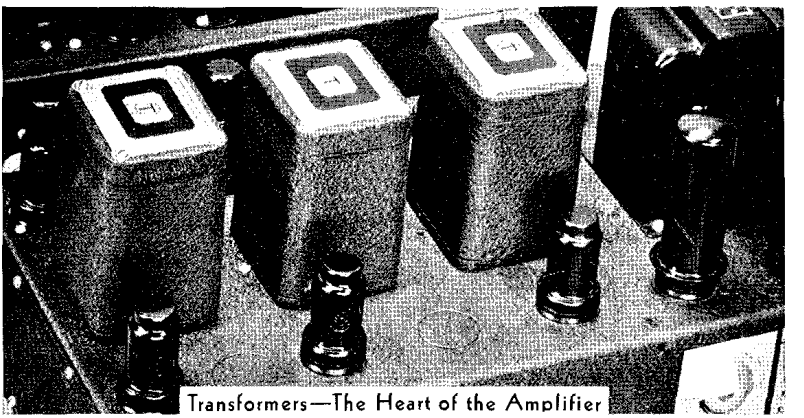
THORDARSON



Transformers—The Heart of the Amplifier

346-B

SOUND AMPLIFIER GUIDE

PRICE 15c

THORDARSON ELECTRIC MFG. CO. . . CHICAGO

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THORDARSON

SOUND AMPLIFIER GUIDE

NO. 346-B

This book is the result of comprehensive work on the design and construction of amplifiers by Thordarson transformer and sound engineers. It has been prepared to fill the fast growing need in the sound amplifier field for practical information on the construction and installation of sound equipment.

The same accuracy and conscientious workmanship that has built for Thordarson the enviable reputation of being the leader in the development and manufacture of highest quality transformers has been exerted in the preparation of the material for this guide.

The circuits have been designed to comply with the latest developments in tubes, transformers, and sound equipment, and in the construction of the amplifier every element has been carefully selected to obtain the highest possible output without overloading the circuit. Each amplifier has been operated under practical conditions to test and to prove its unfailing adaptability to the purpose for which it was designed.

The amplifiers shown range up to 100 watts output, covering practically every sound system requirement. Complete analysis and parts list is given with every amplifier so that the builder or experimenter has full information on every unit. This guide, therefore, is a practical text and workbook for both the construction and installation of sound systems.

If you have any transformer problems, do not hesitate to write the Thordarson engineering department.

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AMPLIFIER CONSTRUCTION

This article contains valuable suggestions on amplifier chassis layout, correct positioning of transformers, and general constructional procedure that will aid the amplifier builder in obtaining the best results from a finished job.

Whether an amplifier is to be used for experimental purposes or for public address work, the following suggestions should help toward producing a superior audio system:

If a foundation unit is not available, the chassis size and layout must be determined. Place the component parts that are to be mounted on top of the chassis in their respective positions on the work bench and decide what size chassis is required. These parts are usually transformers, chokes, condensers, and tube sockets. Allow at least ½" space between the units. Greater spacing is advisable between parts that generate heat, such as power transformers, and power and rectifier tubes. Filter condensers should have one inch or more space around them when they are next to parts giving off heat.

If the power supply is to be on the same chassis, extreme care must be taken to prevent the audio transformers from picking up the A.C. field caused by the power transformer and first filter choke. The power transformer and choke are usually placed at one end of the chassis and the input or microphone and interstage transformers at the other end. Hum pickup from the power transformer will be 60 cycles and from the chokes 120 cycles. The input and interstage transformers are more sensitive to A.C. magnetic fields than driver or output transformers because of the amplification that follows. Usually some of the audio components are closer to the power supply units than others. In this case the input transformer should be farthest away and the output transformer closest to the power supply but still as far from it as possible. The position of transformers is quite as important as their location. All audio transformers should be mounted with their cores at right angles to the power transformer and choke. To do this easily the power transformer and first choke can be fairly close together with cores in parallel. Then the audio transformer cores can all be in the same plane at right angles to the power units. It is also important that input and output transformers are not close together, inasmuch as feedback or oscillation might occur.

It is quite important to arrange the layout so that all leads carrying the signal will be as short as possible. This is especially true of grid leads which are at high impedance and susceptible to capacitive pickup. In some instances shielding of these leads will be required. Shielded leads should always be short to keep down the capacity effect to ground. Capacity of long shielded leads to ground is sure to impair the high frequency response of the system.

After a satisfactory layout is made the chassis size can be determined. A rough sketch of the layout should be made on paper so that the component part positions decided upon will not be forgotten.

A non-ferrous metal is superior for amplifier chassis material from an electrical viewpoint. However, it is more expensive and not as strong as steel. If a steel chassis is used it should be cadmium plated or enameled to prevent rust, after all holes have been made.

The wiring can be started after the parts have been mounted in their respective positions. Usually all filaments or heaters are wired first. All terminals connecting to ground should be wired together with fairly heavy wire and grounded to the chassis at one point. The power supply may be wired before starting the audio system. Upon completion of the wiring, all connections should be inspected for good contact and re-checked against the diagram. A continuity test can also be made to eliminate the possibility of opens or shorts anywhere in the amplifier before connecting the power supply.

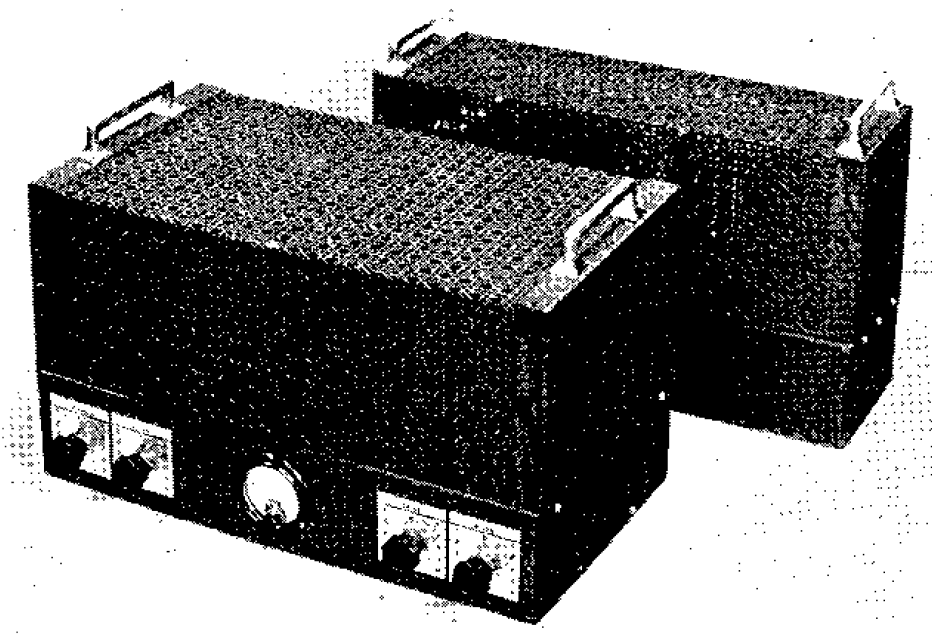
When satisfied that the wiring is completed and correct, the tubes can be inserted and input and output circuits connected. The power supply may be turned on. With a voltmeter having the proper scale and at least 1000 ohms per volt, measure all tube voltages. If possible, insert a milliammeter in the plate circuit of each tube. Plate voltages and plate current should not exceed the tube manufacturer's maximum rating if normal tube life is expected. Less than maximum plate voltage and current tends to prolong tube life. However, power tubes are quite often run at maximum in order to obtain the greatest power output with minimum distortion.

