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Miniaturizing techniques as exemplified in the design of a compact 300-volt supply

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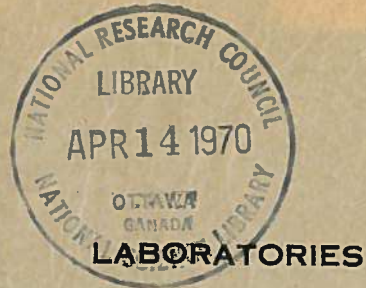
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REPORT NO. ERA - 157

UNCLASSIFIED



OF
THE NATIONAL RESEARCH COUNCIL OF CANADA
RADIO AND ELECTRICAL ENGINEERING DIVISION

ANALYZED

MINIATURIZING TECHNIQUES
AS EXEMPLIFIED IN THE DESIGN OF A COMPACT
300-VOLT SUPPLY

OTTAWA

NOVEMBER, 1948

N.R.C. NO. 1853

(i)

Report No. ERA-157

Unclassified

Laboratories
of
The National Research Council of Canada
Radio and Electrical Engineering Division

MINIATURIZING TECHNIQUES
AS EXEMPLIFIED IN THE DESIGN OF A COMPACT 300-VOLT SUPPLY

by
P. Bennett and E.F.V. Robinson

Introductory pages	3
Text	7
Photos	3
Figures	2-5
Parts lists	6

Ottawa,
November, 1948.

ABSTRACT

A compact regulated power supply employing miniature tubes is described. The unit illustrates some techniques by which the over-all dimensions of electronic apparatus may be reduced.

The type of construction used results in a compact arrangement of components, while permitting easy access for servicing. Standard components are used. By the use of special components, especially transformers, a further reduction of size could be achieved. The present unit is only 9" x 7½" x 7" and weighs 21¼ lb.

The circuit used is similar to that described in more detail in Report No. ERA-156, entitled, "Laboratory Manual for General Purpose D-C Supplies". In addition to the stabilized output, which may be varied from +250 to +300 volts at a load of about 80 ma, a negative output of 150 volts is provided at 20 ma, regulated by means of a VR tube. The filament supply of 6.3 volts, a-c, at 3.5 amperes, for external use, may be operated with grounded centre tap, or either side may be grounded to the chassis. No provision is made for operating with the filament supply floating.

(111)

CONTENTS

	<u>Page</u>
1. Summary	1
Quick Reference Data	
Accessories Required	
2. General	2
Description	
Purpose	
3. Method of Operation	2
4. Detailed Description	3
Circuit Description	
Performance	
5. Calibration and Maintenance	5
Adjustment	
Table of Voltages	
Table of Resistances	
6. Constructional Details	6
Mechanical Drawings	
Parts Lists	

Photographs, Figures, Parts Lists

MINIATURIZING TECHNIQUES

AS EXEMPLIFIED IN THE DESIGN OF A COMPACT 300-VOLT SUPPLY

Unclassified

1. SUMMARY

1.1 Quick Reference Data

Input 105 to 125 volts, 60 cycles, at about 125 watts on full load.

<u>Outputs</u> Positive	250 to 300 v, at 0 to 80 ma
Negative	150 v at 20 ma
AC	6.3 v at 3.5 amps

Regulation is such that at 300 volt output the voltage variation is less than ± 0.25 volts within the regulating region.

Output Resistance is approximately 0.6 ohms within the regulating region.

Ripple Voltage is less than 3 millivolts rms within the regulating region.

Drift during warm-up is about 0.5 volts during the first 3 hours and limits at approximately 1 volt in 8 hours.

Physical Dimensions of the unit are 9" wide, $7\frac{1}{2}$ " deep, 7" high. The weight is $21\frac{1}{4}$ lb. Clearance for venilation should be allowed.

1.2 Accessories Required

Line cord provided with standard two-wire male and female connectors.

Connecting leads.

2. GENERAL

2.1 Description

The unit is 9" wide, 7½" deep, 7" high and weighs 21¼ lb. Exterior views are presented in Photo I. Photo 2 shows the unit opened to expose the vacuum tubes. In Photo 3, top and bottom covers have been removed to expose the wiring. The connectors are mounted on the upper surface of a portion of the chassis which extends beyond the cover. With the exception of the connectors, the unit is fully enclosed by a ventilated steel case. The basic circuit is that used in the RA-57-A Rectifier, designed by Bell Telephone Labs Inc., and manufactured for the U. S. Army Signal Corps by the Western Electric Company. The standard tubes used in that circuit have been replaced, in the present unit, by miniature tubes. The layout is such that without sacrificing accessibility for servicing and replacement of parts the unit occupies a minimum volume consistent with the use of readily available components.

2.2 Purpose

The development of this unit was undertaken with two objectives in mind. Firstly, it was felt that with the increasing interest in miniaturization of equipment it would be useful to investigate and demonstrate some methods of utilizing more effectively the space occupied by a unit, while at the same time retaining the greatest degree of accessibility for general maintenance of the unit.

Secondly, it was thought to be desirable that a compact, general purpose, regulated power supply be designed for use in conjunction with small experimental chassis. The need for a larger general purpose regulated supply of standard design has been met by the unit described in Report No. ERA-156.

