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NRL REPORT 3817

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RANDOM "LOOK-THROUGH"
FOR JAMMING TRANSMITTERS

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NRL REPORT 3817

RANDOM "LOOK-THROUGH" FOR JAMMING TRANSMITTERS

J. R. Williams

June 13, 1951

Approved by:

H. O. Lorenzen, Head, Countermeasures Branch
L. A. Gebhard, Superintendent, Radio Division II



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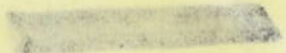
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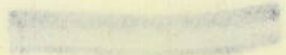
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ABSTRACT

"Look-through" methods as used in countermeasures transmitters have been investigated to find a means of improving the operation of the transmitter and to reduce the time required to obtain satisfactory "look-through." The ideal system would include look-through simultaneously with the jamming. Because of the wide frequency range which modern countermeasures transmitters are required to cover, such systems would require almost constant adjustment by an operator.

Time-sharing "look-through" was investigated and it was found possible to cut off a 1-kw magnetron by electronic means. A system has been developed for the generation of randomly tuned pulses to give look-through at a random rate, making it difficult for the enemy to evade being jammed by deliberate synchronization of the radar pulse repetition frequency (PRF) with the look-through period of the jammer. Such a system has the advantage that it is not limited to a particular radio-frequency range.

PROBLEM STATUS

This is an interim report; work on this problem is continuing.

AUTHORIZATION

NRL Problem R06-21R
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**RANDOM "LOOK-THROUGH"
FOR JAMMING TRANSMITTERS**

INTRODUCTION

In the microwave field there exists a general need for simplification and improvement in jamming system operation. Information concerning the victim signal during jamming is of particular importance. As part of a countermeasure system, a receiver is used to monitor a victim signal while a jamming transmitter in close proximity is radiating energy on the same frequency. Leakage of jamming energy from the transmitting antenna to the receiving antenna usually prevents the victim signal from being observed, and some means is required to overcome this effect. The purpose of this investigation was to explore the possibilities of devising a system which will enable "look-through" to be achieved with a 1-kw magnetron jamming transmitter.

LIMITATIONS OF PRESENT LOOK-THROUGH SYSTEMS

"Look-through" is the process whereby information concerning an intercepted signal is obtained during a jamming period. The ideal system would include look-through information continuously available to an operator simultaneously with the jamming.

During the jamming phase of the operation, the signals picked up by the monitoring receiver antenna include the intercepted signal and that part of the jamming energy which is picked up by stray leakage between the transmitting antenna and the receiving antenna. It would be desirable to have sufficient attenuation between these antennas to reduce the stray pickup to a negligible value, but when it is considered that one kilowatt of energy is being radiated on the same frequency to which a receiver having a sensitivity of the order of microvolts is set, the difficulties become apparent. Under these conditions, an attenuation approaching 150 db is required, whereas the best figure attained practically so far is of the order of 60 to 70 db. The cancellation of the undesired signal has been one approach to overcome this deficiency. A small amount of the jamming signal is extracted from the outgoing transmission line, and fed into the receiver line with the signals from the monitor antenna consisting of jamming plus intercepted signal. By controlling the amplitude and phase of this injected signal, an attempt is made to cancel out the portion of jamming entering through the receiving antenna and leave only the intercepted victim signal.

An early search-and-jam system, the MBE, used a video balance system requiring two i-f systems and video amplifiers having identical frequency and phase characteristics. This system also required high attenuation between transmitting and receiving antennas and good shielding between the transmitter and the receiver.

The X-MBT search-and-jam system employed look-through with balancing at radio frequency instead of video frequency, based also upon high attenuation between the transmitting and monitoring antenna and good shielding between the transmitter and the receiver.

This shielding is essential in a balance system since jamming energy which enters the receiver by paths other than the input transmission line cannot be cancelled out.

In an r-f balance scheme where energy is made to divide equally into two paths and later recombined, a two-leg bridge network is formed. The ultimate objective is to have the two signals combine 180 degrees out of phase and cancel each other regardless of the center frequency or modulation impressed on the original carrier. For the simplest case where cw is used and the frequency is held constant, balance is obtained if the energy in one leg at the combining point is 180 degrees out of phase with the energy in the other leg. In using such a system the following operational difficulties are encountered.

- (a) The system is extremely difficult to balance, and even under laboratory conditions requires the continuous attention of one operator to maintain this balance.
- (b) Under ideal practical conditions with modulation applied, the balance null width obtained is not wide enough to show the entire spectrum of the jammed signal.
- (c) The system could not cope with an enemy signal source employing frequency shift.
- (d) The inevitable sea return, reflections from superstructure, and swaying of masts aboard ships would probably cause the phase and magnitude of the leakage signal to vary in an unpredictable manner and make it even more difficult to balance it out by a constant signal through the balance path than under better-controlled laboratory conditions.

TIME-SHARING LOOK-THROUGH

Because of the critical and delicate balance required for satisfactory operation of look-through simultaneously with jamming, investigation was turned to time-sharing look-through for possible applications over wide frequency ranges. In a system with intermittent look-through, the length of time the jammer is off and the frequency with which this occurs are important. Tests indicate a period of two hundredths of a second to be about the optimum length for the look-through pulse. This is determined to a large extent by the type of victim signal being jammed. Therefore, it is desirable that the look-through period be variable in length, thereby enabling optimum look-through periods to be used.

The automatic airborne jamming system currently under development at the Naval Research Laboratory employs a time-sharing look-through which de-energizes the transmitter at regular intervals, thus allowing the monitoring system a view of the intercepted signal. In this system the interval between look-through pulses may be preset over a range of 1 to 20 seconds, and the frequency of look-through is regular at the chosen value. This method, although not continuous, does have the advantage of not being operationally dependent upon frequency. It is this basic form of look-through which has been selected for application to a 1-kw magnetron jammer system utilizing visual presentation and with random occurrence of look-through intervals for added protection against evasion.

Intermittent operation for transmitters employing low power can be achieved by manually switching the plate supply on and off. This scheme, however, does not lend itself to equipments in the power range of one kilowatt or more, nor can the look-through interval be made of short duration.

A better method of achieving oscillator cut-off is to reduce the voltage across the magnetron electronically to a value below that at which oscillation ceases. Figure 1 shows a VI curve of a typical magnetron having a fixed field. From this it can be seen that by

applying a large enough pulse in the plate circuit of the magnetron it is possible to cut it off and thereby eliminate the r-f voltage. This same method will not work with a magnetron which uses an electromagnetic field that is in series with the magnetron, because the regulation effect of the field permits oscillations to continue down to low values of plate voltage.

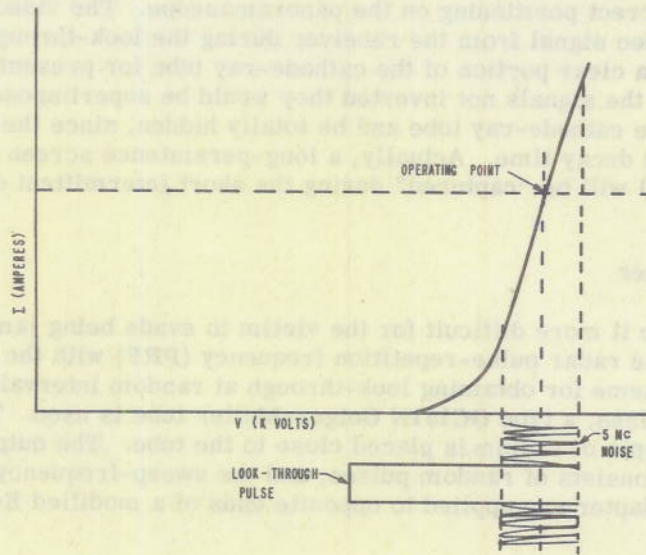


Figure 1 - VI Curve of magnetron

This form of oscillator cut-off may best be achieved by employing a series modulating tube which is utilized for both modulation and look-through purposes. Figure 2 shows a block diagram of the monitoring and jamming system employing random look-through. The modulator receives two inputs, one the noise for modulation purposes and the second a random pulse for intermittent operation.

