



[REDACTED]

DECLASSIFIED

NAVAL RESEARCH LABORATORY REPORT

[Signature]
Entered by

DEVELOPMENT OF PRESELECTOR UNITS
COVERING THE FREQUENCY RANGES 85
TO 180 Mc, 175 TO 355 Mc AND 350
TO 700 Mc

By M. F. Davis and F. C. Isely

- Report R-2985

FR-2985
DECLASSIFIED: By *[Signature]*
Cite Authority

[REDACTED]

DECLASSIFIED by NRL Contract
Declassification Team

Date: 30 Nov 2016

Reviewer's name(s): H. DO, P. HANNA

Declassification authority: NAVY DECLASS
GUIDE/NAVY DECLASS MANUAL, 11 DEC 2012,
06 SERIES

DISTRIBUTION STATEMENT A APPLIES
Further distribution authorized by UNLIMITED only.

DECLASSIFIED

NAVY DEPARTMENT

OFFICE OF NAVAL RESEARCH

NAVAL RESEARCH LABORATORY

WASHINGTON 20, D. C.

Navy Department - Office of Naval Research

NAVAL RESEARCH LABORATORY
Washington, D.C.

* * *

SHIP-SHORE RADIO DIVISION - RECEIVER SECTION

19 November 1946

DEVELOPMENT OF PRESELECTOR UNITS
COVERING THE FREQUENCY RANGES 85
TO 180 Mc, 175 TO 355 Mc AND 350
TO 700 Mc

By M. F. Davis and F. C. Isely

-- Report R-2985

~~CONFIDENTIAL~~

DECLASSIFIED

Approved by:

T. McL. Davis - Head, Receiver Section

L. A. Gebhard, Superintendent
Ship-Shore Radio Division

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

Preliminary Pages a-c
Numbered Pages 7
Plates 15
Distribution List e

ABSTRACT

Problem S499R-C was set up at this Laboratory by the Bureau of Ships in order that improved preselector heads could be developed to replace the TN type used with the Models AM/APR-1, AM/SPR-1, and RDO radio receiving equipments. Three units were developed, though not completed, covering the frequency range of 85 to 700 megacycles. Sensitivities of the order of 2 to 18 microvolts and image rejections of 21 to 80 decibels were obtained with hand-made circuits. A "modified" butterfly type of circuit was used, which, it is believed, is satisfactory in this range of frequencies.



TABLE OF CONTENTS

	<u>Page</u>
ABSTRACT	-b-
INTRODUCTION	1
TUNED CIRCUIT DEVELOPMENT	1
PRESELECTOR UNIT A	3
PRESELECTOR UNIT B	3
PRESELECTOR UNIT C	4
PRESELECTOR UNIT D	4
DEVELOPMENT OF COMPONENT PARTS	4
CONCLUSIONS	4
RECOMMENDATIONS	5
REFERENCES	6
TABLE 1 - Sensitivity and Image Rejection Unit B	
TABLE 2 - Bandwidth Unit B	
TABLE 3 - Sensitivity and Image Rejection Unit D	
PLATE 1 - Modified "Butterfly" Circuit Unit D	
PLATE 2 - Modified "Butterfly" Circuit Unit D	
PLATE 3 - Modified "Butterfly" Circuit Unit D	
PLATE 4 - Split-Stator Capacitor Units B and C	
PLATE 5 - Preselector Unit B	
PLATE 6 - Preselector Unit B Cover Removed	
PLATE 7 - Preselector Unit B Cover Removed	
PLATE 8 - Preselector Unit B Mixer Circuit	
PLATE 9 - Preselector Unit D	



- PLATE 10 - Preselector Unit D Cover Removed
- PLATE 11 - Preselector Unit D Input Circuit
- PLATE 12 - Preselector Unit D Grid Cathode Circuit
- PLATE 13 - Preselector Unit D Grounded Grid Amplifier
- PLATE 14 - Preselector Unit D Local Oscillator Circuit
- PLATE 15 - Preselector Unit D Schematic Diagram

INTRODUCTION

1. The Naval Research Laboratory was authorized by the Bureau of Ships to develop VHF and UHF preselector heads to replace the TN series of heads in use with the Models AN/APR-1, AN/SPR-1, and RDO radio receiving equipment, (Reference 1). The TN heads, though operable in these equipments, did not give overall results comparable to that obtained by standard low-frequency naval radio receiving equipment. The original problem requested heads covering the frequency range of 400 to 3000 megacycles; however, there was need for replacement of all the TN heads. Consequently a modification of the original problem was made to include the range of 40 to 400 megacycles, with emphasis to be placed on the 100 to 1000 megacycle range, Reference 2. The heads were to have good overall performance from the stand point of sensitivity, image and intermediate frequency rejection, low oscillator radiation, minimum of spurious responses, maximum protection against cross modulation and overload, and reliability of operation. The heads were also to have single dial control, operable either manually or with electric drive; and each head to have as wide a frequency coverage as possible, consistent with the overall performance desired.

2. The difficulties involved in this work were considerable because of the limited space available for circuits in the previously-designed TN head castings and particularly because no satisfactory circuits were available for use in most of the frequency range to be covered. A "makeshift" type of unit would not suit the problem requirements. Three preselector heads were developed near the end of the war, and only two of them were near the final model stage for outside commercial production.

RESONANT CIRCUIT DEVELOPMENT

3. The tuned circuit designed for the TN heads had been of the butterfly type, capable of a three-to-one frequency coverage. Two ganged circuits were used, an oscillator circuit and a mixer or antenna circuit, the latter being a low "Q" circuit. This type of resonant circuit did not appear to be capable of convenient ganging or of being developed into an oscillator circuit operating on the fundamental mode for the higher frequencies; consequently, it was discarded. In planning new tuning units, it was calculated that three signal circuits and an r-f amplifier would be required to meet the desired specifications. The oscillator should operate at the required local heterodyne frequency to avoid multiplication of frequency with its attendant spurious responses. This led to a compromise frequency coverage of two-to-one in place of three-to-one as one price for the proposed advantages. Since the TN-1 head was fairly satisfactory, the beginning of the second range could be at 85 megacycles in order to overlap 90 megacycles which is the top frequency of the TN-1 head. This also brought the break between the third and fourth heads at about 350 megacycles, at which the change from "acorn" type tubes to the "light house" type is considered preferable, rather than at 400 megacycles where the "acorn" tube operates with difficulty in equipment having extended frequency coverage.

This gave then, the following frequency ranges:

Preselector Unit A, 40-90 Megacycles (TN-1B)
Preselector Unit B, 85-180 Megacycles
Preselector Unit C, 175-355 Megacycles
Preselector Unit D, 350-700 Megacycles

4. The original directive requested that the preselector frequency coverage begin at 400 megacycles; hence, the circuits originally tried were designed for the range of 400 to 800 megacycles. Many circuits built and tried were not found satisfactory; normal commercial split-stator capacitors have too much inductance to be useful at these higher frequencies, and capacity loading of transmission lines gave increased liability to spurious responses. The circuit finally developed was a "modified" butterfly, similar to that previously developed by the General Radio Company, but not yet published at the time it was under development at this Laboratory. This circuit is of the split-stator type with a wide loop attached to the stator plates, but passing around the rotor plates, (Plates 1, 2, and 3). Since the rotor plates, in the minimum capacity position, occupy the space inside of the loop, the inductance is reduced at the high frequency end of the range. This gives characteristics desirable in high-frequency circuits with the further advantage that the r-f path in the stator plates is not lengthened at higher frequencies, avoiding the increase in inductance which is encountered in the normal split-stator circuit. By incorporating a second inductance on the other side of the stator plates, higher frequencies could be reached; the more easy variation of this inductance permitted ready establishment of the upper frequency limit and also, by a finer screw adjustment, a satisfactory inductive trimmer was provided, (Plate 3). This "modified" butterfly circuit has the following favorable characteristics:

- (a) No sliding or moving electrical contacts.
- (b) Maximum impedance points are readily available for connection to the external circuit.
- (c) Straight-line frequency characteristics may be obtained by proper shaping of the plates.
- (d) The current path through the capacitor varies only slightly with rotor position, giving rise to practically constant inductance in the plates.
- (e) It lends itself to ganging and tracking by conventional methods.
- (f) Possible spurious resonance effects are at a minimum.
- (g) The inductance of this type of split-stator capacitor is low.
- (h) Either "lighthouse" or "acorn" types of vacuum tubes fit nicely on the circuit.
- (i) The tuning range is covered in 180° of rotation.

(j) The rotor can be rotated 360°, making a useful circuit for receivers which require motor-driven tuning elements.

(k) Well-established manufacturing methods can be used in the construction of the tuning capacitor and inductance strap.

(l) The construction is sturdy and no ceramic shafts are used.

5. There are certain disadvantages, mainly in the unbalance of the rotor, mechanically and electrically. The mechanical unbalance can be taken care of by proper shaft couplers; while the electrical unbalance has not caused difficulties, provided the tuned circuits and components are mounted in such a way as to eliminate tight capacity coupling between the rotor and any of the components. Another disadvantage is the lack of self-electrical shielding such as is inherent in concentric line tuning elements.

6. It was found that the same split stator capacitor could be used in the B and C units (also in the A unit if made) with a change only in the inductive strap. For Unit C the strap was used as previously described, (Plate 4), while for Unit B a conventional coil was used (plate 9); a smaller sized capacitor and strap was needed for Unit D (Plate 3).