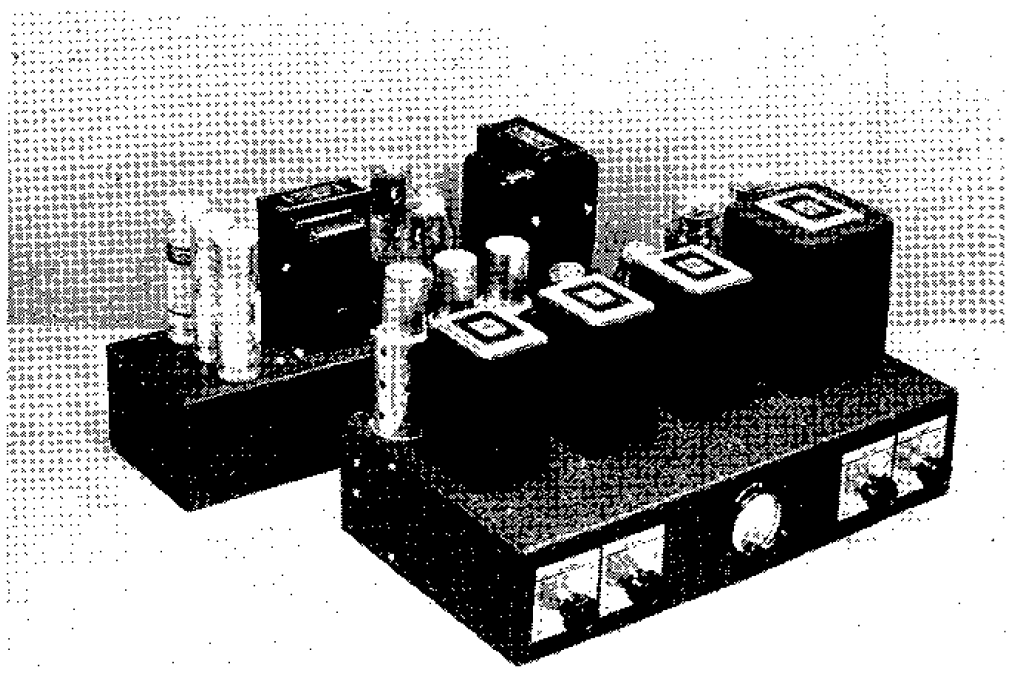
THORDARSON

Tru-Fidelity 2A3 Amplifier

10 WATT

This Tru-Fidelity amplifier is everything the name implies. Its 10 Watt maximum output rating and the use of 2A3 tubes are consistent with the attainment of high quality, faithful reproduction in either recording, broadcasting or P. A. work.





The Thordarson T-10K10 amplifier has been designed to satisfy the need for a high quality unit capable of delivering truly linear and distortionless audio power. Every feature of design involved has been selected or determined to achieve this end. High power output was not a prime consideration and 10 watts was selected as a value low enough to be consistent with the practical attainment of the high quality standards, and high enough to make the unit suitable as a recording amplifier, speech amplifier for broadcast station, or P. A. work, or for sound reproduction where moderate output levels were satisfactory. It consists of a three stage basic amplifier to which may be added pre-amplifier, mixer, and fader equipment; and a power supply to provide plate, grid, and filament voltages for the basic amplifier and all pre-amplifier apparatus which may be associated with it.

Because of their desirable characteristics type 2A3 tubes have been selected for the power output stage. Individual bias adjustment is provided for each tube, and a plate milliammeter arranged with a switch so that the plate current for either tube can be read. This allows individual differences in tubes to be compensated for accurately.

The schematic diagram shows both the three stage basic amplifier and a pre-amplifier, mixer, and fader system. The basic circuit may be constructed alone or the pre-amplifier, mixer, and fader may be incorporated, depending on the kind of service required. Where a single input, such as crystal microphone, is used, a single high gain stage ahead of the first tube of the basic amplifier is adequate.

A new mixer and fader system has been developed in the Thordarson laboratories and has several advantages over other types. Three input circuits are provided—one microphone, one line, and one phono. The microphone feeds into the high gain 6C6 and this stage, along with the other two circuits (line input and phono input) feed into a combination of two fader controls (center tapped volume controls). Each of these fader controls feeds a type 6C6, the outputs of which are connected in parallel for electronic mixing. The operation features are as follows:

1. Individual level control of each input circuit.
2. Any two input circuits can be mixed together.
3. Microphone may be faded against the line circuit with one control.
4. Microphone may be faded against the phono circuit with one control.
5. Line circuit may be faded against phono circuit with two controls.
6. Microphone and phono may be faded against one another with the line mixed in.
7. Microphone and line may be faded against one another with the phono mixed in.

THORDARSON FOUNDATION UNIT
T-10K10 is available for this amplifier. All holes are punched for the basic amplifier and power supply. Knockouts are provided for additional tubes and controls to accommodate practically any type of pre-amplifier and mixer system which may be desirable. Resistor strips and sub-assembly panels supplied to accommodate the maximum parts used.

Technical Data

Power Output 10 watts or +32.2 d b referred to zero d b level of 6 milliwatts.
Gain—Basic Amplifier Circuit.
77.1 d b from 100,000 ohm input.
Basic Amplifier with Pre-Amplifier and Mixer.
110 d b from a crystal microphone input.
77.1 d b from a crystal pickup input.
66.7 d b from line input.
Hum Level— —5.5 d b or 37.5 d b down from max. output or 1.6 milliwatts.
Over-all Frequency Response— ±1½ d b 20 to 15,000 cycles.
Tubes—Basic Circuit.
1 6C6 triode, 2 76's push-pull.
2 2A3's output; 5Z3 and 80 rectifiers.
Basic Circuit with Pre-Amplifier.
1 6C6 pentode; 2 6C6 parallel triodes; 2 76's push-pull.
2 2A3's output; 5Z3 and 80 rectifiers.
Output Impedances—Series or parallel combinations of output transformer secondary windings to obtain any of the following values:

Voice Coil	Line
15.0 ohms 5.0 ohms	500 ohms 200 ohms
10.0 ohms 3.75 ohms	333 ohms 125 ohms
7.5 ohms 1.25 ohms	250 ohms 50 ohms

Two-Unit Base—Amplifier chassis size 9" deep, 16½" wide, and 3½" high, with metal shield 11" high.
Power supply chassis size 5" deep, 16½" wide, and 3½" high, with metal shield 11" high.

Voltage Analysis

Supply Voltage: 60 cycle, 115 volts.

All readings of D.C. taken with a 0-50-250-500 volt (1000 ohm per volt) meter. Deviations of 10% in specified voltages are tolerable. R.M.A. standard system of tube terminal numbers used. See THORDARSON Servicing Guide #342 or any R.M.A. tube chart. All measurements from tube terminals to ground.