3. METHOD OF OPERATION

The control and terminal panel is shown in Fig. 1.

The designations indicated in this figure are those used on the schematic, Fig. 5.

3.1 Throw S1 to the OFF position.

3.2 Unless previously set, turn P1 to its extreme anti-clockwise position.

3.3 Connect the loads to the terminals which are identified on the panel (See Fig. 1)

- 3.4 Insert a line cord into the connector provided and connect to the line.
- 3.5 Throw S1 to the ON position. Pilot light, PL1, will now be illuminated. Fuse, F1, protects the unit from overhead.
- 3.6 Adjust the output voltage by means of P1. As no meters are provided it will be necessary to use an external meter during this adjustment.

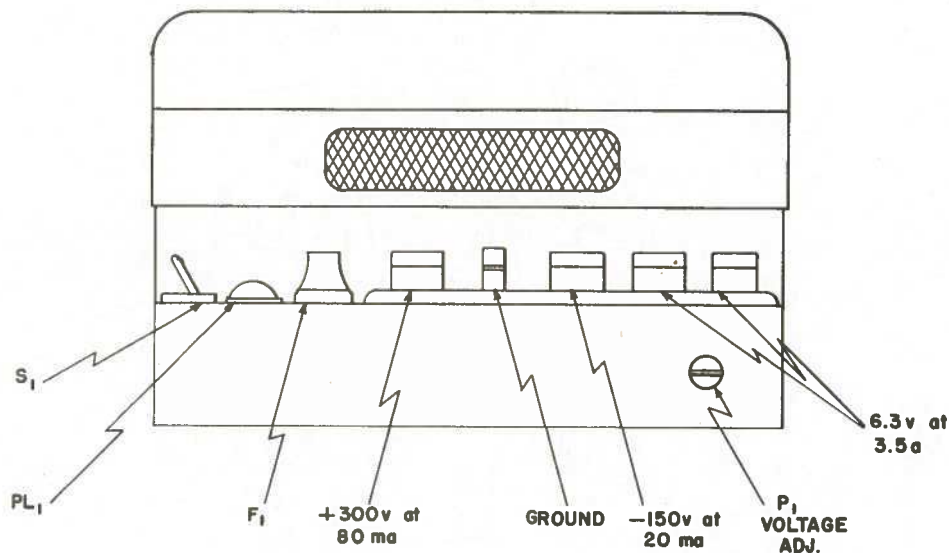


FIG. 1.
CONTROL PANEL

4. DETAILED DESCRIPTION

4.1 Circuit description

The schematic of the unregulated portion of the unit is given in Fig. 2. This figure also includes the schematic of the negative supply and the filament supply. Because the circuits used here are standard, little need be said concerning this portion of the circuit.

One uncommon feature is the transformer connection. To simplify the replacement of transformer T2, a standard Hammond #275 transformer was used. The 5-volt filament winding, which is otherwise superfluous, has been used to supply a second transformer, T1. The latter is the only special component used in this unit. It supplies the heaters of the stabilizer tubes and the rectifier tube used in the negative supply. The 6.3-volt output and the main rectifier heaters are supplied directly from the 6.3-volt winding on T2. The filament output