PRESELECTOR UNIT A (40 TO 90 MEGACYCLES)

7. No work was done on this unit since the cognizant Bureau placed principal emphasis on the higher frequency ranges and the TN-1B head was comparatively satisfactory in the 40 to 90 Mc region.

PRESELECTOR UNIT B (85 TO 180 MEGACYCLES)

8. As indicated previously three signal circuits were planned for this unit; the antenna circuit, amplifier circuit, and mixer circuit; however, in the model built only two signal circuits were installed, the amplifier and the mixer. A contract had been given to the Radio Condenser Company for capacitors designed on the basis of this Laboratory's hand-made models but the result was not satisfactory and the use of hand-made models, had to be continued, although they did not possess the desired mechanical characteristics. A 956 pentode tube was used as an amplifier and type 6F4 tubes were used as mixer and local oscillator. The circuit connections were of the conventional type, the output of the amplifier tube being inductively coupled to the mixer circuit, while the local oscillator energy was capacity coupled to this circuit, (Plates 5, 6, 7, and 8). Due to the use of hand-made tuning capacitors, the input circuit was separately tuned in order to get satisfactory results; however, this would not be necessary in commercially-built units and it is believed that a fourth circuit could be ganged satisfactorily. The sensitivity of this preselector (using a 30% sine wave modulated carrier with a 6 milliwatt output in a 600-ohm audio output load with a 10 decibel modulation-on vs modulation-off ratio) when used with an RDO receiver was between 2 and 7 microvolts with the audio bandwidth sharp and 3 to 14 microvolts on the broad position. The image rejection ratio for standard output varied from 44 to 80 decibels. (Table I). Bandwidth data

are given in Table II.

PRESELECTOR UNIT C (175 TO 355 MEGACYCLES)

9. This unit was designed to be similar to the Unit B; however, no mixer was as satisfactory as the 6F4 for the B Unit. Best results were obtained with a 954 tube using cathode injection from the oscillator, the best sensitivity being in the order of 15 microvolts. Lack of commercially built capacitors held up the building of a model of this preselector.

PRESELECTOR UNIT D (350 TO 700 MEGACYCLES)

10. This unit like the others used only two signal circuits and, though cramped for space, it is believed that it would be possible to add an antenna circuit. (Plates 9 to 15). "Lighthouse" type 2C40 tubes were used for the grounded-grid amplifier and local oscillator and a type IN21-B crystal for the mixer. Because of the use of the grounded-grid circuit, a special casting was made with a plate down the middle, isolating the cathode-grid circuit from the plate-grid circuit. Because of this, two tuning shafts were required, which were geared together just behind the main dial. The whole circuit again was quite conventional, with tracking adjusted by inductive and capacity trimmers. Additional feed back was required in the local oscillator to secure smooth oscillations over the whole range. It was found that an 820-ohm, 2-watt I.R.C. wire-wound resistor gave the best results as a plate-supply lead choke. It was also necessary to have ball-bearings of good quality supporting the tuning capacitor rotor shaft to prevent erratic operation. Since the grid-cathode circuit of a grounded grid amplifier is of rather low impedance, the 50 ohm input circuit was tapped rather high on this circuit. The crystal was tapped down on the amplifier output circuit to reduce the loading and the oscillator injection loop was only lightly coupled to this same circuit. A 100-ohm bias resistor was inserted in the crystal direct current path to secure best conversion. The sensitivity of this unit was less than 10 microvolts over most of the range but the image rejection was only from 21 to 42 decibels. Table III. The poor image rejection was partially due to the hand-made capacitors being imperfectly tracked, but mostly due to the low intermediate frequency used.

COMPONENT PARTS

11. Certain component parts were developed during this work among which were a contact clip for the double-ended acorn tube and several types of jack shields that were more satisfactory than the pin type used in the regular TN heads. References at the end of this report give the drawing numbers for these components.

CONCLUSIONS

12. Although the development of these preselector units was not completed, the performance measurements on the hand-made units indicate that in most respects the fundamental electrical and mechanical design features incorporated in each unit were satisfactory. It would appear that for frequencies

above 350 megacycles, an intermediate frequency higher than 30 megacycles should be used.

RECOMMENDATIONS

13. The urgencies of the war did not allow time for a thorough investigation of various types of resonant circuits for use in this frequency range, therefore, it is recommended that:

(a) Resonant circuits for UHF and ~~VHF~~ work be thoroughly investigated.

(b) Methods for measuring electrical characteristics of UHF circuits be investigated.

(c) A study of r-f contacts be made with the view to elimination of noise and the consequent reduction in size of the circuit structure.

REFERENCES

1. BuShips ltr., Ser. No. 492(925C) of 22 October 1943 to NRL; Assignment of problem S-499R-C.
2. BuShips ltr., Ser. No. 1350(925C) of 23 December 1944 to NRL; Modification of problem S-499R-C.
3. NRL Report No. R-2984. A Survey of UHF Wide Range Circuits.
4. NRL Log Book No. 2623, pages 25, 26 and 35. Sketches and descriptions of split-stator capacity trimmers.
5. NRL Drawings RA 50F 294; UHF Plug-in Preselector.
6. NRL Log Book No. 2623, page 25; Sketches and description of the small inductance coil and inductance trimmer for modified "butterfly" type of tuned circuit.
7. NRL Drawing RA 48F 235; Split-Stator Tuning Capacitor for Modified "Butterfly" Circuit.
8. Receiver Section Drawing 350-499-3; Modified Butterfly Circuit Model No. 4.
9. Receiver Section Drawing 350-499-4; Inductor for Modified Butterfly Circuit Model No. 4.
10. NRL Drawing RA 10F 569; Contact Clip for Receiving Tubes.
11. NRL Drawing RA 25F 216; Jack Shield No. 1.
12. NRL Drawing RA 25F 218; Jack Shield No. 2.

Original data recorded in NRL Log Books Nos. 2045, 2623, 5224, 5478, 5660 and 5670.

TABLE I

PRESELECTOR UNIT B

<u>Signal Frequency In Megacycles</u>	<u>Sensitivity In Microvolts</u>		<u>Image Rejection Ratio In Decibels Standard Output</u>
	<u>Audio Bandwidth Narrow</u>	<u>Audio Bandwidth Broad</u>	
80	2	33	79
90	2	33	77
100	5	11	72
110	7	14	78
120	6	12	80
130	4	7	64
140	2	4	65
150	4	6	58
160	7	14	55
170	7	11	44
175	2	4	56

TABLE II

PRESELECTOR UNIT B

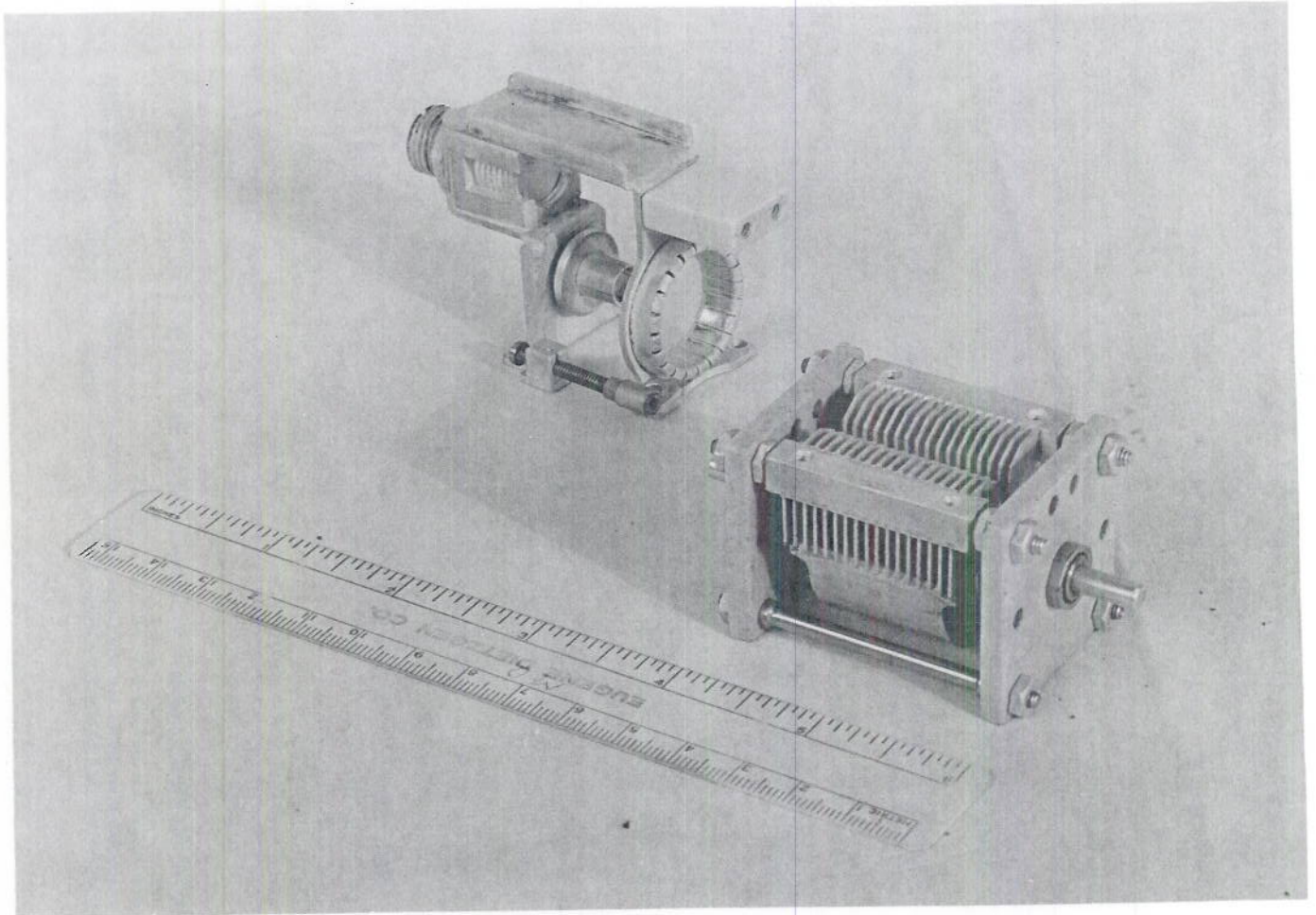
<u>Signal Frequency In Megacycles</u>	<u>30 db Bandwidth Of Preslector Unit In Megacycles</u>	<u>6 db Bandwidth Of Preslector Unit In Megacycles</u>
	80	1.9
100	3.7	2.9
125	3.6	2.7
150	3.7	3.1
175	3.1	2.5

