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N R L REPORT NO.R-3168

SECOND INTERIM REPORT ON A SYSTEM
FOR HIGH SPEED COMMUNICATIONS
BY TELEVISION

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**SECOND INTERIM REPORT ON A SYSTEM
FOR HIGH SPEED COMMUNICATIONS
BY TELEVISION**

by

Howard Gordon and Louis L. George

May 1947

Problem No. 36R01-03

Approved by

Dr. R. M. Page
Superintendent
Radio Division III

Commodore H. A. Schade, USN
Director
Naval Research Laboratory



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ABSTRACT

Experimental work on a system for high speed communications through the use of television is being carried out. Progress toward completion of the problem to date is herein reported. The system operation, description of the circuits developed, modifications of original ideas and additional ones for future consideration are given. Test results completed on various sections of the system are also included as well as several photographs. At the present time all system components comprising one unit have been completed. Additional work will be required to coordinate these components and to make any modifications as required.

PROBLEM STATUS

This is the second interim report on this problem. Work is being continued. The previous report was R-2941 (Confidential).

AUTHORIZATION

This report summarizes the work completed and contemplated to date on a system for high speed communications through the use of television as authorized by the problem directive in (BuShips ltr. to NRL 944DA. Ser. 08238-944ZA dated 16 November 1945), and in accordance with the results of conferences with representatives of the Bureau of Ships. ("Record of Consultative Services" - File No. C-S67/59 (1430) Ser. No. 1400-201A/46 (mmf) dated 29 April 1946, and File No. C-S67/59 (1430:LLG) Ser. No. C-1400-258A/46 (emh) dated 31 May 1946).

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SECOND INTERIM REPORT ON A SYSTEM FOR HIGH SPEED
COMMUNICATIONS BY TELEVISION

INTRODUCTION

1. An interim report,* previously prepared, set forth the requirements for such a system and also discussed additional features that were considered desirable. Experimental work that had been completed or was in the process of completion was reported and the visualized operations of the system components were explained in a general manner. At that time, the components were separately constructed and bench tested. At the present time these separate components have been reconstructed on chassis having appropriate cable connector outlets and designed for relay rack installation. As previously reported, the Block III airborne television equipment is being used as the nucleus for the work.
2. The picture or message transmission time of one-quarter of a second that was specified as desirable has been found to be too short to fall within the capabilities of the present equipment. The reasons for this are subsequently discussed. There are also some modifications in design that are considered to be improvements, from the standpoint of reliability and simplicity of operation, over the original ideas. These modifications are explained as required under the appropriate sections of the report. The most radical departure from the original design consists in the use of capacitance discharges to energize some relays for short periods of time instead of employing single shot multivibrators to accomplish the same purpose. The same idea permitted development of an electrical circuit to replace an air valve operated slow-release relay whose size was cumbersome and operation considered to be less reliable.
3. Since the Block III transmitters cannot be readily modified for spot tuning as being employed, a new transmitter capable of such requirement is under development. This part of the problem has been accepted by the Transmitter Section of Radio Division II of the Laboratory. Accordingly, and pending completion of that problem, a low-power demonstration or test transmitter and video modulator has been constructed and integrated within the present equipment.
4. Throughout the equipment design, the requirement for close tolerances of component values has been avoided as much as possible. The number and types of tubes required have been held to a minimum. The following paragraphs describe the functions of each system component and some test results. Schematic diagrams and performance curves are included as required. Several photographs of the equipment in its present state are included.

* NRL Report R-2941 "Television - Interim report on a system for high speed communications," (Confidential) by Louis L. George, 25 February 1946.

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OPERATIONAL FEATURES

5. The operational features of the high speed communications equipment being designed are summarized briefly as follows:

- (a) The equipment transmits a television picture of maps, photographs or written material, either manually when a push button is depressed or automatically when used in conjunction with the "message placer". Time of transmission is approximately one second.
- (b) The receiving equipment causes a photograph to be taken automatically of the receiver viewing screen at the proper time.
- (c) The transmitter at the receiving position sends out a pulse of carrier frequency modulated 300 to 400 Kc, depending upon the station. This is a signal to acknowledge that the photographic equipment has functioned.
- (d) The receiver at the sending position receives the acknowledgement signals, which causes indicator lights to be turned on. These lights remain illuminated until the transmitter is again operated.
- (e) The station sending the picture or message does not take a picture of its own transmitted material and so does not transmit an acknowledgement signal.
- (f) The carrier of each station may be voice modulated by a 20 Kc/s pulse frequency modulated sub-carrier.
- (g) Any station transmitting either aural or visual information locks out all other transmitters in the system for the duration of that transmission.
- (h) The sweep frequencies in use may be rapidly changed at will by means of a telephone dial.
- (i) The transmitters and receivers of all stations may be shifted rapidly to any of six channels at will by any of the stations. This operation is also by means of a telephone dial.
- (j) The station that initiated the channel change receives acknowledgement signals from those stations whose frequencies were changed.

MODIFICATIONS TO ATK-ARK EQUIPMENT

6. The driven method of receiver sweep oscillator synchronization required that the gain of the respective sync amplifiers be increased. In fact it was necessary to increase the sync pulse amplitudes to the point where the sweep oscillators were locked into synchronization under conditions of minimum signal strength and shortest sweep times encountered. The modifications made were based on the minimum signal that would give a satisfactory picture when using sweep frequencies of 44 and 17,600 c.p.s. The free running times of the vertical and horizontal sweep oscillators were fixed so as to be slightly longer than the sweep frequencies of 36 and 14,400 c.p.s. respectively. The requirements and operation of the driven synchronization system have been described in detail* as well as the considerations determining the choice of sweep frequencies to be used. A complete circuit diagram of the receiver is shown in Figure 1, while Figure 2 shows

* Ibid.

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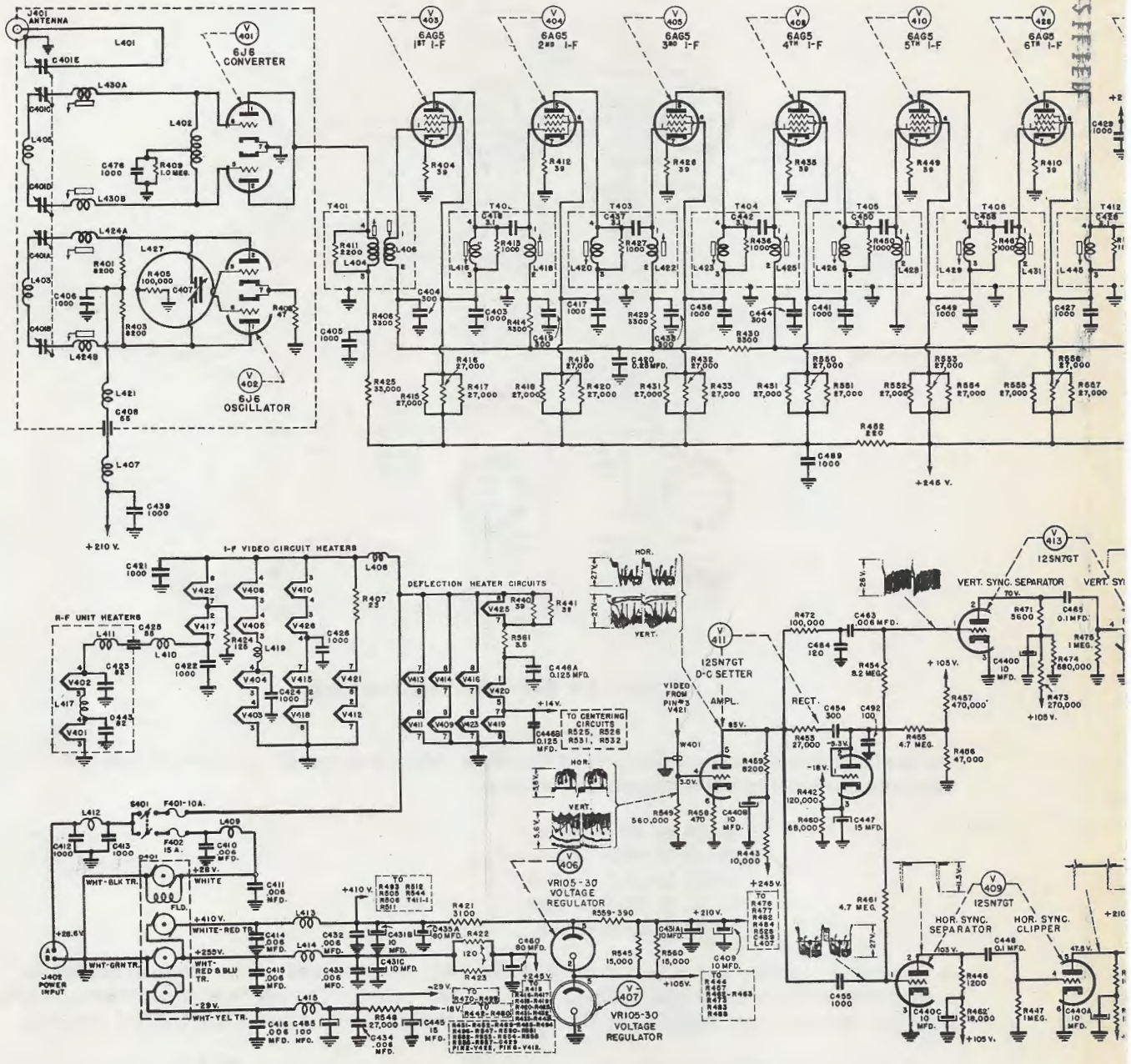
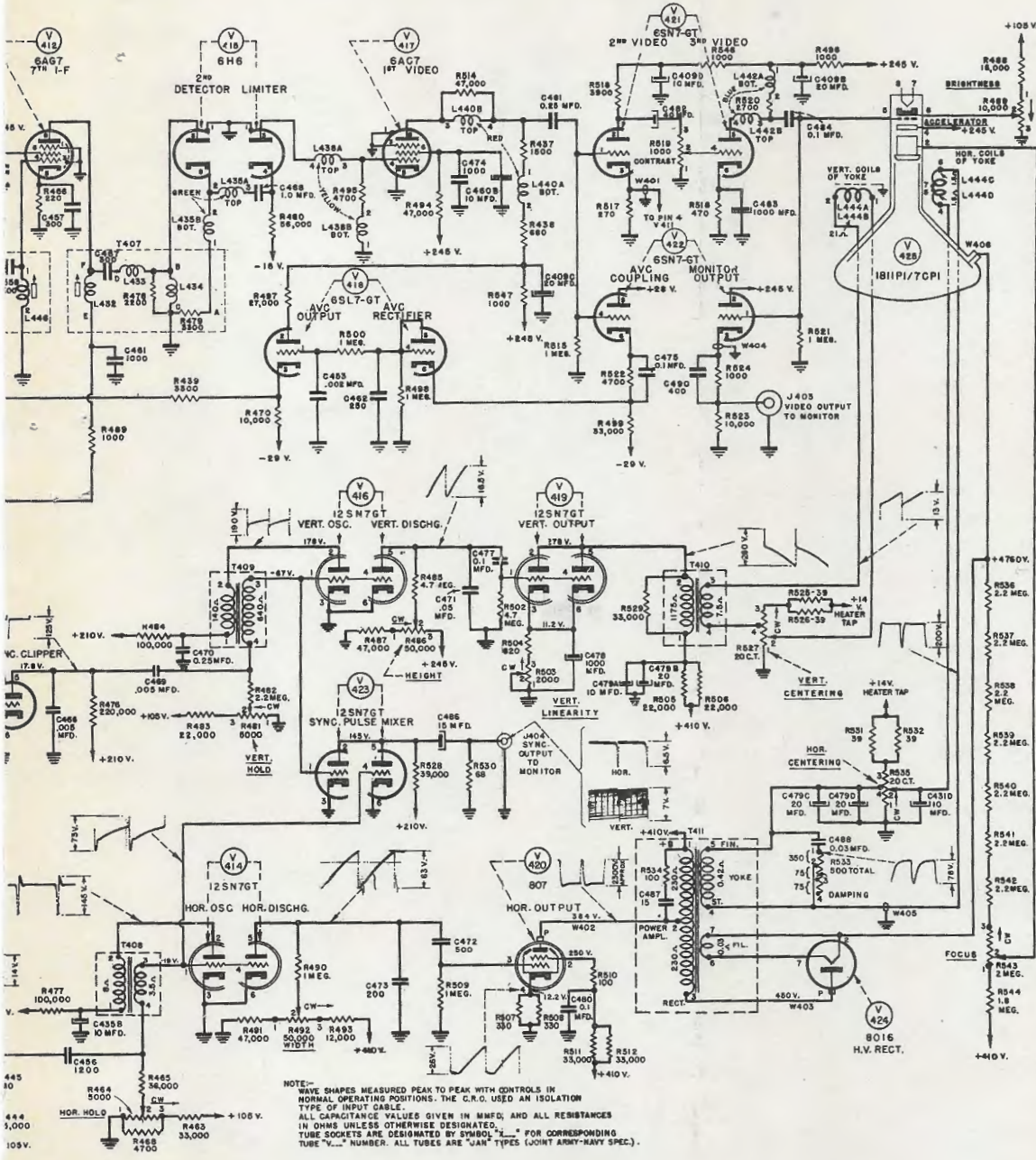


Figure 1 - Complete Rece

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iver Schematic

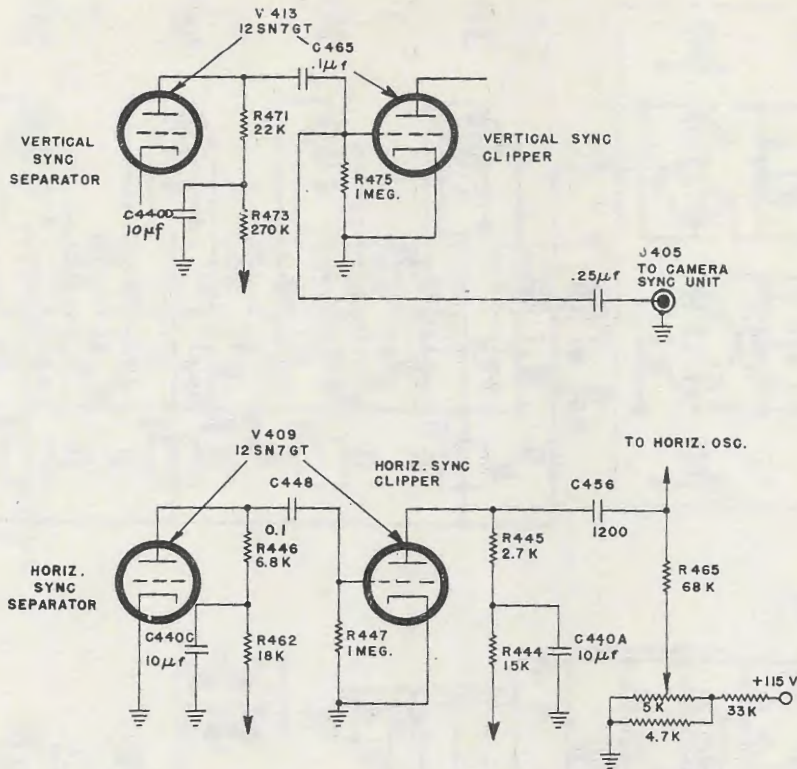


Figure 2 - Receiver Modifications

the modifications made. These were the plate load resistances of the vertical and horizontal sync amplifier stages as follows:

- R445 to 2700 ohms
- R446 to 6800 ohms
- R465 to 68,000 ohms
- R471 to 22,000 ohms
- R474 disconnected.