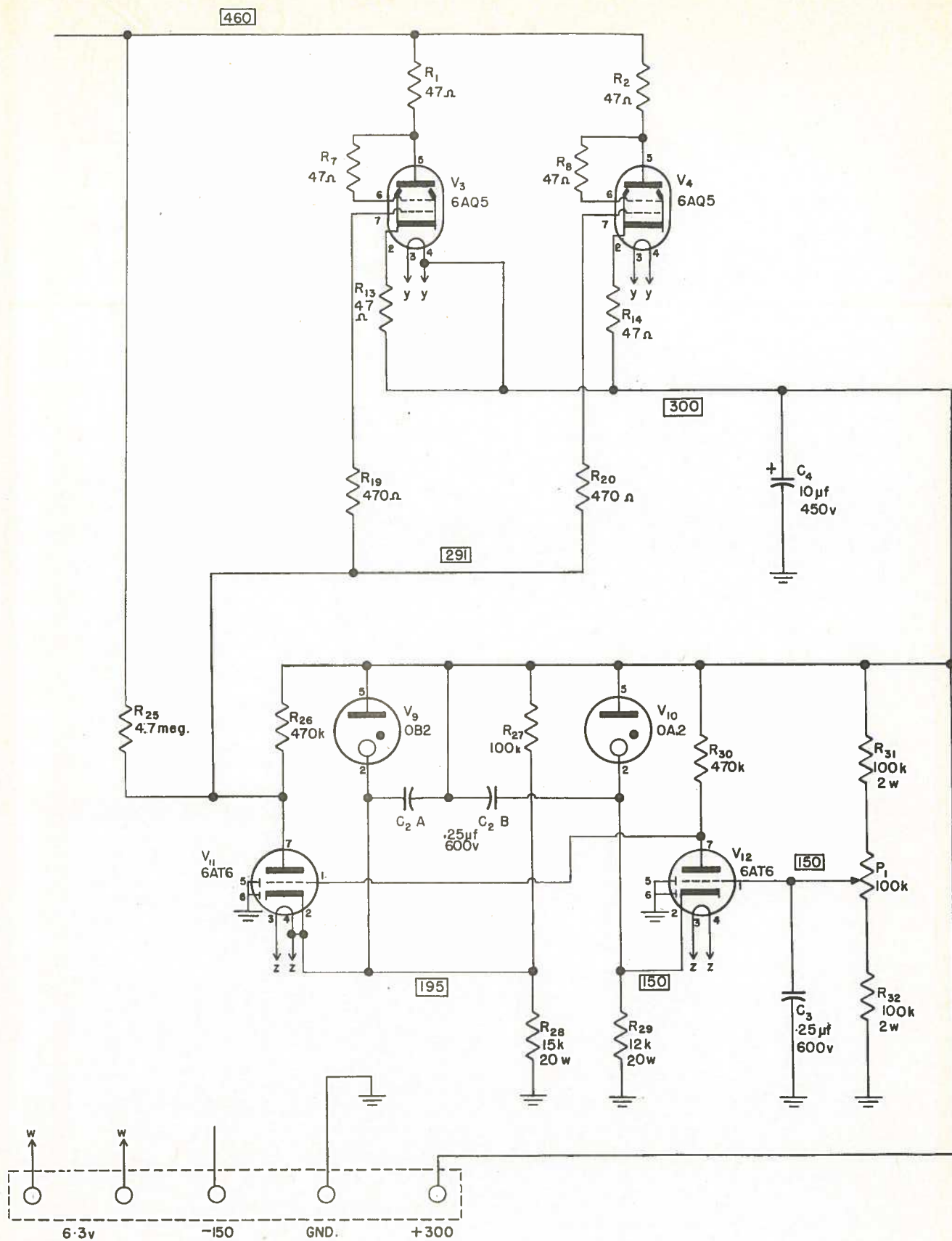


Fig. 3

Schematic of Stabilizer

is centre-tapped to the chassis by means of R₃₇ and R₃₈. Either side of this circuit may be grounded, if desired, without ill effect, as the resistors have been rated with this in mind.

The negative supply is regulated by means of an OA2 miniature gaseous voltage regulator, and is conventional.

The schematic of the stabilizer for the positive supply is shown in Fig. 3. To facilitate comparison, the numbers assigned to the components correspond to those used in the "Laboratory Manual for General Purpose D-C Supplies", as described in ERA-156. A description of the operation of the stabilizer given in that report in Sec. 4.3 applies also to this unit and will not be repeated here. Since this unit was developed, the type 12AX7, nine-pin, miniature, dual triode has become available. The use of this tube to replace the two type 6AT6 tubes would eliminate one tube with, in addition, a possible improvement in performance. The substitution of type 6AV6 tubes for the type 6AT6 tubes in use at present would probably result in an equal improvement in performance. These tubes have not been available for test, however.

The components have been arranged so that the stabilizing circuits are in the upper section of the unit, while the power supply circuits are in the lower section. By interleaving components mounted on the two chassis surfaces, one of the big problems associated with the efficient use of miniature tubes has been overcome. This arrangement permits closer spacing of the tubes while providing sufficient mounting surface for the associated components. In this way all components and tube sockets are readily accessible for servicing while little of the chassis surface remains unoccupied.

For easy access to the tubes, the unit hinges open after two captive screws are loosened. Removal of the base plate exposes the wiring and components of the power supply circuits, and removal of the top cover gives access to the stabilizer wiring.

By using transformers with wound-ribbon cores, (e.g. hypersil), a further considerable reduction in over-all volume could be achieved. However, for the present purpose, it was decided that the unit would be small enough if the more common type of transformers were used.

4.2 Performance

The regulating region is defined by Fig. 4. The curves indicate the maximum load at which the unit will regulate a given output voltage for various line input voltages.