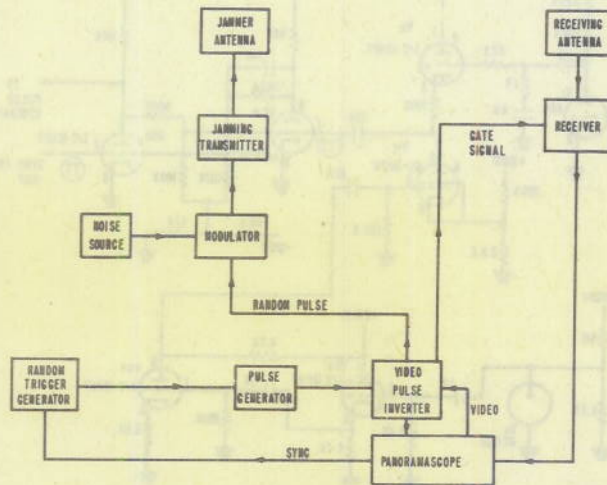


Figure 2 - Jamming system with random time-sharing look-through

The random pulse is initiated in the random trigger generator. In order to present the look-through on the panoramascope, some form of synchronization is necessary. A synchronizing pulse (sync) is therefore taken from the panoramascope and utilized to generate the random trigger in conjunction with a random pulse derived from a Geiger-Muller tube. A pulse generator having variable delay and width control is used to obtain optimum look-through width and correct positioning on the panoramascope. The video pulse inverter is used to invert the video signal from the receiver during the look-through interval. This is done in order to use a clear portion of the cathode-ray tube for presentation of the intercepted signal. Were the signals not inverted they would be superimposed upon the residual jamming signal on the cathode-ray tube and be totally hidden, since the cathode-ray tube does not have a rapid decay time. Actually, a long-persistence screen is used in order that the intercepted signal will be "captured" during the short intermittent operating interval.

Random-Pulse Trigger

In order to make it more difficult for the victim to evade being jammed by deliberate synchronization of the radar pulse-repetition frequency (PRF) with the look-through period of the jammer, a scheme for obtaining look-through at random intervals is used. For a source of random pulses, a type GC151N Geiger-Muller tube is used. To insure firing of the tube a small sample of radium is placed close to the tube. The output of the Geiger-Muller tube, which consists of random pulses, and the sweep-frequency voltage obtained from a panoramic adapter are applied to opposite ends of a modified Eccles-Jordan switching circuit.

Figure 3 is a circuit diagram of the random-pulse trigger. The Geiger-Muller tube delivers a negative pulse to the grid of V_{5a} . This tube is used as a cathode follower and the following triode, which is in the same envelope, is used to give a positive polarity pulse to the grid of V_3 , a thyratron.

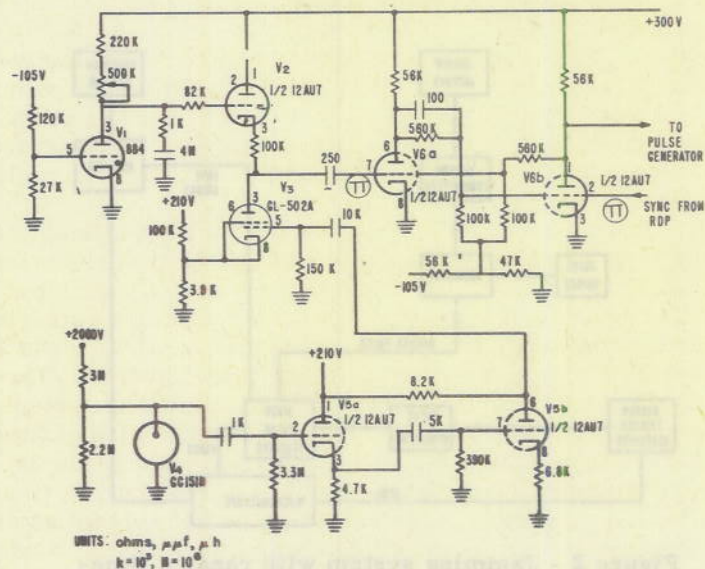


Figure 3 - Random-pulse trigger

A low frequency is generated by V_1 , a thyratron, acting as a saw-tooth generator. The saw-tooth voltage from the plate of V_1 is impressed on the plate of V_3 , another thyratron, through the cathode-follower tube V_2 . With this arrangement, V_3 can fire during the buildup time of V_1 without affecting the frequency of V_1 . V_3 will fire when its plate voltage has risen to some minimum potential above ground, and when a large enough voltage peak arrives at the grid to fire the tube at this plate potential. The voltage impressed on the grid of tube V_3 consists of pulses which are generated by the Geiger-Muller tube. These occur at random time intervals. Tube V_3 can be fired only once during each sweep of the saw-tooth voltage from V_1 because V_3 , after firing, continues in conduction until V_1 fires and discharges the supply voltage on the anode of V_3 . The cathode of V_3 is operated at a fixed voltage above ground to insure that conduction through V_3 will stop completely and the tube will de-ionize when V_1 fires and discharges its plate condenser. The time of firing of V_3 is determined by the gain in the amplifier V_{5b} , which controls the amplitude of the pulses impressed on the grid of V_3 .

The anode voltage from V_3 and the sweep-frequency voltage, which is obtained from an RDP panoramic adapter, are applied to opposite sides of a modified Eccles-Jordan switching circuit. Tube V_{6a} is in conduction almost all the time, and the voltage drop across its plate resistor is enough to hold V_{6b} at cut-off when the drop is applied to the grid of V_{6b} through the voltage-divider resistors. When a negative pulse is applied at the grid of V_{6a} , which occurs when V_3 fires, V_{6a} is cut off and V_{6b} immediately begins to conduct, the drop in its plate voltage holding V_{6a} cut-off. The next negative pulse at the grid of V_{6b} reverses the action. Pulses are applied at the grid of V_{6b} at the panoramic sweep-frequency rate, approximately 30 per second, while pulses are applied at the grid of V_{6a} at the look-through frequency, which is of the order of one per second. However, only those sweep-frequency pulses which immediately follow look-through pulses will have any effect because this is the only time V_{6b} is conducting, the tube being cut off at all other times. The resulting form of the plate voltage of V_{6b} will be a random rectangular wave of varying position and width, the leading edge coinciding with a look-through pulse and the lagging edge coinciding with the next sweep-frequency pulse.

Pulse Generator

The output from the plate of V_{6b} is applied to the input of the pulse generator, which accepts only positive pulses. Consequently, when a differentiating RC combination is used, only the sweep pulses immediately following the look-through pulses pass and the gate position is thus synchronized with the sweep of the panoramascope, although the number of sweeps of the panoramascope passed through without the look-through signal is still random.

The random rectangular wave from the pulse-trigger network is used to trigger the pulse generator. The pulse generator consists of two multivibrators used to generate a gate of variable width and delay. The variable width and delay make possible the positioning of the gate anywhere on the panoramascope as well as controlling the gate width. In the pulse generator, Figure 4, the pulse-delay multivibrator consisting of V_{11a} and V_{11b} , and the gate-length multivibrator of V_{12a} and V_{12b} , are practically identical. The triodes V_{11b} and V_{12b} are normally conducting because the grid is at the cathode potential, while the alternate triodes, V_{11a} and V_{12a} are beyond cut-off, the grids being grounded but the cathode being at some relatively high positive potential. A positive pulse at the input brings the alternate triodes into conduction, this action being cumulative, until V_{11b} and V_{12b} are entirely cut off and the alternate triodes conduct an amount of current as determined by the cathode- and plate-load resistances. When the charge on the coupling condenser in the multivibrator has leaked off sufficiently, V_{11b} and V_{12b} begin to conduct again, cutting off the alternate triodes. The RC combination between the two circuits act as a differentiating device. The negative pulse resulting from the leading edge will not trigger the gate-length

multivibrator, but the positive pulse associated with the trailing edge of the multivibrator waveform of the previous stage will trigger it. Therefore, controlling the width of the waveform of the first multivibrator controls the delay, while controlling the width of the waveform of the second multivibrator controls the gate width. A $0.0015 \mu f$ condenser is used from the plate of the first triode to ground to dampen the sharp spur on the waveform at the point of beginning conduction. Without this condenser the rapid fall of the spur creates enough negative signal to trigger the next tube.