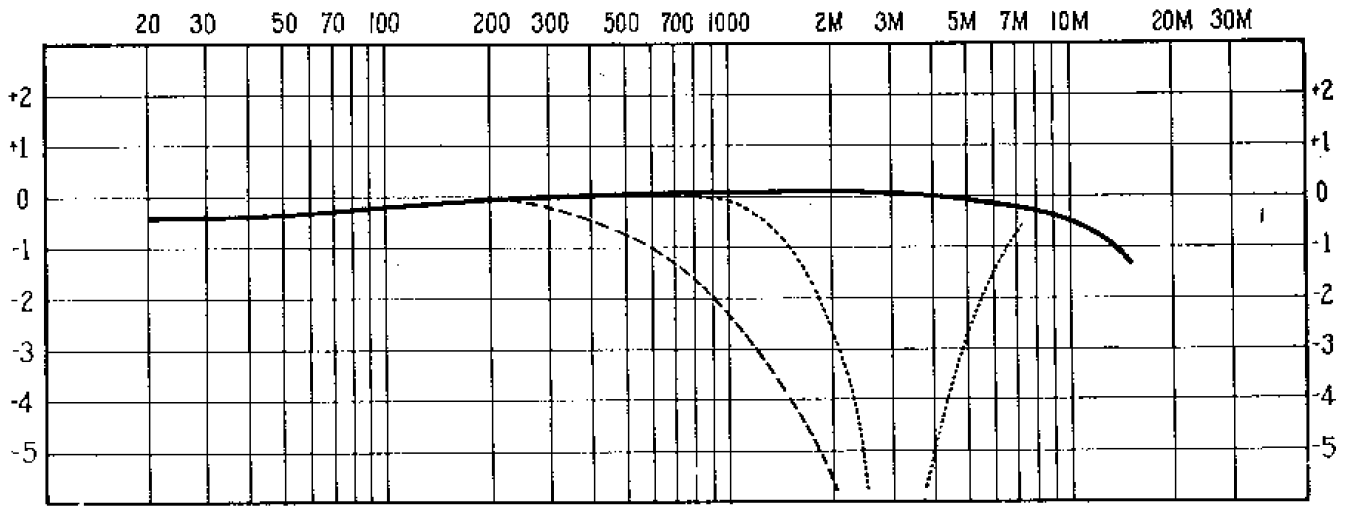
No Signal

1st 6C6: 2, 75 volts; 3, 45 volts; 5, 2 volts.
2 Parallel 6C6s: 2, 147 volts; 5, 5.9 volts.
Push-pull 76s: 2, 295 volts; 4, 11.9 volts.
Push-pull 2A3s: 2, 320 volts; grid return, —63 volts.
5Z3: 1, 332 volts.
80: 2, —71 volts.
Junction T-7551 and T-1892: 322 volts.
Output of T-1892: 310 volts.

Full Output

1st 6C6: 2, 74 volts; 3, 44 volts; 5, 2 volts.
2 Parallel 6C6s: 2, 126 volts; 5, 5 volts.
Push-pull 76s: 2, 265 volts; 4, 11.2 volts.
Push-pull 2A3s: 2, 300 volts; grid return, —63 volts.
5Z3: 1, 318 volts.
80: 2, —71 volts.
Junction T-7551 and T-1892: 303 volts.
Output of T-1892: 290 volts.

D b. vs Frequency-Response Curve



Response of Amplifier without Tone Control.

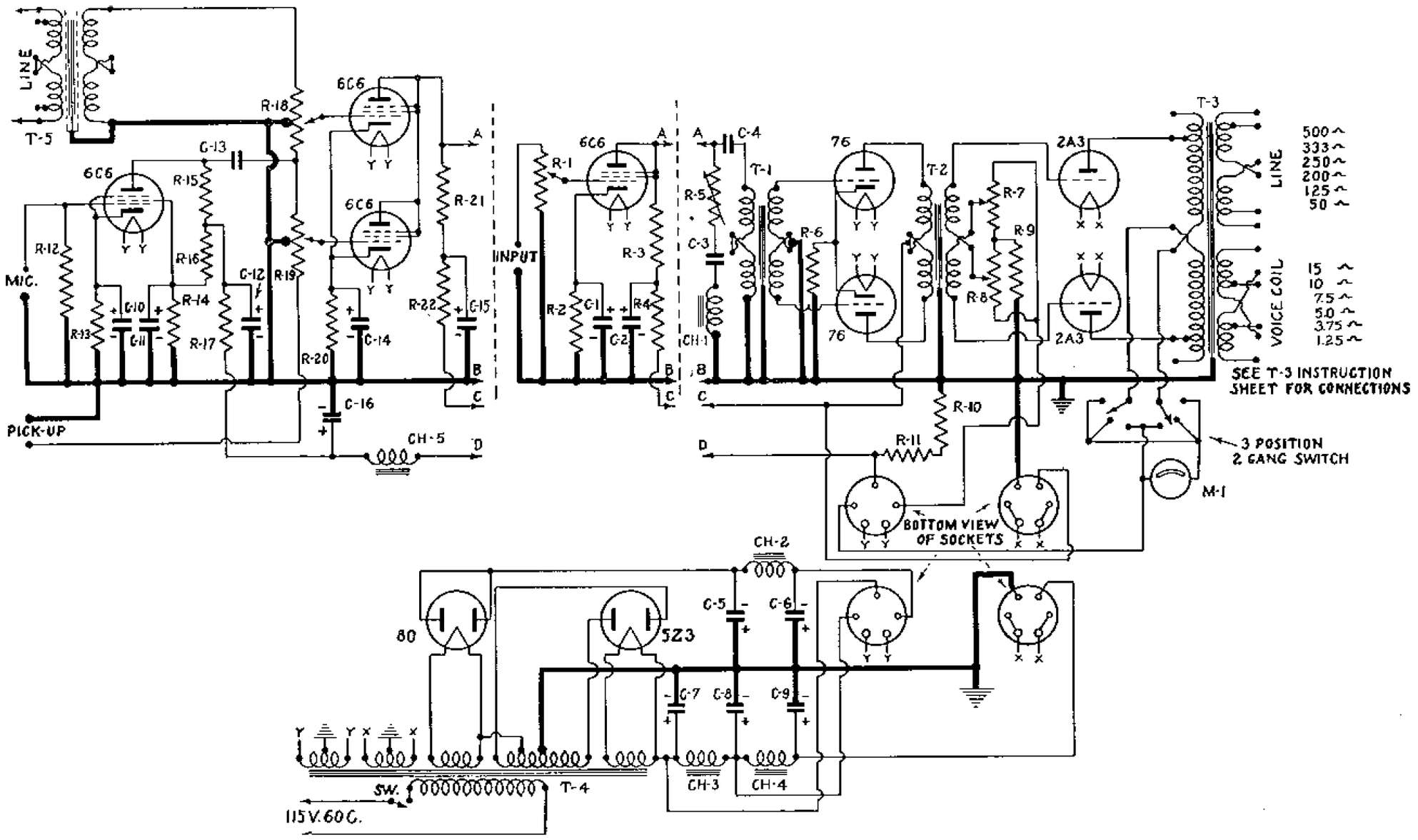
Response of Amplifier with Maximum Tone Control Action using Tuned Circuit Tone Control as in Circuit Diagram (C-3 = .006 Mfd., CH-1 = T-8115, R-5 = 50,000 Ohm Potentiometer).

