 6	BANANA PLUG JACK			
J5	H 6	BANANA PLUG JACK			
J6	H 6	BANANA PLUG JACK			
J7	H 6	BANANA PLUG JACK			

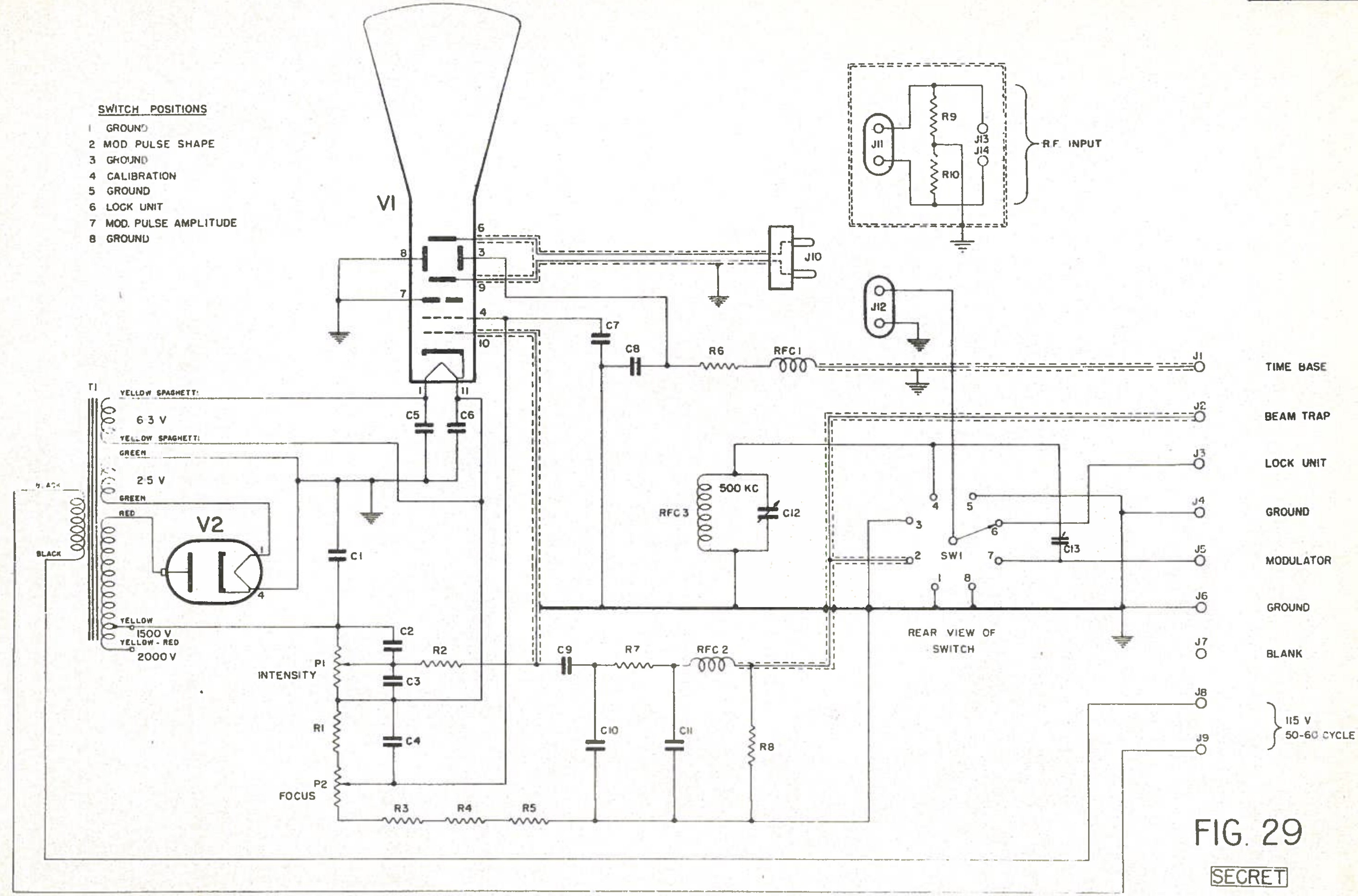


FIG. 29

SECRET

FIG. 29

PARTS LIST

CONDENSERS

ITEM	POS	VALUE	DESCRIPTION	MFGR'S NO.	REF. NO.
C 1	C 6	1· MFD	2500 V CAN		
C 2	D 7	·1 MFD	600 V TUBULAR		
C 3	D 7	·1 MFD	600 V TUBULAR		
C 4	D 8	·1 MFD	600 V TUBULAR		
C 5	D 5	·01 MFD	2500 V MICA		
C 6	D 5	·01 MFD	2500 V MICA		
C 7	F 4	·01 MFD	2500 V MICA		
C 8	F 4	100 MMFD	2500 V MICA		
C9	E 7	·003 MFD	2500 V MICA		
C10	F 8	25 MMFD	2500 V MICA		
C11	F 8	25 MMFD	2500 V MICA		
C12	G 6	140 MMFD	AIR TRIMMER		
C13	K 6	10 MMFD	" "		

RESISTORS

ITEM	POS	VALUE	DESCRIPTION	MFGR'S NO.	REF. NO.
R 1	C 8	220000 Ω	1 W		
R 2	D 7	22000 "	1 W		
R 3	D 9	220000 "	1 W		
R 4	E 9	220000 "	1 W		
R 5	E 9	220000 "	1 W		
R 6	G 4	22000 "	·5 W		
R 7	F 7	22000 "	1 W		
R 8	G 8	470000 "	1 W		
R 9	J 2	100 "	1 W CARBON		
R10	J 2	100 "	1 W CARBON		

CONNECTORS

ITEM	POS	DESCRIPTION	MFGR'S NO.	REF. NO.
J 1	L4	BANANA PLUG JACK		
J 2	L5	" " "		
J 3	L5	" " "		
J 4	L6	" " "		
J 5	L6	" " "		
J 6	L7	" " "		
J 7	L7	" " "		
J 8	L8	" " "		
J 9	L8	" " "		
J 10	G3	TWIN PLUG		
J 11	H2	" JACKS		
J 12	H3	" "		
J13	J1	BANANA PLUG JACK		
J14	J2	" " "		

R.F. CHOKES

ITEM	POS	VALUE	DESCHIPTION	MFGR'S NO.	REF. NO.
RFC1	H 1	9 M.H.			
RFC2	G 7	9 M.H			
RFC3	G 6	2·1 M.H.	2·5 PIES (500 KC)		

TUBES

ITEM	POS	DESCRIPTION	R.E.L. NO.	MFGR'S NO.	REF. NO.
V 1	D 3	1805/P1			
V 2	B 6	879/2X2			

POTENTIOMETERS

ITEM	POS	VALUE	DESCRIPTION	MFGR'S NO.	REF. NO.
P 1	C 7	50000 Ω			
P 2	C 9	250000 "			