TABLE III

PRESELECTOR UNIT D

<u>Signal Frequency In Megacycles</u>	<u>Sensitivity In Microvolts Audio Bandwidth Narrow</u>	<u>Image Rejection Ratio In Decibels Standard Output</u>
350	18	29
400	6	42
450	4	41
500	4	37
550	7	27
600	5	22
650	7	22
700	8	21

DECLASSIFIED

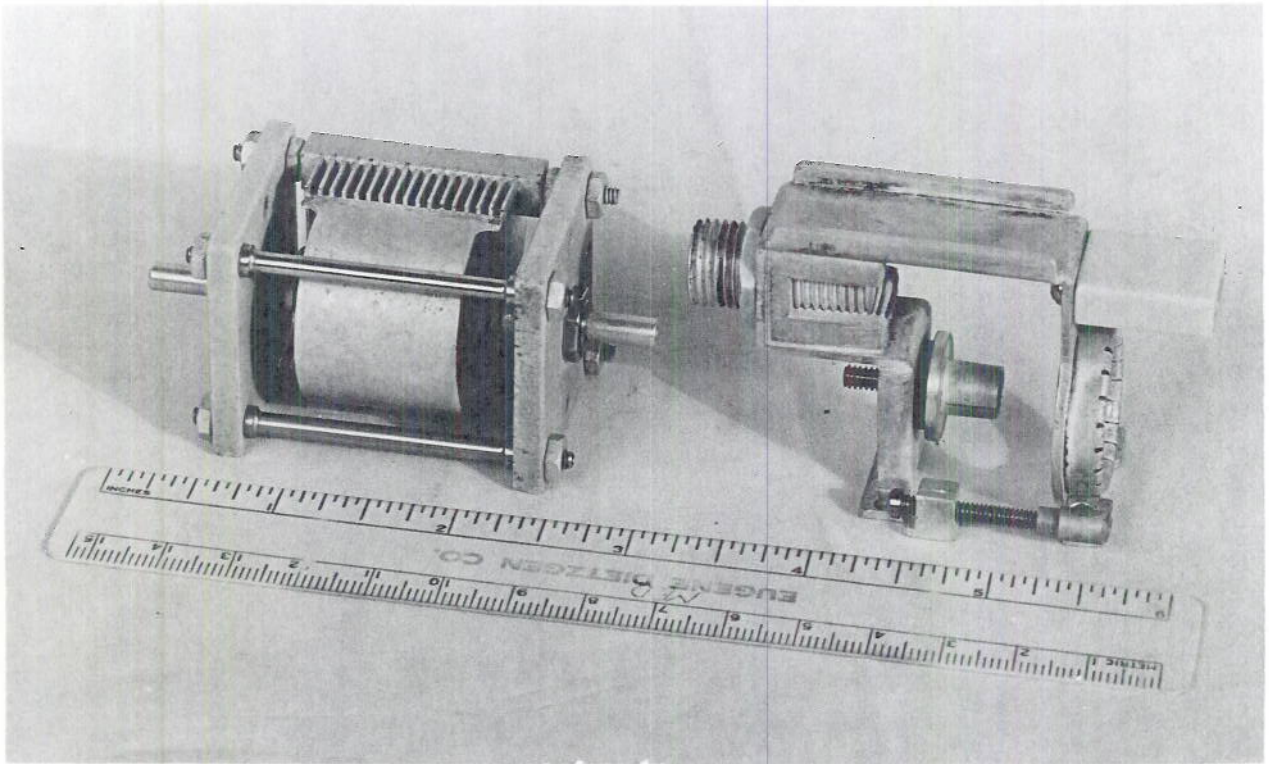


DECLASSIFIED

PRESELECTOR UNIT D

MODIFIED "BUTTERFLY" TYPE OF TUNED CIRCUIT
SPLIT-STATOR TUNING CAPACITOR AND SECOND
INDUCTANCE STRAP FREQUENCY
RANGE 350 TO 700 MC