Response of Amplifier with Simple Series Tone Control Circuit using Condenser and Resistor (C-3 = .025 Mfd., R-5 = 50,000 Ohm Potentiometer).

Tru-Fidelity 2A3 Amplifier

10 WATT

THORDARSON



• • PARTS LIST • •

Thordarson Foundation Unit and Accessories

1 Amplifier chassis with 7 sockets mounted.
1 Amplifier chassis bottom plate.
1 Sub-assembly panel.
1 Input shield.
2 Terminal strips (6 terminals).
8 Resistor mounting strips.
1 Power supply chassis with 4 sockets mounted.
1 Power supply chassis bottom plate.
1 Line cord rubber grommet.
Complete diagrams and assembly instructions.
All above items in one T-10K10 Unit.
Amplifier metal screen cover (less handles) T-10K20.
Power supply metal screen cover (less handles) T-10K21.
Chromium handles (one pair for each cover) T-10K50.

Basic Circuit Parts List

THORDARSON Transformers and Chokes

Number	
T-1	1 T-9004 Tru-Fidelity interstage transformer.
T-2	1 T-9005 Tru-Fidelity interstage transformer.
T-3	1 T-9013 Tru-Fidelity output transformer.
T-4	1 T-8785 Power transformer.
CH-1	1 T-8115 Choke.
CH-2, CH-4	2 T-1892 Chokes.
CH-3	1 T-7429 Choke.

CONDENSERS

Number	Mfds.	Voltage	Type
C-1*	25	25	Electrolytic (Cornell Dubilier #EH-2250 or equiv.)
C-2*	8	450	Electrolytic (Cornell Dubilier #RHM-9080 or equiv.)
C-3	.006	1000	Mica (Cornell Dubilier #4-6D6 or equivalent)
C-4	.5	400	Paper (Cornell Dubilier DT-4P5 or equivalent)
C-5, C-6	8	200	Electrolytic (Cornell Dubilier #EH-7080 or equiv.)
C-7, C-8, C-9	8	450	Electrolytic (Cornell Dubilier #EB-9080 or equivalent)

RESISTORS

Number	Ohms	Watts	Type
R-1	500,000	1	Volume Control (IRC #13-133 or equivalent)
R-2*	2,250	1	Wire-wound (Ohmite Wire-watt or equivalent)
R-3*	50,000	1	Carbon (IRC #BT-1 or equiv.)
R-4*	20,000	1	Wire-wound (Ohmite Wire-watt or equivalent)
R-5	50,000		Tone Control (IRC #13-123 or equivalent)
R-6	1,250	1	Wire-wound (Ohmite Wire-watt or equivalent)
R-7, R-8	3,000		Wire-wound Potentiometer (Yaxley #C3MP or equiv.)
R-9	3,500	10	Wire-wound (Ohmite Brown Devil or equivalent)
R-10, R-11	2,500	50	Wire-wound (Ohmite #0408 or equivalent)

TUBES

1* Type 6C6, 2 Type 76, 2 Type 2A3, 1 Type 5Z3, 1 Type 80

Basic Circuit Miscellaneous Parts

2 6 Contact speaker sockets (if required) (Amphenol or equivalent)
2 6 prong speaker plugs (if required) (Amphenol or equivalent)
2 5 prong male plugs (Amphenol or equivalent)
2 6 prong male plugs (Amphenol or equivalent)
1 Tube shield
1 Grid cap
1 6E5 escutcheon plate (Crowe #435 or equivalent)
1* Volume control plate (Crowe #436 or equivalent)
1 Tone control plate (Crowe #439 or equivalent)
1 Switch escutcheon plate (Crowe #438 or equiv.)
3 Knobs (Crowe #591 or equivalent)
1 2½" 0-150 m.a. D.C. meter (Triplett #223 or eqv.)
1 Single-pole single-throw toggle switch
1 2 Gang 3 position switch (Yaxley #1226 or equivalent)
1 4" extension shaft (Yaxley #RS-242 or equivalent)
1 Panel bearing for extension shaft (Bud #532 or equivalent)
2 Brackets (Yaxley #RB-248 or equivalent)
2 Extruded fibre washers (to insulate metal container of C-8 from chassis)
6 ft. Connecting cable (6 wire)
36 6-32 ½" cadmium plated screws, nuts, and lockwashers
12 10-32 ½" cadmium plated screws, nuts, and lockwashers
1 A.C. line cord and plug
1* ft. Shielded wire

*These parts should be omitted when the pre-amplifier is built up with the basic amplifier, as parts listed under "Pre-amplifier, Mixer and Fader Parts" will replace them.

Pre-Amplifier, Mixer and Fader Parts List

THORDARSON Transformers and Chokes

Number	
T-5	T-9000 Tru-Fidelity Transformer
CH-5	T-7430 Choke

CONDENSERS

Number	Mfds.	Voltage	Type
C-10, C-14	25	25	Electrolytic (Cornell Dubilier #EH-2250 or equivalent)
C-11	8	200	Electrolytic (Cornell Dubilier #EH-7080 or equivalent)
C-12, C-15, C-16	8	450	Electrolytic (Cornell Dubilier #RHM-9080 or equiv.)
C-13	.1	400	Paper (Cornell Dubilier #DT-4P1 or equivalent)

RESISTORS

Number	Ohms	Watts	Type
R-12	5 megohm	½	Carbon (IRC #BT-½ or equiv.)
R-13	2,250	1	Wire-wound (Ohmite Wire-watt or equivalent)
R-14	20,000	1	Wire-wound (Ohmite Wire-watt or equivalent)
R-15	250,000	1	Carbon (IRC #BT-1 or equiv.)
R-16	100,000	1	Carbon (IRC #BT-1 or equiv.)
R-17	50,000	1	Carbon (IRC #BT-1 or equiv.)
R-18, R-19	1 megohm		Fader controls (IRC #VC539 or equivalent)
R-20	1,100	1	Wire-wound (Ohmite Wire-watt or equivalent)
R-21, R-22	20,000	10	Wire-wound (Ohmite Wire-watt or equivalent)

TUBES 3 Type 6C6

Pre-Amplifier, Mixer and Fader Miscellaneous Parts

3 Shielded input sockets (Amphenol PC-3F or equivalent)
3 Shielded input plugs (Amphenol MC-3M or equivalent)
1 6C6 6 contact socket (Amphenol RS-6 or equiv.)
1 6C6 6 contact socket (Amphenol S-6 or equiv.)
2 Fader control plates (Crowe #437 or equivalent)
1 Knob (Crowe #591 or equivalent)
2 Grid caps
2 Tube shields
1 Tube shield base (Amphenol or equivalent)
1 4" extension shaft (Yaxley #RS-242 or equivalent)
1 Panel bearing for extension shaft (Bud #532 or equivalent)
12 6-32 ½" cadmium plated screws, nuts, and lockwashers
2 6-32 1" cadmium plated screws and nuts
2 Rubber Grommets for 5-16" hole
1 ft. Shielded wire
1 ft. High capacity rubber covered shielded wire
2 ft. Low capacity rubber covered shielded wire

