567/26 of Depts

FR-1135

REPORT NO. R-1135

DATE 13 March 1935

SUBJECT

Test of Anti-click Keying Unit

BY

NAVAL RESEARCH LABORATORY

BELLEVUE, D. C.

U. S. GOVERNMENT PRINTING OFFICE: 1935 4—7456

Report No. R-1135
Test of Anti-click Keying Unit

13 March 1932

NRL Report No.R-1135
BuEng. Prob. T9-2

NAVY DEPARTMENT
BUREAU OF ENGINEERING

Report on

Test of Anti-click Keying Unit

NAVAL RESEARCH LABORATORY
ANACOSTIA STATION
WASHINGTON, D.C.

Number of Pages: Text - 8 Plates - 5

Authorization: Bu.Eng. let. S67/52(9-22-W8) of 11 Jan. 1935.
Bu.Eng. let. S67/26(11-6-W8) of 9 Nov. 1934.

Date of Test: January 1, 1935 to February 28, 1935.

Prepared by: L. C. Young, Radio Engr. R. B. Meyer, Assoc.Rad.Engr.

Reviewed by: A. H. Taylor, Physicist, Supt., Radio Division

Approved by: H. R. Greenlee, Captain, U.S.N., Director

Distribution:
Bu.Eng. (5)

mbe

TABLE OF CONTENTS

Appendices

AUTHORIZATION

1. The tests herein reported were authorized under Bureau of Engineering problem T9-2 and references (a) and (b). Other pertinent data are listed as references (c) to (e) inclusive.

Reference: (a) Bueng. let. S67/52(9-22-W8) of 11 Jan. 1935.
(b) Bueng. let. S67/26(11-6-W8) of 9 Nov. 1934.
(c) NRL let. A-13-2(1) of 12 Nov. 1934 to Bueng.
(d) Bueng. let. NOs-37323(1-4-W8) of 16 Jan. 1935.
(e) NRL let. S67/52 of 28 Jan. 1935 to Bueng.

OBJECT OF TESTS

2. The object of the tests was to determine the action of the anti-click keying unit constructed at the Naval Research Laboratory under authority granted in reference (b), and to demonstrate the device to representatives of several interested commercial companies in accordance with the Bureau's instructions as contained in reference (d). In addition, the tests were conducted to determine whether it would be possible to further improve the device and simplify its operation.

ABSTRACT OF TESTS

3. The anti-click keying unit was operated in conjunction with a Model TAQ-4 Transmitter. The ease with which the new type of keying could be applied to this transmitter and other transmitters used in the Naval Service was demonstrated. The reduction in interference resulting from the use of the anti-click keying unit was demonstrated by observing reception on nearby receivers by both aural and visual means. Two methods of keying control were tested and the advantages and disadvantages of both types were illustrated.

CONCLUSIONS

(a) The anti-click keying unit described reduces key click interference to such a low level that troubles from this source are practically eliminated. A reduction in interference of this nature should be of great value in the Fleet and should make possible the utilization of a large number of additional channels of communication by permitting operation on frequencies which are separated from each to a smaller degree than at present.

(b) The circuit which produces the most desirable or perfect results from the stand point of break-in operation does not lend itself readily to adjustment in service. Plans for obtaining these adjustments by less complicated means are being studied and the indications are that if complete break in operation is to be desired, at the expense of some slight difficulty in adjustment, this can be accomplished through the medium of auxiliary devices of a less complicated character than cathode ray oscillographs and synchronized sweep circuits.

(c) It is possible to obtain the same degree of key click elimination with more simple circuits, particularly circuits which are easy to adjust. This type of circuit, however, does not permit of complete break in operation, but it is believed that sufficient break-in operation may be realized so that the use of this circuit will be entirely practicable in the Fleet.

(d) While the present model of the anti-click keying unit is of considerable size, a great reduction in weight and space can be accomplished if the device is designed for each particular transmitter and if the transmitter is provided with a source of bias voltage of somewhat higher potential than is generally provided.

RECOMMENDATIONS

It is recommended:

(a) That the Bureau of Engineering consider the advisability of furnishing at least one unit in the Fleet with anti-click keying units in order that practical information may be obtained as to the operation of such equipment under normal service conditions afloat.

(b) That any further units which may be authorized, be designed around the circuit illustrated in Plate No. 2 in the interests of simplicity of circuit design, operation and adjustment in the field. If such units are constructed, it is believed that best results will be obtained if they are designed for operation in connection with the specific types or groups of transmitters which they are intended to key.

(c) That further work along the lines of improving and simplifying anti-click methods of keying include means for simplifying the adjustment of circuits similar to that illustrated in plate No. 1.

(d) That, in accordance with the information requested in paragraph 4 of reference (a), the following method of specifying and quantitatively

measuring the keying characteristics of transmitters with respect ot their effects on reception, be adopted, until further investigation and study reveals more suitable methods for accomplishing this purpose.