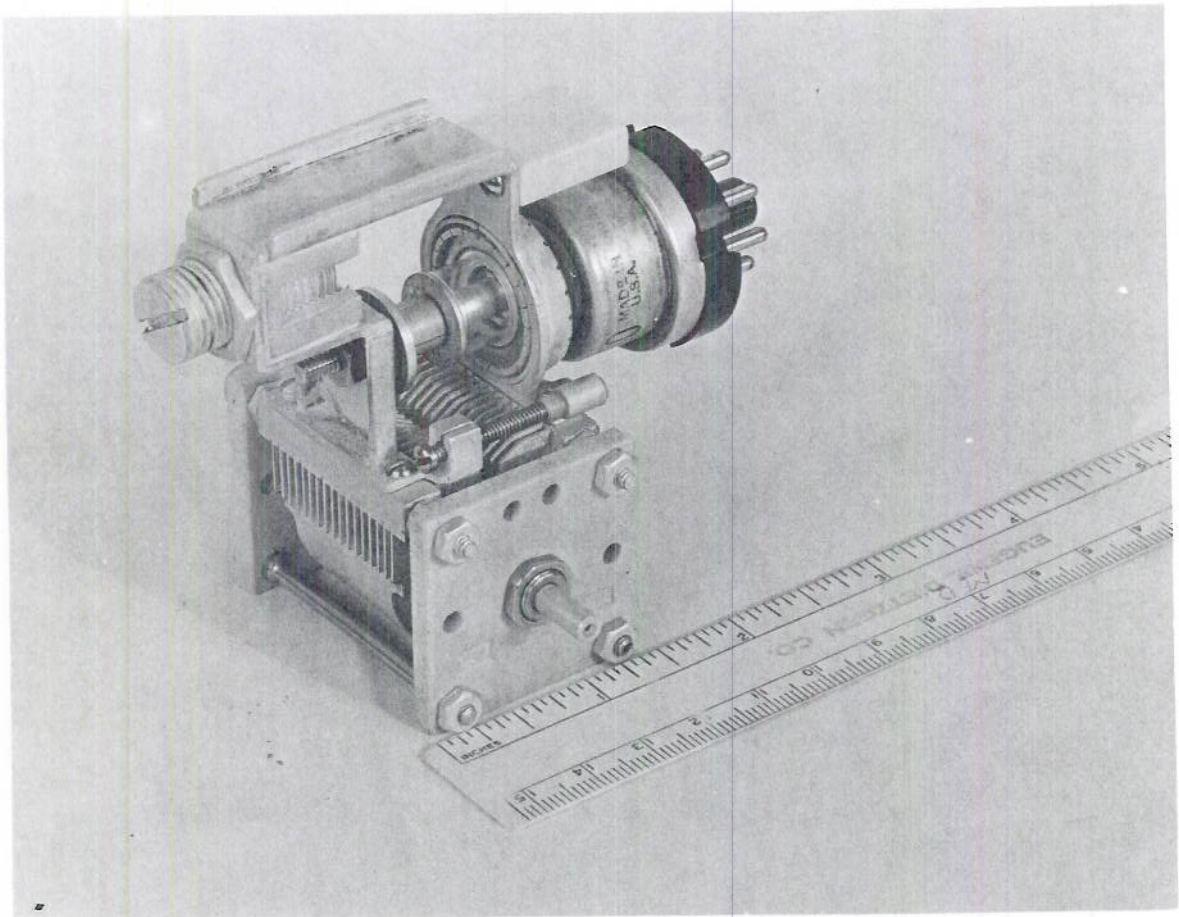
PLATE 1



DECLASSIFIED

PRESELECTOR UNIT D

MODIFIED "BUTTERFLY" TYPE OF TUNED CIRCUIT
SEMI CIRCULAR AND SECOND INDUCTANCE STRAP
FREQUENCY RANGE 350 TO 700 MC

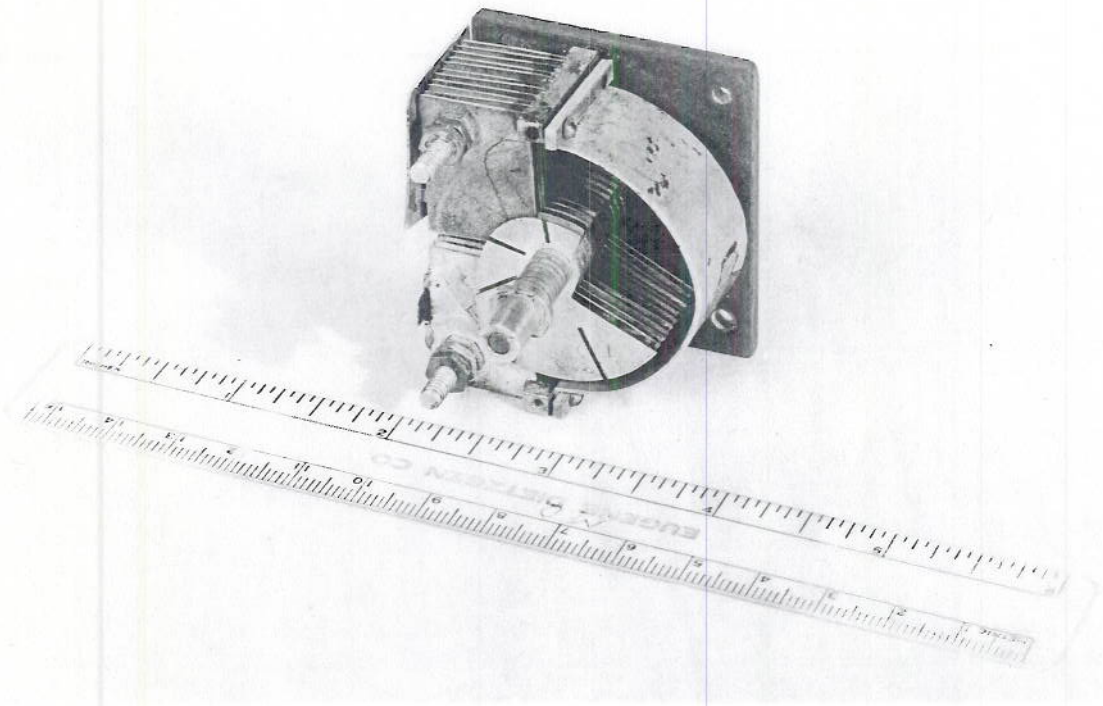


DECLASSIFIED

PRESELECTION UNIT D

MODIFIED "BUTTERFLY" TYPE OF TUNED CIRCUIT
LOCAL OSCILLATOR CIRCUIT FREQUENCY
RANGE 350 TO 700 MC.

PLATE 3

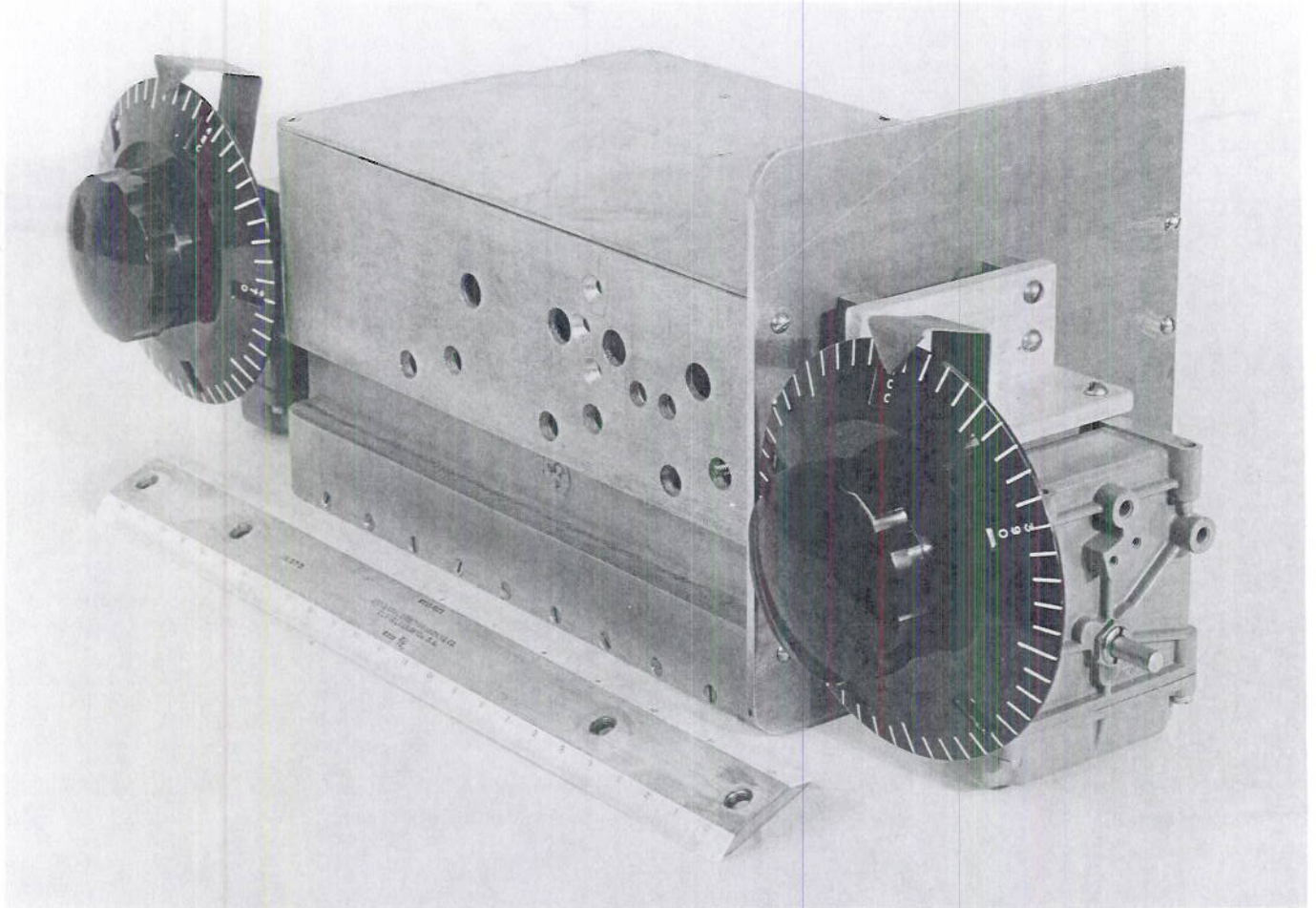


DECLASSIFIED

TUNED CIRCUIT

SPLIT-STATOR TUNING CAPACITOR AND SEMI-CIRCULAR
INDUCTANCE
(INDUCTANCE COIL AND MYCALEX END PLATE REMOVED)
PRESELECTOR UNIT C