TRANSFORMERS

ITEM	POS	DESCRIPTION	MFGR'S NO.	REF. NO.
T 1	A 5	POWER		

SWITCHES

ITEM	POS	DESCRIPTION	MFGR'S NO.	REF. NO.
SW1	J 6	SINGLE POLE EIGHT POSITION		

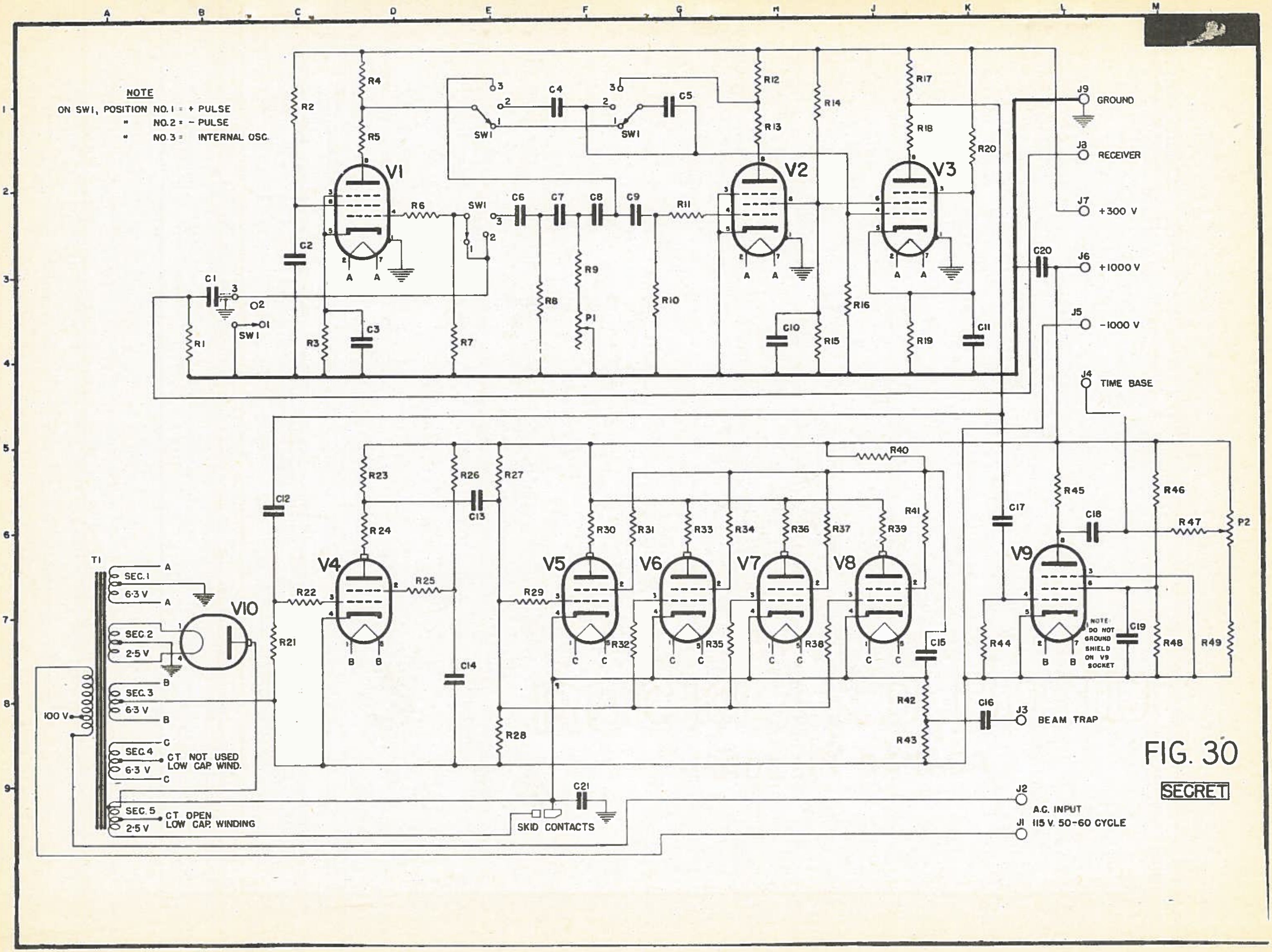


FIG. 30

SECRET

FIG. 30

PARTS LIST

RESISTORS

ITEM	POS	VALUE	DESCRIPTION	MFGR'S NO.	REF. NO.
R 1	B 4	100 OHMS	1 W CARBON		
R 2	C 1	100000 "	1 W		
R 3	C 4	2400 "	·5 W ±2%		
R 4	D 1	82000 "	1 W ±2%		
R 5	D 1	47 "	·5 W CARBON		
R 6	D 2	2700 "	1 W		
R 7	E 4	16000 "	1 W ±2%		
R 8	F 3	16000 "	1 W ±2%		
R 9	F 3	33000 "	1 W ±2%		
R 10	G 3	470000 "	1 W		
R 11	G 2	1 MEG "	1 W		
R 12	H 1	220000 "	1 W		
R 13	H 1	47 "	·5 W CARBON		
R 14	H 1	33000 "	2 W		
R 15	H 4	47000 "	2 W		
R 16	J 3	68000 "	1 W		
R 17	J 1	10000 "	1 W		
R 18	J 1	47 "	·5 W CARBON		
R 19	J 4	4700 "	1 W		
R 20	K 2	47000 "	2 W		