> With a standard Navy Receiver tuned to resonance and operating in close proximity to the transmitter under test the gain of the receiver and the R.F. input from the transmitter shall be adjusted to give an output of ( ) milliwatts with an input of ( ) microvolts. These adjustments shall be determined by means of a Standard Signal Generator and Output Meter. With the same input and the receiver detuned ( ) percent and the receiver gain increased ( ) db, the key clicks shall be inaudibile.

(Note: The proper values to be inserted in this test will be forwarded to the Bureau as soon as sufficient tests have been conducted to determine these values.)

(e) That preliminary models of transmitters tested at the Laboratory be studied by means of oscillographic methods, as outlined in this report.

(f) That the Bureau authorize a continuation of this problem in order that the investigation with a view of eliminating mechanical relays and of providing means for adjusting the keying circuits for various speeds may be investigated further, since at the present time this phase of the problem is only partially completed. (See par. 5 of reference (a).)

MATERIAL UNDER TEST

4. The material under test consisted of a specially designed anti-click keying unit constructed at the Naval Research Laboratory. This equipment is capable of operation in connection with practically any type of Navy transmitter ranging in power from a hundred watts to 10 kilowatts output, and within the range of frequencies regularly employed in the Naval Communication Service. Plates 1 and 2 are schematic diagrams showing details of circuit arrangements while plates 4 and 5 are photographs of the actual equipment used in these tests.

METHOD OF TEST

5. The keying unit was installed adjacent to a Model TAQ-4 transmitter and the proper interconnections made through the medium of two switches, by means of which it was possible to key the transmitter either with the special keying unit or by means of the regular keying system provided with the transmitter in its original form. Observations were made on a Model RAA receiver located adjacent to the transmitter and also on a similar receiver located at a point about three hundred feet distant. The improvement in results obtained through the use of the anti-click keying unit was determined by comparing the interference generated in the receivers, first, by the regular keying method and then by the special method. The degree of interference was determined by aural means and by observing the output of the receiver on a cathode ray oscillograph. Photographic reproduction of the cathode ray traces were made in order to provide permanent records of the results.

DATA RECORDED

6. In addition to the aural observations made, photographic records of the oscillographic traces were recorded. These records are appended hereto as Plate No. 3.

PROBABLE ERRORS IN RESULTS

7. The nature of the tests were such that the probable errors in results are confined to slight differences in opinion by various observers as to the degree of interference elimination as determined by aural means. These differences, however, can readily be compensated for by comparisons made through the medium of the cathode ray oscillograph and the photographic records made of the oscillographic traces.

RESULTS OF TESTS

8. A concise summary of the previous work done in connection with the problem of the reduction and elimination of key-click interference is contained in reference (c). The reference report contains a discussion as to the nature of key clicks, the phenomena by means of which they are generated and themethods by which they are removed. In addition, the report contains a description of an experimental keying unit which was developed as a result of these studies and the results obtained when this unit was used for keying various experimental and standard Navy transmitters.

9. As a result of these investigations and under authority

contained in reference (b), an improved keying unit was designed and constructed. This unit was used in conjunction with the preliminary model TAQ-4 transmitter which was undergoing tests at the Laboratory.

10. The anti-click keying unit is readily adapted for use in connection with practically any transmitter. In the case of the TAQ-4 it was necessary to make only two connections. Referring to General Electric Company drawing T-7659831, which is a schematic diagram of the TAQ-4 transmitter and to Plate No. 1 attached to this report, the necessary connections were made as follows. The ground return of the filament winding of transformer Pt. 60 which lights the filaments of the oscillator tube was broken. Terminals No. (1) and (2) of the keying unit were connected into the circuit at this point. The power amplifier grid circuit was broken between the grid leak Pt. 66 and the bias potentiometer, pt. 78. Terminal No. (5) of the keying unit was connected to the grid leak pt. 66 and the ground terminals of the keying unit and the Model TAQ-4 transmitter were connected together. Then, by merely locking the local test key on the TAQ-4 transmitter panel the equipment was ready for operation. These interconnections were made through the medium of switches so that either type of keying could be used at will by merely throwing the switches from one position to the other.

11. A brief description of the keying circuit illustrated in Plate No. 1 follows. The keying **unit is connected to the key line through the medium** of relay No. 3, which relay is fitted with front and back contacts. The marking contact "M" of relay No. 3 controls the coil circuit of relay No. 1 through the timing net work and the grid and plate circuit of one half of the double vacuum tube, while the spacer contact "S" controls relay No. 2 through its timing network and the other half of the type '53 tube. The contacts of relay No. 1 control the keying of the master oscillator circuit of the transmitter while the contacts of relay No. 2 key the power amplifier circuit through the medium of the four 38145 tubes and associated circuits. With the key line open relay No. 3 is making contact on the spacer side which grounds grid No. 2 through resistance No. 4 allowing plate current to flow through the coil circuit of relay No. 2, holding the armature of this relay on the marker side, or in the open position. While this condition prevails, resistance R-5 is disconnected from ground allowing a high bias to build up on grid G-1 through resistor R-6, thus blocking this half of the type '53 tube. Therefore, no current is flowing in the coil circuit of relay No. 1 and the armature of this relay remains on the spacer side, or in the open position. Under these conditions the master oscillator circuit of the transmitter is in a non-oscillating condition and the power amplifier tube is blocked due to the high bias impressed upon the grid. With relay No. 2 in the open position, resistor R-8 is disconnected from the filament of the 38145 tubes, allowing a high bias to build up on the grids through resistor R-7, thus increasing the impedance or effective resistance of these tubes which form part of the bias divider. This bias divider consists of resistor R-9 in series with the 38145 tubes.