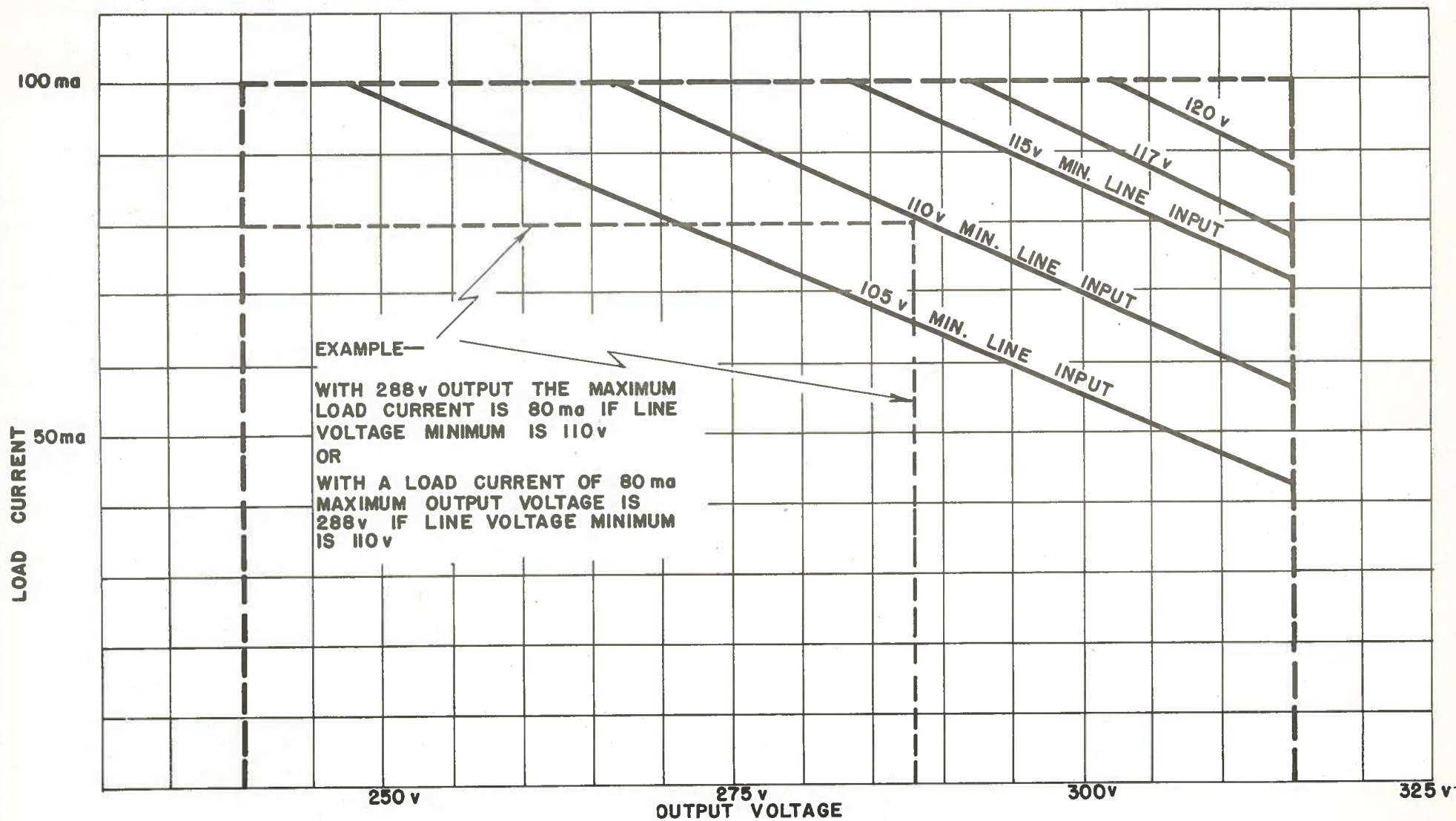


FIG. 4.
REGULATION LIMITS

They can be used also to indicate the maximum output voltage at which the unit will regulate a given load current for various line voltages, or to indicate the minimum line voltage at which a given output voltage may be applied to a known current load.

As an example, a load of 80 ma may be regulated at 288 volts with a line voltage of 110 volts or greater.

Line voltages of greater than 125 volts, or output voltages below 250 volts can cause overloading of the type 6AQ5 tubes, but within the regions shown all tubes run within their recommended ratings. A load of more than 100 ma will overload the transformer, T2.

The tests for output voltage vs. line voltage and output voltage vs. load current were not as thorough as in the case of the larger unit referred to above, so curves are not included. The general trend, however, is similar. Measurements indicate that, with a line input of 117 volts, the variation in output is less than ± 0.03 volts when the unit is set at 300 volts and the load is varied between zero and 90 ma. With output voltage set at 300 volts and a load of 55 ma, line voltage changes between 105 and 125 volts result in a change in output voltage of approximately 0.46 volts. With 200 volts output at 85 ma, the output voltage change is about 0.41 volts.

The output resistance is about 0.6 ohms and the ripple on the output is about 3 millivolts, measured as in ERA-156.

5. CALIBRATION AND MAINTENANCE

- 5.1 The only adjustment provided is P1, by which the output voltage may be varied over a range somewhat greater than 250 to 300 volts. It is uncalibrated.
- 5.2 For convenience in servicing the instrument, the following table of voltages is given as typical for the conditions listed. Some variation from these values may be expected.

Line Voltage - 117 v, 60 cycles
Output Voltage - 300v
Output current - 0 ma.

Tube Type	Tube no.	Voltage to Chassis from Pin Shown							Bias
		1	2	3	4	5	6	7	
6X4	1&2	425ac	-	3.3ac	3.3ac	-	425ac	465	-9.0
6AQ5	3&4	-	300	300	300	460	460	291	
OB2	9	-	195	-	-	300	-	-	
OA2	10	-	150	-	-	300	-	-	-1.5
6AT6	11	193	195	195	195	-	-	291	
6AT6	12	150	150	195	195	-	-	193	-0.1
6X4	13	-465	-	425ac	425ac	-	-465	425ac	
OA2	14	-	-150	-	-	0	-	-	

5.3 The following table shows the resistances measured on a typical power supply which had been adjusted for 300-volt operation.

Caution: Disconnect line cord before taking these readings.