A connector, (J405), was also installed at the rear of the receiver in order to facilitate connection to the grid of the vertical sync clipper stage. The vertical sync pulses, when they are present, are then fed to the camera synchronizer unit on the control chassis.

7. Test results obtained up to the present time indicate that the operation of the driven method of synchronization will be satisfactory. When the receiver was operated in conjunction with the demonstration transmitter, the picture was observed to lock in rapidly. The time required for so doing is limited by the necessary inductance in the circuits following the vertical output stage V419. It is reasoned that since this time is believed to be less than that required for operation of the camera, satisfactory operation of the system will be obtained. In the event of a complete equipment re-design, however, consideration should be given to the use of electrostatic deflection for reducing this time lag.

8. The receiver tuning shaft has been geared to a Yardeny spot tuner as can be seen in the equipment photograph in Figure 3. A rear view of the equipment, Figure 4, shows the back end of the receiver, and the connection outlet to the camera synchronizing unit contained on the control chassis.



Figure 3 - Photograph of Equipment
Front View



Figure 4 - Photograph of Equipment
Rear View

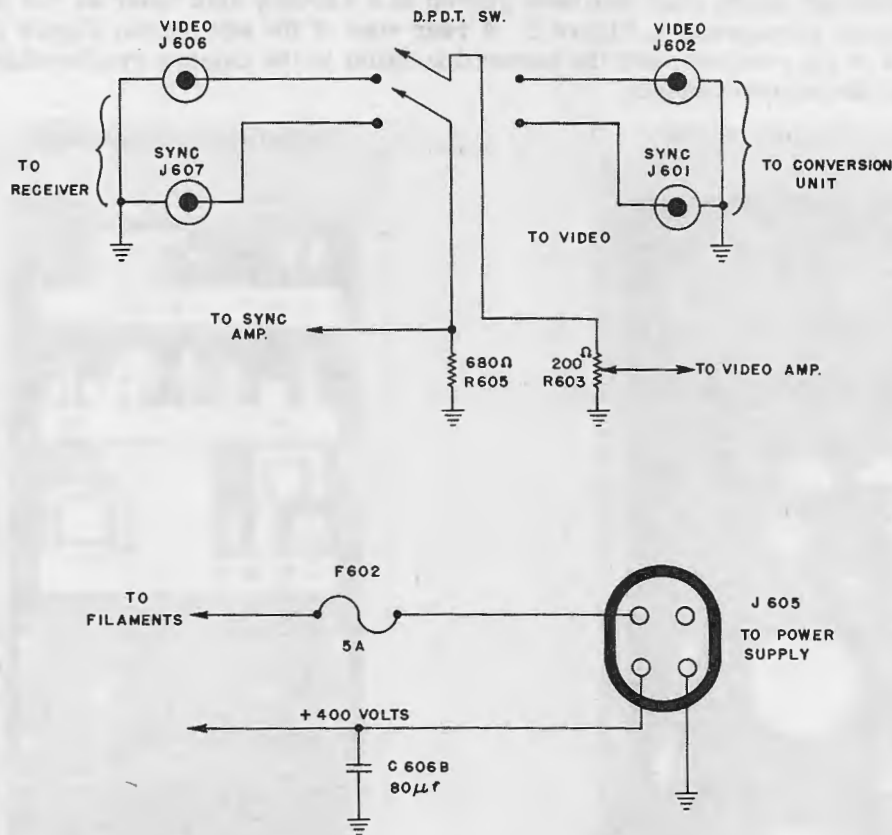


Figure 5 - Monitor Modifications

9. Modifications made to the Monitor Unit were those concerned with power supply and video sync switching. The dynamotor, D101, was disconnected from terminal board TB604 and the power input receptacle, J603, replaced with another having four pin connections. This receptacle, designated J605 was wired for connection to 28 and 400 volts from the power supply chassis. Figure 5 is a circuit diagram of the modifications made, while Figure 6 shows the original complete monitor schematic. The switch shown in Figure 5 is for the purpose of connecting the video and sync lines of either conversion unit or receiver outputs to the monitor as desired. Figures 7 and 8 are photographs of the modifications made.

10. The conversion unit being used is the same one used during preliminary experiments. This unit contains an extra video stage that was previously added so as to provide a negative image when viewed on the receiver screen. Figure 9 is a photograph of this modification. Capacitor C138 has been changed in value to 0.02 mfd. for the purpose of increasing the vertical sync pulse width. In order to allow for rapid sweep frequency change, the conversion unit sweep oscillators were modified as follows: The grid return of the vertical sweep oscillator VIII and that of the horizontal oscillator V112 were disconnected and wired to an outlet receptacle, (J105). Resistor R170 in the grid return of the horizontal oscillator was decreased in value to 27,000 ohms. The Monitor output receptacle, J102, was replaced with another, designated (J105) having 7 pin connections, and wired to provide for the above changes. The modifications made concerning

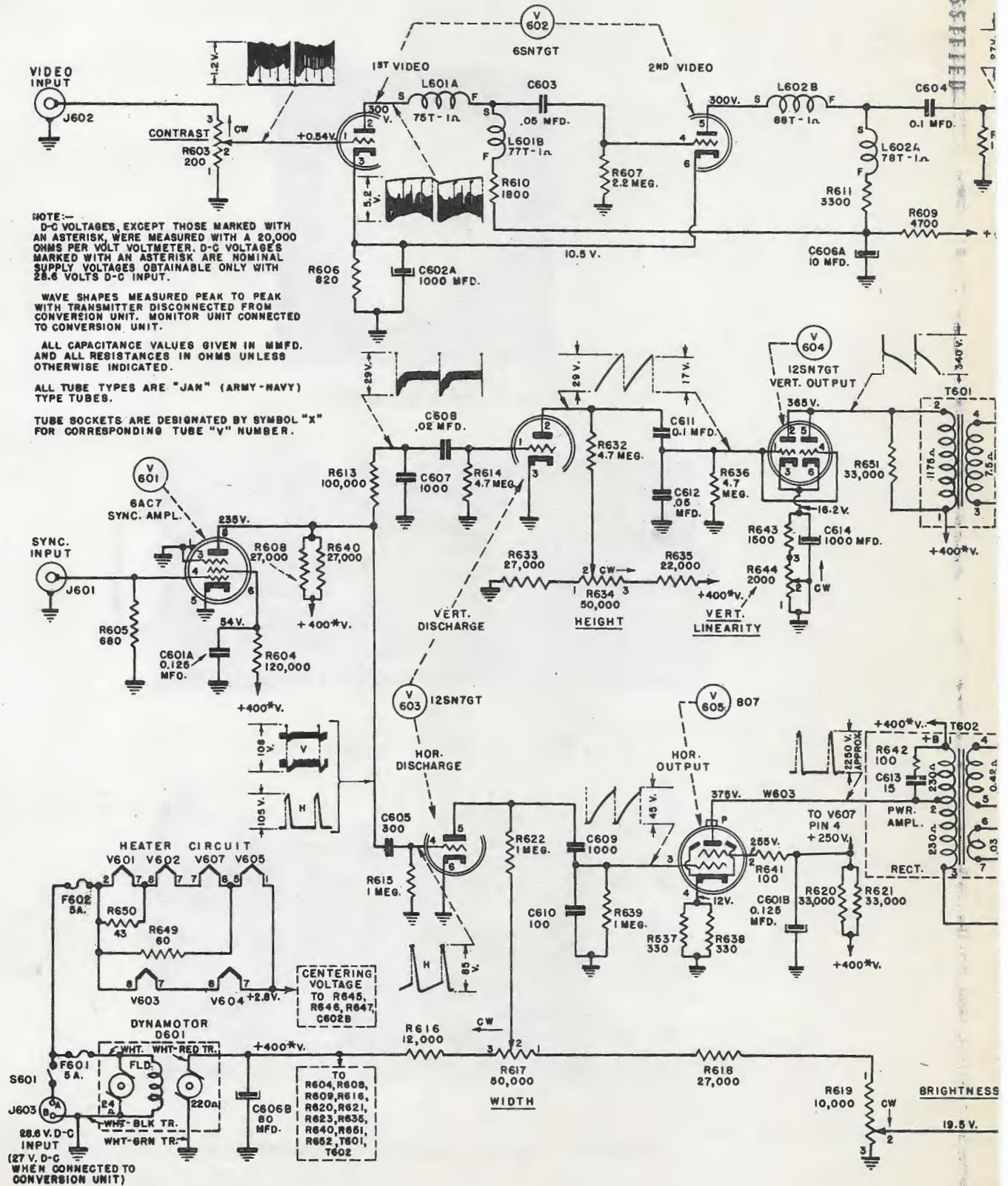
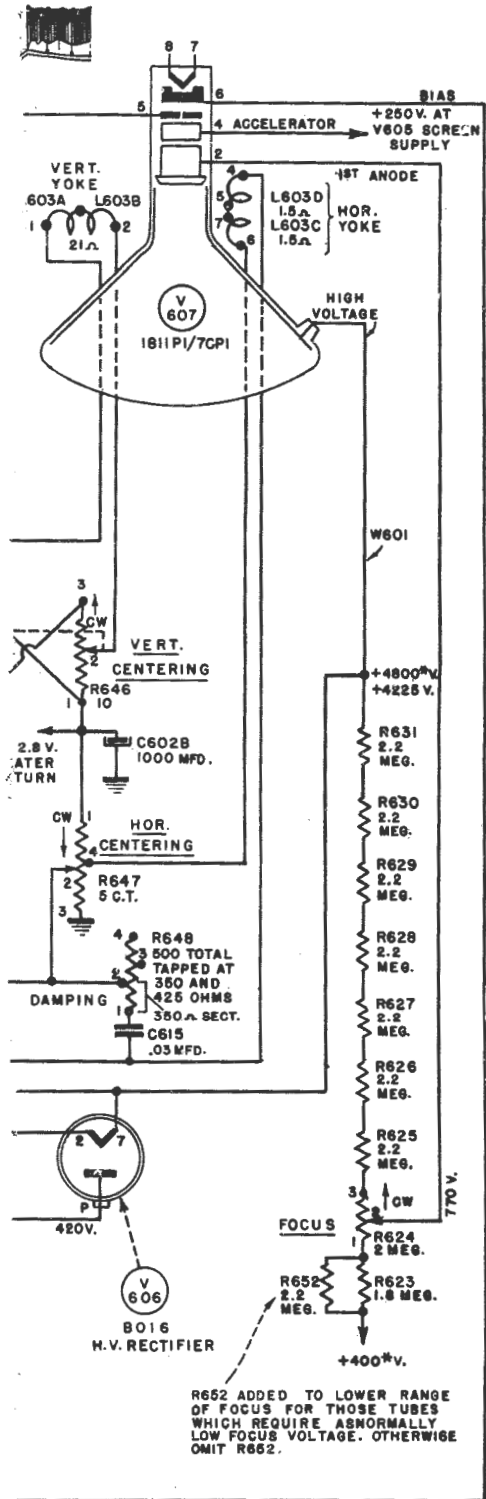


Figure 6 - Complete Monitor Schematic



R652 ADDED TO LOWER RANGE OF FOCUS FOR THOSE TUBES WHICH REQUIRE ABNORMALLY LOW FOCUS VOLTAGE. OTHERWISE OMIT R652.