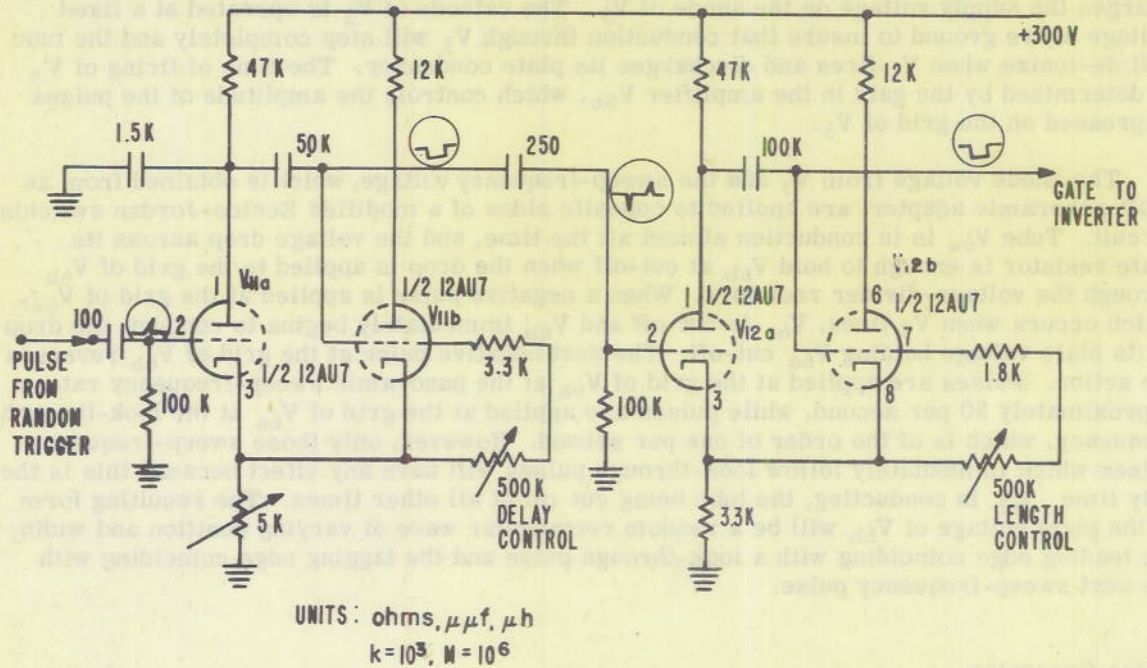


Figure 4 - Pulse generator

Video Pulse Inverter

The video pulse inverter consists of a push-pull amplifier for driving the vertical plates of a cathode-ray tube and associated amplifiers for gating each half of this amplifier alternately on and off. Incoming detected signals are fed to the input grids of both halves of the push-pull amplifier in parallel. During normal intercept of a signal, only the amplifier driving the plate which gives upward deflection is on. When the look-through interval occurs, this amplifier is turned off and the amplifier driving the plate which gives downward deflection is turned on. The intercept of a signal with no look-through will therefore be presented in an upward direction as will also be the noise from the jamming transmitter if it is on. When the look-through gate is applied to the transmitter, the noise is removed. At the same time the amplifier giving downward deflection is turned on by means of a gating pulse, allowing a clear presentation of the intercepted signal.

Figure 5 is a diagram of the video pulse inverter. The output from the pulse generator is used as the gating voltage. It is necessary in this circuit to shape the gate into a square waveform. This is accomplished mainly by V_{21a} although the two halves of the diode V_{22a}

and V_{22b} also improve the waveform while acting as clamping devices. The grid of V_{21a} is normally at cathode potential. When the high-amplitude gate signal of negative polarity arrives, the grid is driven beyond cut-off, thus squaring the top. When the trailing edge of the pulse arrives, the grid is driven positive, clipping the transient spike. This gate signal is passed on to the grids of V_{23a} and V_{23b} through the large time-constant RC combinations, with V_{22a} and V_{22b} clamping the reference voltage. All negative voltages are shunted through the diode, so that the zero gate signal level is held at ground potential. The action of V_{23b} is similar except that the gate signal has the opposite polarity and the cathode of the diode is held at a positive potential giving a zero gate signal level of approximately 1.9 volts.

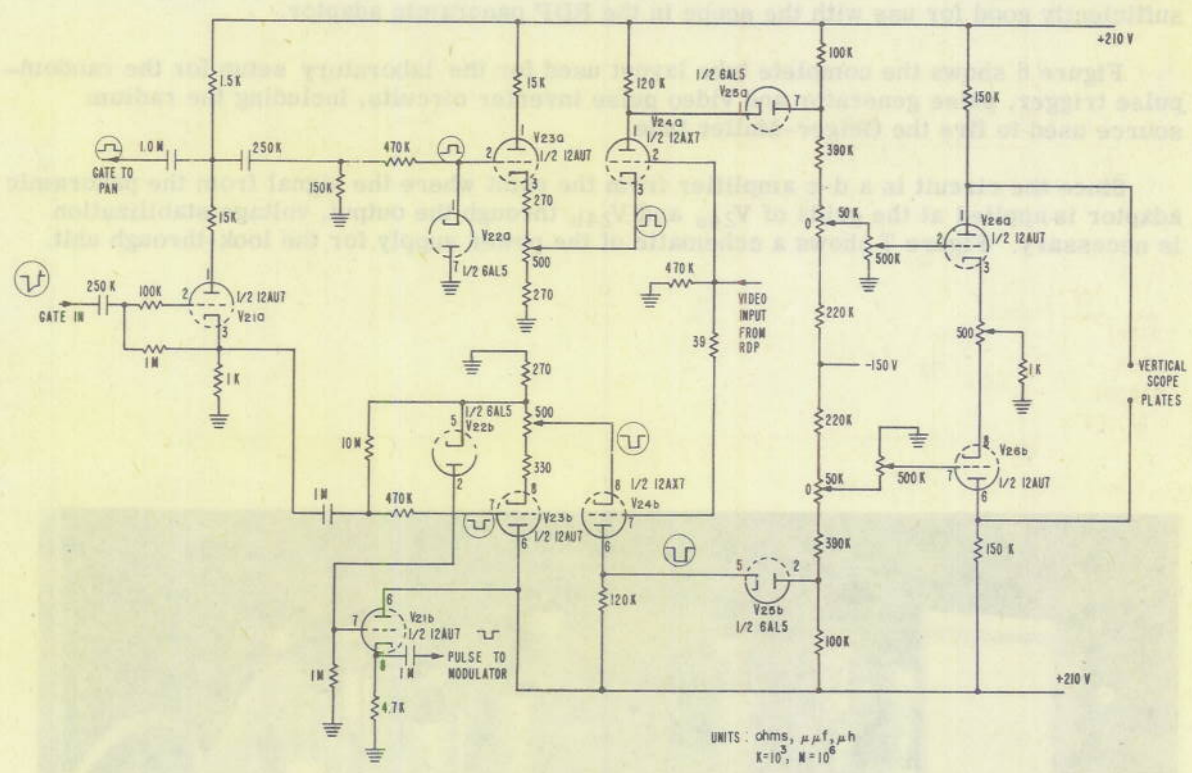


Figure 5 - Video pulse inverter

With these reference levels, V_{23b} conducts a considerable amount, approximately 7.6 ma, while V_{23a} conducts only 5.2 ma. Under these conditions V_{24a} is at the verge of conduction, the cathode to grid potential being approximately 2.5 volts, while V_{24b} is far beyond cut-off, the bias being approximately 5.8 volts. The gate signal then raises the grid of V_{23a} to give considerable conduction so that V_{24a} is completely cut off, while the converse occurs with V_{23b} and V_{24b} , the cathode potential imposed upon V_{24b} dropping to 2.5 volts so that the signals at the grid of V_{24b} can be amplified.