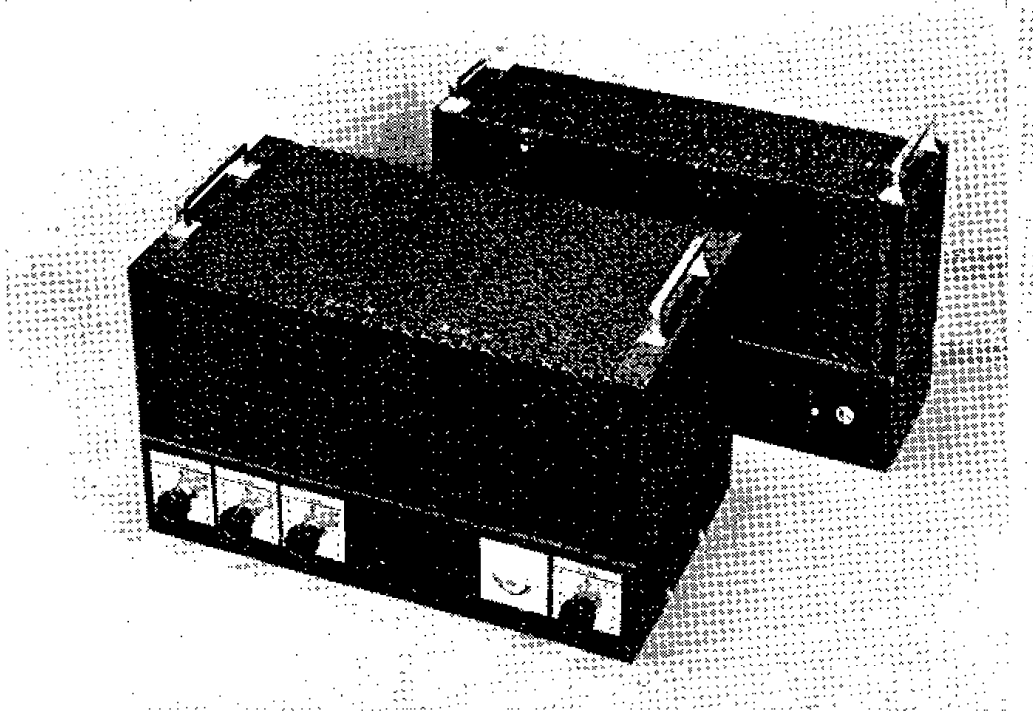
NOTE: The brands and types specified in the parts list were used in the original laboratory models. Parts of equivalent quality may be substituted except where physical limitations prohibit.

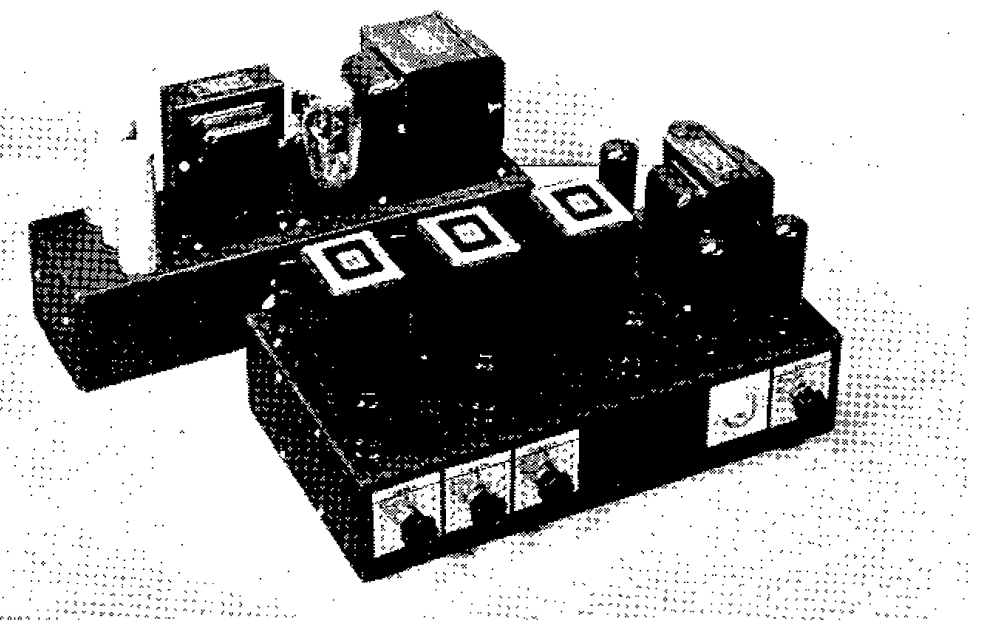
THORDARSON

P. P. Parallel 6L6 Amplifier

60 WATT

The use of four of the new 6L6 beam power tubes in push-pull parallel makes it possible to obtain 60 watts output with simple driver requirements. Performance, too, is improved from the standpoint of gain, frequency response and wave distortion.





The new 6L6 beam power amplifier tubes make possible the construction of a high power amplifier with unusually low plate voltage and a minimum of driving power. The Thordarson T-10K60, 60 watt 6L6 amplifier, uses four of these tubes in push-pull parallel, operating under Class AB_1 conditions. Since each pair of tubes will deliver 32 watts with a total of only 2% distortion, four will develop 64 watts of audio power. There are several advantages in using four tubes to obtain 60 watts output rather than two operating in Class AB_2 with fixed bias. One is that no grid current flows, simplifying the driver stage, and, of more importance, resulting in improved performance from the standpoint of gain, frequency response, and wave distortion. Another advantage is that the change in the plate current from no signal to full output is less, reducing the effect of power supply regulation on power output and quality. Tube life is also extended.

Inverse feedback may be added to this amplifier if desired. The resistor capacity method is recommended rather than a tertiary or tapped winding on the output transformer. The addition of inverse feedback will reduce the gain of this amplifier about 10 d b.

A separate chassis is used for the power supply which incorporates a special circuit feature for biasing the output tubes. The bias voltage is obtained by a resistor through which only the 6L6 plate current passes. The bias is more stable with this method inasmuch as the plate current change from no signal to full output is only 14%, as compared to 21% when both the screen and plate current pass through the self bias resistor. Two rectifiers are used in the power supply, an 83 for the 6L6 plate and bias supply, and an 80 for the 6L6 screen supply and plate supply for the balance of the amplifier.

The schematic diagram shows both the basic circuit and a 4 circuit pre-amplifier, mixer, and fader. The input system is similar to that used with the Thordarson 2A3 Tru-Fidelity amplifier except that an additional low level microphone can be accommodated. Mixing and fading can be accomplished to satisfy almost any condition.

THE THORDARSON FOUNDATION UNIT T-10K60 is available for this amplifier and includes all special parts and assembly instructions for its construction. All holes are punched and tube sockets supplied for the basic circuit. Knockouts are provided for pre-amplifier tubes and controls to satisfy all input requirements.

Voltage Analysis

Supply Voltage: 60 cycle, 115 Volts.
All readings of D.C. taken with a 0-50-250-500-volt (1000-ohm per volt) meter. Deviations of 10% in specified voltages are tolerable. R.M.A. standard system of tube terminal numbers used. See THORDARSON Servicing Guide #342 or any R.M.A. tube chart. All measurements from tube terminals to ground.