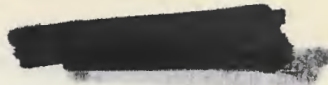


Figure 7 - Monitor Modifications

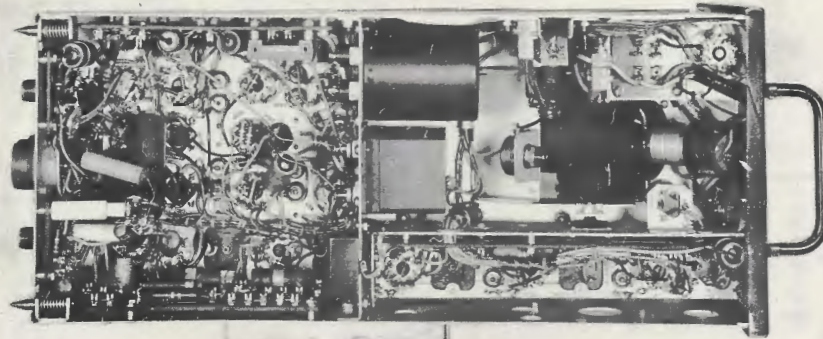


Figure 8 - Monitor Modifications

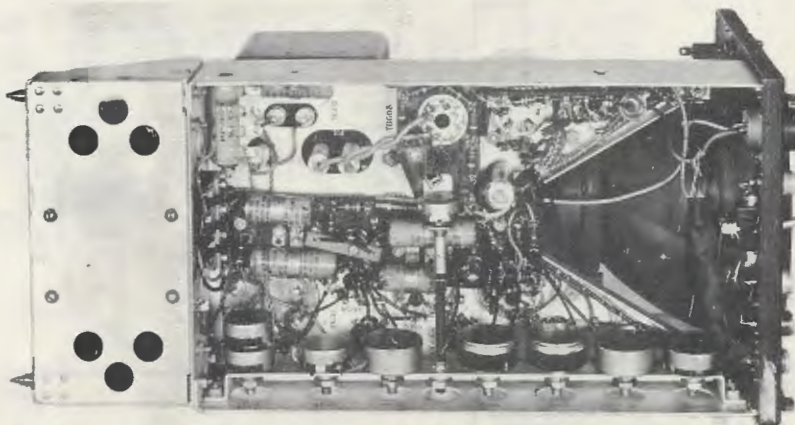


Figure 9 - Added Video Stage in Conversion Unit

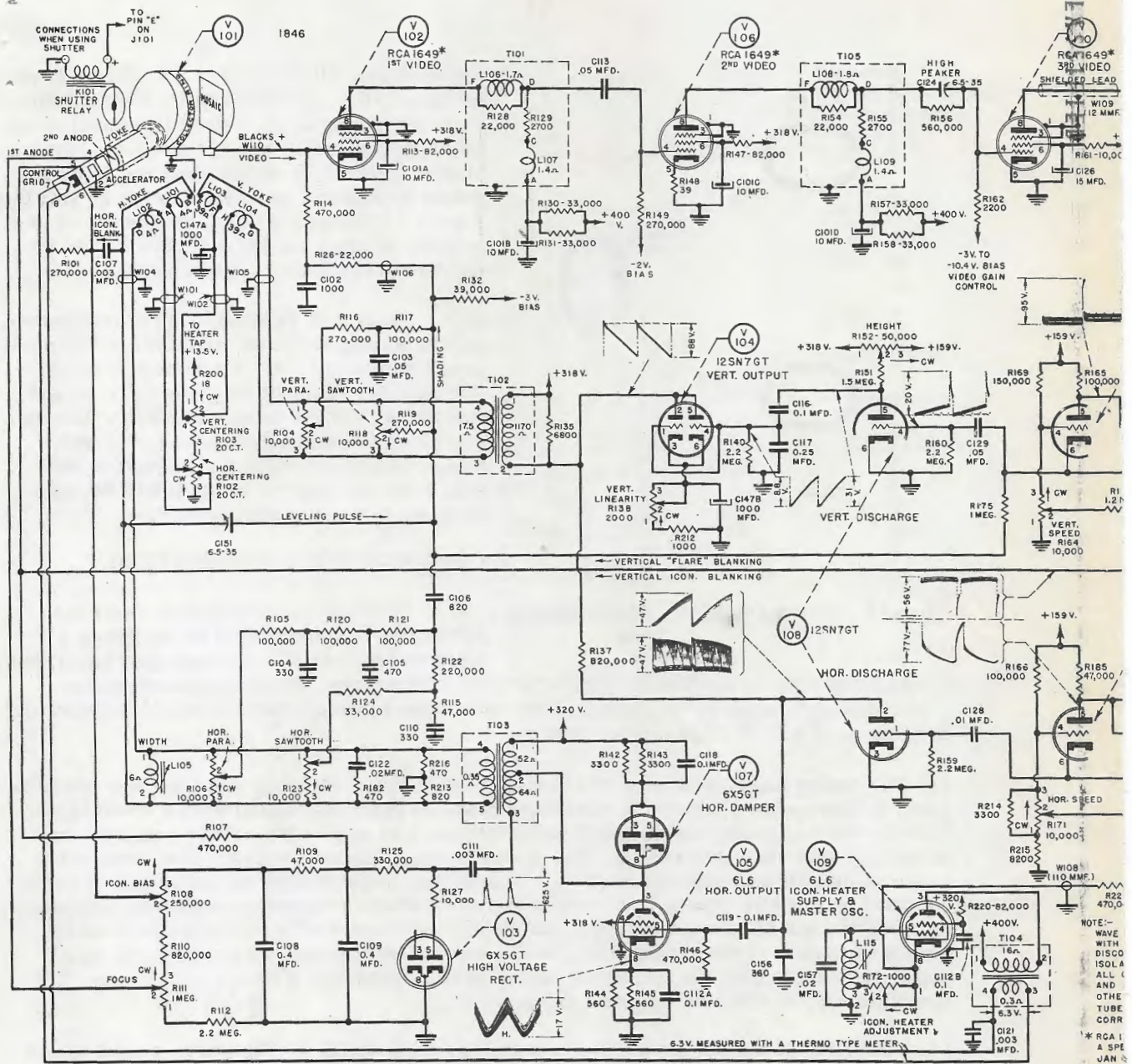
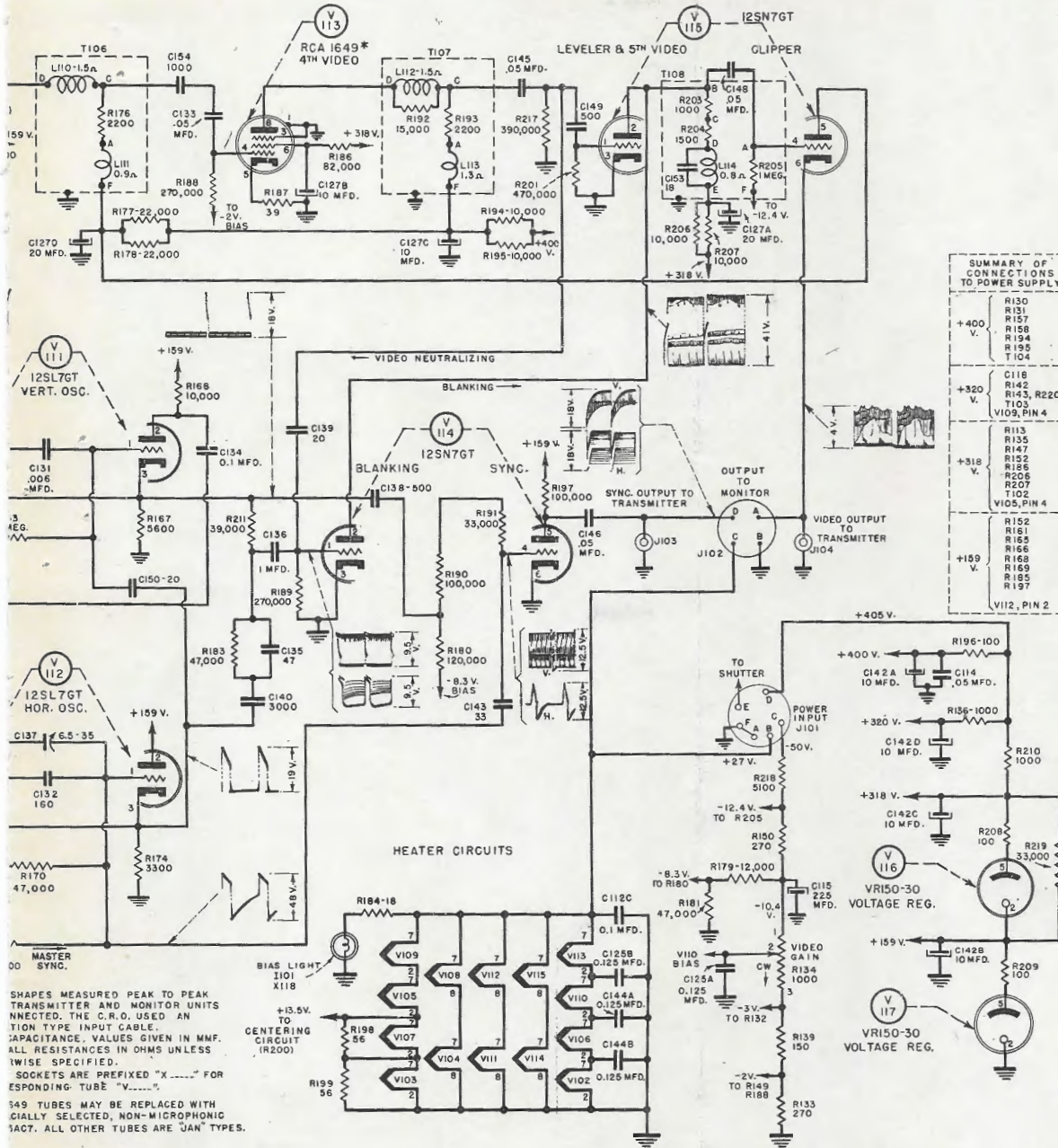


Figure 10 - Conversion U



SHAPES MEASURED PEAK TO PEAK TRANSMITTER AND MONITOR UNITS CONNECTED. THE C.R.O. USED AN ION TYPE INPUT CABLE. CAPACITANCE, VALUES GIVEN IN MMF. ALL RESISTANCES IN OHMS UNLESS OTHERWISE SPECIFIED. SOCKETS ARE PREFIXED "X" FOR RESPONDING TUBE "V" TYPES.

549 TUBES MAY BE REPLACED WITH GENUINELY SELECTED, NON-MICROPHONIC FACT. ALL OTHER TUBES ARE "JAN" TYPES.

nit Schematic

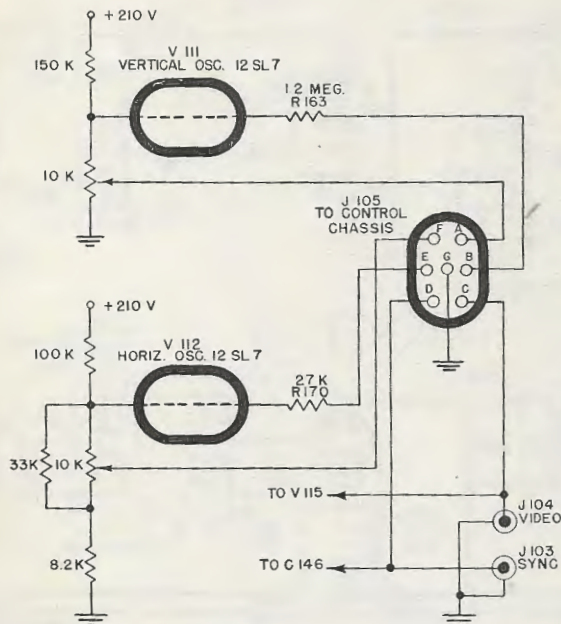


Figure 11 - Sweep Oscillator Modifications

the sweep oscillators were for allowing connection to the control chassis, wherein circuits for changing the sweep frequencies are incorporated. The power line to the lens shutter poleoid was disconnected from the power receptacle and wired to the 28 volt bus. Figure 10 shows the original conversion unit schematic diagram while Figure 11 shows the sweep oscillator modifications.

11. Since it is desired that the conversion unit scan only the area contained in the proposed message form, it was necessary to increase the distance between the lens and mosaic to permit proper focusing. In order to reduce the distance between lens and televised subject matter still further and still scan the desired area, it will be necessary to use a wider angle lens.

DEMONSTRATION TRANSMITTER

12. As noted in paragraph 3 under the Introduction, the problem of designing a transmitter, capable of being spot tuned, has been turned over to another section within the Laboratory. In the meantime a low-power demonstration or test transmitter with video modulator has been constructed and is being used with the present equipment.

13. The tuning head, oscillator and mixer, taken from a Block III receiver was investigated to determine whether the oscillator could be plate modulated with a video signal. Considerable success was obtained when the unit was used with a video amplifier and modulator that was constructed. The power output, however, was too low, mostly because of insufficient antenna coupling. Therefore, an oscillator almost identical to the one used in the ARK tuning head was constructed whose frequency range was sufficient to cover the six channels with ease, and permitted a more efficient antenna coupling. The combination of video amplifier, modulator and oscillator was constructed on a separate chassis with the oscillator tuning shaft geared to a Yardeny spot tuner. The complete circuit diagram is given in Figure 12.

14. Operation of the demonstration transmitter is as follows: The video signal output from the conversion unit is applied through J302 to the cathode of a 6SL7 tube arranged in a grounded grid amplifier circuit. The 470 ohm cathode resistance becomes the load resistance for the cathode follower output stage, V115, in the conversion unit, when the two units are connected. Sync signal input is made at J303 through a 1000 ohm resistance to the cathode. The polarities of the blanking pedestal and sync signals are negative at this point. The amplified signals are then applied to a cathode follower using the other triode section of the 6SL7 and then to a 6AG7 voltage amplifier. The output of this combination is applied to a 6AG7 modulator stage. The 6J6 oscillator is the cathode load resistance for this stage, with the bias for the 6AG7 obtained from the 680 ohm cathode resistance. Keying of the transmitter is accomplished by the application of 255 volts to the modulator plate for a period of one second. A switch has been incorporated

on the front panel to enable continuous R. F. transmission for tuning purposes. The unit also contains its own regulated power supply. Photographs of the demonstration transmitter are shown in Figures 13 and 14.

POWER SUPPLY

15. Two power supplies were constructed on one chassis and replace the dynamotor ordinarily required for the ATK television equipment. A circuit diagram of these supplies and cable connections is shown in Figure 15. The power requirements of the conversion unit are 400, -50 and 28 volts D. C. and are available at receptacles J701. Another power supply makes connection to receptacle J703 for the Monitor, which requires 400 and 28 volts D. C. Receptacle J704 provide filtered 28 volts D. C. for the receiver. When operating the equipment from cold start the precaution of first turning on the 28 volt source should be observed, otherwise the danger exists that the filter capacitors in the plate supplies will be subjected to voltage in excess of their rating. Photographs of this unit are shown in Figures 16 and 17.

16. As noted in NRL Report R-2941, D. C. operation of the filaments in the conversion and monitor units has been continued. The fact that D. C. centering voltages are taken from a point in the series-parallel filament wiring and that the shading signals are tied in between the deflection yokes and negative bias supply were considerations dictating the continued D. C. operating of tube heaters.

CONTROL PANEL

17. The control panel and chassis contain the circuit components of the system that comprise the heart of the present equipment. All functions such as, channel changing, sweep frequency changing, picture or message transmission and voice communication are all incorporated on the one chassis. The design of the present equipment has been such that the selection and operation of any one of the above functions are capable of being performed rapidly and easily. This unit may be seen in Figures 18, 19 and 20. A master circuit diagram of the control panel is shown in Figure 21, while the following paragraphs discuss the operation of each function and its associated circuits.

18. When a picture or message is received, the equipment is arranged to automatically actuate a camera for the purpose of photographing the receiver screen, thereby recording the information during the short transmission time of one second. Immediately after the receiver screen has been photographed, the equipment also automatically transmits a pulse of r.f. energy modulated within the range 300-400 Kc/s. This is known as the acknowledgement signal, having a duration of 0.8 seconds which confirms that the photographic equipment has functioned. Transmission is on the same channel as the received message signal.

19. The circuit for actuating the camera (Figure 22) has been designated the camera synchronizer circuit. The actuating signal is derived from vertical sync pulse (negative polarity) which is available from the back end of the receiver through J405 to J210. One triode section of a 6SL7 is used as a low frequency amplifier, while the second triode section is connected as a diode rectifier. The D. C. voltage output of the diode rectifier is then applied to the grid of a 6SN7 relay stage, having both triode sections in parallel. When relay 7 is energized, contacts B apply 28 volts DC to J211 for actuating a solenoid (external to the equipment) which trips the camera shutter. During the time relay 7 is energized, Contacts C, being in series with the ground return of the transmitter keying relay 1, are open thus locking out the transmitter at the receiving position. Also during

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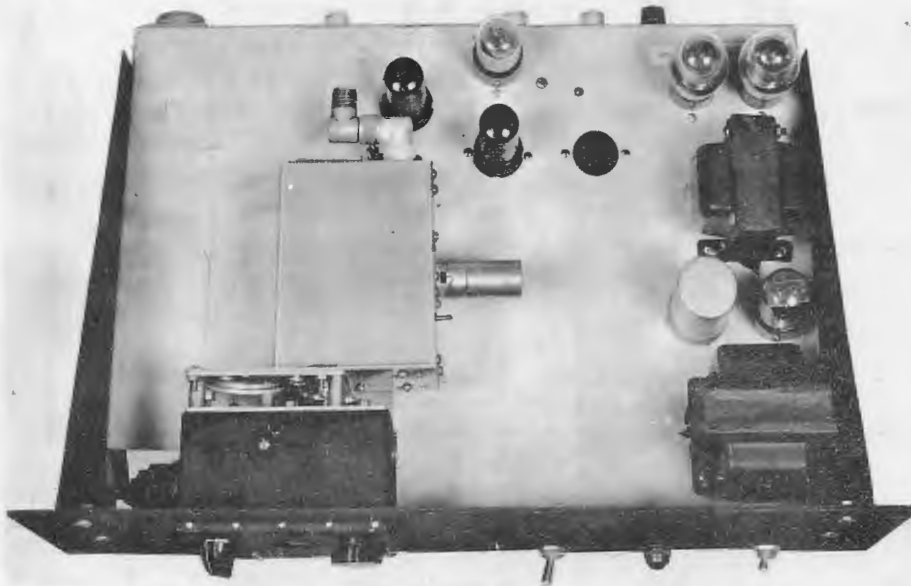