Tube Type	Tube no.	Resistance to Chassis from Pin Shown						
		1	2	3	4	5	6	7
6X4	1&2	110 Ω	-	10 Ω	10 Ω	-	110 Ω	3 meg*
6AQ5	3&4	-	85K	85K	85K	3 meg*	3 meg*	550K
OB2	9	-	13K	-	-	80K	-	-
OA2	10	-	12K	-	-	80K	-	-
6AT6	11	550K	13K	-	-	0	0	550K
6AT6	12	95K	12K	-	-	0	0	550K
6X4	13	65K	-	-	-	-	65K	110 Ω
OA2	14	-	50K	-	-	0	-	-

* These readings drift slowly upwards in value as the filter condensers are charged.

6. CONSTRUCTIONAL DETAILS AND PARTS LISTS

6.1 Mechanical drawings are available, under separate cover, as Report no. ERB-218.

- 6.2 Parts lists include reference number, if any, used on the schematic; description; location on the schematic as given by grid reference. The NRC part number or drawing number is included as "NRC no." The manufacturer's part number, if available, is also included and other relevant information appears under "remarks".

COMPACT REGULATED POWER SUPPLY

SHEET NO. 1 OF 6

SCHEMATIC REFERENCE	DESCRIPTION	GRID REFERENCE	N.R.C. NO.	MANUF. NO.	REMARKS
	<u>CONDENSERS</u>				
C ₁	8 ufd, 600v, electrolytic	7C		BS - 91	Mallory - bathtub
C _{2a}	.25 ufd, 600v, oil-filled	11I	223 - 103		C - D bathtub
C _{2b}	.25 ufd, 600v, oil-filled	12I	223 - 103		C - D bathtub
C ₃	.25 ufd, 600v, oil-filled	14K	223 - 103		C - D bathtub
C ₄	10 ufd, 450v, electrolytic	14F	245 - 101	FP - 142	Mallory - can
C ₅	8 ufd, 600v, electrolytic	6C		BS - 91	Mallory - bathtub
C ₆	8 ufd, 600v, electrolytic	7K		BS - 91	Mallory - bathtub
C ₇	10 ufd, 450v, electrolytic	8K	245 - 101	FP - 142	Mallory - can
	<u>FUSES</u>				
F ₁	Fuse, 250v, 2A	2G		3AG	Littelfuse
	<u>JACKS</u>				
J ₁	Motor plug - miniature	2I		2711	G.E.
	<u>CHOKES</u>				
L ₁	Choke - 135 M.A. 10H.	7B	158	158	Hammond

COMPACT REGULATED POWER SUPPLY

SHEET NO. 2 OF 6

SCHEMATIC REFERENCE	DESCRIPTION	GRID REFERENCE	N.R.C. NO.	MANUF. NO.	REMARKS
L ₂	Choke - 40 M.A. 30 H.	6I	155	155	Hammond
	<u>POTENTIOMETER</u>				
P ₁	Potentiometer - 100K	15I	190 - 611	AB	Allan-Bradley
	<u>PILOT LIGHTS</u>				
PL ₁	Bulb - Pilot Light	2F	NE51	NE51	Dialite Corporation
	<u>RESISTORS</u>				
R ₁	47 ohms - $\frac{1}{2}$ watt	11B	130 - 117		Ohmite - Little Devil
R ₂	47 " " "	13B	130 - 117		" " "
R ₇	47 " " "	10C	130 - 117		" " "
R ₈	47 " " "	12C	130 - 117		" " "
R ₁₃	47 " " "	11D	130 - 117		" " "
R ₁₄	47 " " "	13D	130 - 117		" " "
R ₁₉	470 " " "	10F	130 - 141		" " "
R ₂₀	470 " " "	12F	130 - 141		" " "
R ₂₅	47 M " "	8H	130 - 237		" " "

COMPACT REGULATED POWER SUPPLY

SHEET NO.....3.....OF.....6.....

SCHEMATIC REFERENCE	DESCRIPTION	GRID REFERENCE	N.R.C. NO.	MANUF. NO.	REMARKS
R26	470K - 1/2 watt	10H	130 - 213		Ohmite - Little Devil
R27	100K - " "	12H	130 - 197		" " "
R28	15K - 20 "	12K		BROHI	" Brown Devil
R29	12K - 20 "	13K		BROHI	" " "
R30	470K - 1/2 "	14H	130 - 213		" Little Devil
R31	100K - 2 "	15H	132 - 197		" " "
R32	100K - 2 "	15K	132 - 197		" " "
R37	20 ohms - 4.8 watt	5E	180 - 104	D.F.	I. R. C.
R38	20 ohms - 4.8 watt	5F	180 - 104	D.F.	I. R. C.
R39	15K - 20 "	7I		BROHI	Ohmite - Brown Devil
R40	47K - 2 "	8K	132 - 189		" Little Devil
	SWITCHES				
S1	Switch, S.P.S.T., 250V 3A	2H	101 - 010		A.E. & H. Bat Handle
	TRANSFORMERS				
T1	Transformers, filament	5G		23224	Hammond, special
T2	" power	3D		275Z	Hammond

COMPACT REGULATED POWER SUPPLY

SHEET NO.....4.....OF.....6.....