Detected output, which includes both the intercepted and the jamming signals from the panoramascope, is fed to the grids of V_{24a} and V_{24b} . Output signals are taken from the plates of V_{24a} and V_{24b} and fed into the grids of V_{26a} and V_{26b} through base line adjustment potentiometers. The base line potentiometers are so set that at zero signal the d-c potential at the movable contact will be zero. This permits the use of a gain control following this point, because any change in the setting of the gain potentiometer will

then have no effect on the position of the base line, both ends of the potentiometer being at zero potential. Diodes V_{25a} and V_{25b} keep the preceding tubes ineffective until the plate current reaches approximately a third of a milliamper. At this point the diodes begin to conduct and the signal is passed on to V_{26a} and V_{26b} .

The common cathode resistor between V_{26a} and V_{26b} furnishes a signal coupling between these triode sections. This vertical centering control, which serves also as cathode resistor of V_{26a} and V_{26b} , acts to shift part of the load current from one triode to the other, which causes a change of the potential gradient between the vertical plates of the scope. Although this coupling is somewhat degenerative, the resulting inverting action is sufficiently good for use with the scope in the RDP panoramic adaptor.

Figure 6 shows the complete tube layout used for the laboratory setup for the random-pulse trigger, pulse generator and video pulse inverter circuits, including the radium source used to fire the Geiger-Muller tube.

Since the circuit is a d-c amplifier from the point where the signal from the panoramic adaptor is applied at the grids of V_{24a} and V_{24b} through the output, voltage stabilization is necessary. Figure 7 shows a schematic of the power supply for the look-through unit.

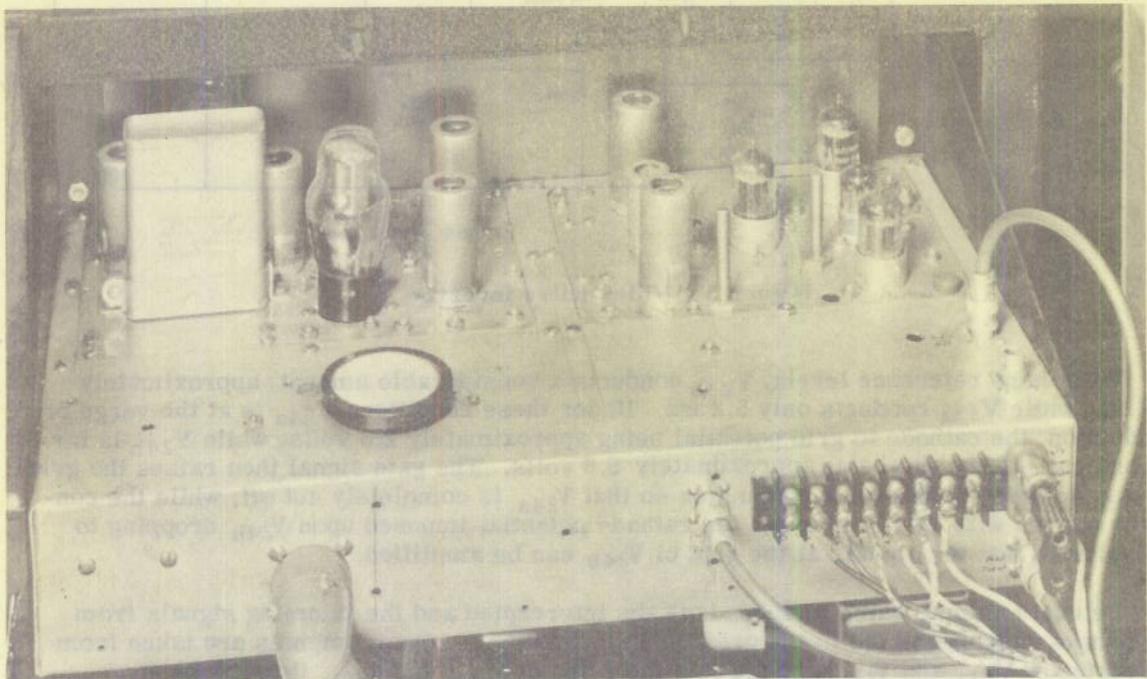


Figure 6 - Random look-through unit

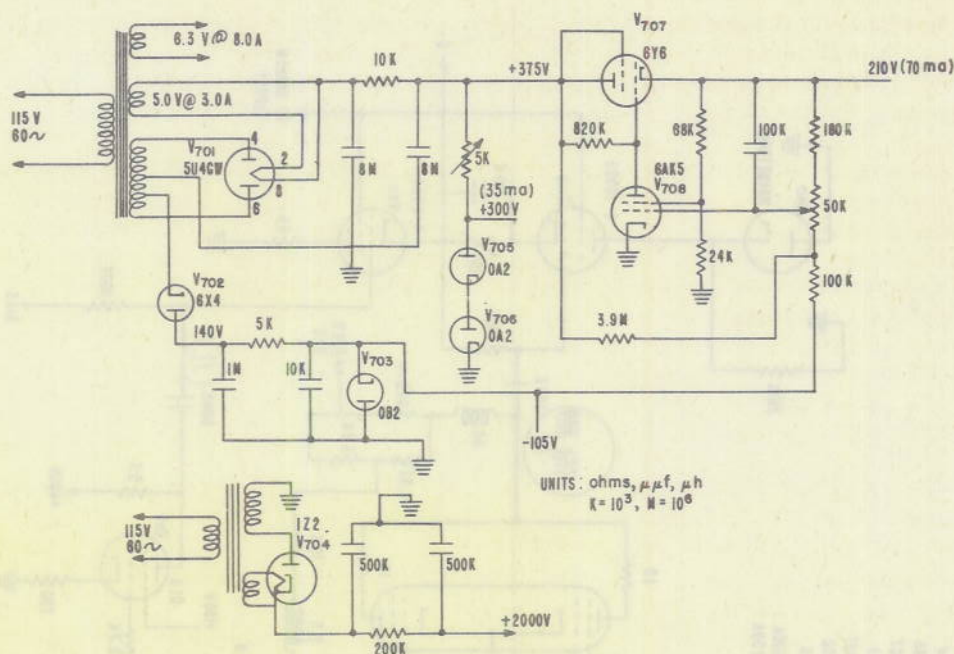


Figure 7 - Power supply for the look-through unit

Modulator

Figure 8 is a diagram of the noise generator, amplifiers, and modulator used with the random look-through system to drive the magnetron oscillator. Series modulation rather than the shunt type normally applied at this power level is used because it simplified coupling between the modulator plates and the magnetron. In order to obtain wide bandwidth of modulation from this system it is necessary to keep the lead from the plate of the series-modulator tube to the magnetron as short as possible and thereby keep the capacity loading on the magnetron down. Consequently, for best operation the series-modulator tube should be located close to the magnetron. By using this type of modulation, which is a current control rather than a voltage control, it is possible to cut off the series modulator tube, and thus the magnetron, with much less voltage than would be required to cut off the magnetron directly for the purpose of look-through.

Figure 9 shows the schematic of the power supply used with the modulator. Because of the extreme power drain on the power supplies due to the long pulses being applied to the d-c amplifier, a well regulated supply is used.

Figure 10 shows the rear view of the pulser, modulator, and power supplies used in the laboratory test setup. The complete unit was assembled in a six-foot test rack as shown in the figure. This unit does not represent a typical layout nor does it follow all Navy specifications. The pulser-inverter circuits are all grouped together in the upper chassis with their power supply in the unit below. Included on this chassis is the 2000-volt supply. The chassis in the center of the rack contains the modulator and noise circuits with their power supply in the unit below. The lower chassis contains the filament back-heating control necessary for the operation of the 5607 magnetron.