R 21	C 7	47000 "	1 W		
R 22	C 7	470 "	·5 W CARBON		
R 23	D 5	10000 "	100 W W.W.		
R 24	D 6	47 "	·5 W CARBON		
R 25	D 7	100 "	·5 W CARBON		
R 26	E 5	50000 "	50 W W.W.		
R 27	E 5	1 MEG "	1 W		
R 28	E 8	150000 "	1 W		
R 29	E 7	470 "	·6 W CARBON		
R 30	F 6	47 "	·5 W CARBON		
R 31	F 6	100 "	·5 W CARBON		
R 32	F 7	470 "	·5 W CARBON		
R 33	G 6	47 "	·5 W CARBON		
R 34	G 6	100 "	·5 W CARBON		
R 35	G 7	470 "	·5 W CARBON		
R 36	H 6	47 "	·5 W CARBON		
R 37	H 6	100 "	·5 W CARBON		
R 38	H 7	470 "	·5 W CARBON		
R 39	J 6	47 "	·5 W CARBON		
R 40	K 5	120000 "	2 W		
R 41	J 6	100 "	·5 W CARBON		
R 42	J 8	10000 "	20 W W.W.		
R 43	J 8	1000 "	1 W CARBON		
R 44	K 7	220000 "	1 W		
R 45	L 5	110000 "	10 W (5X22000Ω 2W IN SERIES)		
R 46	M 5	220000 "	2 W		
R 47	M 6	1 MEG "	1 W		
R 48	M 7	220000 "	2 W		
R 49	M 8	1 MEG "	1 W		