SCHEMATIC REFERENCE	DESCRIPTION	GRID REFERENCE	N.R.C. NO.	MANUF. NO.	REMARKS
	<u>TUBES</u>				
V ₁	6X4	5B			
V ₂	6X4	5C			
V ₃	6AQ5	11C			
V ₄	6AQ5	13C			
V ₉	0B2	11H			
V ₁₀	0A2	13H			
V ₁₁	6AT6	10J			
V ₁₂	6AT6	13J			
V ₁₃	6X4	4I			
V ₁₄	0A2	6J			
	<u>MISCELLANEOUS</u>				
	Spacers, condenser				BA - 1 - 46A
	Chassis				BA - 1 - 50D
	Bottom Plate				BA - 1 - 51A
	Terminal Plate				BA - 1 - 51A
	Cover				BA - 1 - 55D

COMPACT REGULATED POWER SUPPLY

SHEET NO.....5.....OF.....6.....

SCHEMATIC REFERENCE	DESCRIPTION	GRID REFERENCE	N.R.C. NO.	MANUF. NO.	REMARKS
	Mounting Board, resistor				BA - 1 - 60A
	Rod, resistor mtg.				BA - 1 - 61A
	Bracket, potentiometer mtg.				BA - 1 - 62A
	Spacer, resistor mtg.				BA - 1 - 63A
	Binding Posts			DF - 30	Superior Electric, 4 req'd
	Binding Post			138 - X	General Radio, 1 req'd
	Bracket, resistor mtg.				I.R.C. 2 req'd
	Coupler, potentiometer				1/4" solid brass
	Fuse Holder, extractor			342001	Littelfuse
	Lugs, terminal				
	Lugs, turret		310 - 010	X1548D	Cambridge Thermionic, 4 req'd
	Lugs, turret		310 - 030	X1558B	" " 6 "
	Pilot Light Assembly			PLN-849-95408	Dialite Corporation
	Plate, name				Division of Radio and Elec. Eng.
	Shields, tube		120 - 006		Eby, medium, 2 req'd
	Shields, tube		120 - 007		Eby, large, 4 req'd
	Stud, Dzus fastener			A4 - 30	Modified

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SHEET NO.....6.....OF.....6.....,