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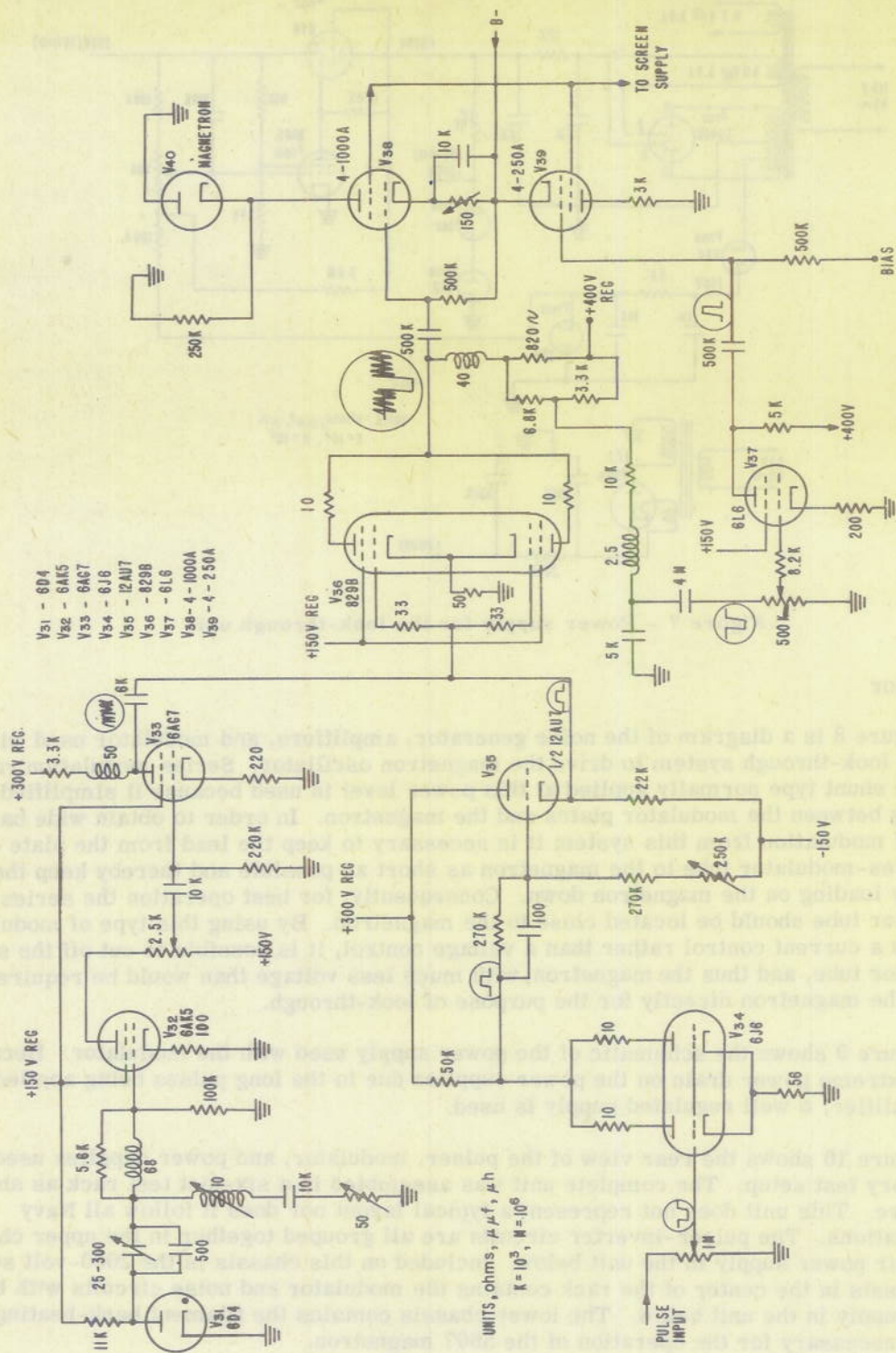


Figure 8 - Modulator

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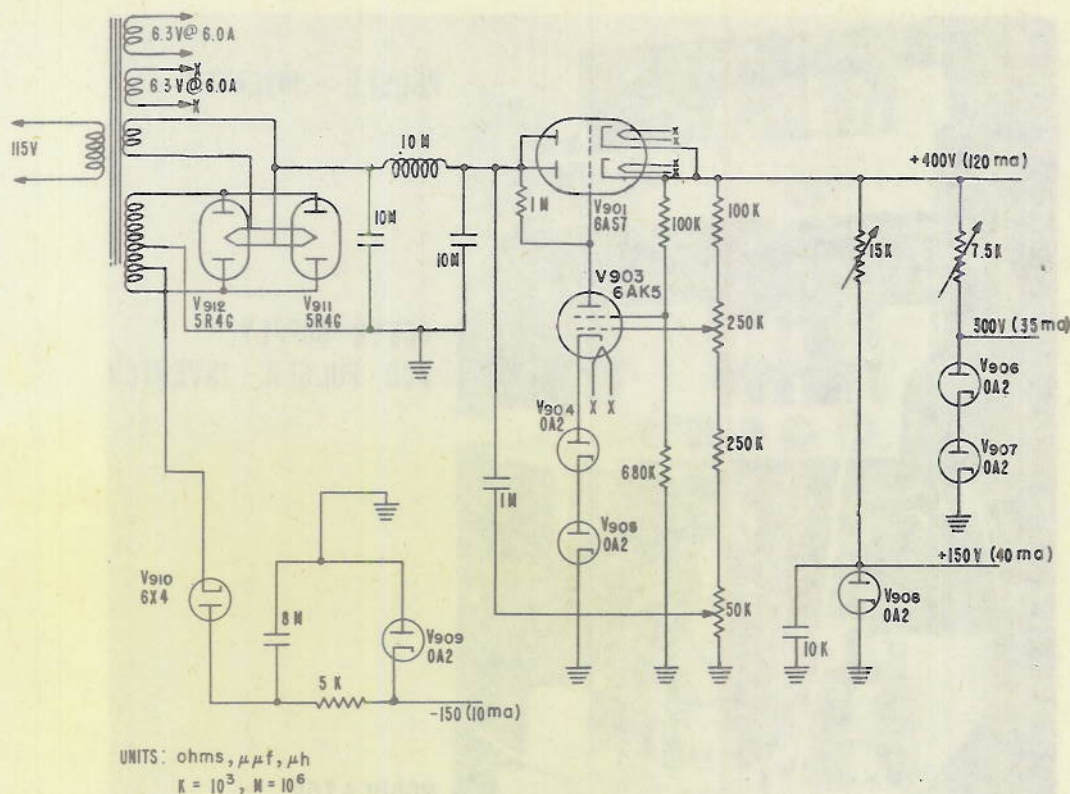


