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NAVY DEPARTMENT

BUREAU OF ENGINEERING

Report

on

Test of Model TBR Band Change Switch. Addenda to Report on Band Change Switch of Models TBO and TBO-1 Portable Radio Equipment. General Electric Company, Contractor.

(NEW CONSTRUCTION)

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WASHINGTON, D.C.

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Date of Test: 2 August 1937 to 24 September 1937.

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Appendices

AUTHORIZATION

1. The test herein reported was authorized by paragraph 5 of reference (a). The subject switch not being available during the TBO switch tests, it could not be tested simultaneously with that switch as suggested in reference (a).

Reference: (a) BuEng.ltr. S67/24 (1-8-W8) of 9 Jan.1937.
(b) NRL Report No. R-1374.

OBJECT OF TEST

2. The object of this test was to determine:

(a) The suitability of this design for Naval use.
(b) The mechanical wear involved during the test period.
(c) If a low and uniform contact resistance could be maintained.

ABSTRACT OF TEST

3. The test circuit used in testing the subject switch was the identical one used in testing the TBO switch, as described in reference (b). The switch was connected in an oscillating circuit as shown on Plate 2. The frequency was approximately 18.2 megacycles, and the feed-back to control oscillations was adjustable by the potentiometer "R". The position of potentiometer "R" in angular divisions, at which oscillations start with the short test jumper in circuit, was taken as a reference condition. The position at which oscillations start, with the contacts in circuit as selected by the various switch positions, was recorded and taken as a relative indication of contact resistance. Measurements of relative contact resistance were made in this manner at the start of test and after periods of rotation and exposure to humidity.

(a) Conclusions

This switch has demonstrated that with occasional cleaning and lubrication it can be expected to function satisfactorily for well over 47,000 complete rotations. As it is estimated that under average service conditions a band switch will not be required to operate more than 2,500 times per year, it is probable that the switch will outlive the other parts of the receiver. It is simple in construction, sturdy, and easily disassembled for cleaning and lubricating. The mechanical wear during the test period was negligible after the contacts were lubricated. Although some indication of galling at the silver contacts was observed after about 1,800 revolutions, in an unlubricated condition, it is probable that the switch would have functioned satisfactorily for several thousand additional revolutions without lubrication, as the actual wear on the contact surfaces was slight. The application of a lubricant after galling started appeared to not only relieve the mechanical wear, but improved its electrical performance as well. This switch appears to be the most satisfactory receiver band switch for frequencies up to 23 megacycles that the Laboratory has tested.

(b) Recommendations

It is recommended that:

(1) The subject band switch be considered satisfactory for use in the Model RAL-1 or other equipments requiring similar performance.

(2) The switch control be lubricated with a thin film of non-corrosive grease after assembly.

(3) The instruction book contain instructions for periodic cleaning and lubrication.

DESCRIPTION OF MATERIAL UNDER TEST

4. The switch is of the rotary type with nine positions for 180 degrees of rotation, thus providing a double pole nine-way switch. The switch base is of 1/4" thick ceramic material measuring 2-3/8" x 2-5/8". There are two types of fixed contacts mounted on the base, concentrically. The outer contacts are of the button type having 1/4" diameter flat silver contact faces which appear to be sweated on brass studs. The studs have the full contact diameter at the top but are conically cut so that an appreciably smaller diameter contacts the ceramic. This gives a leakage path between contacts of .1 and an air path of .05. The studs extend through the ceramic and are riveted and soldered to terminals at the back side of the base plate. These contacts, of which there are 18, are arranged to form a complete circle with a mean diameter of 1-3/4 inches. The other contacts, of which there are 2, are semi-circular in shape, having a width of 3/16", an outside diameter of 1-5/16", and a thickness of approximately 1/16", bringing them to the same height as the round contacts. These semi-circular contacts appear to be solid silver and each is secured in place with two round head brass screws which extend through the ceramic base into threaded holes in the contact rings. One of the screws in each contact also secures a terminal lug for connection to the circuit. These lugs are soldered to the studs to provide a continuous metallic circuit to the contact face.

5. The rotor contacts are silver buttons 3/64" thick and 3/16" in diameter provided with studs which pass through a 3/16" x .02" flat spring and are riveted in place. There are two flat spring assemblies, one operating on one semi-circular contact sector and half of the round button contacts and the other on the second semi-circular contact and the remainder of the button contacts. Each spring is connected to the ceramic insulating hub by a rivet at the midpoint of the spring and the hub is so formed as to prevent rotation of the spring with respect to the hub. The springs are of such length that each contact has a spring arm of approximately 1/2".