12. Upon closing the key line the armature of relay No. 3 makes contact on the marker side "M", grounding grid G-1 through resistor R-5, lowering the bias on grid G-1, thus discharging capacitor C-1 to a lower potential. R-5 being a relatively low value this action is very fast, allowing plate current to build up in the coil circuit of relay No. 1 almost immediately, thus throwing contacts of relay No. 1

to marker side. The closing of this contact completes the master oscillator circuit permitting oscillations to build up. In the meantime resistor R-4 being disconnected from ground, the bias on grid G-2 starts to build up but is retarded due to the time constant of C-2 and R-3. Thus the fall of plate current in the coil circuit of relay No. 2 is gradual and the armature of the relay moves over to the spacer side "S" an appreciable time after relay No. 1 has closed the master oscillator circuit. The closing of the contacts of relay No. 2 connects the grids of the 38145 tubes to filament through resistor R-8 which lowers their bias gradually due to the time constant of capacitor C-4 and resistors R-8 and R-7. As the grid bias decreases the impedance or resistance of the 38145 tubes gradually decreases until it reaches the point where a suitable working bias is obtained.

13. When the key line is opened the armature of relay No. 3 returns to the spacer contact grounding grid G-2 through resistor R-4. The value of R-4 being low as compared to R-3 the discharge of capacitor C-2 takes place rapidly and the plate current builds up in relay No. 2 in a similar manner thus causing its armature to move to the marker contact almost instantly. This in turn disconnects resistor R-8 from the filament of the 38145 tubes allowing a blocking bias to build up on the grids of the 38145 tubes through the retarding action of the timing circuit. The impedance of the 38145 tubes is increased to the point where the power amplifier tubes are blocked. In the meantime resistor R-5 has been disconnected from ground allowing the bias to build up on the grid G-1 through resistor R-6. This action is retarded due to the time constant of C-6 and R-1 causing the contacts of Relay No. 1 to open after the contacts of relay No. 2 have opened.

14. From the foregoing it will be seen that the contacts of relay No. 1 make before the contacts of relay No. 2, and that the contacts of relay No. 2 open before the contacts of relay No. 1. The amount of this overlap can be controlled at either end by the selection of the proper values of resistance and capacity used in the timing circuits. The retarding action of the timing circuits connected with the grid of the 38145 tubes causes a rounding off of the beginning and end of the transmitted dot or dash. This rounding off action results in the practical elimination of key clicks as described in reference (c).

15. The method described above and outlined in Plate No. 1 produces operation, the results of which approach the ideal method of keying. Key clicks are greatly reduced and the system lends itself to complete break in operation since there are no radiating circuits when the key is open. Graphic comparisons between the results obtained with the anti-click unit, an ordinary method, and the regular keying method employed in the TAQ-4 transmitter, are shown in Plate No. 3. In the ordinary method of keying as used for these tests, the intermediate and power amplifiers have the working grid bias applied all the time and only the master oscillator is keyed. This is accomplished by shorting the working contacts of No. 2 relay (plate No.1) which puts the power amplifier grids at their proper working voltage, and allows keying via relay No. 1 (plate No.1) and the master oscillator. The illustrations in this plate are numbered from 1 to 15, inclusive.

(a) No. 1 shows the rounded dot produced by the special keying system, with the receiver adjusted to produce a low beat note.

(b) No. 2 shows a dot obtained under similar conditions except that the receiver was adjusted to a higher beat note.

(c) No. 3 shows the dot produced by the ordinary method of keying with the receiver adjusted to a high beat note. It will be noted that this dot persists for a longer period of time since there is no overlapping adjustment as in the case of No. 1 and 2. The abrupt beginning and almost as abrupt termination of the dot is plainly visible.

(d) No. 4 is similar to No. 3 except that the receiver was adjusted to a lower beat note.

(e) No. 5 is a record obtained by the special keying system wherein the receiver was detuned approximately 1.5%; the effect of key clicks is entirely lacking.

(f) No. 6 was made with the receiver off tune 1.5 percent as in the case of No. 5, but the ordinary keying system was used. The effect of the key clicks is plainly visible.

(g) No. 7 is a record obtained by the special keying system with the receiver off tune approximately 3 percent and with the receiver sensitivity increased over the value used previously. No key clicks are noted.