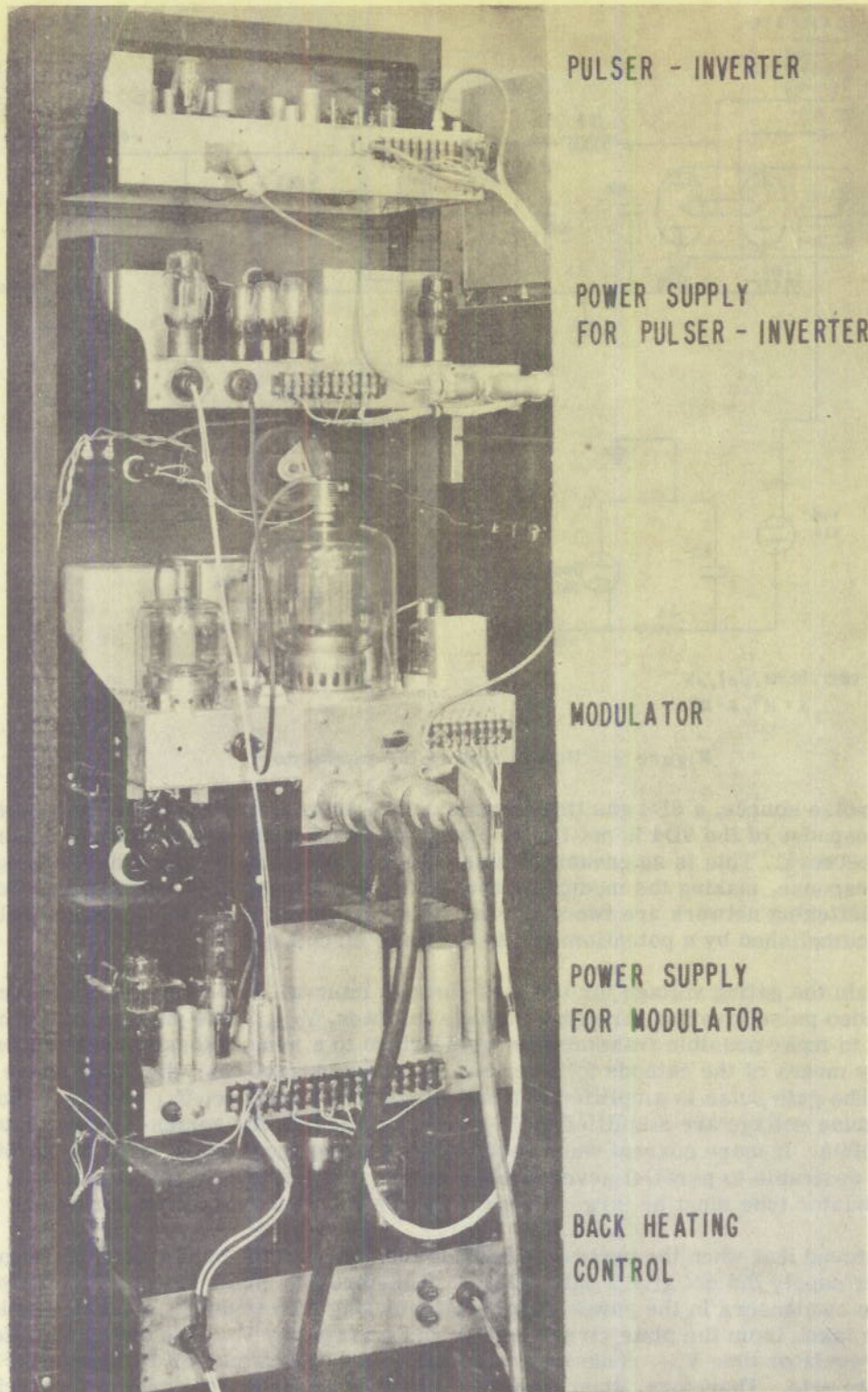
Figure 9 - Power supply for modulator

For a noise source, a 6D4 gas thyratron in a 370-gauss field is used as the generator. Since the response of the 6D4 is not flat to 5 Mc, spectrum flattening circuits are used in the output network. This is an advantage since the following stages may then be designed for a flat response, making the modulator available for other types of modulation. Following the noise-flattening network are two stages of video amplification. Amplitude control of the noise is accomplished by a potentiometer in the plate circuit of V_{32} .

To obtain the gating voltage for the look-through interval, a random pulse is taken from the video pulse inverter through a cathode follower, V_{21b} . The purpose of the cathode follower is to make possible transmission of the video to a remote location without deterioration. By means of the cathode follower and a low-impedance line, the pulse shape can be retained. The gate pulse is amplified in a two-stage, d-c amplifier, V_{34} and V_{35} . Both the noise and pulse voltage are amplified by V_{36} and passed on to the series-modulator tube, V_{38} , a 4-1000A. If more current were required by a magnetron than is used by the 5607, it would be desirable to parallel several tubes rather than using a larger single tube. The series modulator tube must be large enough to handle the total magnetron current.

It was found that when the series modulation tube was cut off by the gate, the regulation of the power supply did not give a satisfactory look-through pulse shape. To eliminate the use of large condensers in the power supply, a regulating tube is used. A small portion of the pulse is taken from the plate circuit of V_{36} and inverted by V_{37} , the output of which is applied to regulator tube V_{39} . This tube is normally held below cut-off by a negative bias applied to its grid. Therefore, when a negative pulse is applied to the grid of the series-modulator tube, a positive pulse is applied to the grid of the regulator tube, which then conducts, thus holding the load on the power supply fairly constant.

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PULSER - INVERTER

POWER SUPPLY
FOR PULSER - INVERTER

MODULATOR

POWER SUPPLY
FOR MODULATOR

BACK HEATING
CONTROL

Figure 10 - Modulator and pulse circuits

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Separate screen and bias supplies for the series modulator tube and regulator tube are required. These are shown in Figure 11. Since all the elements of the final stage of the modulator are at high potential below ground, these supplies are isolated from ground. The insulation of the transformers must be sufficient to withstand a test voltage of 12,000 volts or an isolation transformer must be used as shown in Figure 10.

Figure 12 shows the laboratory test setup of the 5607 magnetron and water load used for the look-through tests. The load contains a low-loss glass tube (not shown) that slants across the waveguide from the center of one broad side to the center of the other. This tube is slanted so that the load provides excellent impedance matching and reasonably uniform power dissipation along the length of the water column within the tube. An open-flow system using an elevated, continuously overflowing tank is used to maintain a constant pressure head on the stream flowing through the water load.