6. The ceramic hub has an outer diameter of 1-5/16" and is 1/4" thick. It has a 1/2" center hole into which fits a 7/8" long nickel-plated brass hub. The brass hub has a 1/4" square hole in the center into which a square shaft fits for rotational driving. This hub in turn drives the ceramic hub with its contacts through a stamped sheet metal collet which is spun on to the end of the brass hub and connects to the ceramic hub through

two ears which fit into two 3/32" holes in the ceramic, that are on a 7/16" radius. This assembly rotates in a nickel-plated bronze bushing in the switch base plate and is secured against longitudinal motion by a "C" washer which fits into a lateral slot in the brass hub, and a cup in the bronze bushing. The tension produced by the rotor flat spring contacts holds the "C" washer in place. The rotor assembly is easily removable by a slight pressure against the flat spring tension which permits removal of the "C" washer. Inasmuch as the switch is complete in itself, as many switches as required may be driven from a single 1/4" square shaft, the only function of which is to deliver the required torque to the rotor assemblies. There is no clicker or positioning device as a part of the switch and if required, it would have to be a separate device that could also be connected to the same driving shaft. The switch has a capacitance of from 3.5 to 5.35 uufd., depending upon the position of the rotor contacts with respect to the semi-circular fixed contacts and the path through the dielectric as governed by the switch position.

METHOD OF TEST

7. The subject switch was given a very careful mechanical inspection. This inspection disclosed that the switch had no oil or grease on it anywhere. Tool marks were clearly visible on the surfaces of the contacts. The switch contact resistance was determined relatively by connecting the contacts under test in an oscillating circuit as shown on Plate 3, and determining the amount of feed-back required to produce oscillation, as indicated by the divisions on the control dial. Prior to inclusion in the test circuit, all of the fixed contacts were connected together electrically and the oscillating circuit was solder-connected to the two semi-circular contacts A and B. The fixed contacts were numbered 1-9, inclusive, and 11-19, inclusive. Those numbered 11-19 were complementary to those number 1-9.

8. The half circle segments were lettered "A" and "B", and the movable arms were lettered "C" and "D". Each switch position placed four contacts in the oscillating circuit. For example, on contact #1 the circuit is through parts A-C-1-11-D-B; the contacting surfaces are between A and C, C and 1, 11 and D, and D and B. Each complete test revolution involved 36 contacts.

9. Should any radical change of contact resistance take place, each of the four series contacts in the circuit could be shorted, one at a time, until the poor contact was found. Before starting the rotational tests, the short circuit jumper was connected and the reference point as indicated by the angular position of the regeneration control "R", at which oscillations started, was recorded as a reference point. The jumper was then removed and the switch rotated by hand one revolution, recording the divisions indicated by a scale on "R", at which oscillations, started for each of the nine positions.

10. Following this procedure the switch was rotated by a motor at 20 r.p.m. for several test periods. After each test and prior to the next, the jumper was connected and the reference point of oscillation was checked.

11. After 1862 rotations the switch contact surface appeared to be galling as a deposit of silver dust had gathered on a piece of paper placed under it. After inspection it was evident that the galling could be reduced if the switch contacts were slightly oiled. Consequently, a very thin film of vaseline was rubbed on the surface of the fixed contacts and along the half circle segments. A drop of oil was also put on the shaft. The switch was then run through various cycles of rotation and humidity baths with the results as shown under "Data Recorded during Test."

DATA RECORDED DURING TEST

12. The first test consisted of obtaining the reference point with the switch shorted out of the circuit. The point of oscillation came at 42° on "R", the regeneration control dial. The short was removed and the switch rotated by hand from point to point through the nine positions with the following readings taken for the position of "R".

Test #1

Position	R	Position	R	Position	R
1	115°	4	110°	7	107°
2	114.5	5	110	8	105
3	110	6	108	9	106

A clear piece of white paper was placed directly under the switch to assist in determining the start and amount of wear of the contracts by the metallic dust deposited thereon.

13. The switch was rotated by power a total of 460 alternate revolutions and then given a mechanical inspection. This inspection disclosed that about 20% of the contact area of the fixed contacts had been polished by operation. A set of readings was also taken which was as follows:

Test #2

Position	R	Position	R	Position	R
1	120°	4	113°	7	110°
2	117	5	112	8	108
3	113	6	111	9	109

14. The switch was allowed to set over night and the following morning a set of readings were taken, rotating the switch by hand.