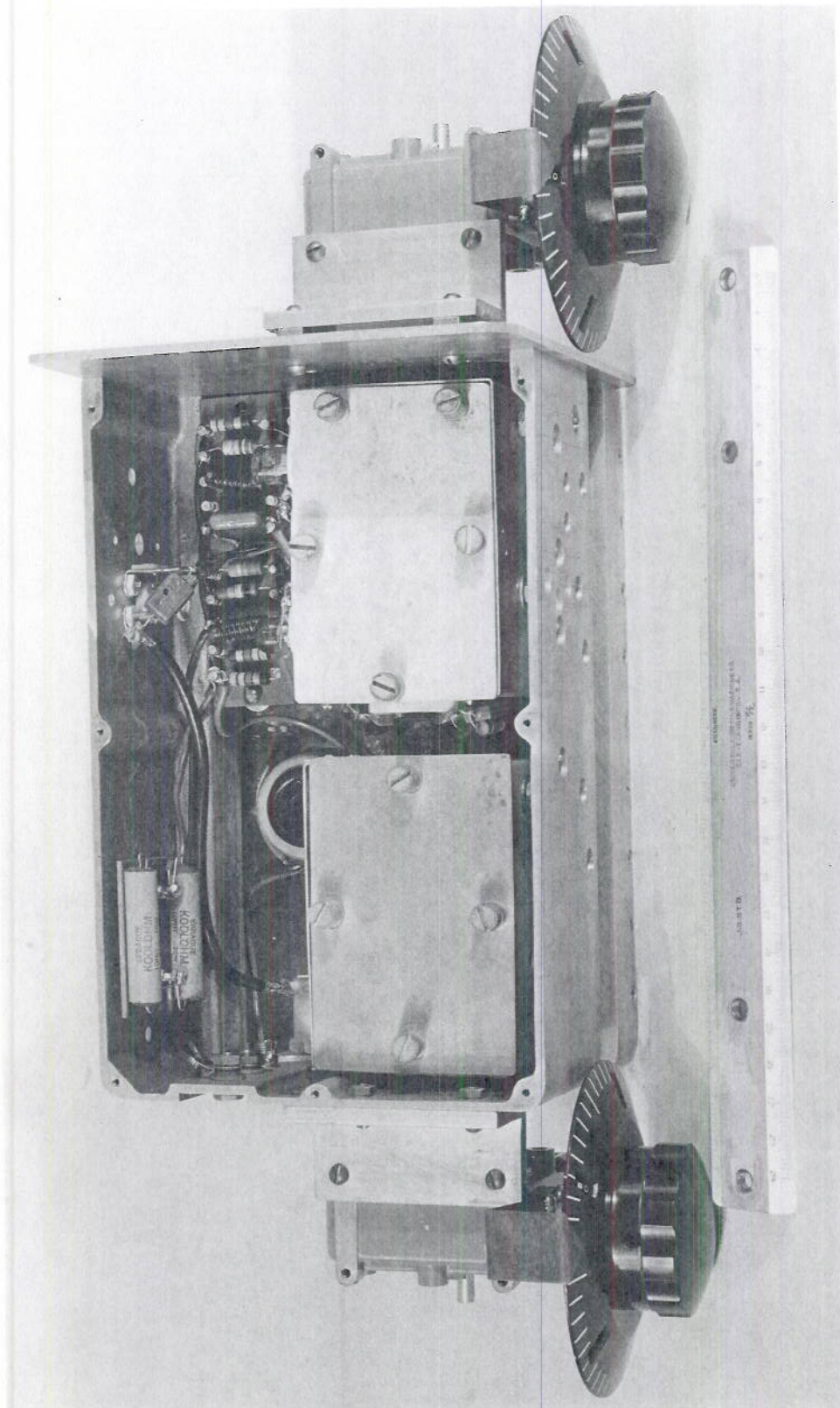
PLATE 4



PRESELECTOR UNIT B
FREQUENCY RANGE 85 TO 150 MC

DECLASSIFIED

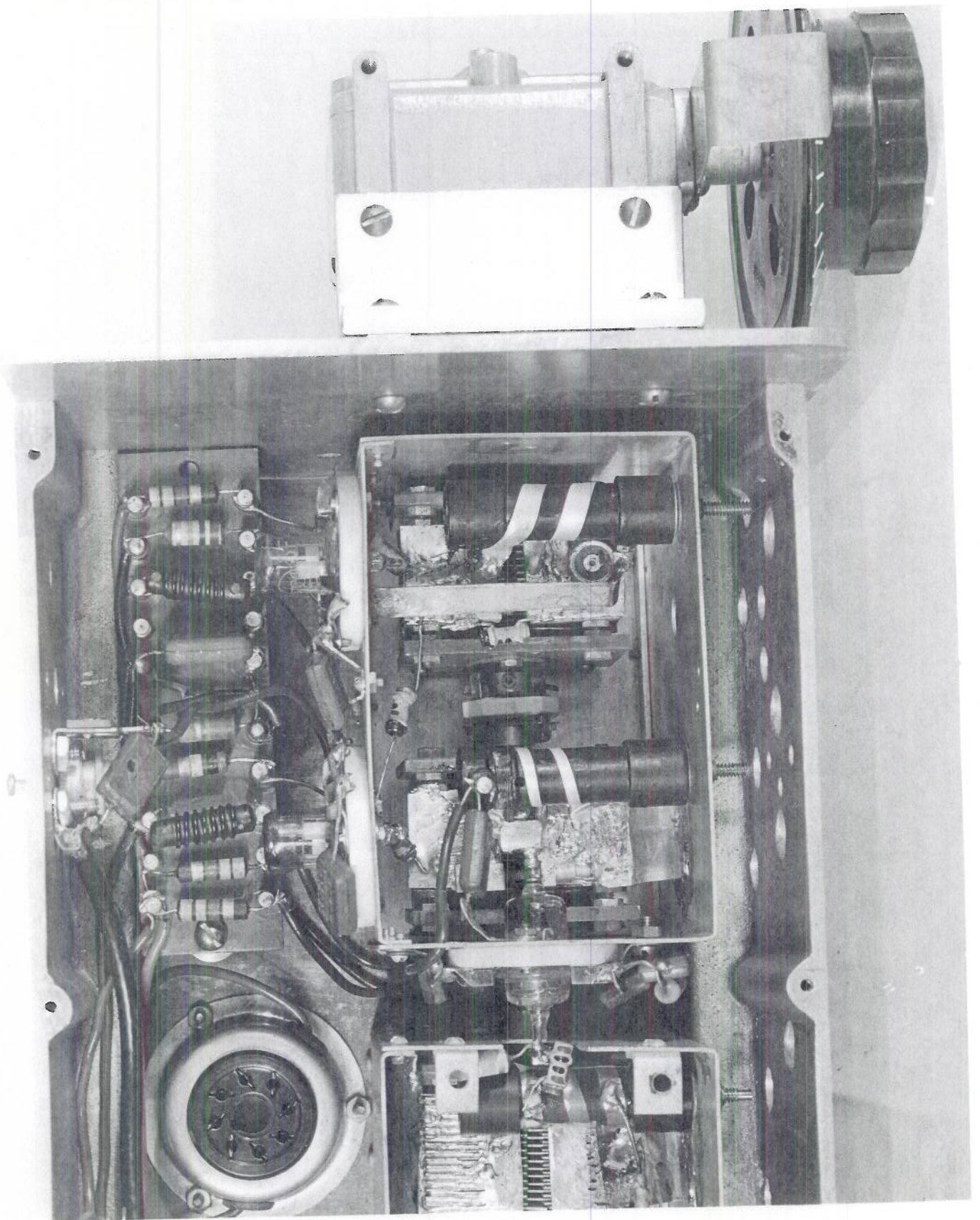
PLATE 5



DECLASSIFIED

PRESELECTOR UNIT B
COVER PLATES REMOVED

PLATE 6

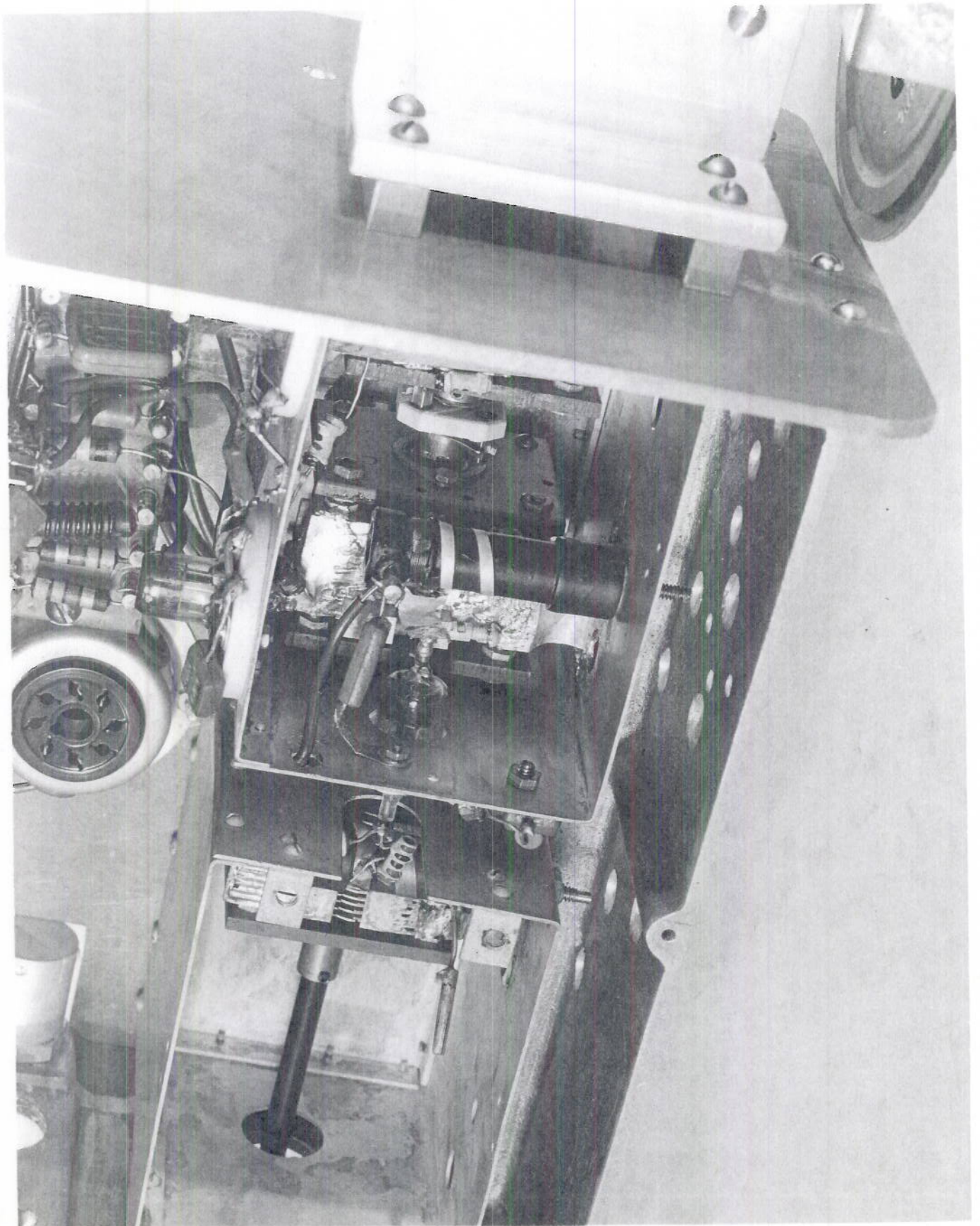


DECLASSIFIED

PREFECTOR UNIT B

COVER PLATE ON SHIELDING COMPARTMENTS REMOVED SHOWING