(h) Nos. 8 and 9 were made with the receiver off tune 3 percent and the same sensitivity as in the case of No. 7, but using the ordinary keying system wherein only the master oscillator is keyed. The key clicks are clearly shown.

(i) Nos. 10, 11 and 12 are beat note records made with the keying system provided in the TAQ-4 transmitter. A key bounce is plainly visible although every effort was made to adjust the relay for best results.

(j) Nos. 13, 14 and 15 are records made with the keying system provided in the TAQ-4 transmitter, the receiver being off tune approximately 1.5 percent, and the sensitivity adjusted to the same level as used in illustrations No. 5 and 6. The key clicks are plainly evident, including the interference caused by the relay bounce.

16. The reduction in interference, when making aural observations, is probably more apparent when the special keying system is used than is illustrated in the oscillographs. With the receiver detuned approximately 1.5 percent and with the sensitivity increased to a point where the key clicks generated by ordinary keying methods produce impacts in the phones of decidedly uncomfortable strength, the interference produced by the anti-click keying unit is almost, if not entirely absent. It would be possible to copy comparatively weak signals which differed in frequency by 1.5 percent from the local transmitter frequency when using the special keying system, while with the regular keying system the interference would be of sufficient magnitude to prevent copy being made.

17. While the advantages of the keying circuit illustrated in plate No. 1 are manifest, there are certain serious disadvantages. Due to the minute differences in the time constants involved in the operation of relays No. 1 and No. 2, the adjustment of these relays and the associated circuits must be made with extreme care and precision. Once this adjustment is made for any given installation there is little reason to believe that it would not remain fixed over considerable periods of time. However, should the circuit become misadjusted or should it be necessary to change the adjustment for any reason, it would be a difficult matter to make these adjustments in the field or afloat. At the present time these adjustments are made through the medium of a cathode ray oscillograph equipped with a synchronized sweep circuit, or through the use of an automatic transmitter, which is merely another means of synchronization. The use of such synchronizing apparatus can hardly be considered as entirely practical in the fleet. With this in view attempts were made to develop simplified circuits and especially circuits which could be adjusted directly without employing additional equipment.

18. The circuit shown in Plate No. 2 accomplishes this purpose. It involves no critical adjustments and is decidedly less complex than the circuit illustrated in Plate No. 1. This is readily seen when it is understood that circuit No. 2 is substituted for that portion of the circuit shown in plate No. 1 which lies below the dotted line. The terminals labelled (1), (2), (3) and (4) accomplish similar purposes in the two circuits.

19. Briefly the operation of the circuit illustrated in Plate No. 2 is as follows. With the key open the contacts of relay No. 1 are open in which condition the master oscillator circuit is in a non-oscillating condition. The coil circuit of relay No. 2 is open and therefore the armature of this relay is on the spacer side, or in the open position. When these circumstances prevail the power amplifier circuit is blocked as described in paragraph 11 of this report. When the key is closed full operating potential is impressed upon the coil of relay No. 1 causing the contacts to close immediately. The upper pair of contacts completes the master oscillating circuit while the lower pair of contacts completes the coil circuit of relay No. 2 which is a polarized relay. The direction of the current through the relay coils, under this condition, is such that the armature makes contact on the marker side. It will be seen that the contacts of relay No. 1 must be closed before the contacts of relay No. 2 can close. As soon as the contacts of relay No. 2 are in the closed position the power amplifier circuit of the transmitter is unblocked and the set is in a radiating condition. Relay No. 1 is of the instantaneous closing, delayed opening type. Therefore when the key is opened the contacts of relay No. 1 remain closed for an appreciable time. A delayed opening of approximately one tenth of a second has been found suitable. At this time the current in relay coil No. 2 is reversed due to the differential action of the bridge circuit used and the armature of relay No. 2 returns to the spacer side, blocking the grids of the power amplifier tubes in the manner described heretofore. If the key is again closed before the contacts of relay No. 1 have had an opportunity to open, the current is reversed in the coil circuit of relay No. 2 and the armature is again thrown to the marker side or keying position, and since the contacts of relay No. 1 are still closed the master oscillator

circuit is still in operation and the set will radiate. If the key remains open for longer than one tenth of a second the master oscillator is shut down.

20. The degree of key click elimination obtained with the circuit illustrated in Plate No. 2 is equal to that obtained with the circuit illustrated in Plate No. 1. Circuit No. 2 possesses the disadvantage, however, since it does not actually key the master oscillator for each dot and dash, but maintains the circuit in an oscillating condition until the key is left open for a substantial part of a second, that radiation from the master may produce signals in nearby receivers similar to that obtained with crystal oscillators. Thus, it does not lend itself to complete break in operation. In actual practise, however, it is believed that this type of operation will cause little difficulty. The slow acting relay can be adjusted so that it will open in one tenth of a second after the key is opened, so that it would be possible to obtain break in operation between words when slow sending speeds are being used. No system will permit of reliable break in operation at high rates of keying. The adjustment of the circuit is simple, in fact, the same type and degree of adjustment as is required by ordinary key relays is all that is necessary. In accordance with oral instructions from the Bureau, the two units now being constructed will utilize the circuit shown in Plate 2.