Test #3

Position	R	Position	R	Position	R
1	125°	4	119°	7	116°
2	122	5	119	8	113
3	119	6	117	9	114

15. The switch was then revolved by power for a total of 1400 revolutions. At the end of this run a very appreciable amount of silver dust was found on the paper beneath the switch and the readings were:

Test #4

Position	R	Position	R	Position	R
1	120°	4	112°	7	108°
2	119	5	111	8	105
3	112	6	110	9	106

16. After this test it was decided to lubricate the switch. Accordingly, a very thin film of white vaseline was rubbed over each fixed contact surface and a drop of oil was put on the shaft bearing. After 400 revolutions the switch was again tested. (Note: The shaft bearing is not in the electrical circuit.)

Test #5

Position	R	Position	R	Position	R
1	111°	4	106°	7	103°
2	109	5	105	8	102
3	105		104	9	102

17. The switch was revolved by power again, 6000 alternate revolutions, and tested.

Test #6

Position	R	Position	R	Position	R
1	115°	4	110°	7	108°
2	113	5	109	8	106
3	110	6	109	9	107

18. At this time the switch contacts appeared to be in good condition and there was no further sign of galling. The contact surfaces had become smoother than at the start of the tests. The switch was then put in a controlled chamber kept at about 90% humidity and 48°C for 72 hours. At the end of this period it was removed and tested for each position previous to further rotation.

Test #7

Position	R	Position	R	Position	R
1	118°	4	112°	7	108°
2	116	5	112	8	107
3	112	6	110	9	107

19. After 1600 additional revolutions by power the following results were obtained:

Test #8

Position	R	Position	R	Position	R
1	122°	4	116°	7	112°
2	120	5	116	8	110
3	116	6	114	9	111

20. The switch was then replaced in the humidity chamber for a 48-hour period after which it was removed and turned by hand one revolution, with the following results:

Test #9

Position	R	Position	R	Position	R
1	123°	4	118°	7	114°
2	121	5	116	8	111
3	117	6	116	9	112

21. The switch was again placed under power and revolved 34,800 alternate revolutions, with results as follows:

Test #10

Position	R	Position	R	Position	R
1	123°	4	119°	7	114°
2	121	5	118	8	114
3	119	6	116	9	114

22. The switch was then replaced in the humidity chamber for 72 hours, at the end of which it was removed and tested with the following results:

Test #11

Position	R	Position	R	Position	R
1	123°	4	119°	7	115°
2	121	5	118	8	113
3	119	6	116	9	113

At the end of this test it was rotated 600 revolutions and then replaced in the chamber for a total of 28 days.

23. Upon removal from the chamber it was allowed to set in a normal atmosphere for 4 hours, then connected into the test circuit. At the end of the 4-hour rest period inspection showed that the rotating contact arms were resting about 20% on contacts 9 and 19; therefore, the first reading was made on this point without moving the rotating arm at all, with the following results:

Test #12

Position	R	Position	R	Position	R
1	H	4	119°	7	105°
2	120°	5	119	8	112
3	118	6	116	9*	115

* When the rotating contact was moved, so as to be 100% over contact 9, this reading changed from 115 to 119.

H The howl which occurred while on #1 position was because of poor contact between the rotating contact of arm D and the segment contact E. Moving the arm a little further along on #1 contact stopped the howl and gave a reading of 115 on #1.

28. All contacts were then given a thin coat of white vaseline and the switch rotated once and tested with the following results:

Test #17

Position	R	Position	R	Position	R
1	110°	4	110°	7	105°
2	110	5	109	8	104
3	110	6	106	9	105

29. The switch was then rotated by power 600 revolutions in each direction and tested with the following final results which indicated that the contact resistance was even lower than at the start of tests.

Test #18

Position	R	Position	R	Position	R
1	108°	4	109°	7	105°
2	110	5	109	8	104
3	109	6	107	9	105

30. After removing the switch from the test circuit it was broken down and carefully inspected. This inspection disclosed that the contact on the end of the "D" arm which rides on the segments "A" and "B" was riding over the edge of these segments, and had worn a very slight shoulder on the movable contact. The surfaces of the fixed contacts were polished by the movable contacts for about 20% of their area on their outside edges, although the rotating contacts were making very nearly a line contact. This is accounted for by the fact that there is play in the central shaft and that the contacts of the "C" and "D" arms do not track.

PROBABLE ERROR IN RESULTS

31. The errors involved in the test of this switch constitute primarily those due to the reading of the regeneration control dial "R". These readings can be considered accurate to $\pm$ 0.5°.