Figure 13 - Demonstration Transmitter

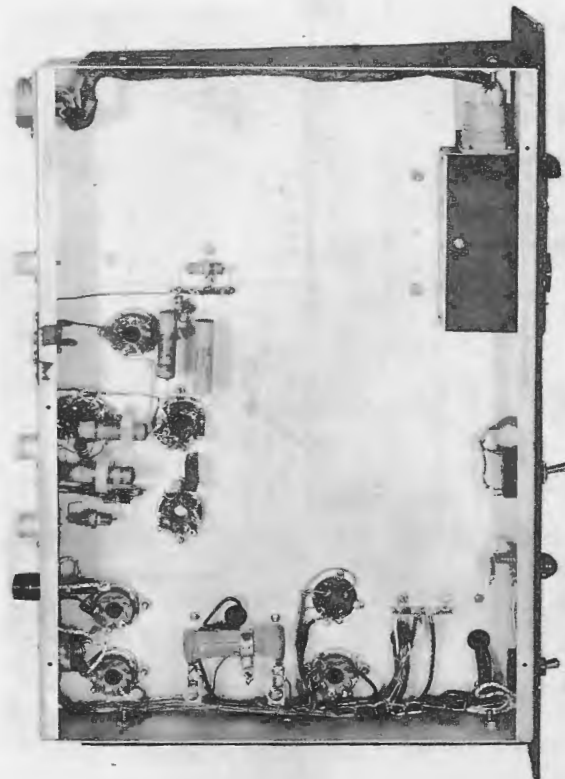


Figure 14 - Demonstration Transmitter

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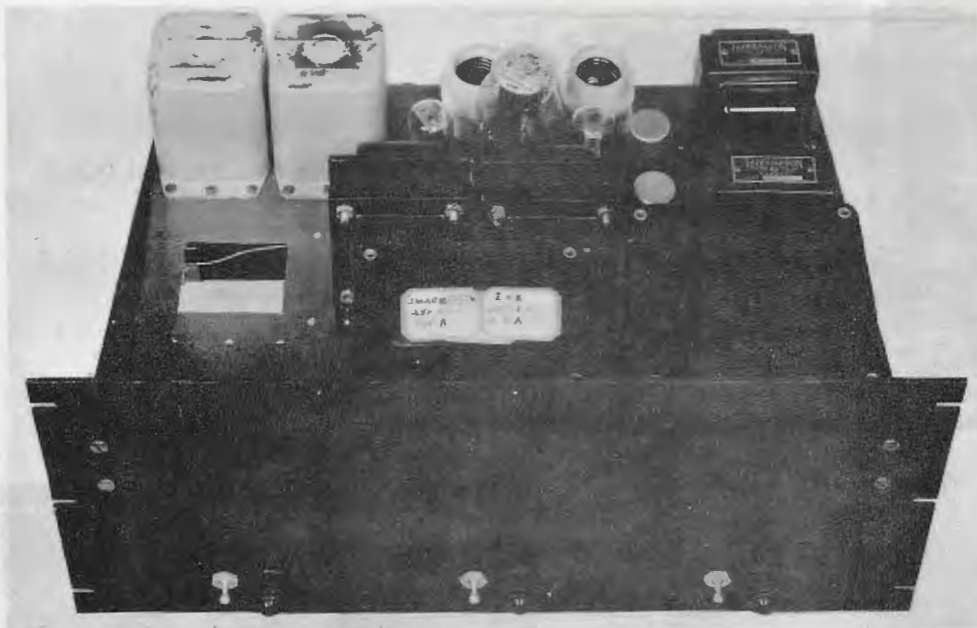


Figure 16 - Power Supply

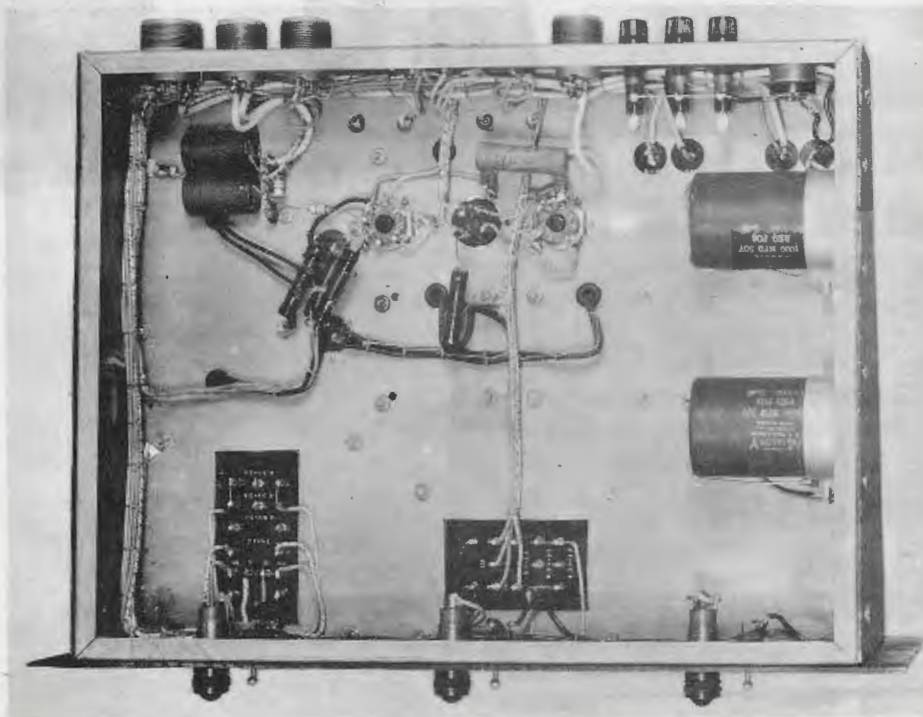


Figure 17 - Power Supply

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Figure 18 - Control Panel



Figure 19 - Control Panel

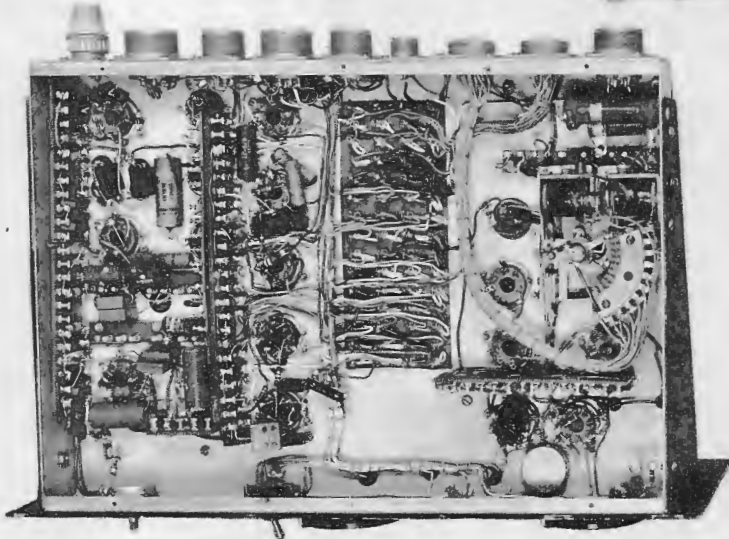


Figure 20 - Control Panel

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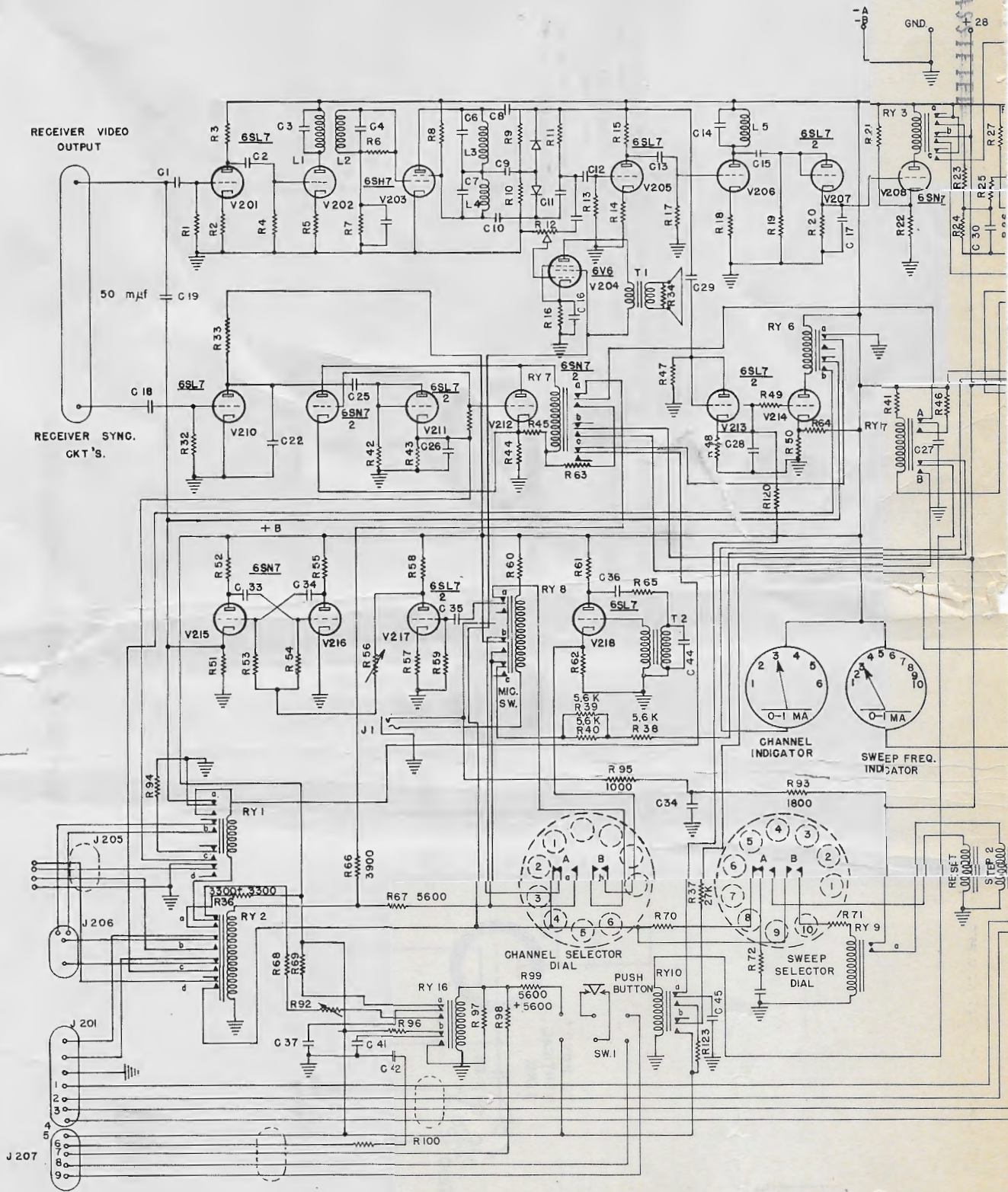
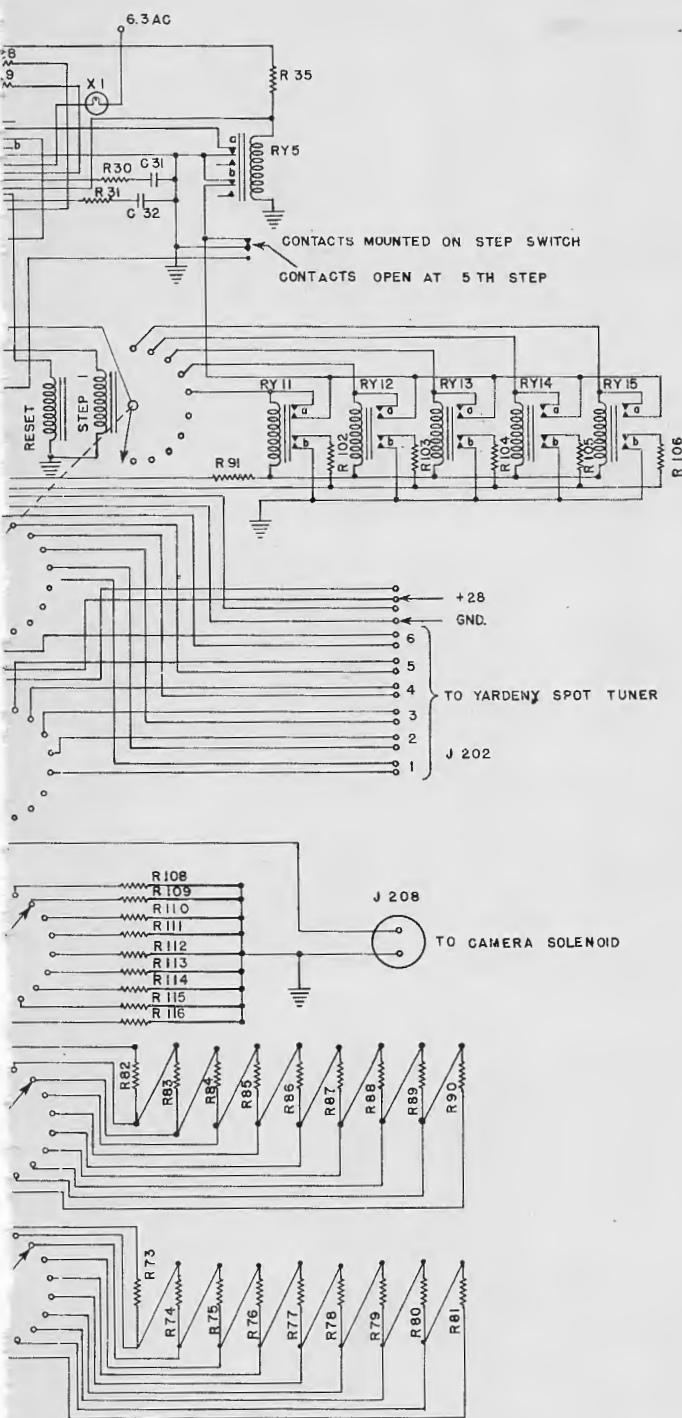


Figure 21 - Control Panel - Circuit Schematic



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this time contacts A are closed and capacitor C27 (40 mfd) charges to 210 volts through resistor R46A (1,500 ohms). At the end of the message transmission the vertical sync pulses disappear and relay 7 becomes de-energized. Capacitor C27 then discharges through the closed contacts A and thence through R66 (3,900 ohms) and the coil of relay 2, thereby keying the transmitter for 0.8 seconds and transmitting the acknowledgement signal. Operation of the transmitter keying and acknowledgement circuits are discussed further on in the report.

20. Operation of the camera synchronizing unit has been obtained over the vertical sync pulse range from 36 to 44 cps. The complete frequency characteristics, however, has not yet been measured although it is known that the unit will operate up to approximately 600 cps when using a sine wave signal input. Negative input pulses applied to the 6SL7 low frequency amplifier will drive the grid past cut-off. The amplitude of the positive pulse appearing, with the circuit constants used, in the plate circuit, therefore, depends upon the time of cut-off or pulse width. The minimum pulse width required for satisfactory operation is approximately 350 u/secs. Thus, some discrimination against narrow interferences pulses is afforded.

21. The original idea of obtaining the transmission time by use of a single shot multivibrator has been superseded by that of energizing the keying and signal switching relays by means of a capacitance discharge through the relay coils. This idea has been carried throughout the control circuits design for reset operations of stepping switches, and relay energizing in various circuits. Accordingly, it was possible to reduce the number of tubes required for the system.

22. It will be noticed that in either the charging or discharging of a capacitor, series resistances are used. The charging resistance limits the maximum current through the relay contacts as well as minimizing the surge current drain from the power supply. Values of the charging resistances vary depending upon the charging time desired. The resistances in series with the capacitor discharge path also limits the maximum discharge current and lengthens the time of energizing the relay. Stated in another way the series resistance permits the same operating time to be obtained when using a capacitor of lower value. Referring to Figure 23 it is seen that the relay contacts will close when the current through the coil (6500 ohms) exceeds 12 ma. and will open when it drops below 5 ma. The series resistance, R_s , in the discharge path slows the rate of current decay in the circuit. This fact increases the time that the relay is energized. The limitations are that the initial discharge current must be greater than that re-

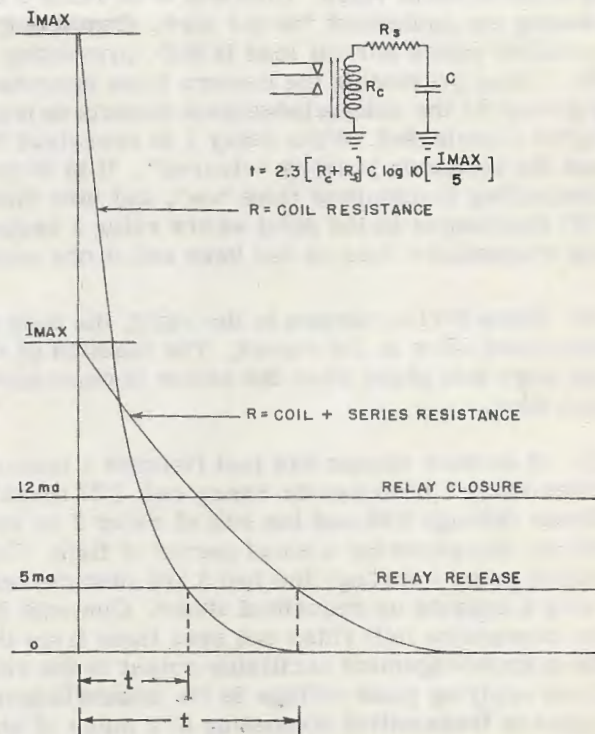


Figure 23 - Relay Operation

required to energize the coil and that the current decay to the drop-out or release value at the desired time. In the case under consideration the currents at the closure and release points are 12 and 5 ma. Since the discharging capacitor has been previously charged to 210 volts, the maximum instantaneous discharge current is given by $210/R_S + R_C$. The time t is then given by:

$$T = 2.3 \left[R_S + R_C \right] C \log_{10} \left[\frac{I_{\max. \text{ ma}}}{5} \right]$$

where R_S series resistance
 R_C = relay coil resistance.