21. Plates No. 4 and 5 are photographs of the anti-click keying unit used in the tests described above. The dimensions of the unit are as follows:

Height - 72"
Width - 16"
Depth - 16"

It should be understood that this particular piece of equipment was designed to be sufficiently flexible so that it could be used in conjunction with practically any type of transmitter. It contains a source of variable bias voltage in order that it may be entirely independent of the power supply of the transmitter with which it is used. Naturally, these provisions increased the size and weight of the unit. If the unit were designed for any one particular type of transmitter and the transmitter was provided with a suitable source of bias voltage, the size of the keying unit could be radically decreased. If this keying system was incorporated in the design of a new transmitter the additional space required would be greatly reduced.

22. In accordance with the authority contained in reference (d), the anti-click keying unit was described to the representatives of various commercial companies. Demonstrations were conducted by means of which the representatives could observe personally the reduction in interference realized when the special keying unit was used as compared with ordinary methods of keying. Representatives of the following companies viewed these demonstrations:

General Electric Company
R.C.A. Manufacturing Company
Westinghouse Elec. & Mfg. Company

These companies were furnished with detailed information and complete wiring diagrams of the equipment.

CONCLUSIONS

23. The anti-click keying unit described reduces key click interference to such a low level that troubles from this source are practically eliminated. A reduction in interference of this nature should be of great value in the Fleet and should make possible the utilization of a large number of additional channels of communication by permitting operation on frequencies which are separated from each other to a smaller degree than at present.

24. The circuit which produces the most desirable or perfect results from the standpoint of break-in operation does not lend itself readily to adjustment in service. Plans for obtaining these adjustments by less complicated means are being studied and the indications are that if complete break in operation is to be desired, at the expense of some slight difficulty in adjustment, this can be accomplished through the medium of auxiliary devices of a less complicated character than cathode ray oscillographs and synchronized sweep circuits.

25. It is possible to obtain the same degree of key click elimination with more simple circuits, particularly circuits which are easy to adjust. This type of circuit, however, does not permit of complete break in operation, but it is believed that sufficient break-in operation may be realized so that the use of this circuit will be entirely practicable in the Fleet.

26. While the present model of the anti-click keying unit is of considerable size, a great reduction in weight and space can be accomplished if the device is designed for each particular transmitter and if the transmitter is provided with a source of bias voltage of somewhat higher potential than is generally provided.