RESULTS OF TEST

32. This switch has been subjected to a total of 47,100 alternate revolutions. After 1860 revolutions with the switch in the ungreased condition as originally received, the switch contacts had started to gall appreciably. This condition probably existed from the start of the test, but at this time it appeared that deterioration was accelerating to the extent that continued operation in this condition would greatly shorten the life of the switch.

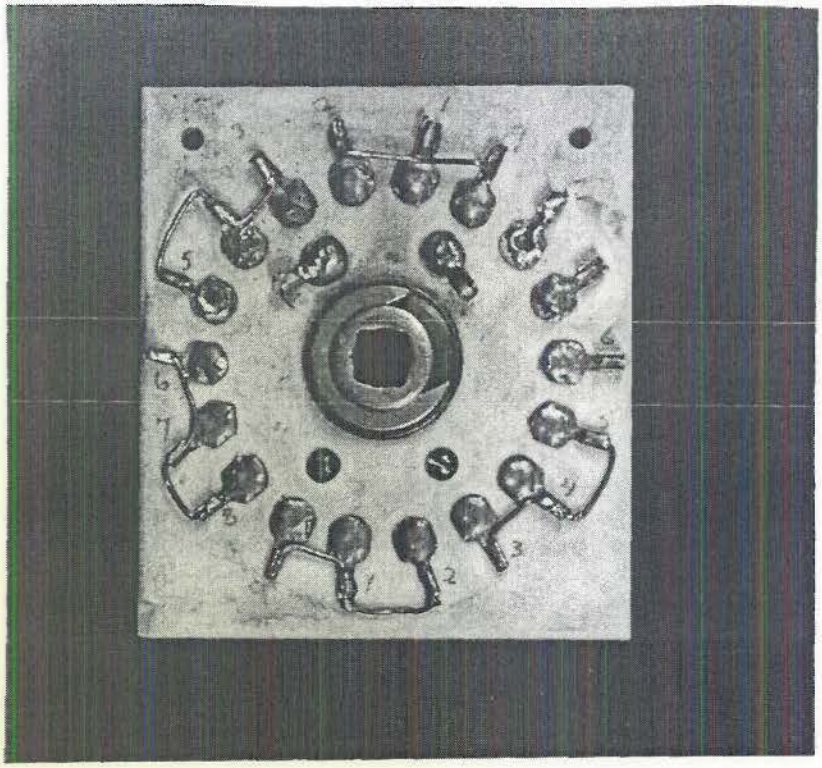
33. The switch contacts were greased, but not smoothed, and the test continued with the result that after 40,000 revolutions including a total of 33 days exposure to high humidity, the switch was functioning as well, if not better, than at the start of the tests.

SUMMARY OF DEFECTS

34. The switch contacts showed a tendency to gall prior to lubrication.

CONCLUSIONS

35. This switch has demonstrated that with occasional cleaning and lubrication it can be expected to function satisfactorily for well over 47,000 complete rotations. As it is estimated that under average service conditions a band switch will not be required to operate more than 2500 times per year, it is probable that the switch will outlive the other parts of the receiver. It is simple in construction, sturdy, and easily disassembled for cleaning and lubricating. The mechanical wear during the test period was negligible after the contacts were lubricated. Although some indication of galling at the silver contacts was observed after about 1800 revolutions, in an unlubricated condition, it is probable that the switch would have functioned satisfactorily for several thousand additional revolutions without lubrication, as the actual wear on the contact surfaces was slight. The application of a lubricant after galling started appeared to not only relieve the mechanical wear, but improved its electrical performance as well. This switch appears to be the most satisfactory receiver band switch for frequencies up to 23 megacycles that the Laboratory has tested.