23. The transmitter keying and switching circuits schematic diagram is illustrated in Figure 24. Sequence of circuit operation is described as follows: A message or map is to be transmitted. Switch SW1 is thrown to the left position used for all manual operation. Pushing the button momentarily applies 210 volts to relay 16 through the current limiting 5600 ohm resistances, causing the relay to be energized. Contacts B apply the voltage across C41, which has been charged through 3900 ohms, to the relay coil through 8200 ohms, holding the relay closed until the voltage across C41 decays to some critical value. Contacts A also close, causing C37 which has been charged through R69, to discharge through R92 and R68, through contacts A on relay 2, through the coil of relay 1 to ground through the closed contacts of two other relays (Ry 7 and Ry 6). Relay 1 is thus energized. As soon as this relay closes, contacts A bypass the ground return through relays 6 and 7. Relay 1 remains closed until the charge on C37 decays to some critical value. Contacts B on relay 1 close the transmitter keying circuits, placing the equipment "on the air". Contacts C place a "locking" resistor, R94, on the rectifier whose normal load is R43, preventing operation of relay tube V212 controlling Ry 7, thus preventing the camera from operating. Contacts D on relay 1 normally supply a ground to the acknowledgement chassis to hold the acknowledgement relays closed and lights illuminated. When relay 1 is energized however, the holding circuit is broken and the indicator panel is "cleared". It is to be noted that R92 is the adjustable element controlling transmitter time "on", and also that C41 must hold relay 16 energized until C37 discharges to the point where relay 1 becomes de-energized. As previously noted, the transmitter time on has been set at one second.

24. When SW1 is thrown to the right, the push button is connected to a "message placer" described later in the report. The function of the message placer is to draw a new message into place when the button is depressed and key the transmitter at the end of that time.

25. If another station has just finished a transmission, circuit operation is as follows: When relay 7 becomes de-energized, C27 discharges through the closed contacts A and thence through R66 and the coil of relay 2 as noted in paragraph 19. Thus relay 2 becomes energized for a short period of time. Contacts A apply 210 volts to the coil of relay 1 through the two 3,300 ohm current limiting resistors. The contacts on relay 1 operate as described above. Contacts B and C on relay 2 close, disconnecting the conversion unit video and sync lines from the transmitter. Contacts B also connects the acknowledgement oscillator output to the video line to the transmitter. Contacts D close applying plate voltage to the acknowledgement oscillator. Thus an acknowledgement signal is transmitted consisting of a pulse of short duration of the VHF carrier modulated at a given frequency in the band 300-400 Kc/s. When C27 has discharged to some critical value, relays 1 and 2 become de-energized, returning the system to a quiescent state.

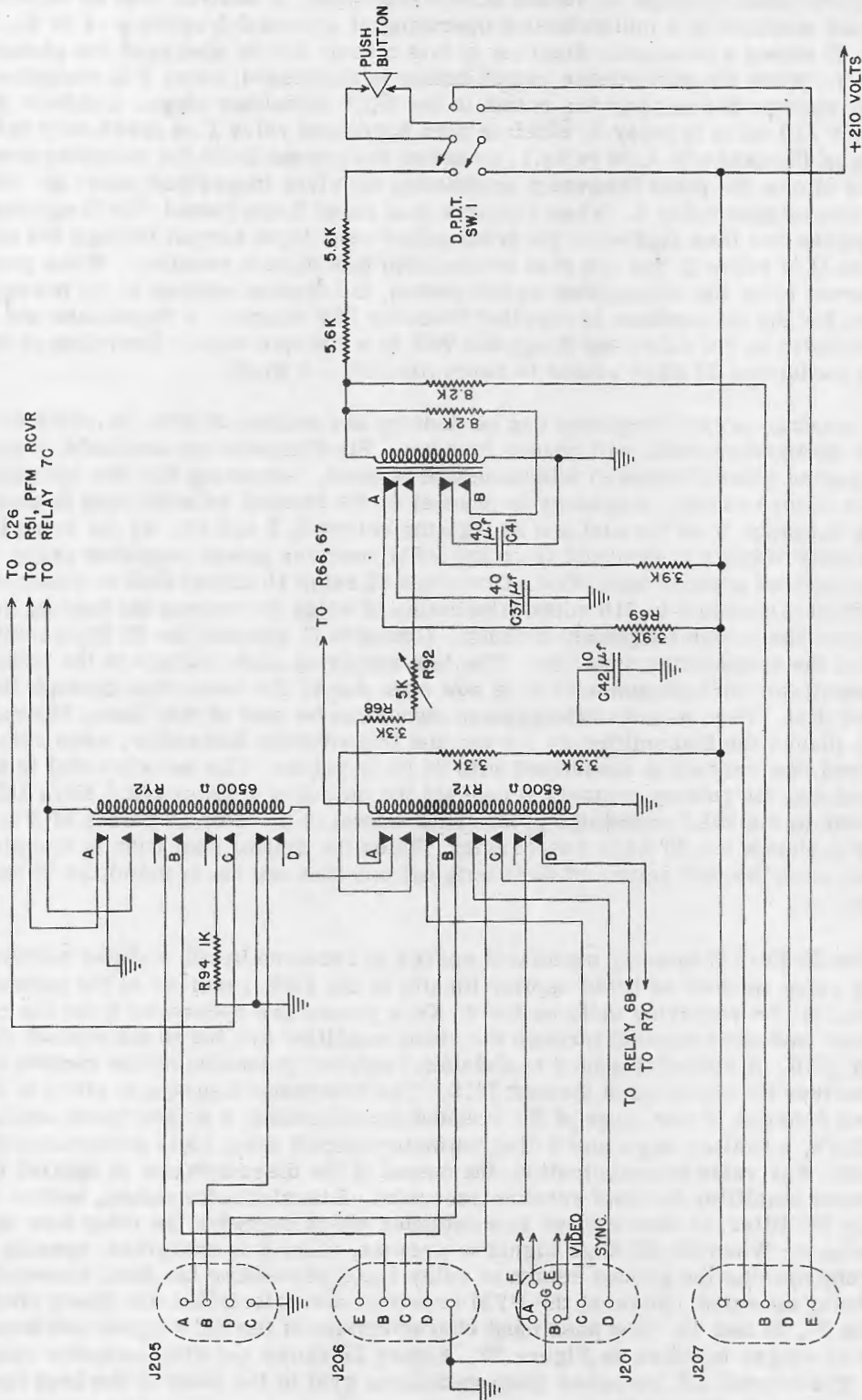


Figure 24 - Transmitter Keying and Switching Circuits

26. Voice communication or verbal acknowledgement, if desired, can be obtained by frequency modulating a multivibrator operating at a normal frequency of 20 Kc/s. Figure 25 shows a schematic diagram of this circuit that is also used for changing channels. When the microphone switch button is depressed, relay 8 is energized. Contacts A connect the microphone output to the 6SL7 modulator stage. Contacts B close and apply 210 volts to relay 2, which in turn energizes relay 1 as previously noted. Closing of the contacts A of relay 1, removes the ground from the multivibrator output line and allows the pulse frequency modulation receiver (described later) to use the signal to energize relay 6. When contacts B of relay 6 are closed, the frequency modulated pulses are then applied to the transmitter sync input circuit through the closed contacts C of relay 2, and are thus transmitted to a distant receiver. When pressure is removed from the microphone switch button, the system returns to its normal state. Current for the microphone is supplied from the 28V source. A resistance and capacity network form an RC filter and drops the 28V to a suitable value. Deviation of the frequency modulated 20 Kc/s pulses is approximately ± 3 Kc/s.

27. Changing carrier frequency can be done by any station at will. All stations, once using a common channel, will change together. Six channels are available, leaving four guard pulses when a standard telephone dial is used. Assuming that the operator desires to change carrier frequency to channel 6, the channel selector dial is pulled over, closing contacts A on the dial and energizing relays 1, 2 and 10. At the same time, plate supply voltage is removed from the PFM receiver power amplifier stage, thereby preventing loud speaker operation. Operation of relay 10 allows C45 to charge through a 15,000 ohm resistor to 210 volts. Operation of relay 2 removes the holding ground and clears the acknowledgement circuits. Contacts C connect the 20 Kc/s multivibrator output to the transmitter sync line. The line supplying plate voltage to the acknowledgement oscillator through contacts D is now open due to the connection through the channel selector dial. Thus no acknowledgement signal can be sent at this time. Operation of relay 1 places the transmitter on the air and immediately thereafter, when relay 6 is energized, the carrier is modulated with 20 Kc/s pulses. The selector dial is then released and the pulsing contacts B connect the output of a stabilized 5 Kc/s LC oscillator to the 6SL7 modulator grid. Thus a total of 6 + 4 or 10 pulses of 5 Kc/s energy modulate the 20 Kc/s sub-carrier. When the dialing operation is completed, contacts A on the dial return to their original position and the transmitter is taken off the air.

28. The 20 Kc/s frequency modulated energy is received by all stations within transmitting range as well as being applied locally to the PFM receiver in the control chassis. At the receiving stations the 20 Kc/s pulses are recovered from the carrier frequency and after passing through the video amplifier are fed to the control chassis through J210. A pulse frequency modulation receiver is located on the control chassis and receives its signal input through J210. The schematic diagram is given in Figure 26. The unit consists of one stage of RC coupled amplification, a double tuned amplifier at 20 Kc/s, a limiter stage and a discriminator circuit using 1N34 germanium diode crystals. For voice communication, the output of the discriminator is applied to a 6V6 power amplifier for loud speaker reception. Discriminator output, before the 20 Kc/s RC filter, is also applied to a rectifier which operates the relay tube controlling relay 6. When the 20 Kc/s signal is present, relay 6 is energized, opening contacts A thereby opening the ground return of relay 1 and preventing the local transmitter from being operated. Some of the PFM receiver characteristics are illustrated in Figures 27, 28 and 29. The pass band characteristic of the RC coupled and double tuned amplifier stages is shown in Figure 27. Figure 28 shows the discriminator characteristic. The overall a.f. response from modulator grid to the plate of the loud speaker stage is shown in Figure 29.

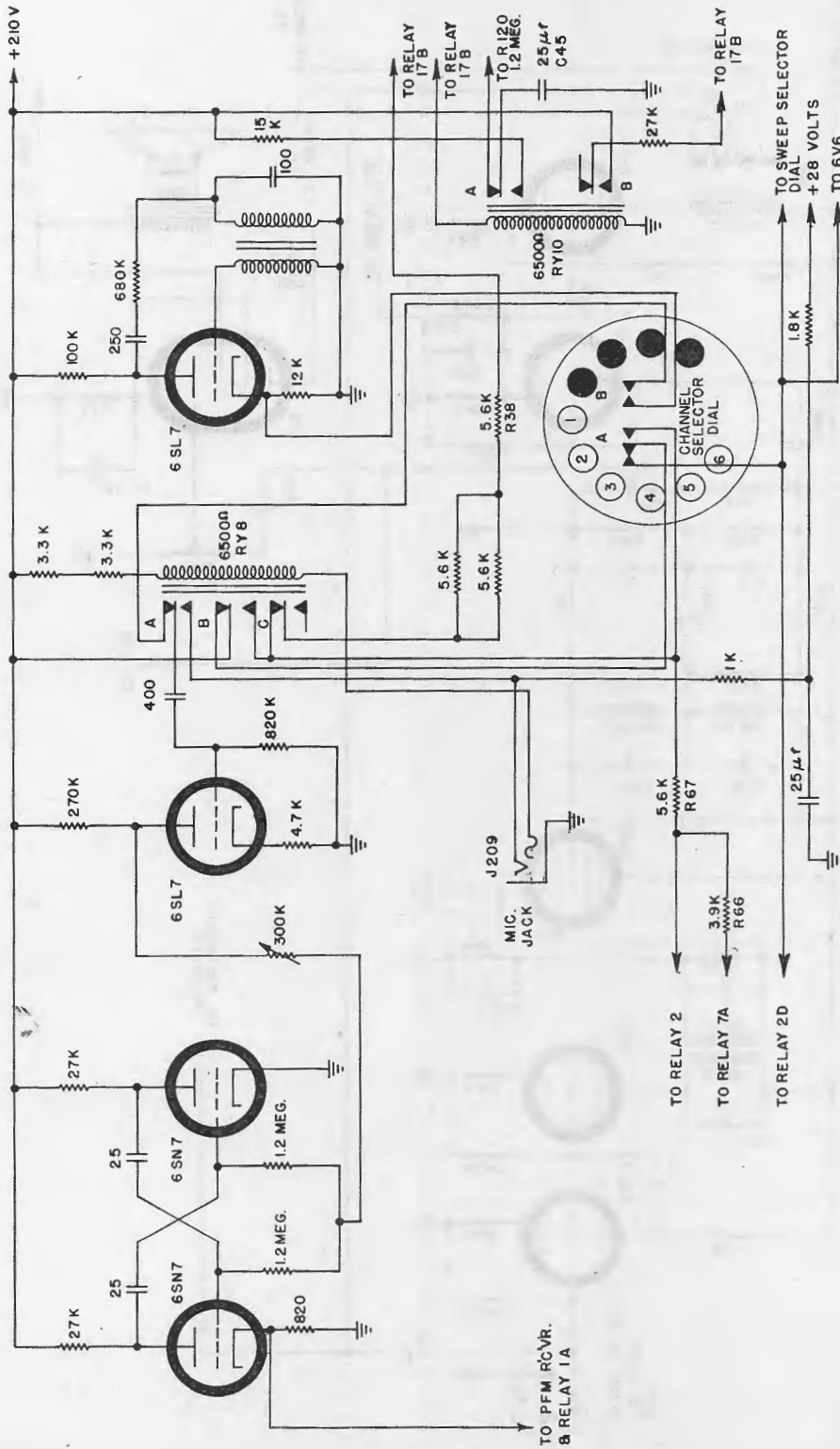


Figure 25 - Channel Change Circuit Schematic

Figure 27 - PFM Receiver Pass Band Characteristics

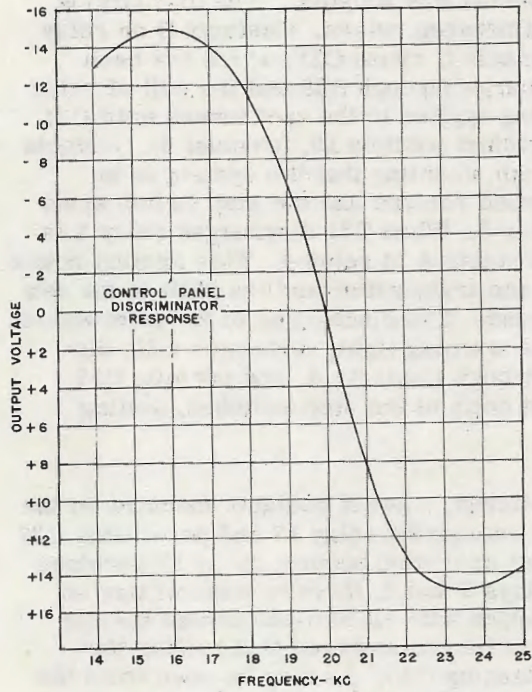
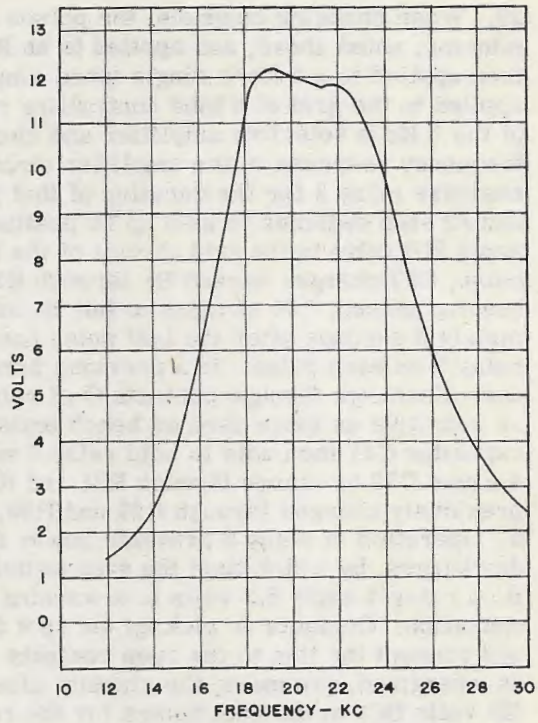