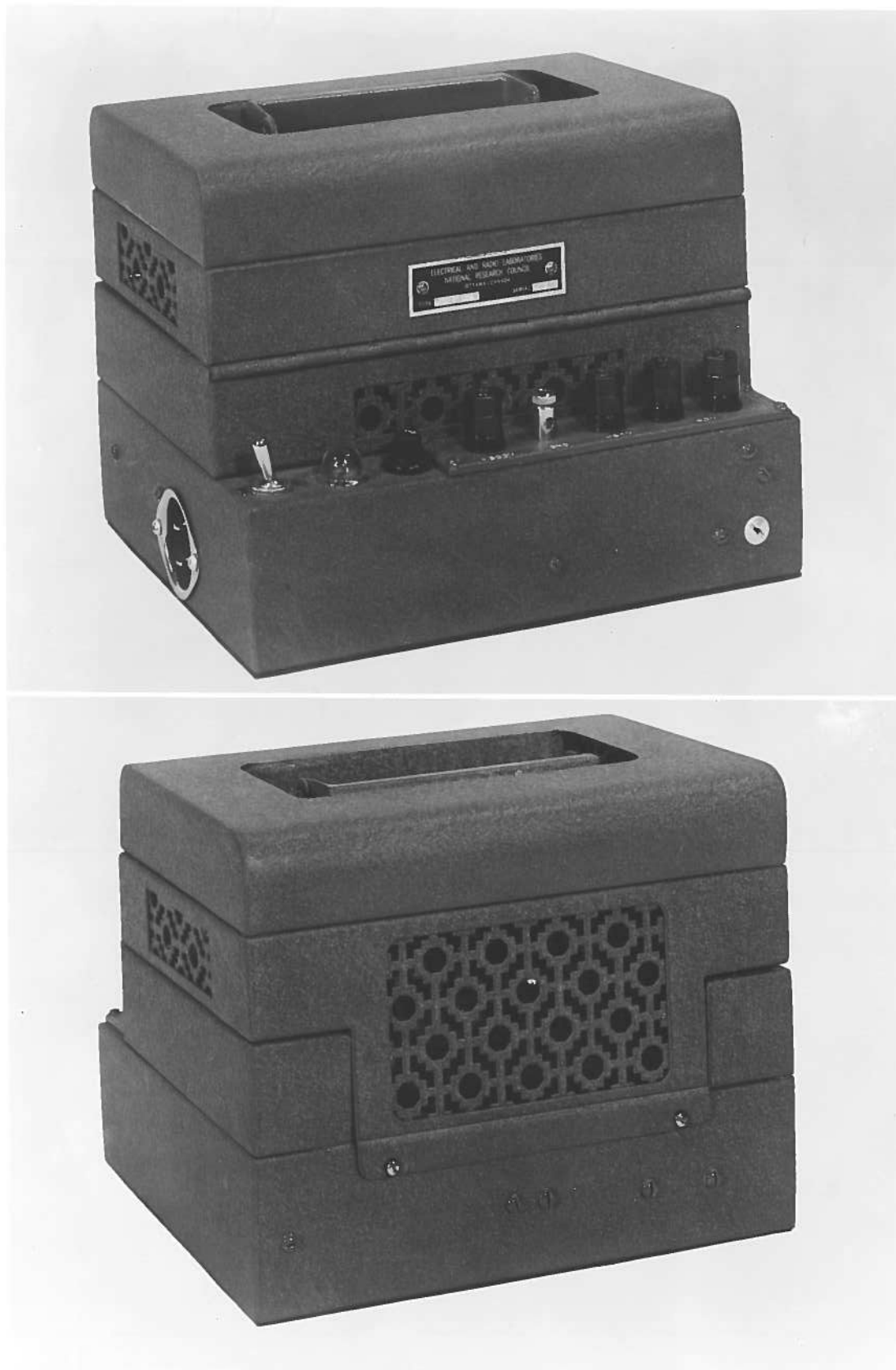


Photo 1 Compact Regulated Power Supply
exterior views

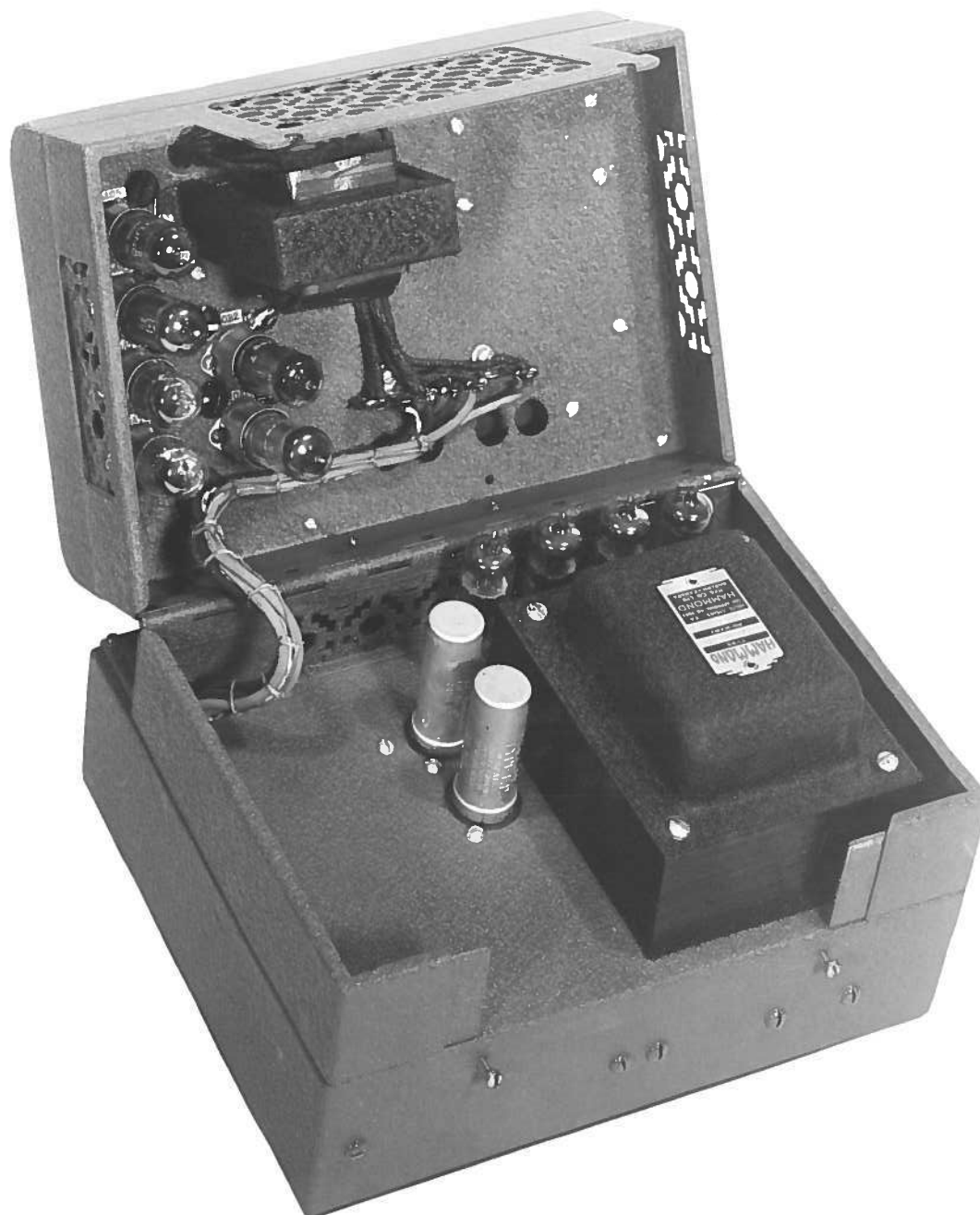


Photo 2 Compact Regulated Power Supply