No Signal

1st 6F5; 4, 125V; 8, 1.25V.
3 Parallel 6C5; 3, 98V; 5, 0V; 8, 4V.
Push-pull 6C5; 3, 277V; 5, 0V; 8, 10V.
Push-pull Parallel 6L6; 3, 406V; 4, 310V; 5, —24V; 8, 0V.
80; 1, 340V; 4, 340V.
83; 1, 435V; 4, 435V.
Junction T-4707 and T-1892 Chokes, 313 Volts.
Junction T-1892 and 10,000 ohm resistor, 285 Volts.
Junction T-7551 and 25,000 ohm resistor, 432 Volts.

Full Output (60 Watts)

1st 6F5; 4, 112V; 8, 1V.
3 Parallel 6C5; 3, 85V; 5, 0V; 8, 3.5V.
Push-pull 6C5; 3, 246V; 5, 0V; 8, 8.5V.
Push-pull Parallel 6L6; 3, 387V; 4, 278V; 5, —29V; 8, 0V.
80; 1, 321V; 4, 321V.
83; 1, 429V; 4, 429V.
Junction T-4707 and T-1892, 278 Volts.
Junction T-1892 and 10,000 ohm resistor, 259 Volts.
Junction T-7551 and 25,000 ohm resistor, 403 Volts.

Technical Data

Power Output 60 watts or +40 d b referred to a zero d b level of 6 milliwatts.

Gain—Basic Amplifier Circuit.
95.0 d b from 100,000 ohm input.

Basic amplifier with 4 channel electronic mixed inputs.

122.5 d b from a crystal microphone at 100,000 ohms.
87.3 d b from a crystal pickup at 100,000 ohms.
86.5 d b from a 200 ohm line through T-9000.

Hum Level— —4.7 d b or 44.7 d b down from rated output or 3.333 milliwatts.

Over-all Frequency Response ±3 d b from 30 to 10,000 c.p.s.

Tubes—Basic circuit: 1 6C5 triode, 2 6C5 push-pull triodes, 4 6L6 push-pull parallel output tetrodes, 80 and 83 rectifiers. Amplifier with 4 channel electronic mixed inputs: 2 6F5 triodes, 3 6C5 parallel mixer triodes, 2 6C5 push-pull triodes, 4 6L6 push-pull parallel output tetrodes, 80 and 83 rectifiers.

Output Impedances—500, 333, 250, 200, 125, 50 ohms.

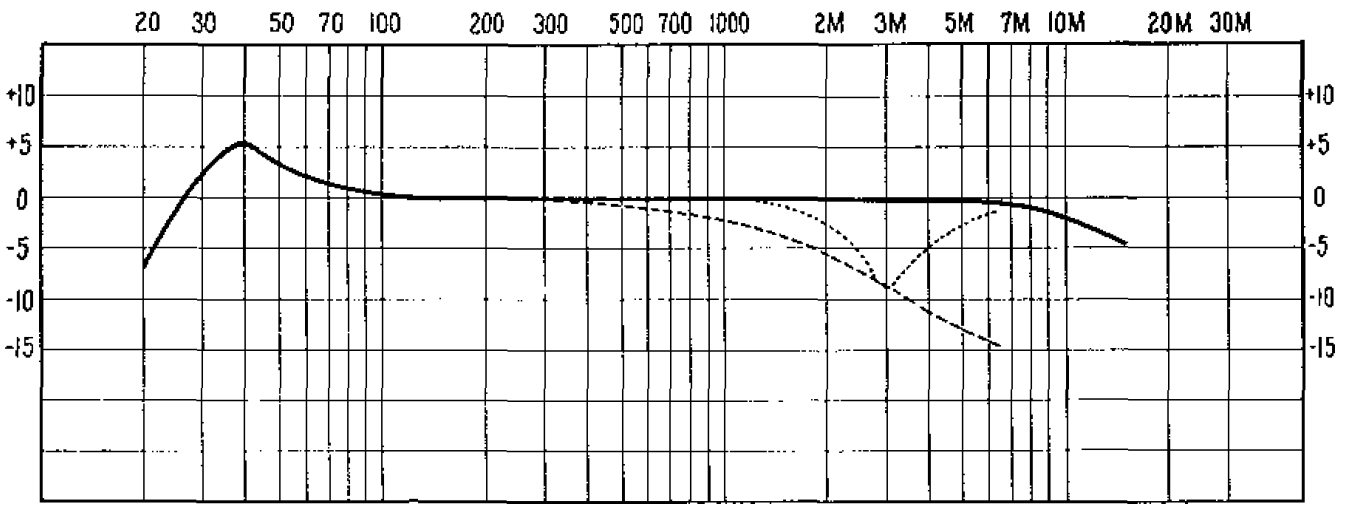
Two-Unit Base—Amplifier chassis size 9" deep, 16½" wide, and 3½" high, with metal shield 11" high.

Power supply chassis size 5" deep, 16½" wide, and 3½" high, with metal shield 11" high.

Amplifier and power supply bases furnished with sockets for basic circuit tubes (knockouts are provided for the addition of pre-amplifier and mixer circuit tubes). Resistor strips and sub-assembly panels provided to accommodate the maximum parts used.

Terminal strips for input and output connections are provided, also knockout holes for the addition of input and output connector receptacles.