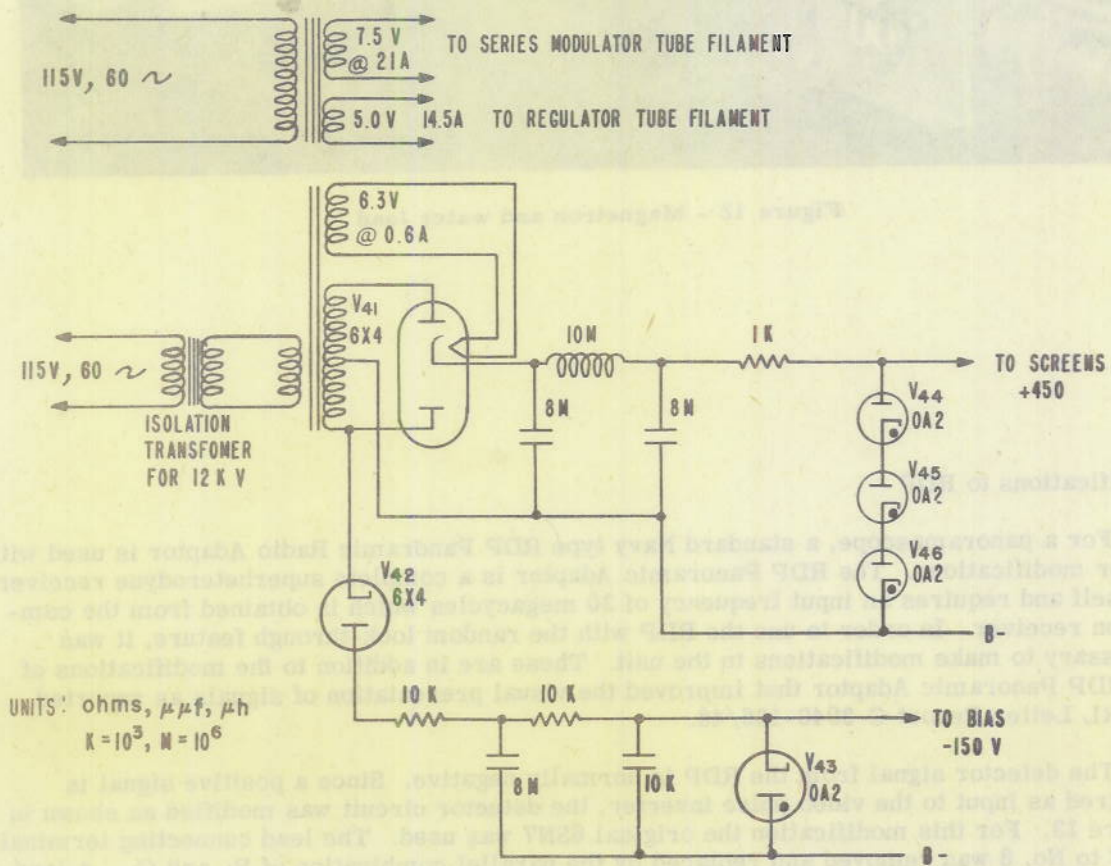


Figure 11 - Screen and bias supply

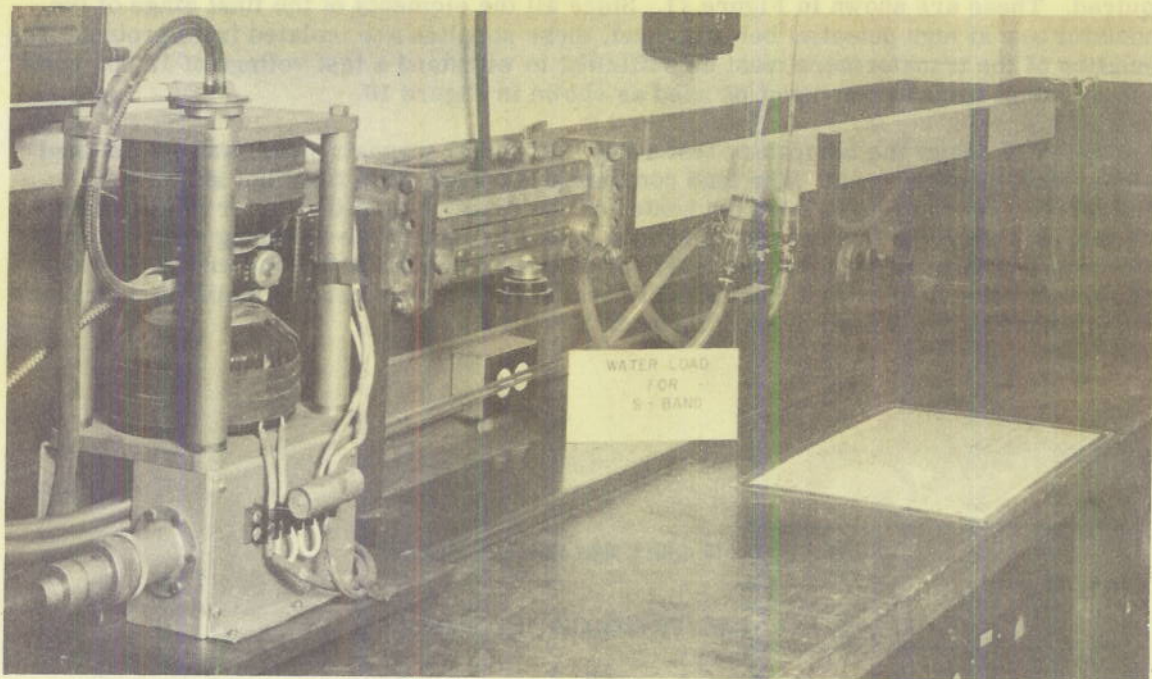


Figure 12 - Magnetron and water load

Modifications to RDP

For a panoramascope, a standard Navy type RDP Panoramic Radio Adaptor is used with minor modifications. The RDP Panoramic Adaptor is a complete superheterodyne receiver in itself and requires an input frequency of 30 megacycles which is obtained from the companion receiver. In order to use the RDP with the random look-through feature, it was necessary to make modifications to the unit. These are in addition to the modifications of the RDP Panoramic Adaptor that improved the visual presentation of signals as reported in NRL Letter Report C-3940-136/48.

The detector signal from the RDP is normally negative. Since a positive signal is required as input to the video pulse inverter, the detector circuit was modified as shown in Figure 13. For this modification the original 6SN7 was used. The lead connecting terminal No. 3 to No. 8 was removed and replaced by the parallel combination of R_1 and C_1 . A lead was taken from terminal No. 3 to a jack in the back of the chassis so that the detector output could be fed to the video pulse inverter circuit. Also a lead was run from terminal No. 4 of Z104-09 to terminal No. 6 of V106. Terminals No. 4 and No. 5 were connected together and a lead run to R123 and C107.

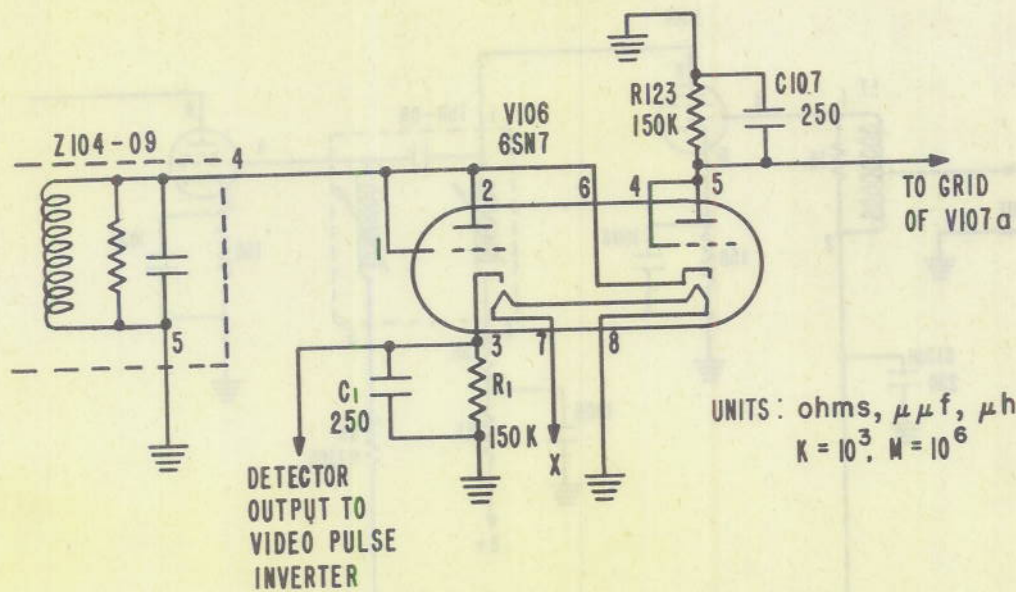


Figure 13 - Detector modifications to RDP for random look-through

Synchronization voltage was obtained from terminal No. 1 of T105 of the RDP through a 0.001 μ f condenser. R156 was removed, and the connection left open. The vertical plates of the panoramascope were brought out to jacks on the rear of the unit.

In order to be able to reduce the sensitivity of the RDP during the time the jammer is on, and still be able to see the intercepted signal during look-through, the input circuit of the RDP was further modified to accept a gate pulse from the video pulse inverter. Figure 14 shows the circuit which was used.

The gain of the RDP is manually set to obtain the desired gain. During intercept without jamming the gain can be set high. When noise from the jammer is being received the gain can be reduced. During the look-through period a positive pulse is applied, thereby cancelling the bias and bringing the RDP unit to its original sensitivity.

The RDP cathode-ray tube, which in the original units was a 5CP1, was replaced by a long-persistence tube, a 5CP7. In order to obtain the high persistence it was necessary to supply a 2000-volt positive potential to the intensifier anode from an external source.

In order to use the 5CP7 cathode-ray tube for a dual-persistence display with the victim signal presented with long persistence while the jamming signal is presented with short persistence, it was necessary to use an optical filter. Since the initial flash for a P7 phosphor is blue and the persistence is yellow, a two-persistence effect is accomplished by using a filter, which will pass only the blue light over half of the cathode-ray tube face, thus cutting out the persistence. The jamming signal is then presented in this half of the scope face, and the look-through signal in the other half. Glass filters were tried and worked satisfactorily, but because of the danger of breakage plastic filters were finally used. For the upper half of the scope, a blue sheet of Plexiglas is used and for the lower half, a yellow sheet of Plexiglas.