vacuum tubes exposed

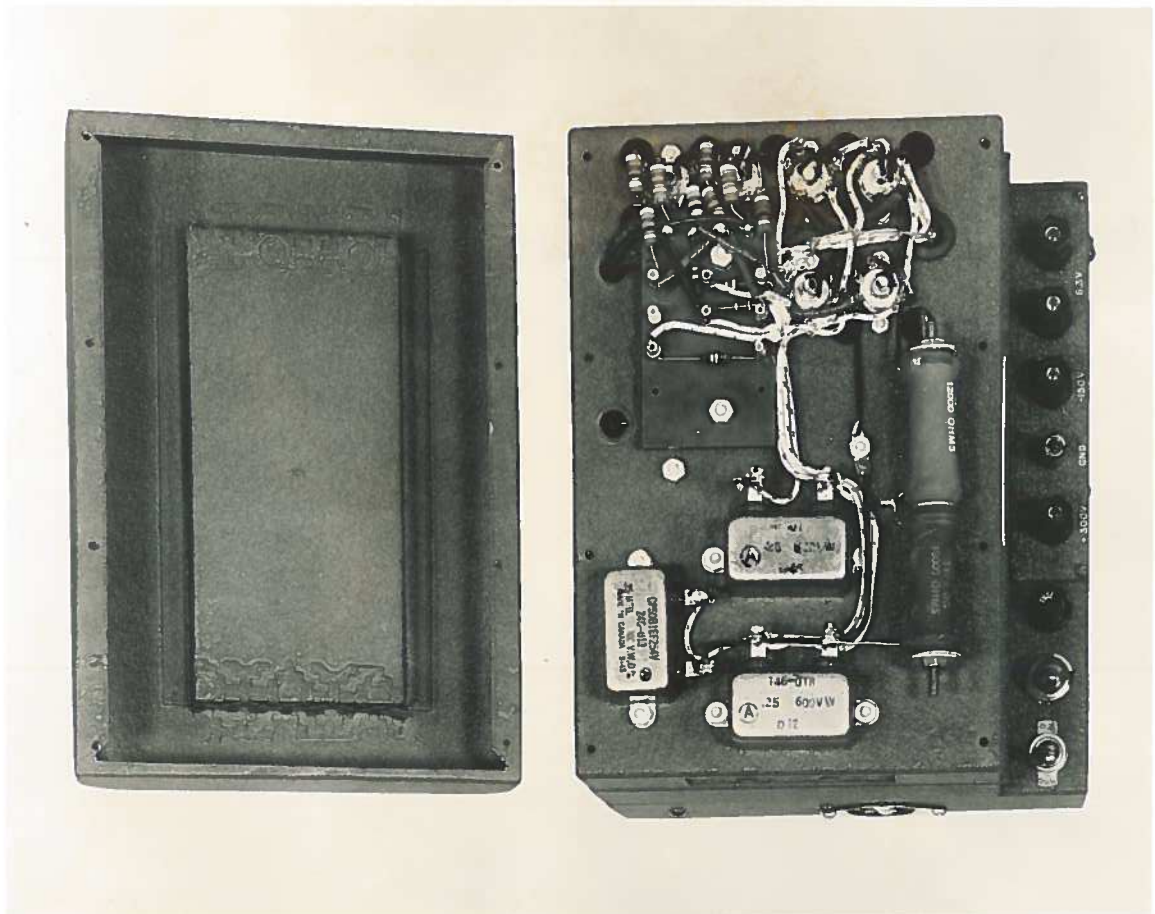
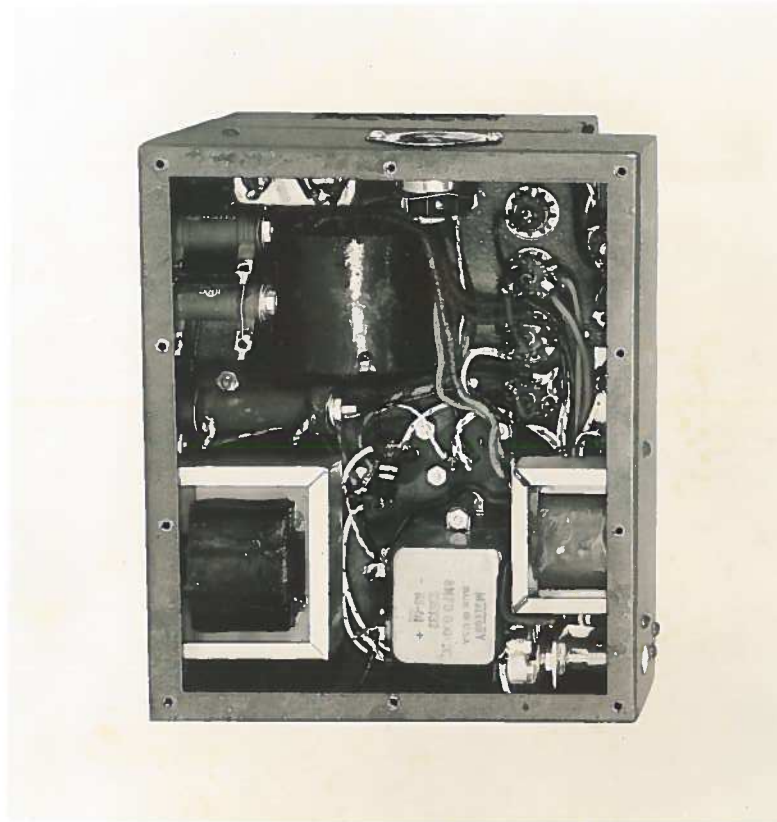


Photo 3 Compact Regulated Power Supply
wiring exposed