OSCILLATOR (NEXT TO DIAL DRIVE), MIXER AND AMPLIFIER
CIRCUITS

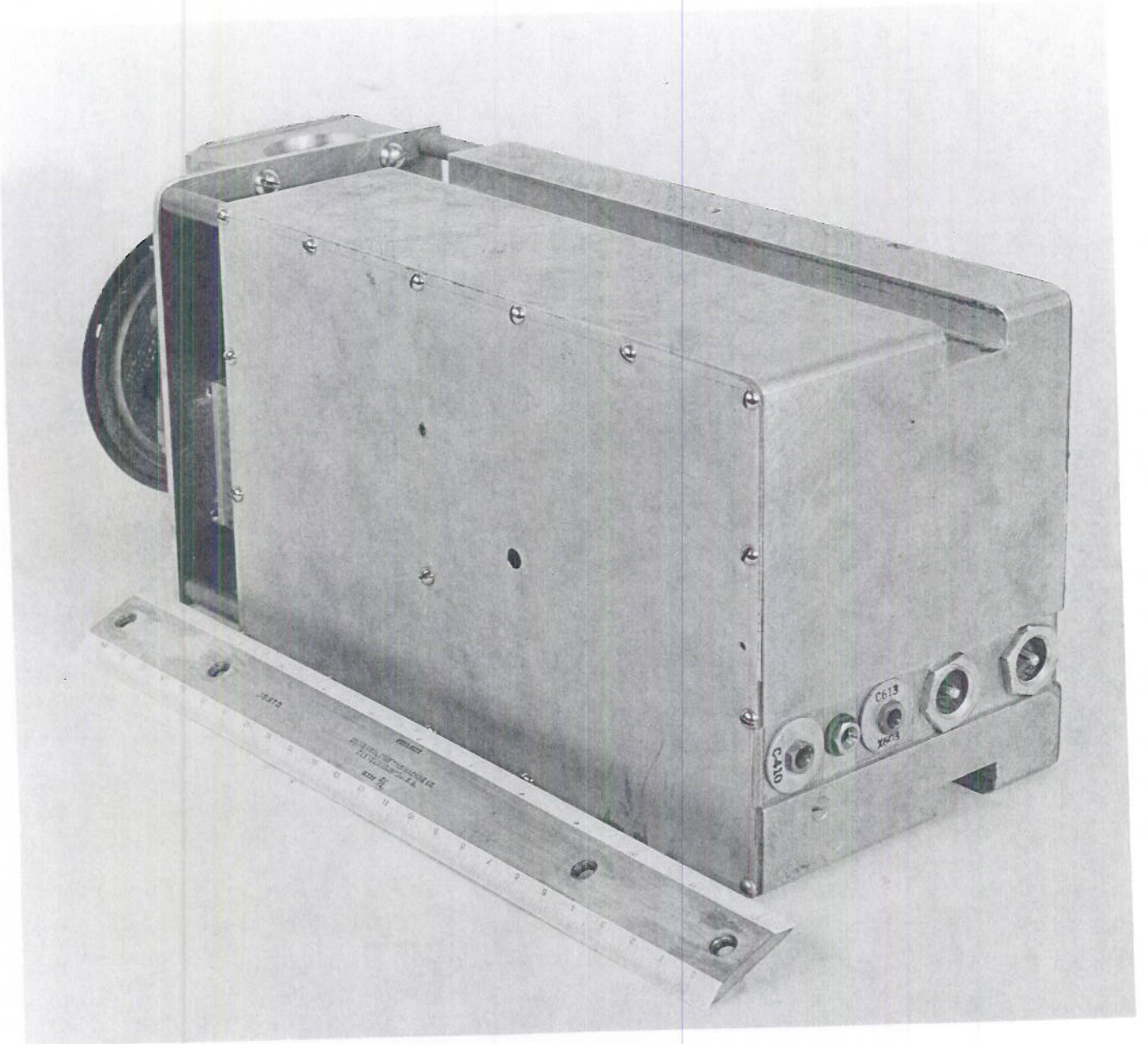
PLATE 7



DECLASSIFIED

PRESELECTOR UNIT B
MIXER CIRCUIT

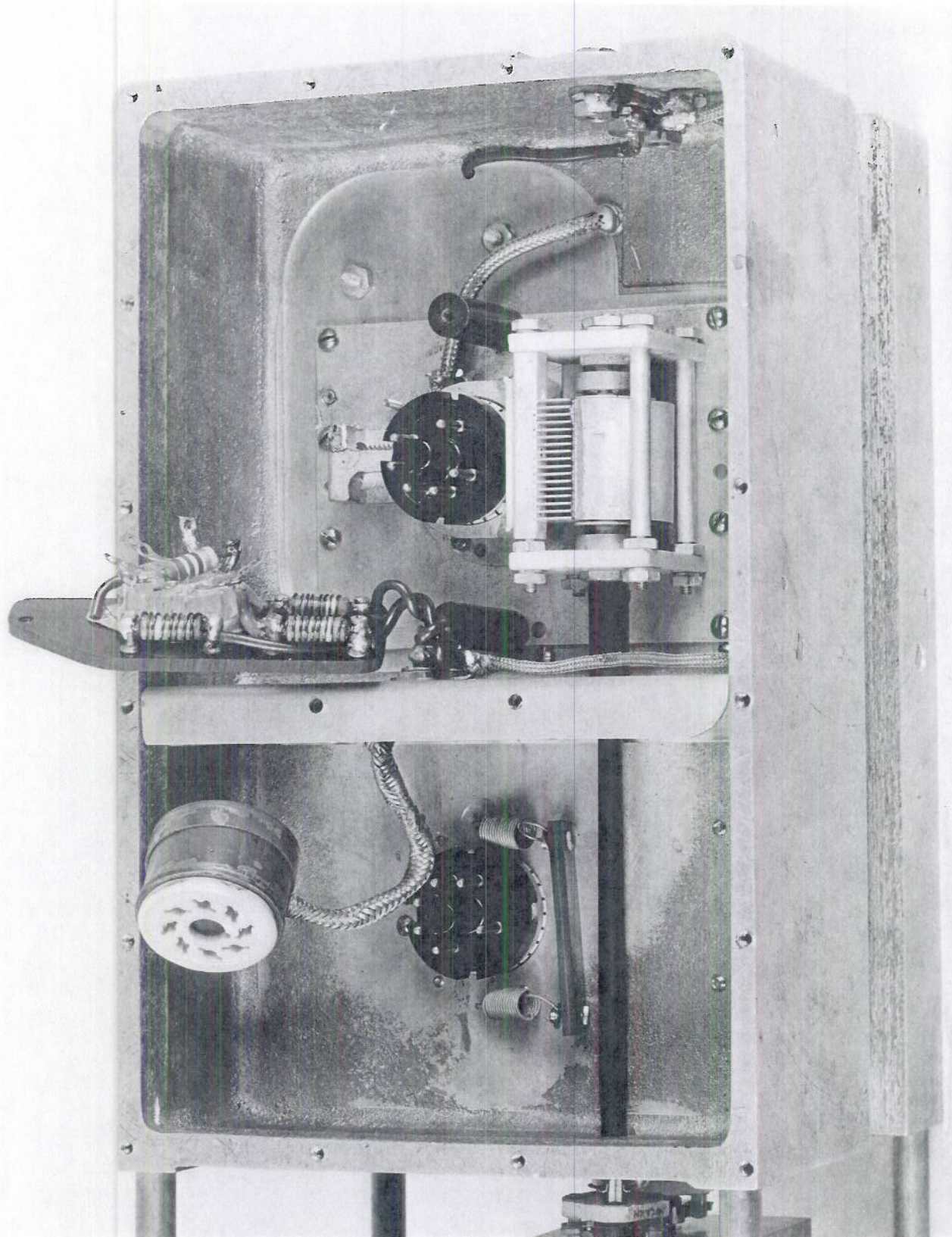
PLATE 8



DECLASSIFIED

PRESELECTOR UNIT D
FREQUENCY RANGE 350 TO 700 MC

PLATE 9

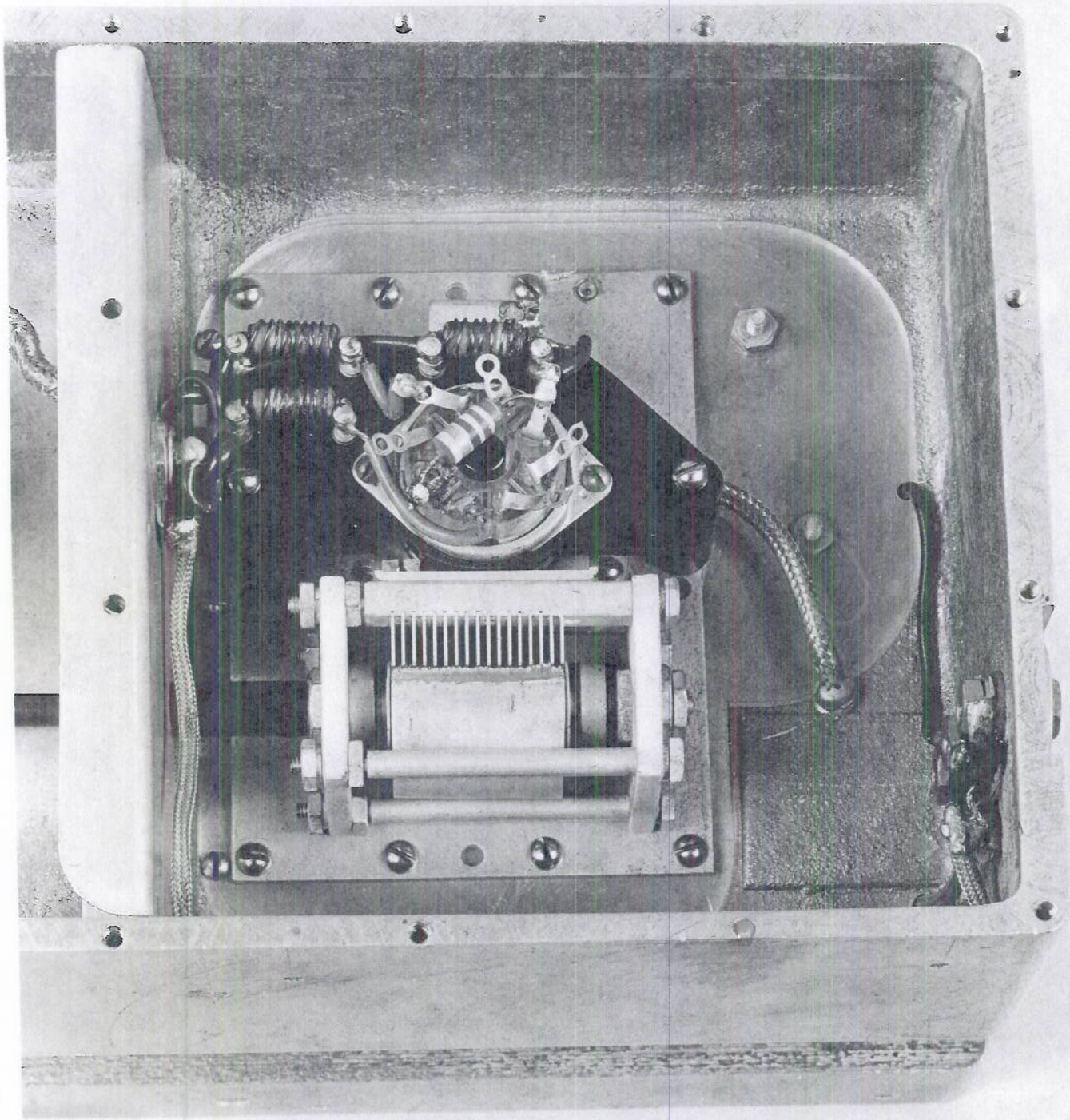


DECLASSIFIED

PRESELECTOR UNIT D

INPUT CIRCUIT AND LOCAL OSCILLATOR TUBE