Db. vs Frequency-Response Curve



Response of Amplifier without Tone Control Action

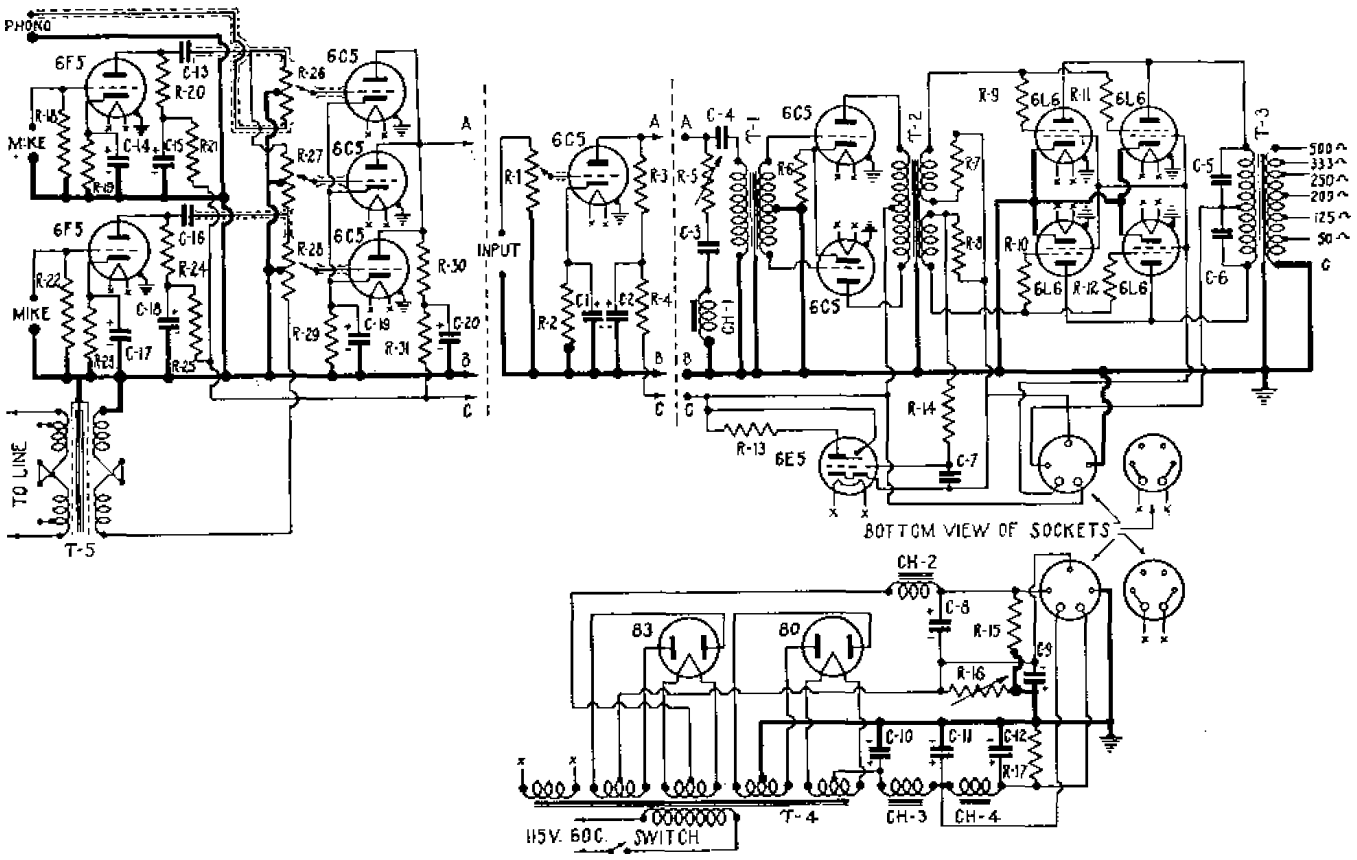
Response of Amplifier with Maximum Tone Control Action using Tuned Circuit Tone Control as in Circuit Diagram (C-3 = .006 Mfd., CH-1 = T-8115, R-5 = 50,000 Ohms Potentiometer).

Response of Amplifier with Simple Series Tone Control Circuit of Condenser and Resistor (C-3 = .025 Mfd., R-5 = 50,000 Ohms Potentiometer).

P. P. Parallel 6L6 Amplifier

60 WATT

THORDARSON



P A R T S L I S T

Thordarson Foundation Unit and Accessories

1 Amplifier chassis with 9 sockets mounted.
1 Amplifier chassis bottom plate.
2 Sub-assembly panels.
1 Input shield.
2 Terminal strips (6 terminals).
18 Resistor mounting strips.
1 Power supply chassis with 4 sockets mounted.
1 Power supply chassis bottom plate.
1 Fuse cover plate and two #6 Parker drive screws.
1 Line cord rubber grommet.
Complete diagrams and assembly instructions.
All above items in one T-10K60 unit.
Amplifier metal screen cover (less handles), T-10K20.
Power supply metal screen cover (less handles), T-10K21.
Chromium plated handles, T-10K50.
(1 pair required for each cover.)

Basic Circuit Parts List

THORDARSON TRANSFORMERS and CHOKES

Diagram Number		
T-1	1	T-9004 Tru-Fidelity Transformer, or T-5741 Interstate Transformer.
T-2	1	T-9005 Tru-Fidelity Transformer, or T-5870 Interstage Transformer.
T-3	1	T-8968 Output Transformer.
T-4	1	T-8928 Power Transformer.
CH-1	1	T-8115 Choke.
CH-2	1	T-7551 Choke.
CH-3	1	T-4707 Choke.
CH-4	1	T-1892 Choke.

CONDENSERS

Diagram Number	Capacity in Mfds.	Working Voltage	Type
C-1*	25	25	Electrolytic (Aerovox #PB25 or equivalent)
C-2*	8	450	Electrolytic (Aerovox #PB5 or equivalent)
C-3	.006	1000	Mica (Aerovox #1450 or equivalent)
C-4, C-7	.1	400	Paper (Aerovox #484 or equivalent)
C-5, C-6	.005	1000	Mica (Aerovox #1450 or equivalent)
C-8	8	500	Wet Electrolytic (Aerovox #WG5 or equivalent)
C-9	25	50	Electrolytic (Aerovox #PB50 or equivalent)
C-10	8	450	Electrolytic (Aerovox #G5 or equivalent)
C-11, C-12	8-8	450	Electrolytic (Aerovox #2G5 or equivalent)

RESISTORS

Diagram Number	Ohms	Watts	Type
R-1*	500,000	..	Volume Control (IRC #13-133 or equivalent)
R-2*	2,250	1	Wire-wound (Ohmite Wirewatt or equivalent)
R-3*	50,000	1	Metalized (IRC #BT-1 or equivalent)
R-4*, R-7, R-8	20,000	1	Wire-wound (Ohmite Wirewatt or equivalent)
R-5	50,000	..	Tone Control (IRC #13-123 or equivalent)
R-6	500	1	Wire-wound (Ohmite Wirewatt or equivalent)
R-9, R-10, R-11, R-12	200	1	Wire-wound (Ohmite Wirewatt or equivalent)
R-13, R-14	1 Megohm	1	Metalized (IRC #BT-1 or equivalent)
R-15	25,000	50	Wire-wound (Ohmite #0418 or equivalent)
R-16	200	75	Semi-variable Wire-wound (Ohmite #0774-B or equivalent)
R-17	10,000	50	Wire-wound (Ohmite #0414 or equivalent)

TUBES

3 Type 6C5
4 Type 6L6
1 Type 83
1 Type 80

Basic Circuit Miscellaneous Parts

1 6 Contact 6E5 Socket (Amphenol or equivalent).
3 7 Contact speaker sockets (if required) (Amphenol or equivalent).
3 7 Prong male speaker plugs (if required) (Amphenol or equivalent).
2 5 Prong male plugs (Amphenol or equivalent).
2 6 Prong male plugs (Amphenol or equivalent).
1 6E5 Escutcheon plate (Crowe #435 or equivalent).
1* Volume control plate (Crowe #436 or equivalent).
1 Tone control plate (Crowe #439 or equivalent).
2 Knobs (Crowe #591 or equivalent).
1 Single-pole single-throw toggle switch.
1 Fuse mounting (Littlefuse or equivalent).
1 3 Ampere fuse (Littlefuse or equivalent).
1 A.C. Line cord and plug.
6 ft. Connecting cable (6 wire).
2 5/8" Bushings 1/8" hole.
1 1/4" Bushing 1/8" hole.
5 1/2 doz. 6-32x1/2" cadmium plated screws, nuts, and lockwashers.
8 10-32x1/2" cadmium plated screws, nuts, and lockwashers.
2 6-32x1" cadmium plated screws and nuts.
1 ft. Shielded wire.
Hookup wire.

*These parts are not used when the pre-amplifier is incorporated with the basic amplifier since parts listed under "Pre-Amplifier Mixer and Fader Parts" will replace them.

Pre-Amplifier Mixer and Fader Parts List

Diagram Number	
T-5	T-9000 Tru-Fidelity Transformer.