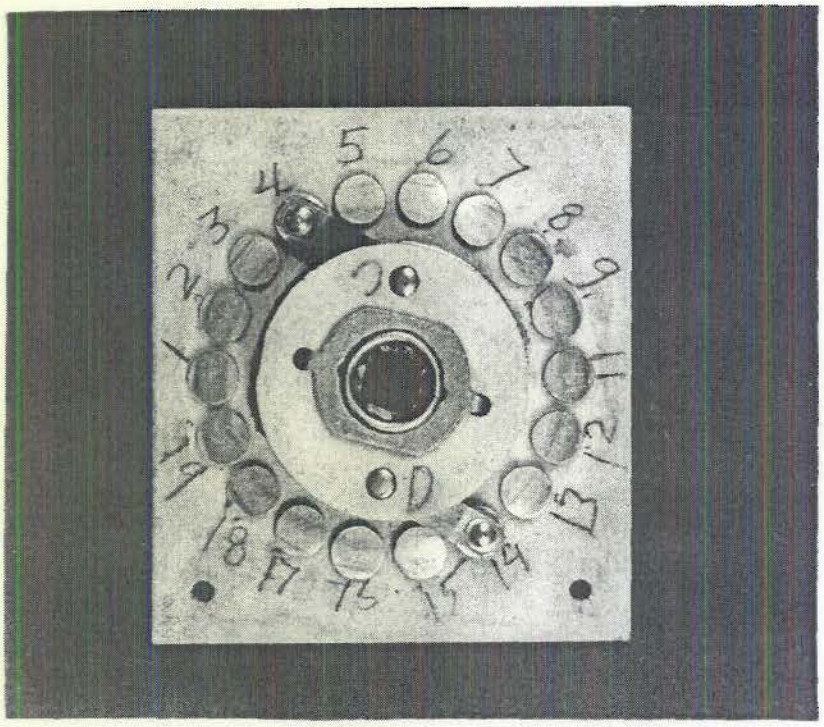
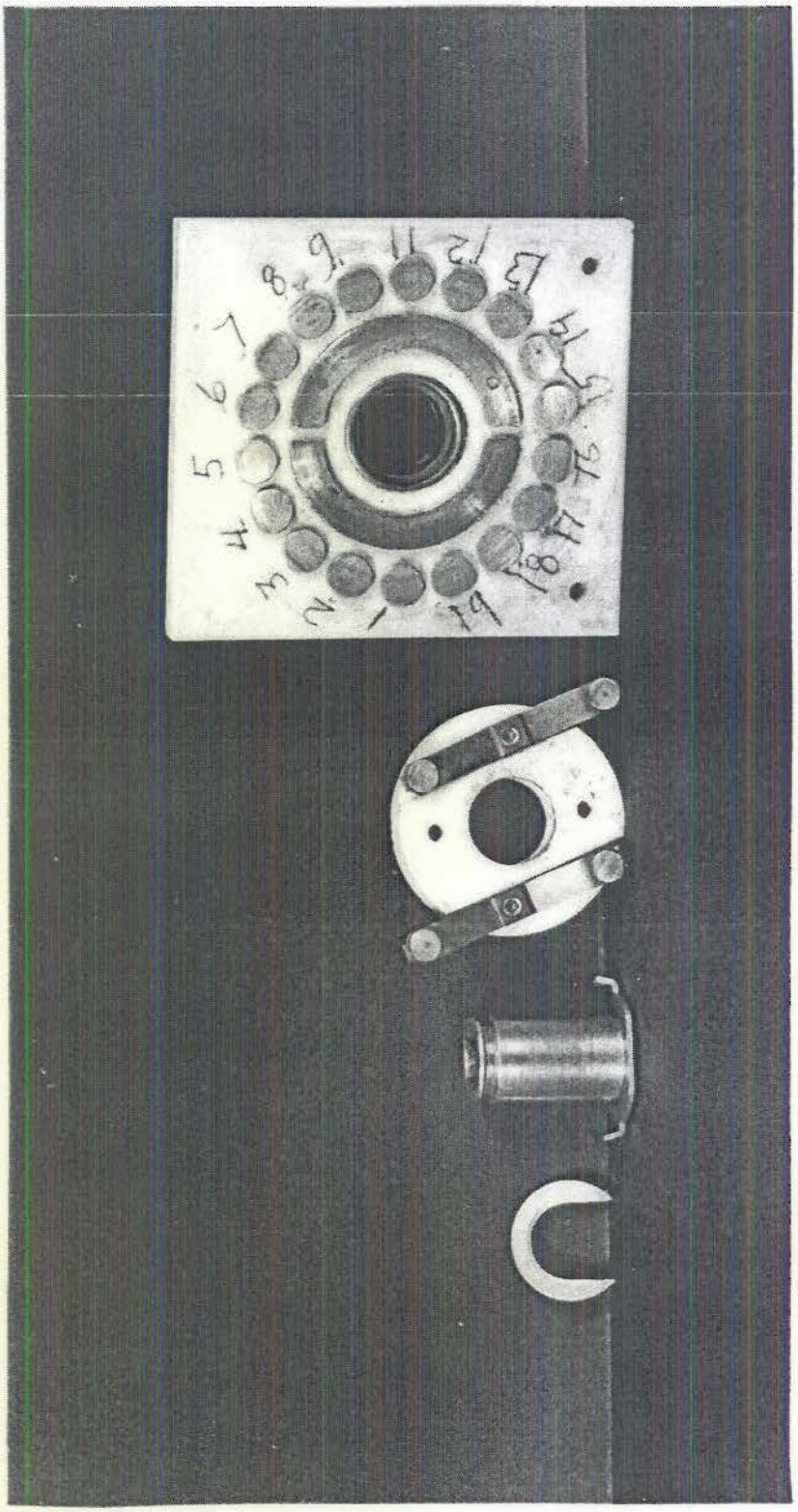