Figure 28 - PFM Receiver Discriminator Characteristics

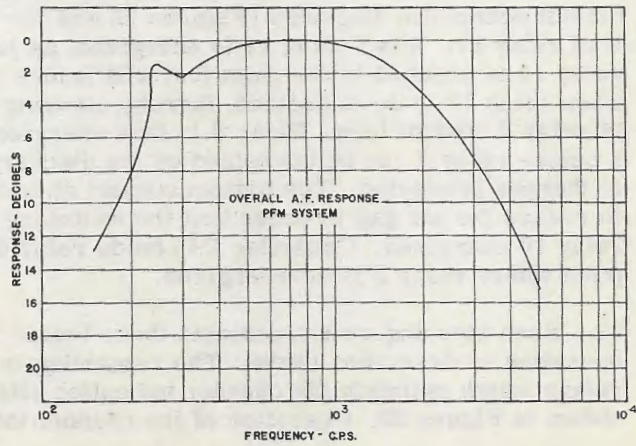


Figure 29 - Overall A.F. Response PFM System

29. When changing channels, the pulses of 5 Kc/s energy are recovered in the discriminator, noted above, and applied to an RC coupled amplifier. The amplified signal is then applied to a 5 Kc/s single tuned amplifier stage, the output of which is rectified and applied to the grid of a tube controlling relay 3. Figure 30 shows a schematic diagram of the 5 Kc/s selective amplifier and channel control circuits and Figure 31 shows the frequency response of the amplifier circuit. Each pulse causes the relay tube to energize relay 3 for the duration of that pulse, so that contacts B on relay 3 cause #1 and #2 step switches to step up 10 positions - corresponding to channel 6. Contacts A apply 210 volts to the grid circuit of the tube controlling relay 4. During the first pulse, C30 charges toward B+ through R23, and the relay 4 is energized. During succeeding pulses, C30 charges to full B+ and maintains relay 4 energized for approximately 8 seconds after the last pulse has been received. Contacts C on relay 3 energizes relay 5 on each pulse. In a previous arrangement, relay 5 was energized by a capacitance discharge through contacts C of relay 4, however, since the relays used are not as sensitive as those used on bench tests, this method was adopted. The discharging capacitor C31 then acts to hold relay 5 energized between pulses. Contacts D on relay 4 cause C32 to charge through R31 and R28. Contacts C cause C31, which has been previously charged through R29 and R30, to discharge through R30 and the coil of relay 5. Operation of relay 5 prevents power from being applied to the spot tuners until C31 discharges, by which time the step switch has reached position 10, (channel 6). Contacts B on relay 4 apply 6.3 volts to a warning pilot lamp, denoting that the system is in operation. Contacts A pick up the spot tuner ground returns and the step switch arms and connect the line to the open contacts A of relay 5. When C31 discharges relay 5 is de-energized, grounding the circuits closed by contacts A of relay 4. This applies power (28 volts DC) to the spot tuners for the receiver and transmitter and the shift to the new channel (#6) is made. After approximately 8 seconds, C30 discharges to the point where relay 4 is de-energized. This action releases the warning light, recharges C31, disconnects spot tuner power by removing ground through Contacts A, and permits C32 to discharge through R31, contact D and the reset coils of the step switches, setting them back in "home" position.

31. During the stepping operation of the step switches, a set of contacts mounted on the arm of #1 switch closes at the fifth step, thereby energizing relay 17 and permitting C27 to charge to 210 volts. When the step switch reset operation occurs, relay 17 becomes de-energized and C27 discharges, energizing relays 1 and 2, thereby transmitting an acknowledgement signal. This last action will happen with all stations except the one whose signals caused the frequency change. It will be remembered that pulling the channel selector dial over energized relay 10, charging C45. As may be seen from the circuit schematic diagrams (Figures 25 and 30) relay 10 is energized through contacts B of relay 17. When relay 17 is energized, as just explained, the operating voltage to relay 10 is reduced to the point that will insure a rapid relay drop-out. This occurs when relay 17 is de-energized, thereby allowing C45 to discharge into the grid circuit of relay 6 control tube. Relay 6 is thus energized, breaking the ground return of relay 1 before relay 2 can be energized by the discharge of C27. Keying of the transmitter is thereby prevented. The bottom contact of contacts B on relay 17 was adjusted so as to reduce the air gap in order that the switching action would be fast enough to hold relay 10 energized. Capacitor C45 holds relay 6 energized until C27 discharges to the point where relay 2 is de-energized.

32. Each stepping switch contains three levels, two levels being used for spot tuner operation as described above. The remaining level is used in connection with holding relays which maintain the channel indication after the step switch has been reset as shown in Figure 32. Operation of the channel indicator is as follows. After C31 discharges

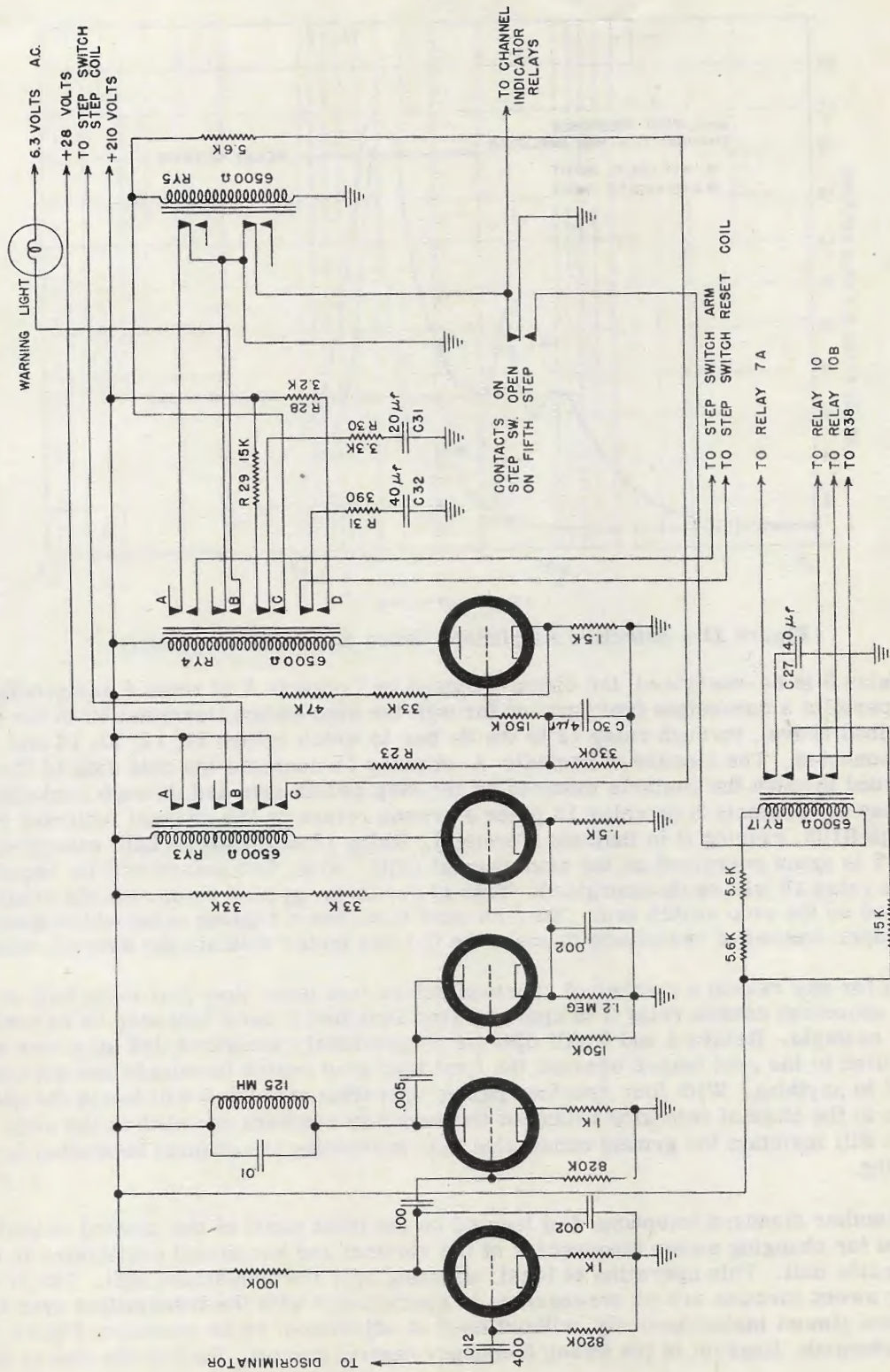


Figure 30 - Selective Amplifier and Channel Control Circuits

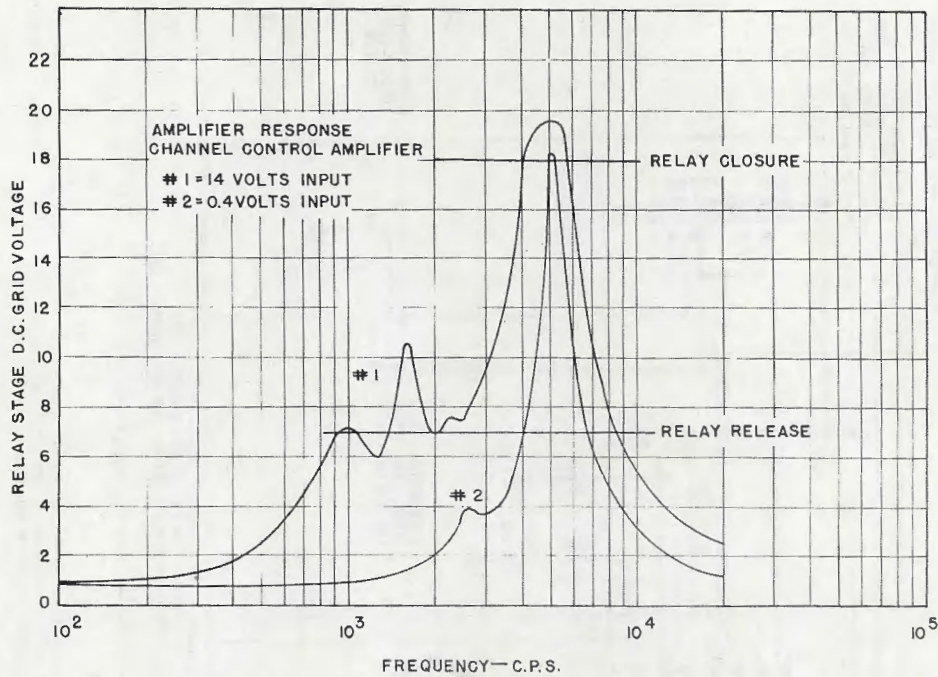


Figure 31 - Selective Amplifier - Pass Band Characteristics

and relay 5 is de-energized, the circuits closed by Contacts A of relay 4 are grounded. This permits a connection from ground through the step switch (terminal 10 in the case described above), through relay 12 to the B+ bus to which relays 11, 12, 13, 14 and 15 are connected. The closure of contacts A of relay 15 connects the cold side of the coil to ground through the contacts mounted on the step switch arm and through contacts B on relay 5. Contacts B on relay 15 place a ground return on the channel indicator meter through R103, causing it to indicate channel 6. Relay 15 will thus be held energized until relay 5 is again energized on the next channel shift. Also, five pulses will be required before relay 15 will be de-energized. This is due to the ground return via the contacts mounted on the step switch arm. Each channel then, has a holding relay which inserts the proper amount of resistance to make the 0-1 ma meter indicate the correct channel.

33. If for any reason a number of spurious pulses (not more than four occurring in rapid sequence) causes relay 3 to operate, step switches 1 and 2 will step up to position 4, for example. Relays 4 and 5 will operate as previously explained, but no power will be applied to the spot tuners because the first four step switch terminals are not connected to anything. With four spurious pulses operation of relay 5 will break the ground return to the channel indicator relay but the auxiliary contacts mounted on the step switch will maintain the ground connection thus preventing the channel indication from changing.