PLATE 10

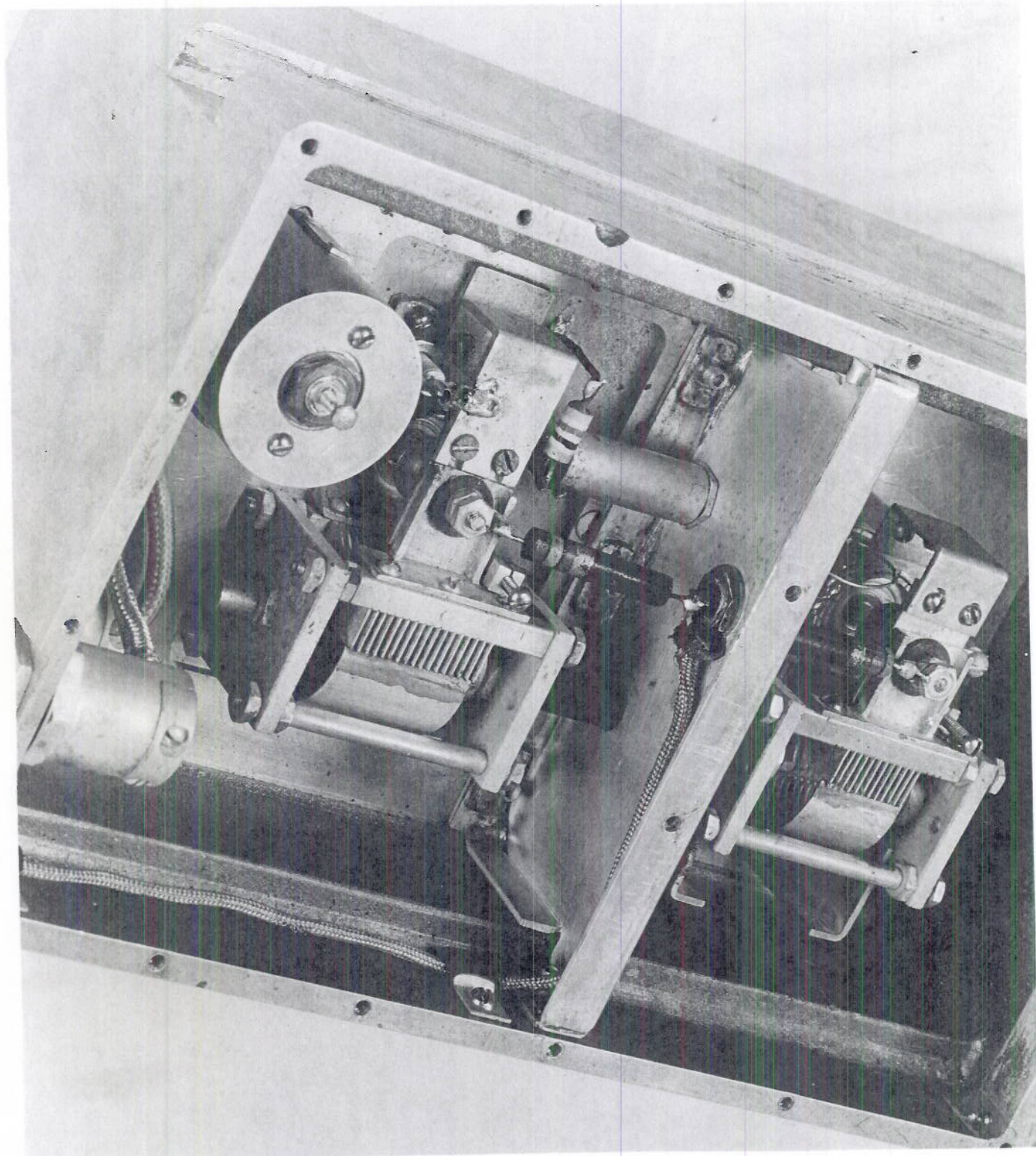


DECLASSIFIED

PRESELECTOR UNIT D

VIEW OF VARIABLE TUNED GRID-CATHODE
CIRCUIT OF GROUNDED-GRID AMPLIFIER

PLATE II

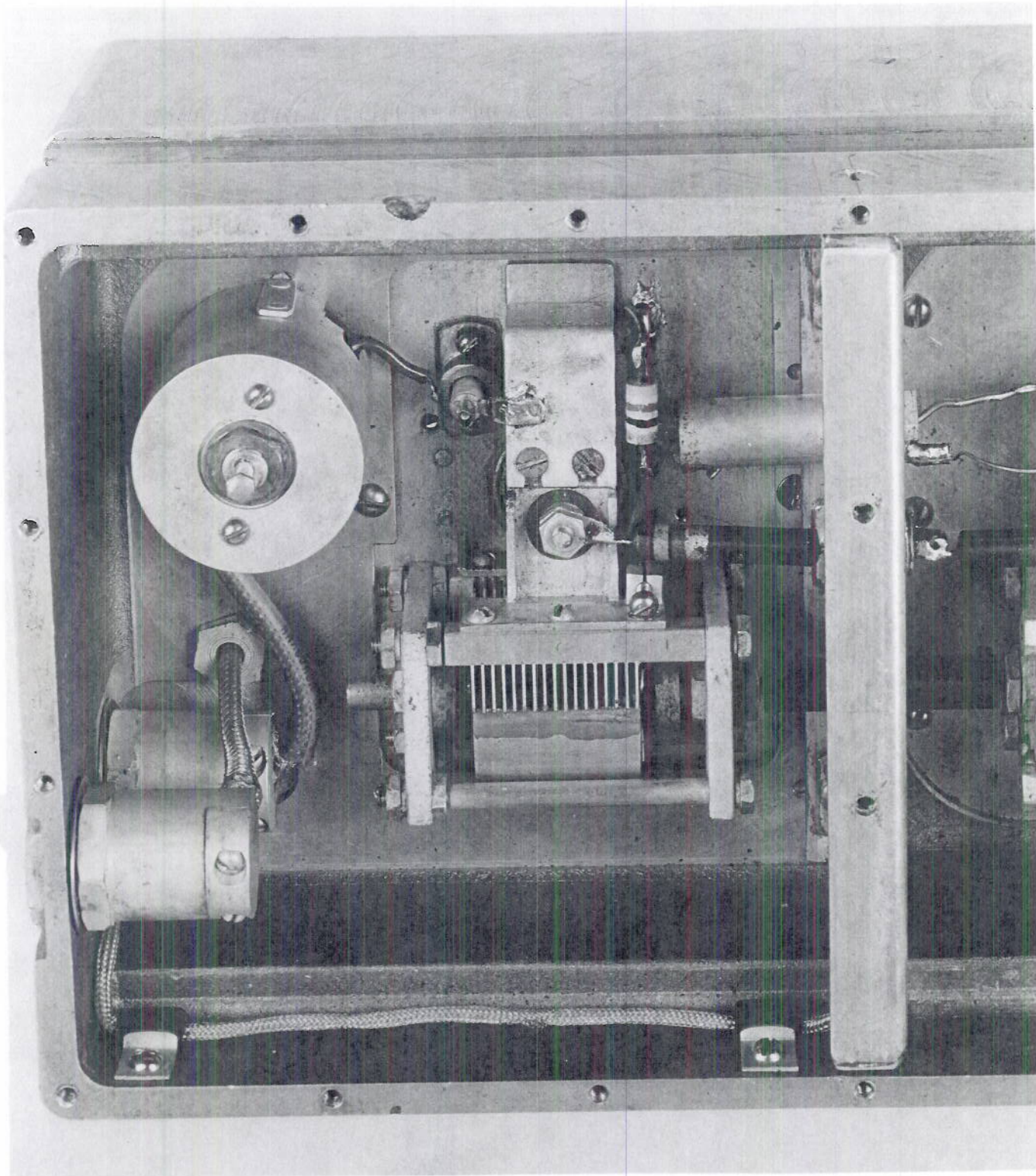


DECLASSIFIED

PRESELECTOR UNIT D

LEFT-HAND COVER PLATE REMOVED SHOWING GRID-PLATE
TUNED CIRCUIT OF THE GROUNDED-GRID AMPLIFIER
AND THE LOCAL OSCILLATOR CIRCUIT (ON THE LEFT)