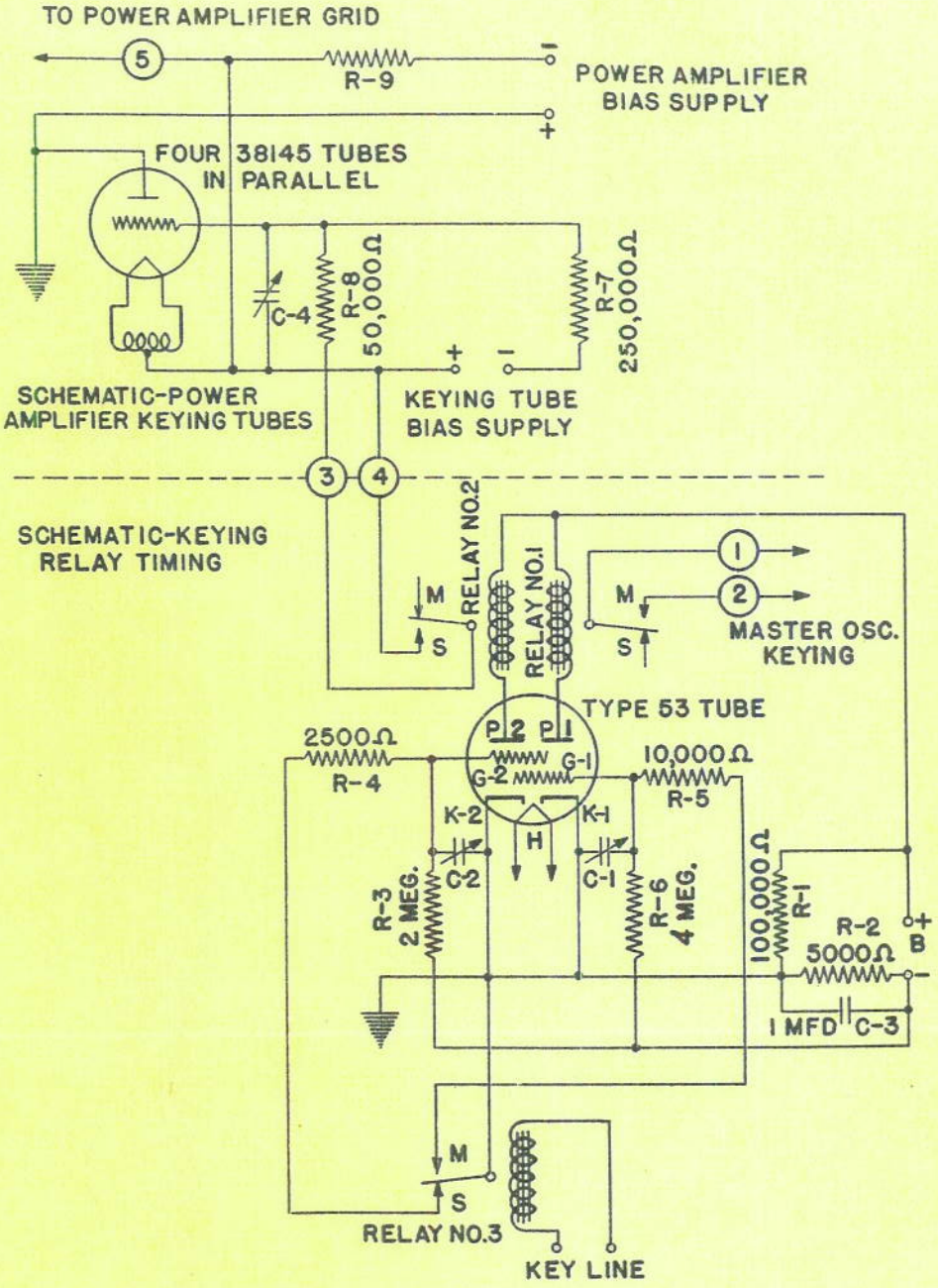

TO POWER AMPLIFIER GRID
5
R-9
POWER AMPLIFIER
BIAS SUPPLY
FOUR 38145 TUBES
IN PARALLEL
C-4
R-8
50,000Ω
R-7
250,000Ω
SCHEMATIC-POWER
AMPLIFIER KEYING TUBES
KEYING TUBE
BIAS SUPPLY
3
4
SCHEMATIC-KEYING
RELAY TIMING
RELAY NO.2
RELAY NO.1
M
S
1
2
MASTER OSC.
KEYING
TYPE 53 TUBE
P2
P1
G-2
G-1
2500Ω
R-4
10,000Ω
R-5
K-2
K-1
H
C-2
C-1
R-3
2 MEG.
R-6
4 MEG.
100,000Ω
R-1
R-2
5000Ω
B
1 MFD
C-3
RELAY NO.3
KEY LINE

PLATE I

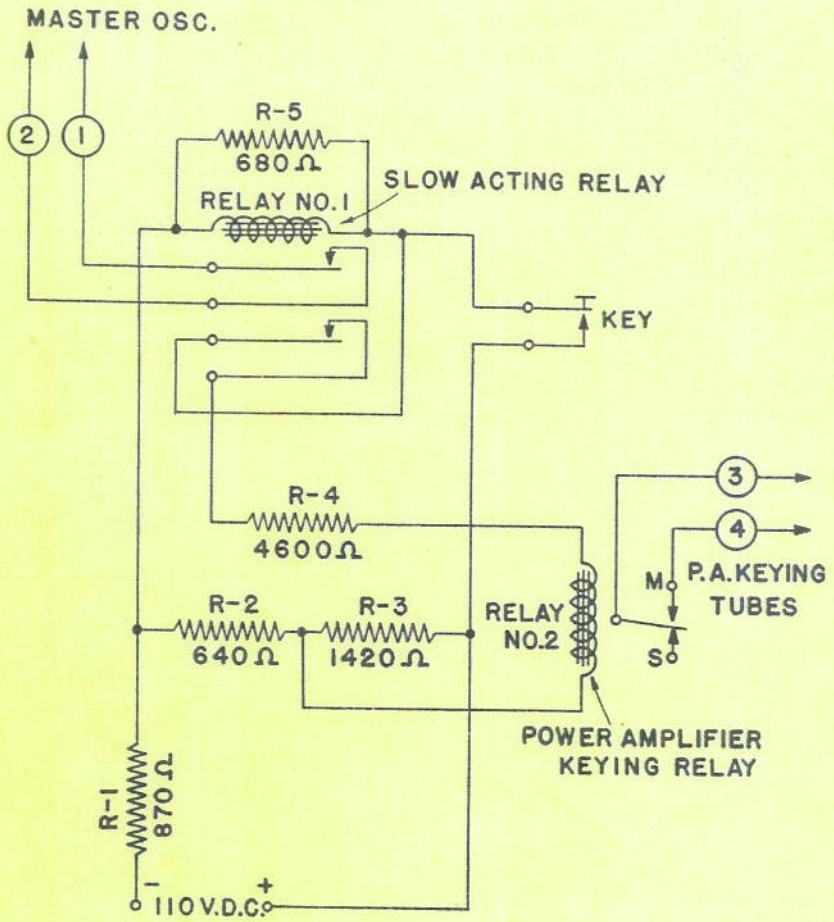

MASTER OSC.
2
1
R-5
680 Ω
RELAY NO. 1
SLOW ACTING RELAY
KEY
R-4
4600 Ω
3
4
M
P.A. KEYING TUBES
S
R-2
640 Ω
R-3
1420 Ω
RELAY NO.2
POWER AMPLIFIER KEYING RELAY
R-1
870 Ω
-
110 V.D.C.
+