34. Another standard telephone dial located on the front panel of the control chassis is used for changing sweep frequencies of the vertical and horizontal oscillators in the conversion unit. This operation is local, affecting only the conversion unit. The receiver sweep circuits are so arranged as to synchronize with the transmitted sync frequencies almost instantaneously, without need of adjustment by an operator. Figure 33 is a schematic diagram of the sweep frequency control circuit. Pulling the dial of the

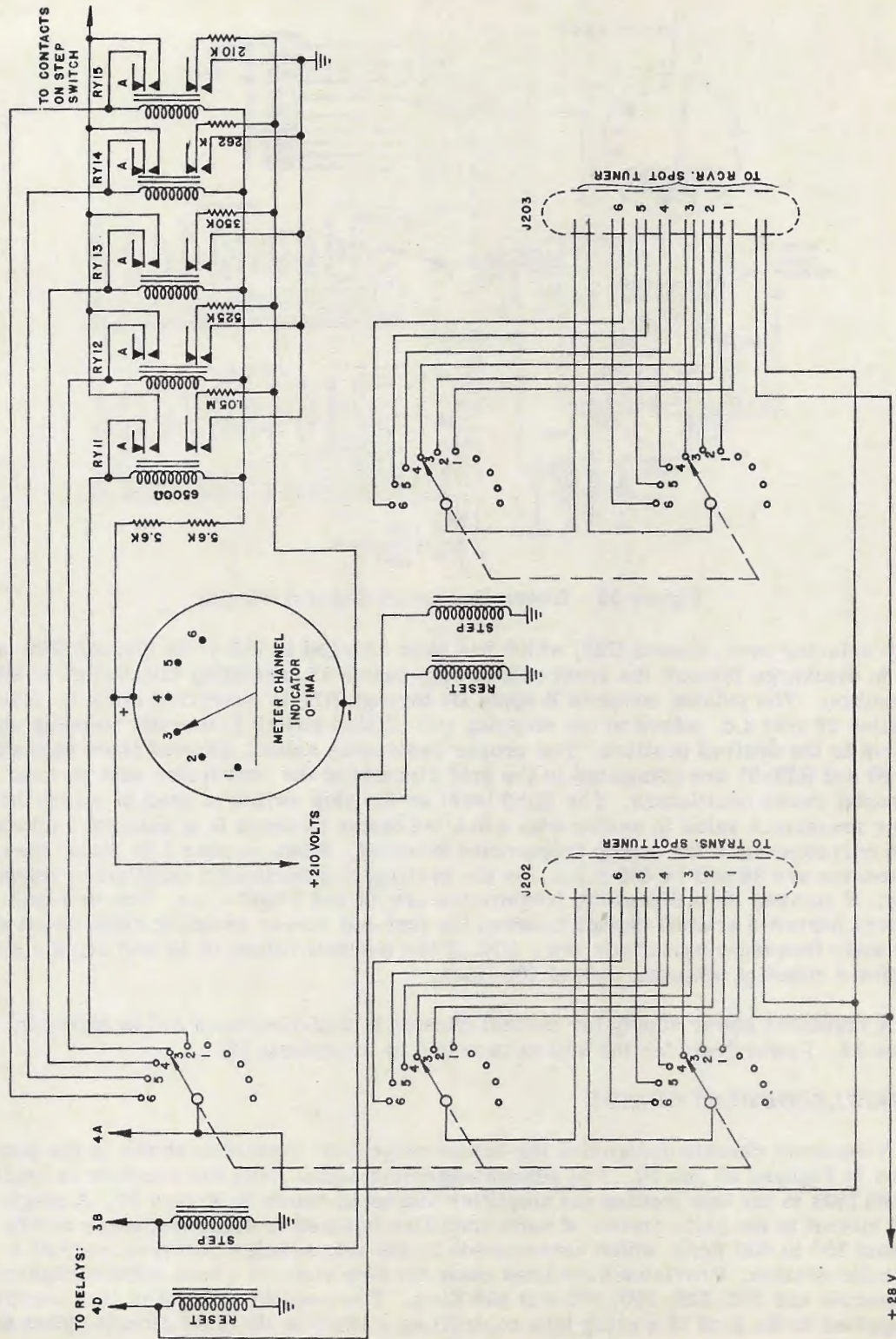


Figure 32 - Channel Indicator Circuit

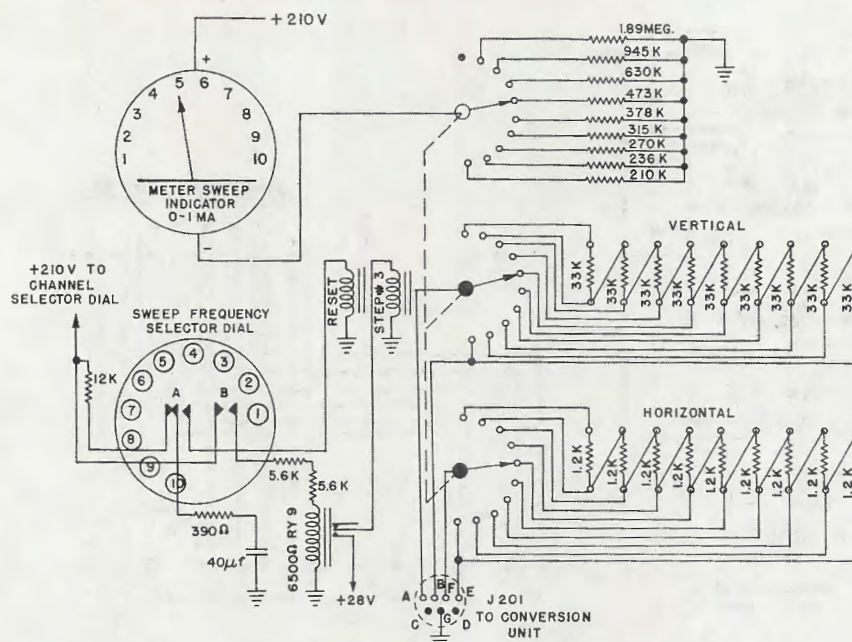


Figure 33 - Sweep Frequency Control Circuit

sweep selector over, causes C38, which has been charged to 210 volts through R70 and R72, to discharge through the reset coil of step switch #3, resetting this switch to the off position. The pulsing contacts B apply B+ through R71 to energized relay 9. Relay 9 applies 28 volt d.c. pulses to the stepping coil of step switch 3, thereby stepping up the arm to the desired position. The proper resistance values, derived from networks R82-90 and R73-81 are connected in the grid circuits of the conversion unit vertical and horizontal sweep oscillators. The third level on the step switch is used to insert the proper resistance value in series with a 0-1 ma meter to cause it to indicate a number which corresponds to the sweep frequencies selected. When number 1 is dialed these frequencies are 36 and 14,400 c.p.s. for the vertical and horizontal oscillators respectively. If number 10 is dialed the frequencies are 44 and 17600 c.p.s. The included numbers permit a gradual change between the fast and slower scanning rates noted above. The sweep frequency variations are $\pm 10\%$ of the nominal values of 40 and 16,00 c.p.s. and give a constant scanning rate of 400 lines.

35. A regulated power supply for control chassis is self-contained and is shown in Figure 34. Power input for the unit is provided by receptacle J204.

ACKNOWLEDGEMENT CHASSIS

36. A separate chassis designated the acknowledgement chassis is shown in the photographs in Figures 35 and 36. The acknowledgement signal from the receiver is applied through J503 to the line feeding six amplifier stages as shown in Figure 37. A single tuned circuit in the plate circuit of each amplifier is tuned to some frequency within the band 300 to 400 Kc/s which corresponds to the acknowledgement frequency of a particular station. Provision have been made for five stations whose acknowledgement frequencies are 300, 325, 350, 375 and 400 Kc/s. The amplified signal is then rectified and applied to the grid of a relay tube controlling a relay in its plate circuit. When the

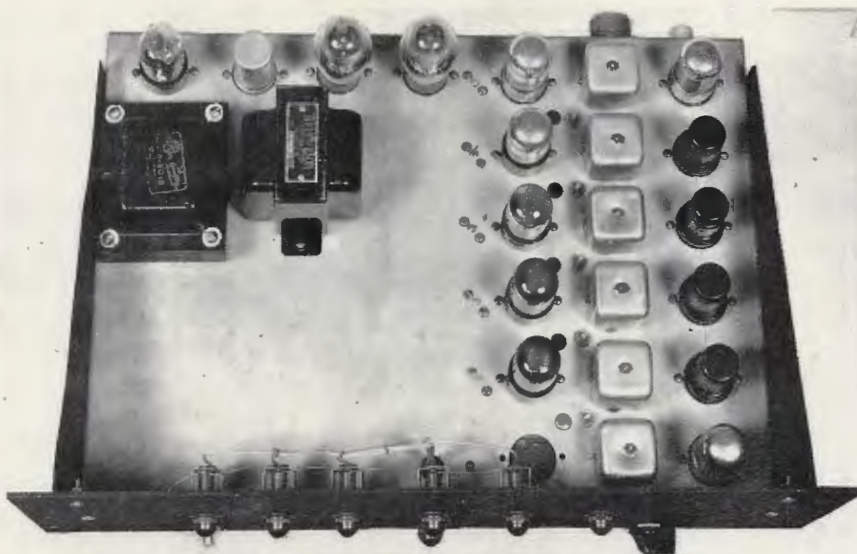


Figure 35 - Acknowledgement Chassis

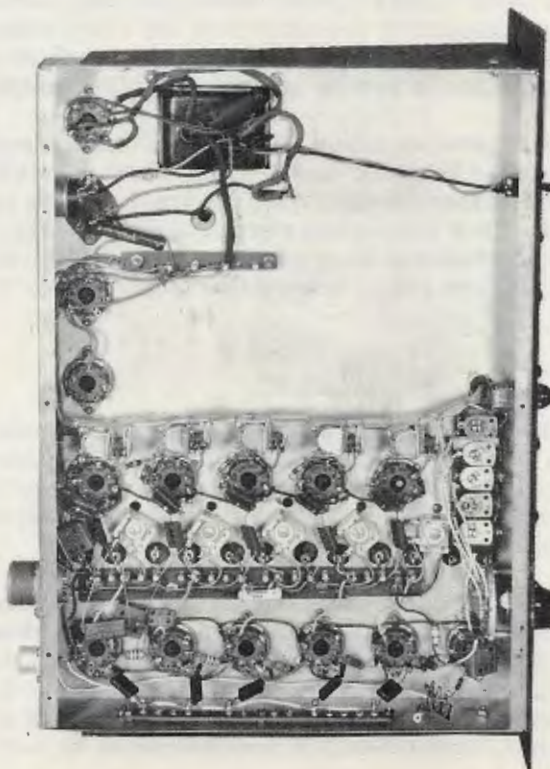


Figure 36 - Acknowledgement Chassis

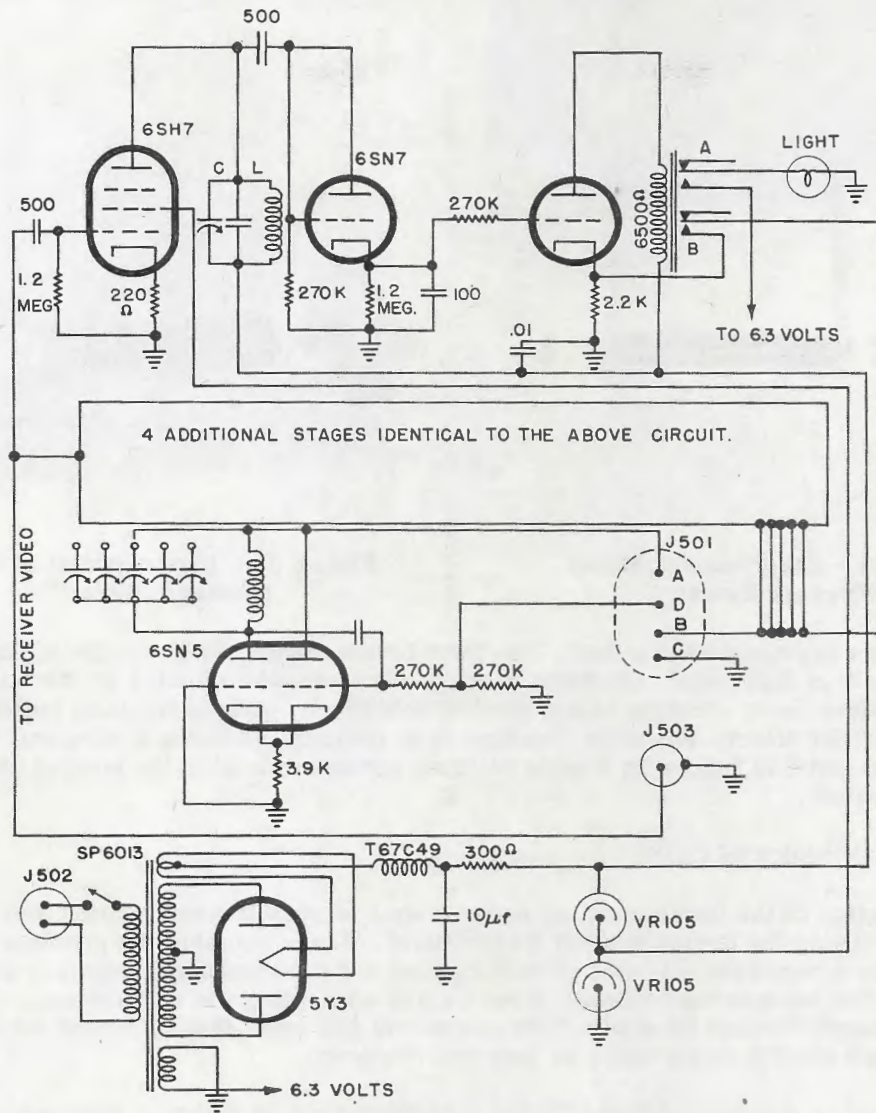


Figure 37 - Acknowledgement Chassis Circuit Schematic

and then to the message placar. The message form is then guided under the television camera at the correct distance from the lens and fed into the take up rollers which will move each message into place when a push button on the control panel is depressed. The take-up rollers are driven by a small motor having a quick stop clutch to disengage them the instant the message form is in proper position.

40. An arrangement to key the transmitter after the message is in position is shown in Figure 40. When the motor is operated, contacts A (mounted on the motor) allows C42 to charge toward 210 volts through R100. When the message has been placed and the motor stops, contacts A return to their normal position allowing C42 to discharge through R98 and the coil of relay 16. After relay 16 is thus energized, operation of the

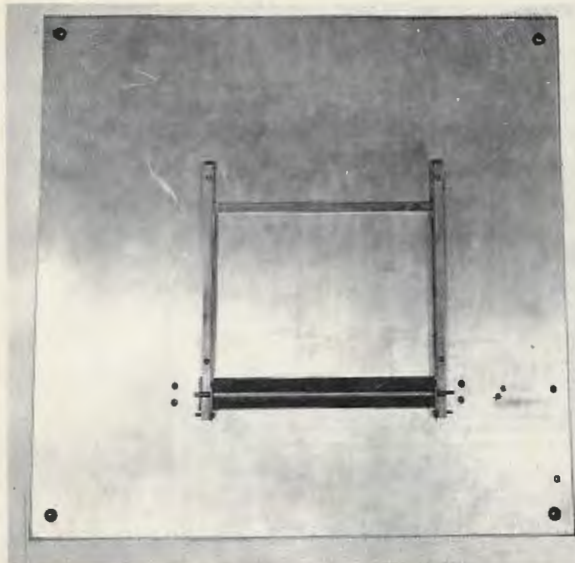


Figure 38 - Experimental Model
Message Placer

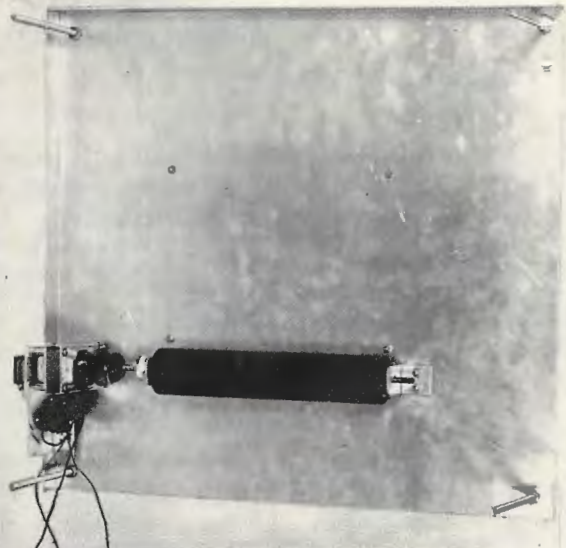


Figure 39 - Experimental Model
Message Placer

circuits is as previously described. The push button closes the 110 volts AC line to the motor when it is depressed. Contacts B are a micro-switch actuated by the motor when it starts. When these contacts close, the 110 volt line by-passes the push button so that it has no further effect. When the message is in position, contacts B open and the motor stops. R100 and C42 (shown in Figure 21) have not been wired in the control chassis at the present time.

PROBLEM CONSIDERATIONS

41. The status of the problem at the present time is such that one station unit is near completion (using the demonstration transmitter). There remains the problem of mounting the conversion unit with proper lighting for the iconoscope together with a better constructed message placer. Also, cables connecting the various units of the equipment together must be made. The completed unit must then be tested for overall operation and modifications made as they are required.