CONDENSERS

ITEM	POS	VALUE	DESCRIPTION	MFGR'S NO.	REF. NO.
C 1	B 3	·1 MFD	400 V TUBULAR		
C 2	C 3	·5 MFD	400 V CAN		
C 3	D 4	1· MFD	200 V CAN		
C 4	F 1	·01 MFD	1000 V MICA		
C 5	G 1	50 MMFD	500 V MICA		
C 6	E 2	·002 MFD	500 V MICA ±2%		
C 7	E 2	·002 MFD	500 V MICA ±2%		
C 8	F 2	·002 MFD	500 V MICA ±2%		
C 9	F 2	·1 MFD	400 V TUBULAR		
C 10	H 4	1· MFD	400 V CAN		
C 11	K 4	1· MFD	200 V CAN		
C 12	G 5	·01 MFD	2500 V MICA		
C 13	E 6	·01 MFD	2500 V MICA		
C 14	D 6	·01 MFD	2500 V MICA		
C 15	J 7	·01 MFD	2500 V MICA		
C 16	K 9	·01 MFD	2500 V MICA		
C 17	K 6	·001 MFD	2500 V MICA		
C 18	L 6	·01 MFD	2500 V MICA		
C 19	M 7	·1 MFD	800 V TUBULAR		
C 20	L 4	·1 MFD	400 V TUBULAR		
C 21	F 9	·002 MFD	2500 V MICA		

TUBES

ITEM	POS	DESCRIPTION	MFGR'S NO.	REF. NO.
V 1	D 2	1852		
V 2	H 2	6SJ7		
V 3	J 2	1852		
V 4	D 7	807		
V 5	F 7	807		
V 6	G 7	807		
V 7	H 7	807		
V 8	J 7	807		
V 9	L 7	6SK7		
V 10	B 9	866		

CONNECTORS

ITEM	POS	DESCRIPTION	MFGR'S NO.	REF. NO.
J 1	K 9	BANANA PLUG JACK		
J 2	K 8	" " "		
J 3	K 8	" " "		
J 4	L 4	" " "		
J 5	L 3	" " "		
J 6	L 3	" " "		
J 7	L 2	" " "		
J 8	L 2	" " "		
J 9	L 1	" " "		

POTENTIOMETERS

ITEM	POS	VALUE	DESCRIPTION	MFGR'S NO.	REF. NO.
P 1	F 4	50000 Ω			
P 2	M 6	500000 "			