PLATE 2

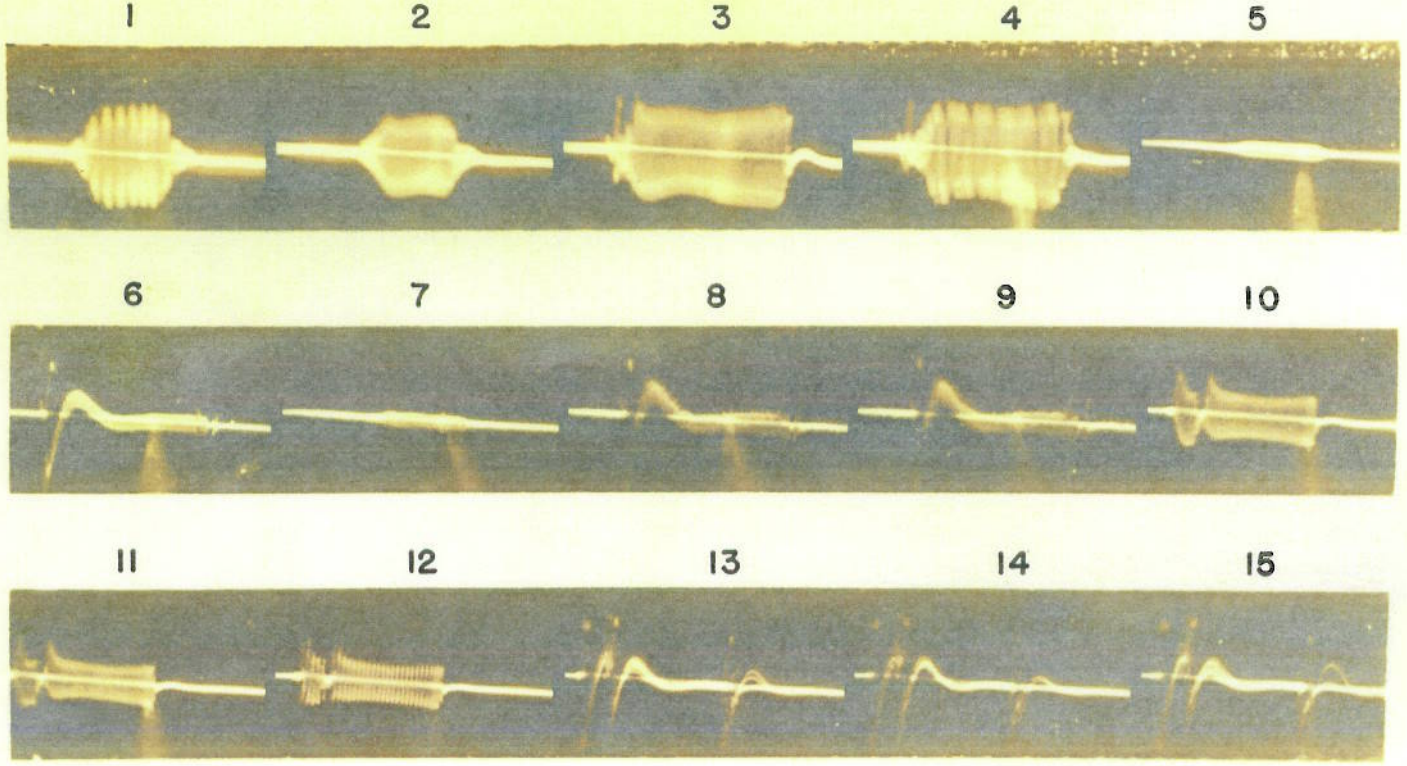


PLATE 3

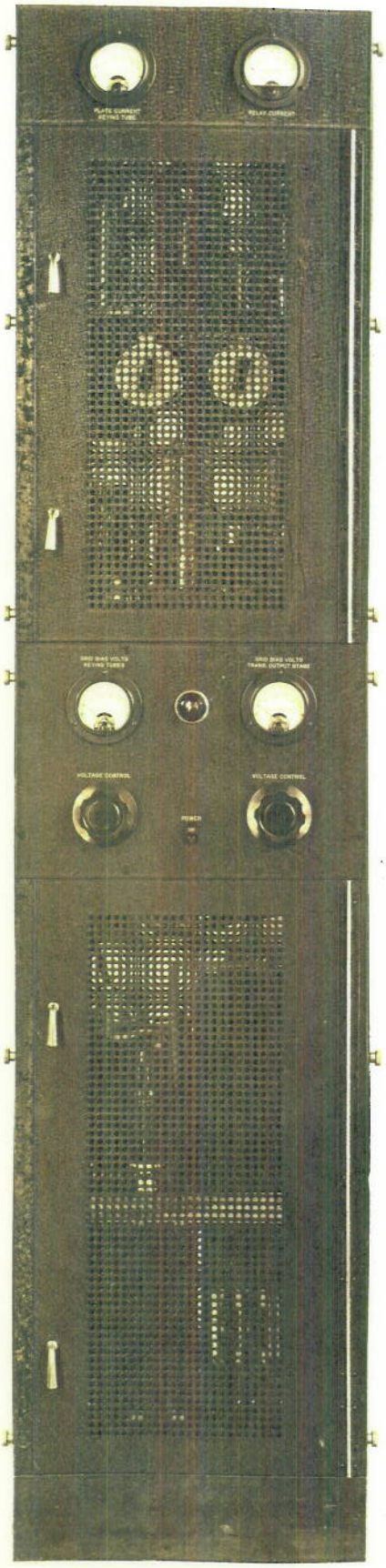
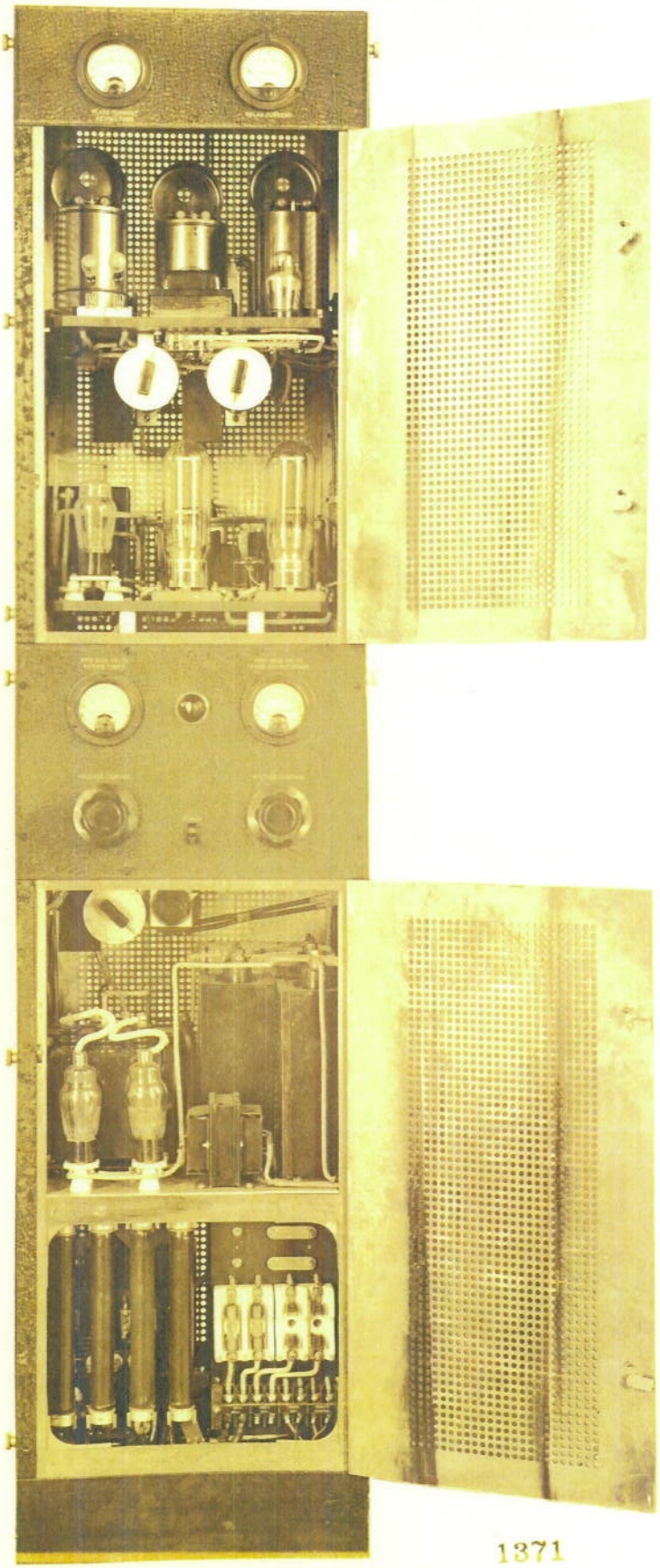


PLATE CURRENT
KEYING TUBE
RELAY CURRENT
GRID BIAS VOLTS
KEYING TUBES
GRID BIAS VOLTS
TRANS. OUTPUT STAGE
VOLTAGE CONTROL
VOLTAGE CONTROL
POWER

1372

PLATE 4



1371

PLATE 5