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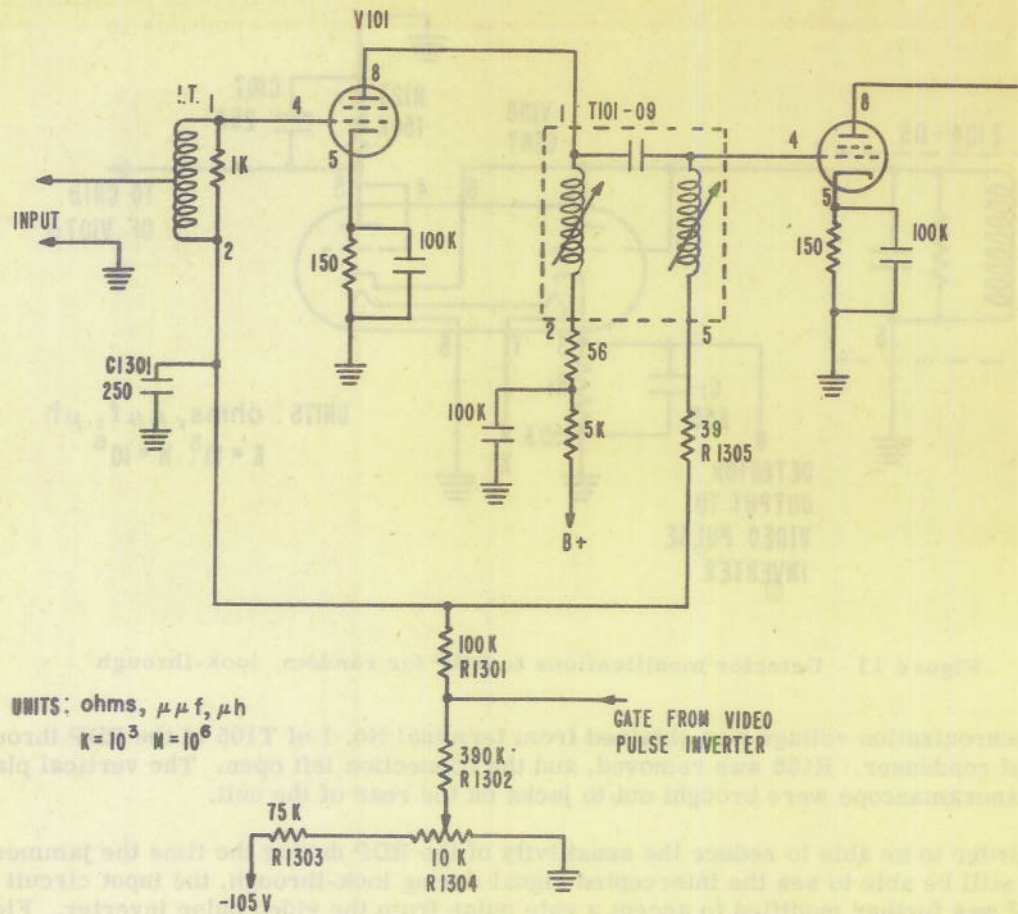


Figure 14 - Gating modifications to RDP

Figure 15 shows the type of presentation obtained on the modified RDP. The sweep interval presented by the long trace is 1/30 sec and the look-through interval is 1/100 sec. The noise-modulated output of the 5607 magnetron is displayed on the upper half of the scope while the intercepted signal is displayed on the lower half of the scope. If no look-through were present in the system only the jammer output above the sweepline would be obtained and there would be no means of seeing the intercepted signal since it would be completely covered up by the jammer spectrum. Therefore, by inverting the intercepted signal it is possible to see both the jammer spectrum and the intercepted signal. With this presentation it is possible to adjust the jammer for optimum conditions such as frequency and spectrum.

Figure 16 shows the complete random look-through system minus the magnetron. Since this is a laboratory setup, a six-foot rack was used to mount the modulator, random pulse circuits, and power supply. The high-voltage power supply is a large laboratory unit used in making the look-through tests, and is much larger than would be necessary for any

military application were the unit to be built into a complete system rather than a laboratory test setup. The modified RDP with the two-color filter on its scope face is located on top of the high-voltage power supply with the SPR-2 intercept receiver alongside it.

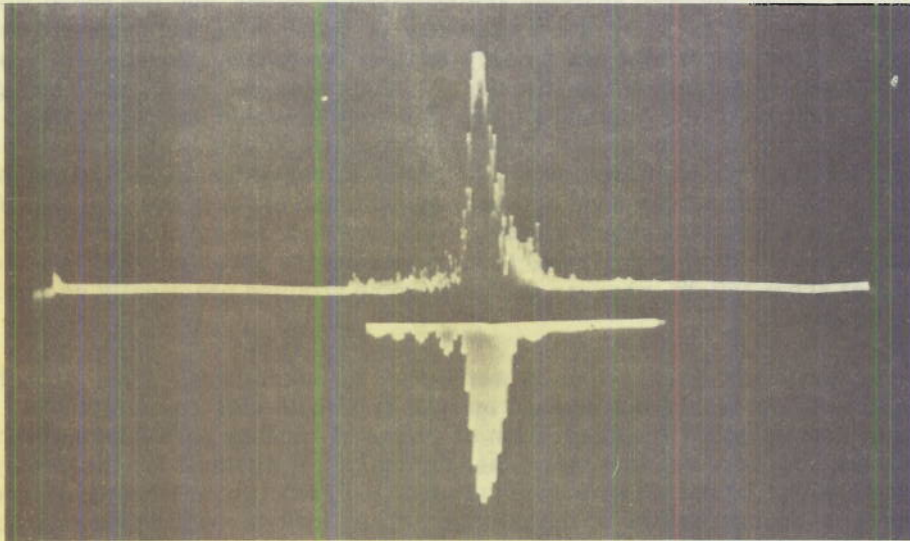


Figure 15 - Look-through presentation

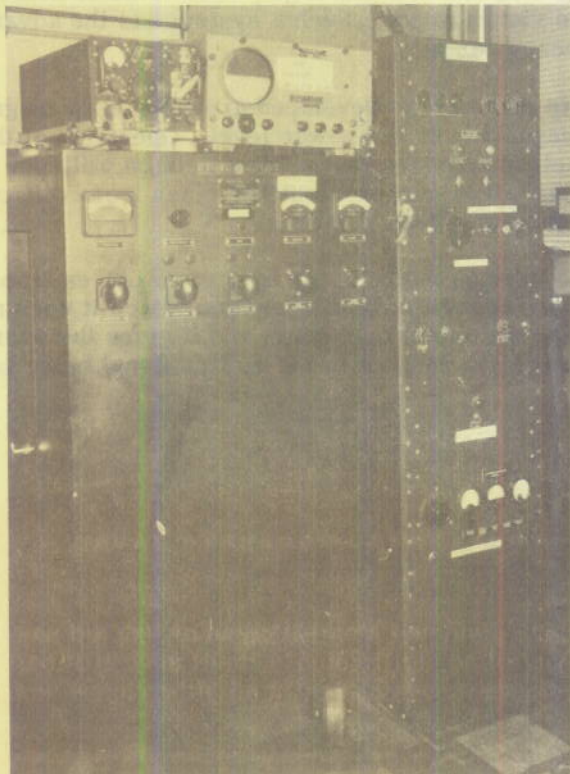


Figure 16 - Random look-through system

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SUMMARY AND CONCLUSIONS

The look-through methods used in present countermeasures systems have been investigated and found to be very difficult to adjust as well as being unreliable. Because of the wide frequency range modern systems are required to cover, and the speed with which operation must take place, the present r-f balancing or video balancing systems would require almost constant adjustment and be slow in their operation. Under ideal practical conditions with modulation applied, the balance null width obtained is not wide enough to show the entire spectrum of the jammed signal. The system could not cope with an enemy signal source employing frequency shift. The inevitable sea return, reflections from superstructure, and swaying of masts aboard ships would cause the phase and magnitude of the leakage signal to vary in an unpredictable manner and make it even more difficult to be balanced out by a constant signal through the balance path than under better controlled laboratory conditions. It is also desirable to have attenuation between receiving and transmitting antenna of about 150 db, whereas the best figure attained practically so far is of the order of 60 to 70 db.

Because of these difficulties, attention was turned to intermittent look-through. It was found possible to cut off a 1-kw magnetron tube by simple electronic methods. A system was then developed for the generation of pulses of random period such that the look-through occurred at a random rate, thereby making it difficult for the enemy to evade being jammed by deliberate synchronization of the radar pulse-repetition frequency (PRF) with the look-through period of the jammer. The look-through period may be varied in length, thereby enabling optimum periods to be used for observing the victim signal being jammed, and enabling the jammer operator to obtain optimum information about the victim signal. For some radars, tests indicate a two-hundredth of a second period to be about the optimum length for the look-through pulse. This is determined to a large extent upon the PRF of the victim signal. Such a system has the advantage that it is not limited to any radio frequency range.

Although this complete system was developed around a 1-kw magnetron, it can be modified to work with a magnetron of any power level. Operation of this form of look-through with a 1-kw magnetron requires that a fixed field be utilized. Magnetrons utilizing a field generated by the magnetron current would be much more difficult to cut off in this manner because of the regulation effect of the field.

By using random look-through methods for countermeasures transmitters, it is possible to obtain a system which permits rapid operation, since it does not depend upon the radio frequency at which the system is operating, and it gives the operator a clear picture of how his jammer is operating in respect to the victim signal being jammed.

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