TRANSFORMERS

ITEM	POS	DESCRIPTION	MFGR'S NO.	REF. NO.
T 1	A 8	FILAMENT		

SWITCHES

ITEM	POS	DESCRIPTION	MFGR'S NO.	REF. NO.
SW 1		FOUR POLE THREE POSITION		

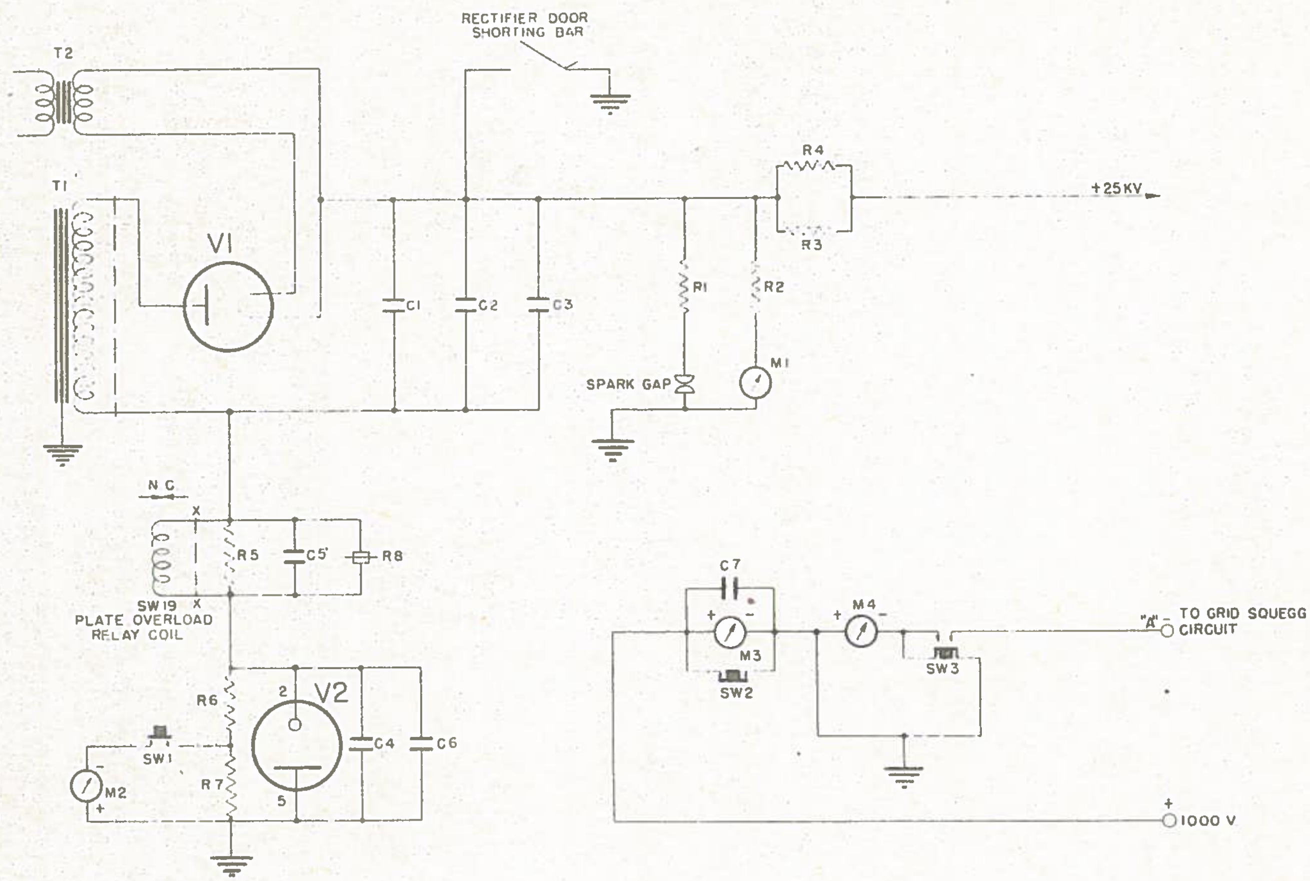


FIG. 31

SECRET

FIG. 31

PARTS LIST

RESISTORS

ITEM	POS.	VALUE	DESCRIPTION	MFGR'S NO.	REF. NO.
R 1	G 4	25,000 OHM	80 W.		
R 2	H 4	10 MEG	50 W.		
R 3	H 3	20,000 OHM	80 W.		
R 4	H 3	20,000 "	80 W.		
R 5	D 6	1000	20 W. W.W.		
R 6	D 7	560	2 W. CARBON		
R 7	D 7		METER SHUNT FOR M2		
R 8	E 6		THYRITE RESISTANCE UNIT		

CONDENSERS

ITEM	POS.	VALUE	DESCRIPTION	MFGR'S NO.	REF. NO.
C 1	E 4	1.0 MFD	25000 V.		
C 2	F 4	1.0 "	25,000 V.		
C 3	F 4	1.0 "	25,000 V.		
C 4	E 7	.0001 "	1,000 V.		
C 5	D 6	2.0 "	1000 V.		
C 6	E 6	4.0 "	1000 V		
C 7	G 6	.1 "	600 V.		