42. It should be pointed out that with the present system of message acknowledgement, some difficulty is expected as to its reliability. Since all stations transmit their acknowledgement signals simultaneously, the possibility of beat notes occurring in the receiver due to the carrier frequencies thereby exists. For instance, two carriers operating 350 kilocycles per second apart would possibly energize one of the acknowledgement lights, thereby giving a false indication, provided that the 350 Kc/s channel is assigned to some station. It may be possible to work out a time sharing basis where each transmitted acknowledgement signal is delayed for a given period of time, so that only one station is transmitting at any time. Another possibility may lay in the station that sends the message also insert, at some time during its transmission, signals that will request an acknowledgement from a particular station. The time sharing basis wherein each carrier transmission is delayed appears to offer the solution. This could be done by simply delaying the discharging of capacitor C27 for a given period of time depending upon the assigned delay for a particular station.

43. The relays used during bench tests reported in reference 4, while having the same value of coil resistance as those used in the present equipment, required only 60 volts for satisfactory operation. The ones received from the manufacturer (C. P. Clare Mfg. Co.) and used in the equipment require 75 to 80 volts. This necessitated some changes in circuit values that were mostly concerned with timing. Although the former relays were ordered, the latter ones were received and had to be used.

44. A circuit diagram of the Yardney spot tuner is shown in Figure 41, pages 36 to 37. In the present equipment, the control boxes containing the channel selector switches have been replaced with stepping switches. Also it was found necessary to disconnect the jumper wire connecting ground #9 and #17 leads at the connector receptacle.

45. The 20 Kc/s RC filter following the PFM receiver discriminator output should be changed to an LC type filter having a sharp cut-off characteristic at 6 Kc/s for better performance. Some difficulty was experienced due to the relatively high filter output at 20 Kc/s. This caused some grid biasing of the succeeding amplifier stage thereby reducing its gain at 5 Kc/s.

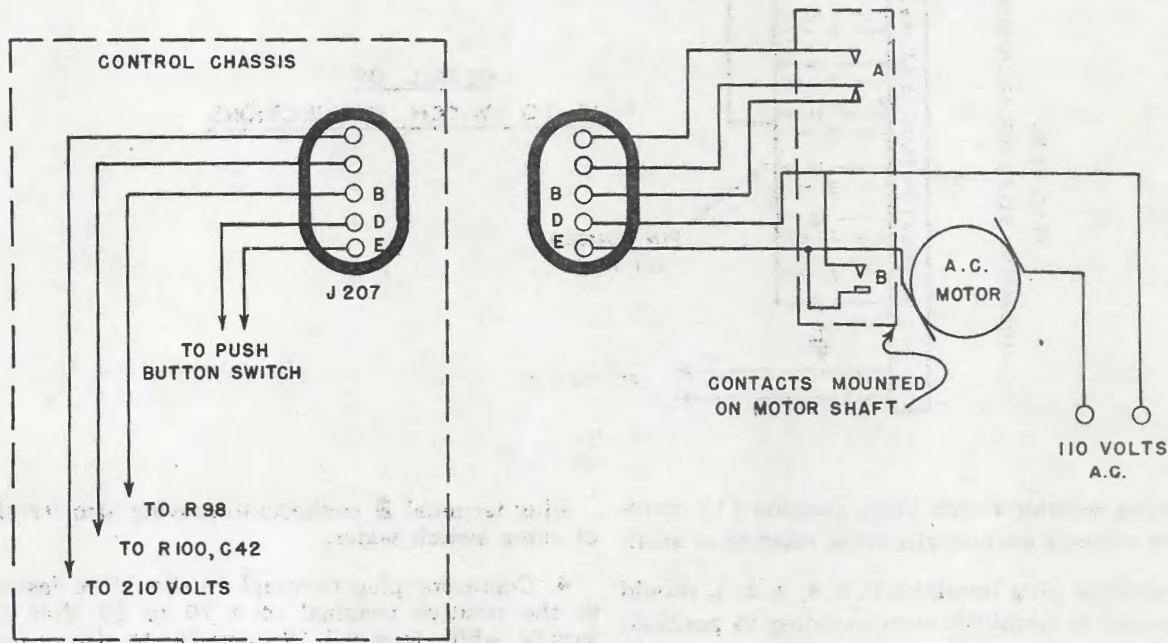
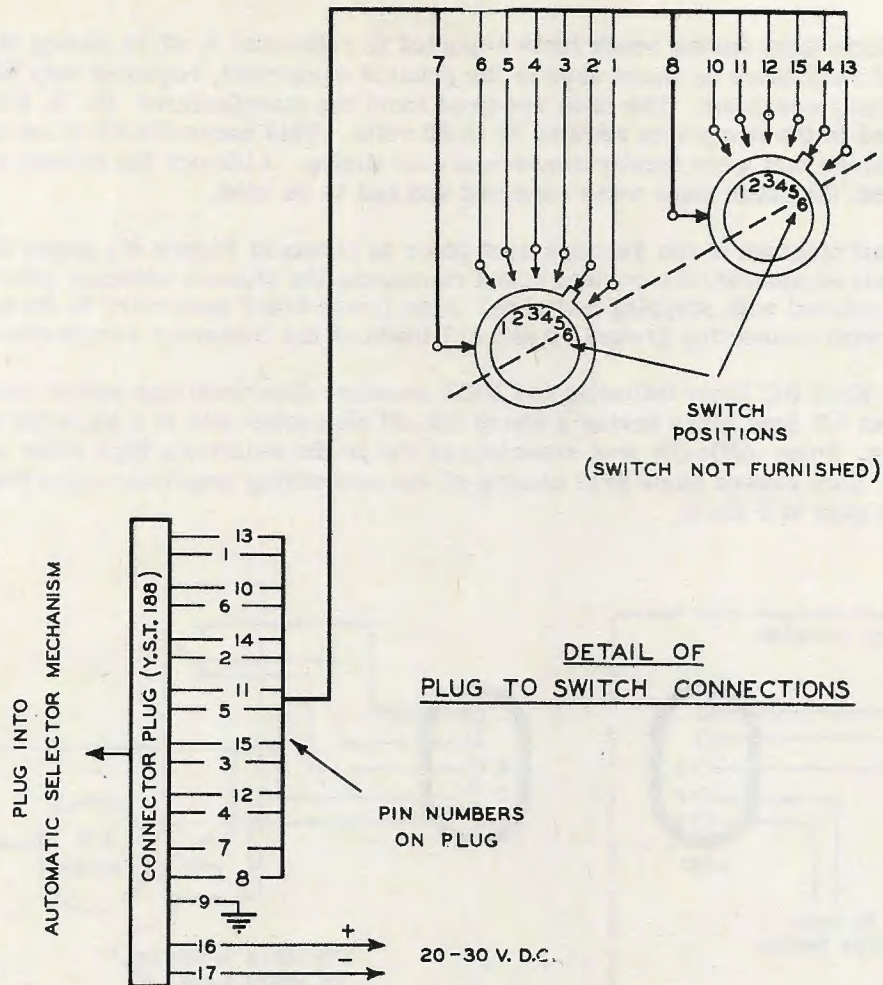


Figure 40 - Transmitter Keying by Message Placer

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1. Facing selector switch knob, position (1) corresponds to extreme counter-clockwise rotation of shaft.

2. Connector plug terminals 6, 5, 4, 3, 2, 1, should be connected to terminals corresponding to positions 1, 2, 3, 4, 5, 6, respectively, of one of the two switch wafers.

Plug terminal 7 connects to moving arm terminal of same switch wafer.

3. Connector plug terminals 10, 11, 12, 15, 14, 13, should be connected to terminals corresponding to positions 1, 2, 3, 4, 5, 6, respectively, of the other switch wafer.

Plug terminal 8 connects to moving arm terminal of same switch wafer.

4. Connector plug terminal 16 should be fastened to the positive terminal of a 20 to 30 Volt D.C. supply, while terminal 17 connects to the negative side of the D.C.

5. Connector plug terminal 9 may be soldered to cable shield (if shielded cable is used; otherwise, terminal should be grounded), which may also be ground at the switch end of cable.

IMPORTANT: Unstaple operation of the Spot Tuner (hunting), may result if the above connections are not observed. Therefore, cable connections should be checked carefully if trouble exists after installation.

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UNCLASSIFIED

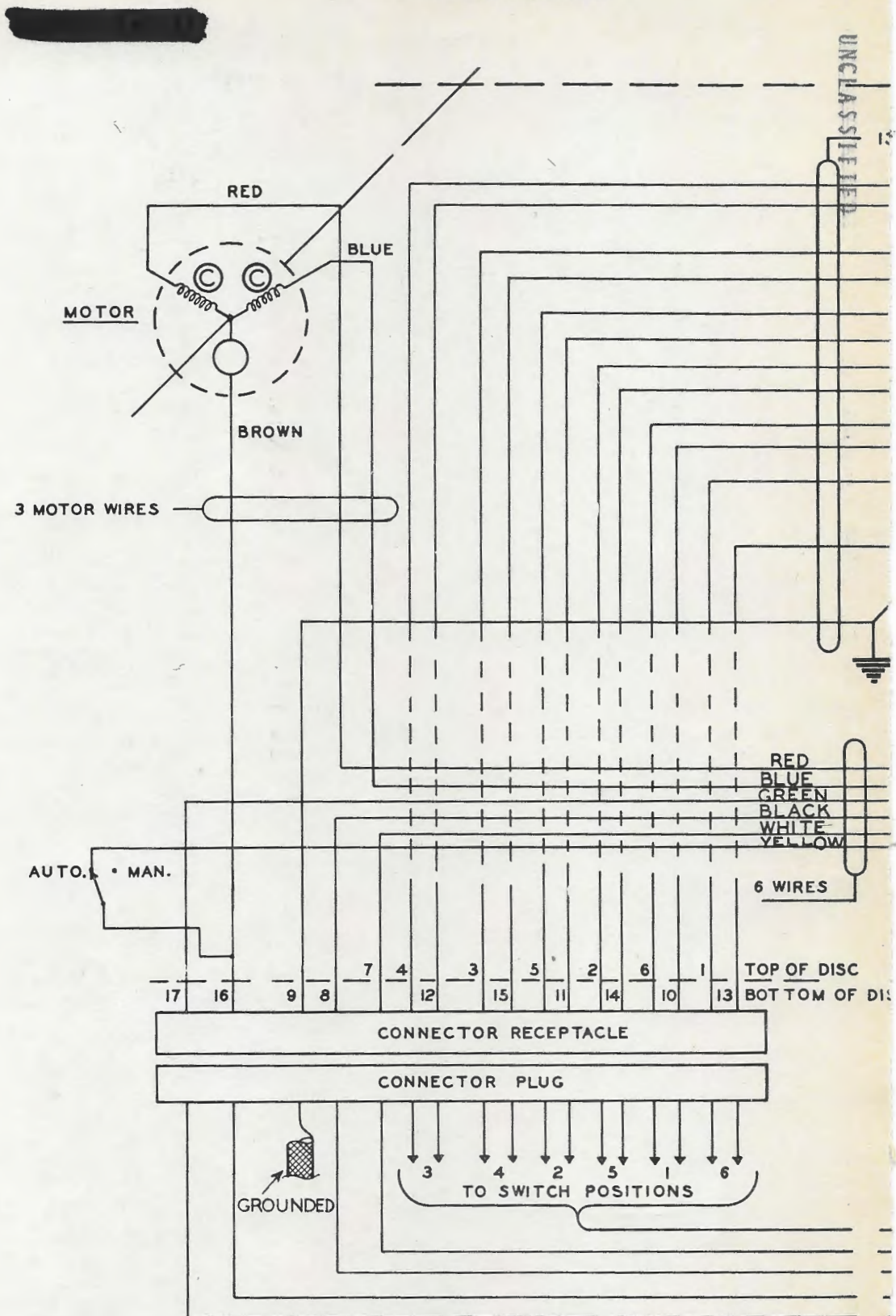
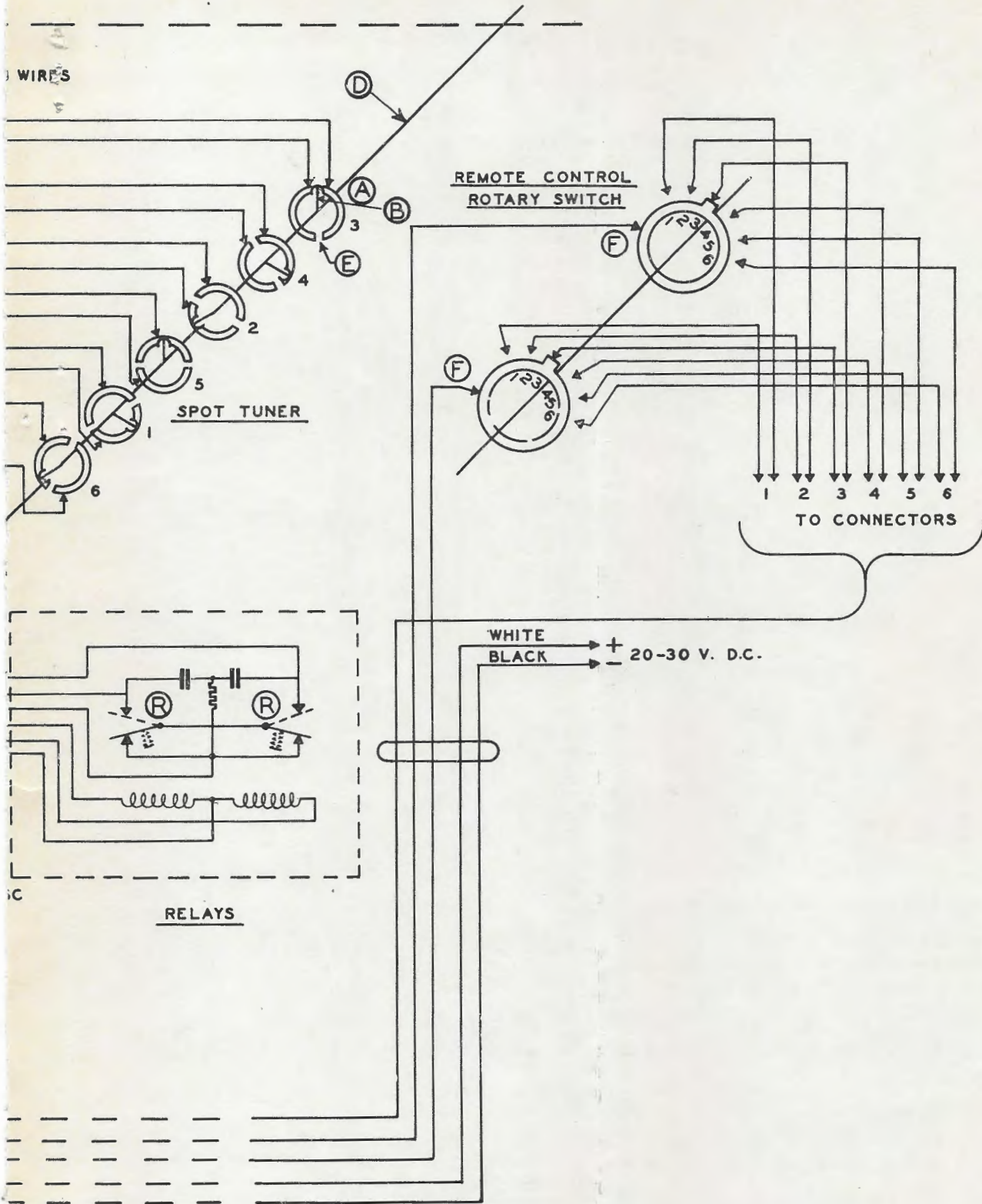


Figure 41 - Yardney



Spot Tuner - Circuit Schematic