PLATE 12

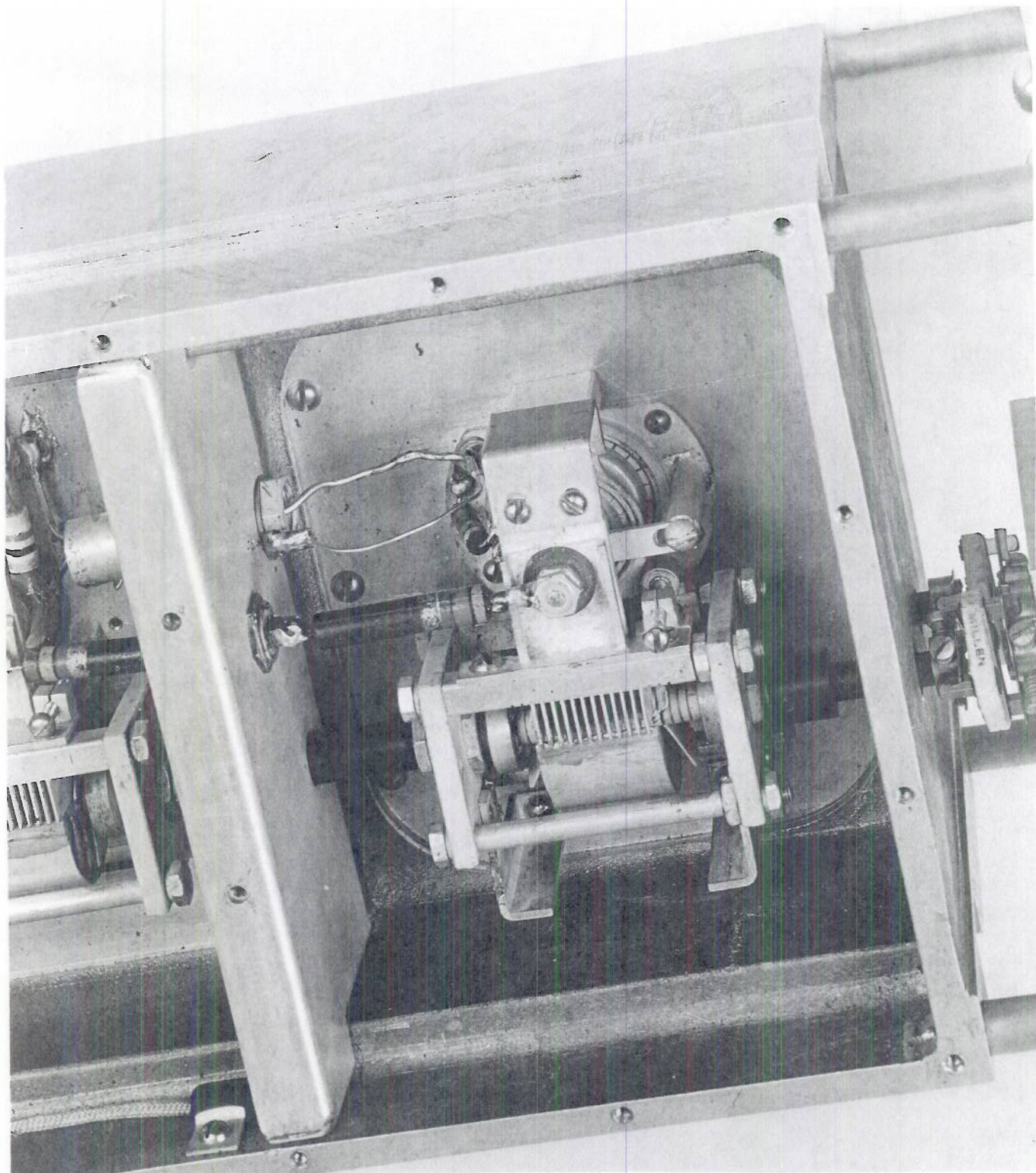


DECLASSIFIED

PRESELECTOR UNIT D

VIEW OF THE VARIABLE TUNED GRID-PLATE CIRCUIT OF THE
GROUNDED GRID AMPLIFIER. NOTE CRYSTAL MIXER NEAR
THE TOP-CENTER OF THE VIEW

PLATE 13

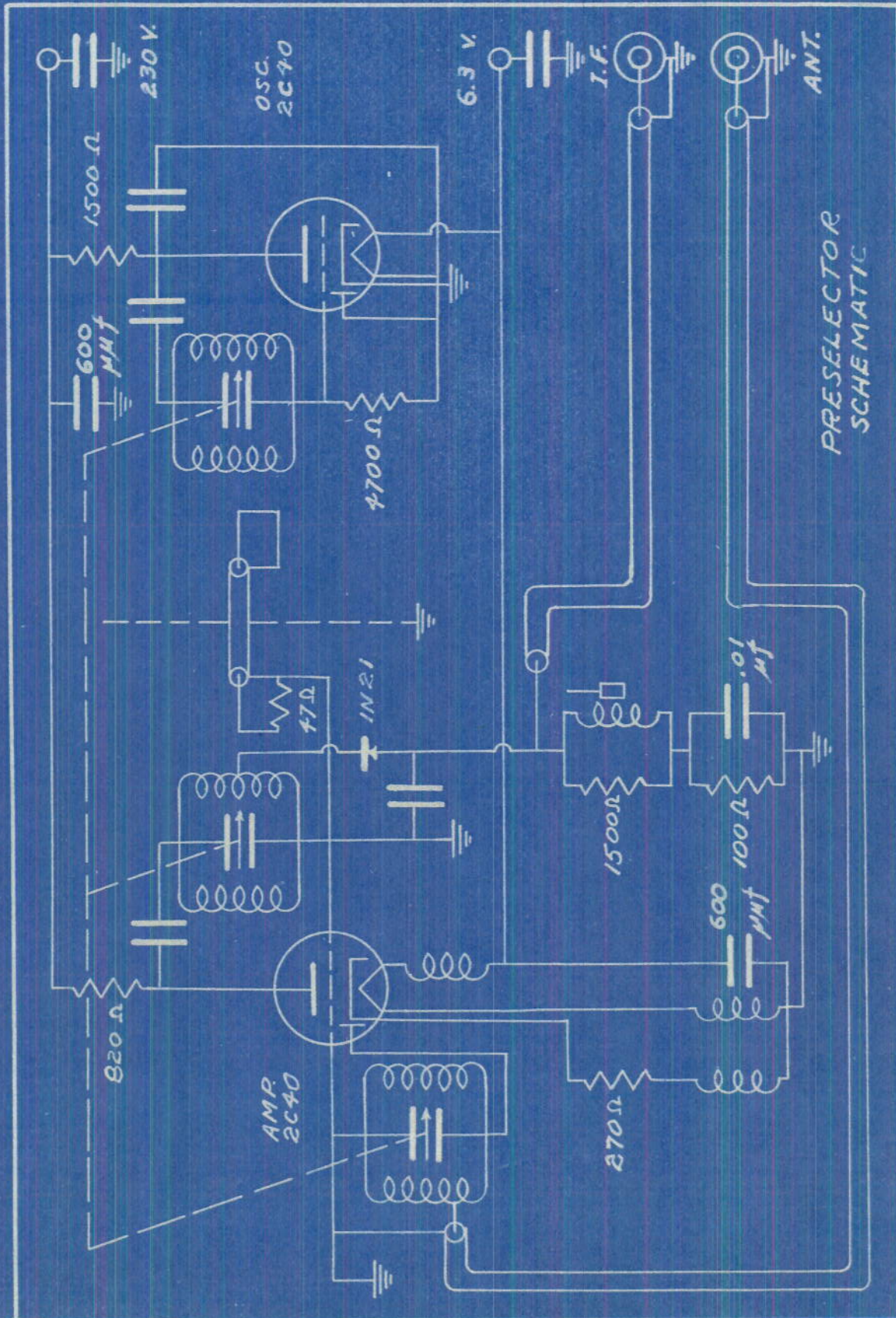


PRESELECTOR UNIT D

VIEW OF THE VARIABLE TUNED LOCAL OSCILLATOR CIRCUIT

DECLASSIFIED

PLATE 14



DECLASSIFIED