SWITCHES

ITEM	POS.	DESCRIPTION	MFGR'S NO.	REF. NO.
SW 1	D 7	PUSH BUTTON TYPE		
SW 2	H 7	" " "		
SW 3	J 6	" " "		
SW 19	D 6	PLATE OVERLOAD RELAY		

METERS

ITEM	POS.	DESCRIPTION	MFGR'S NO.	REF. NO.
M 1	H 4	0-35 K.V. D.C. VOLTMETER		
M 2	C 7	0-100 M.A. D.C. MILLIAMMETER		
M 3	G 6	25-0-25 M.A. MILLIAMMETER		
M 4	H 6	0-15 K.V. D.C. VOLTMETER		

TRANSFORMERS

ITEM	POS.	DESCRIPTION	MFGR'S NO.	REF. NO.
T 1	C 3	PLATE TRANSFORMER		
T 2	C 2	RECTIFIER FIL. TRANS.		

TUBES

ITEM	POS.	DESCRIPTION	MFGR'S NO.	REF. NO.
V 1	D 4	218		
V [illegible]	E 7	VR 105-30		

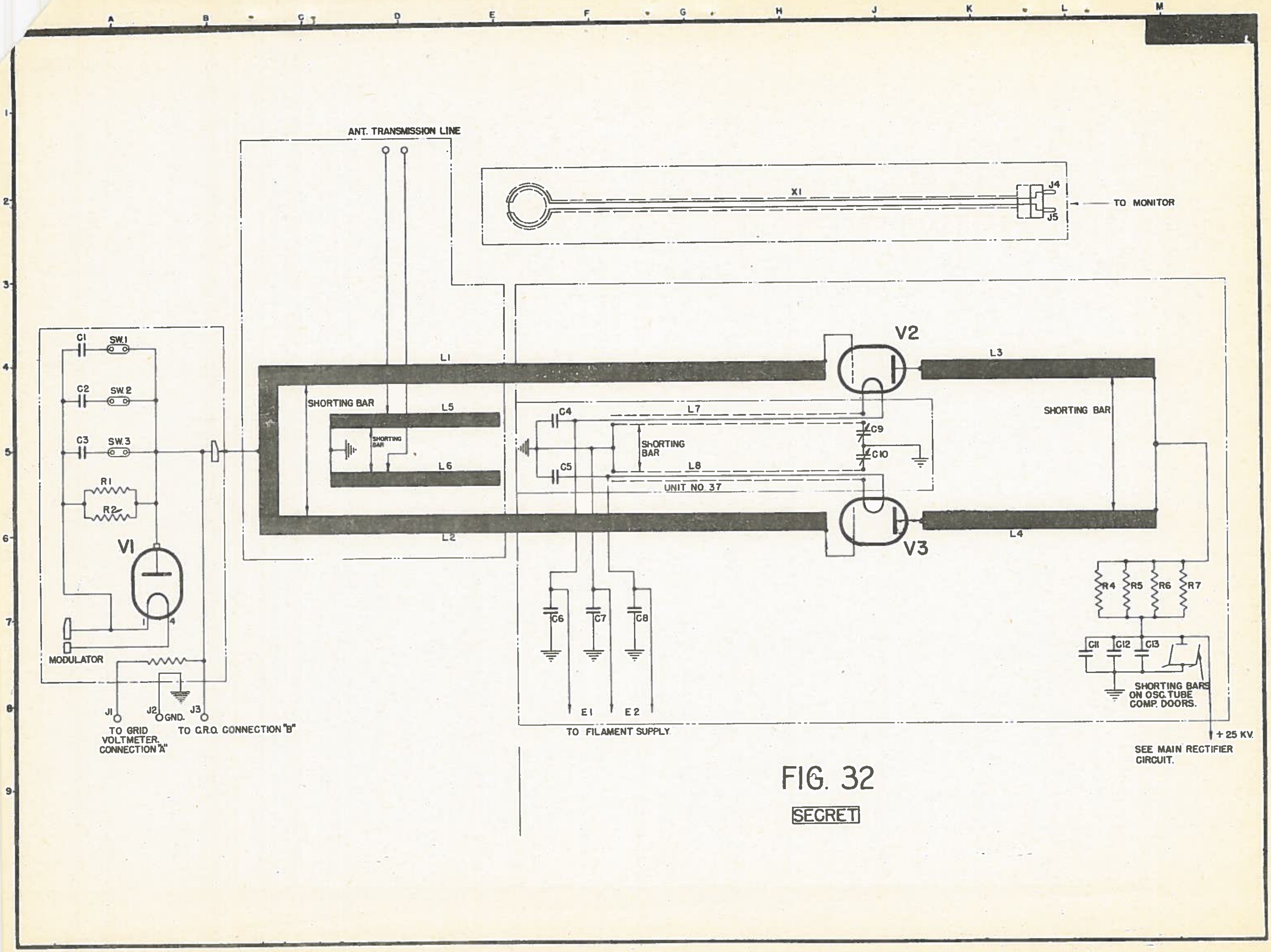


FIG. 32

SECRET

FIG. 32

PARTS LIST

CONDENSERS

ITEM	POS.	VALUE MF.	DESCRIPTION		MFGR'S NO.	REF. NO.
C1	A 4	·005	6000 V.			
C2	A 4	·002	6000 V.			
C3	A 5	·002	6000 V.			
C4	E 4	·0002	2500 V.			
C5	E 5	·0002	2500 V.			
C6	E 7	·004	200 V. ±25%			
C7	F 7	·004	200 V. ±25%			
C8	F 7	·004	200 V. ±25%			
C9	J 5		VARIABLE			
C10	J 5		VARIABLE			
C11	L 8	·0025	25000 V. ±5%			
C12	L 8	·0025	25000 V. ±5%			