Plate 1



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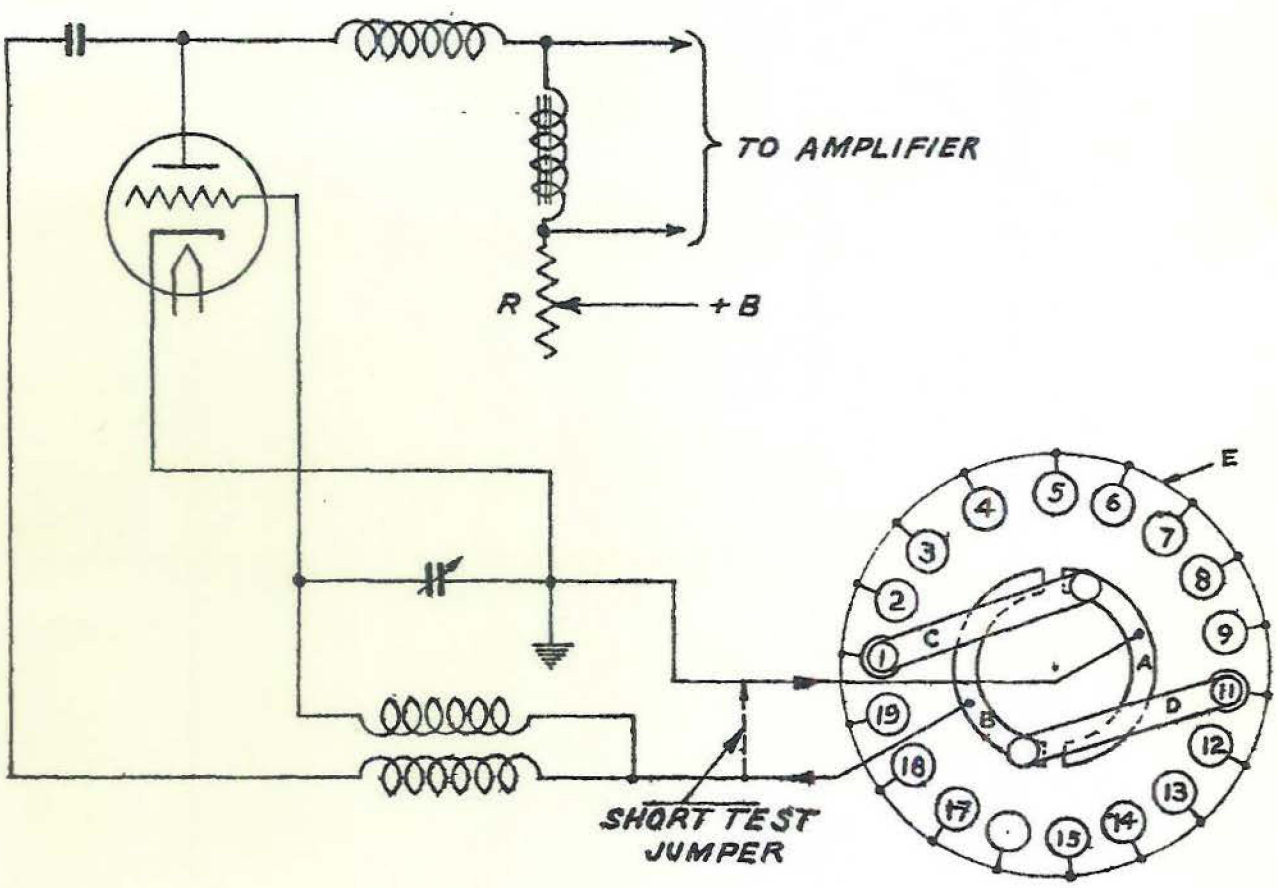

MODEL TBR SWITCH TEST ASSEMBLY

PLATE 3