C13	L 8	·0025	25000 V. ±5%			

RESISTORS

ITEM	POS.	VALUE Ω	DESCRIPTION		MFGR'S NO.	REF. NO.
R1	A 5	220,000	2·0 W.			
R2	A 5	220,000	2·0 W.			
R3	A 6	10 MEG	1W. TYPE - MG. 6 ±5%			
R4	L 7	200	5 W CARBON			
R5	L 7	200	5 W. CARBON			
R6	M 7	200	5 W. CARBON			
R7	M 7	200	5 W. CARBON			

INDUCTORS

ITEM	POS.	VALUE	DESCRIPTION		MFGR'S NO.	REF. NO.
L1	D 4		GRID LINE			
L2	D 6		GRID LINE			
L3	K 4		PLATE LINE			
L4	K 6		PLATE LINE			
L5	D 5		ANTENNA COUPLER			
L6	D 5		ANTENNA COUPLER			
L7	G 5		FILAMENT LINE			
L8	G 5		FILAMENT LINE			

TUBES

ITEM	POS.	DESCRIPTION	R.E.L. NO.	MFGR'S NO.	REF. NO.
V1	A 7	1616			
V2	J 4	NO. 5			
V3	J 6	NO. 5			

SWITCHES

ITEM	POS.	DESCRIPTION		MFGR'S NO.	REF. NO.
SW. 1	A 4	LINK			
SW. 2	A 4	LINK			
SW. 3	A 5	LINK			

MISCELLANEOUS

ITEM	POS.	DESCRIPTION	R.E.L. NO.	MFGR'S NO.	REF. NO.
X1	H 2	C.R.O. PICKUP BOX & CABLE ASSEMBLY.	1690		

CONNECTORS

ITEM	POS.	DESCRIPTION		MFGR'S NO.	REF. NO.
J1	A 8	BANANA PLUG JACK			
J2	B 8	" " "			
J3	B 8	" " "			
J4 } J5	L 2	DOUBLE PLUG			

[redacted]

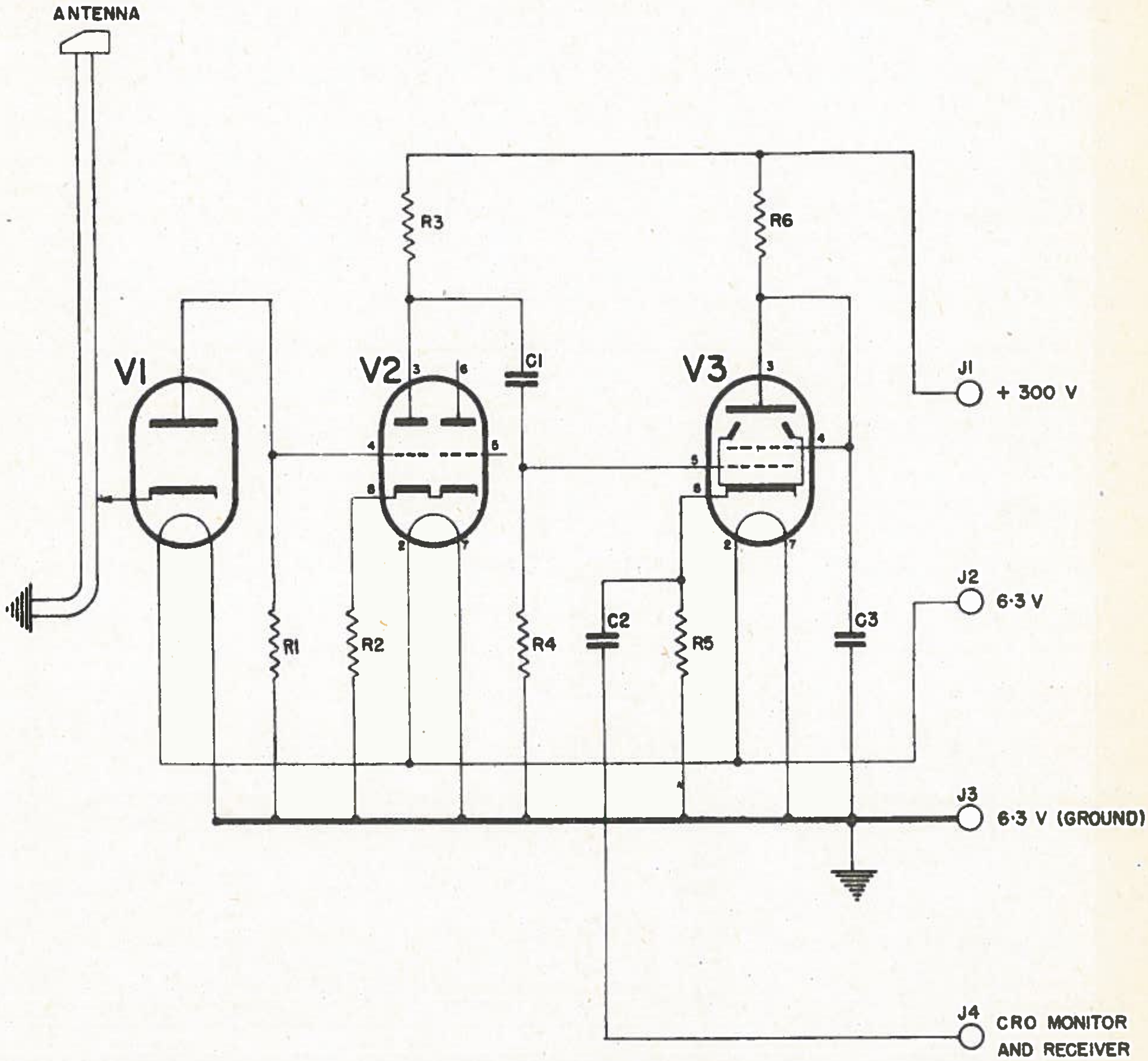


FIG. 34

SECRET

FIG. 34

PARTS LIST

RESISTORS

ITEM	POS	VALUE	DESCRIPTION		MFGR'S NO	REF. NO
R 1	B 6	22000 Ω	1 W ±10 %			
R 2	C 6	470 "	·5 W ±10 %			
R 3	C 3	22000 "	1 W ±10 %			
R 4	D 6	22MEG. "	1 W ±10 %			
R 5	F 6	10000 "	2 W ±10 %			
R 6	F 3	4700 "	1 W ±10 %.			

CONDENSERS

ITEM	POS	VALUE	DESCRIPTION		MFGR'S NO	REF. NO
C 1	D 4	·01 MFD	300 WV MICA ±10 %			
C 2	E 6	·1 "	400 WV TUBULAR			
C 3	G 6	·1 "	400 WV "			

TUBES

ITEM	POS	DESCRIPTION		MFGR'S NO	REF. NO
V 1	B 5	R 6048A			
V 2	D 5	6N7			
V 3	F 5	6L6G			

CONNECTORS

ITEM	POS	DESCRIPTION		MFGR'S NO	REF. NO
J 1	H 4	BANANA PLUG JACKS			
J 2	H 6	" " "			
J 3	H 7	" " "			
J 4	H 8	" " "			