CONDENSERS

Diagram Number	Capacity in Mfds.	Working Voltage	Type
C-13, C-16	.1	400	Paper (Aerovox #484 or equivalent).
C-14, C-17, C-19	25.	25	Electrolytic (Aerovox #PB25 or equivalent)
C-15, C-18, C-20	8.	450	Electrolytic (Aerovox #PB5 or equivalent)

RESISTORS

Diagram Number	Ohms	Watts	Type
R-18, R-22	5 Megohm	1/2	Metalized (IRC #BT-1/2 or equivalent)
R-19, R-23	3,000	1	Wire-wound (Ohmite Wirewatt or equivalent)
R-20, R-24	1/4 Megohm	1	Metalized (IRC #BT-1 or equivalent)
R-21, R-25	20,000	1	Wire-wound (Ohmite Wirewatt or equivalent)
R-26, R-27, R-28	1 Megohm	..	Fader Control (IRC #VC-539 or equivalent)
R-29	800	1	Wire-wound (Ohmite Wirewatt or equivalent)
R-30, R-31	20,000	10	Wire-wound (Ohmite Wirewatt or equivalent)

TUBES

2 Type 6F5
2 Type 6C5

Pre-Amplifier, Mixer and Fader Miscellaneous Parts

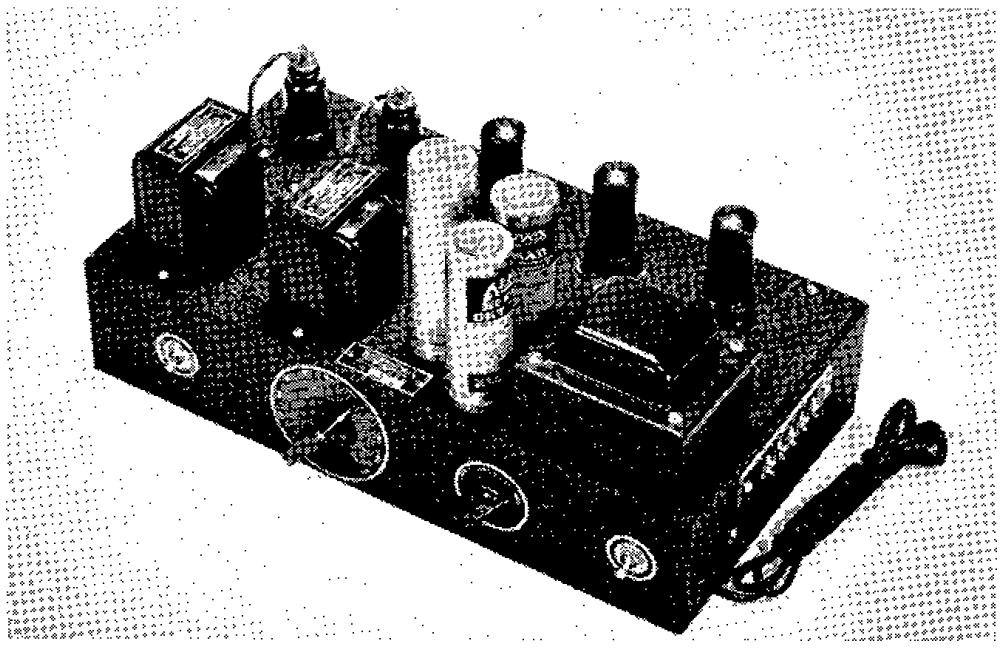
4 Shielded input sockets (Amphenol #PC-3F or equivalent).
4 Shielded input plugs (Amphenol #MC-3M or equivalent).
4 8 Contact octal sockets (Amphenol S8 or equivalent).
3 Fader control plates (Crowe #437 or equivalent).
2 Knobs (Crowe #591 or equivalent).
2 Grid caps.
2 Grid cap shields.
1/2 doz. 6-32x1" cadmium plated screws, nuts, and lockwashers.
2 doz. 6-32x1/2" cadmium plated screws, nuts, and lockwashers.
2 Rubber grommets (for 5-16" hole).
1/2 doz. Solder lugs.
5 ft. Shielded wire.

NOTE: The brands and types specified in the parts list were used in the original laboratory models. Parts of equivalent quality may be substituted except where physical limitations prohibit.

THORDARSON

T-7506-M 6F6 Amplifier

6 WATT



The Thordarson 6 watt amplifier is ideal where a high quality, low power amplifier is required. Four input circuits accommodate either a Crystal or High impedance velocity microphone, carbon microphone, high impedance pickup and 200 ohm pickup or line. The level of each input circuit is corrected permitting change of input without requiring a radical change in the volume control setting. A switch is provided for operation from either microphone or phono. Should a mixer circuit be desired in addition to the switch change-over, the circuit and information on page 14 may be followed.

The power supply circuit furnishes 10 watts for speaker field excitation independent of the filter system. Either one 2500 ohm field, one 5000 ohm field or two 2500 ohm fields can be used by properly connecting to the output speaker plug as indicated in the diagram. The output transformer is designed with secondary impedances of 4.8 and 15 ohms for voice coil connection and 500 ohms where the speakers are located some distance from the power supply.

As noted by the frequency response curve, the loss is slightly accentuated to compensate for small speaker baffles as used with portable equipment or inefficiencies of associate equipment. The tone control permits adjustment to suit individual installation requirements.

THORDARSON FOUNDATION UNIT T-7506-M is available for this amplifier including the chassis which is punched and supplied with sockets for metal tubes. Foundation Unit T-7506 is similar to above but furnished with sockets and instructions for glass tubes. (6C6's, 42's, 80.)

Technical Data

Power Output—6 watts or +30 d b referred to a zero d b level of 6 milliwatts.

Gain—106.25 d b from crystal microphone input at 100,000 ohms.
79.1 d b from 200-ohm input (line or carbon microphone).
62.1 d b from 10,000-ohm input (high impedance pickup or radio tuner).

Hum Level—down 40.8 d b from maximum level.

Over-all Frequency Response—±2 d b from 35 to 3500 cycles; ±3 d b from 32 to 5000 cycles.

Tubes—6J7 pentode, 6J7 triode, push-pull 6F6 Class A output, type 5Z4 rectifier.

Field Supply—10 watts. 36 M.A. at 275 volts. (Note: Built-in bleeder circuit dissipates field supply when externally excited speakers are used.)

Microphone Current—for double-button carbon microphone. Averages 10 mils per button.

Output Impedance—500, 15, 8, or 4 ohms.

Single Unit Base—Size 8" deep, 15" wide, and 3¼" high.

Voltage Analysis

Supply Voltage: 60 cycles, 110 to 120 volts. Tests made at 115 volts.

All readings of D.C. taken with a 0-50-250-500 volt (1000-ohm per volt) meter. Deviations of 10% in specified voltages are tolerable. The R.M.A. standard system of tube terminal numbers is used. See THORDARSON Servicing Guide #342 or any R.M.A. standard tube chart. All measurements are from point indicated to ground. A single 2500-ohm speaker field was included in the circuit for the voltage tests.

1st 6J7; 3, 65V; 4, 37V; 5, 1.5V; 8, 1.5V; Grid 0.

2nd 6J7; 3, 137V; 4, 137V; 5, 137V; 8, 5V; Grid 0.

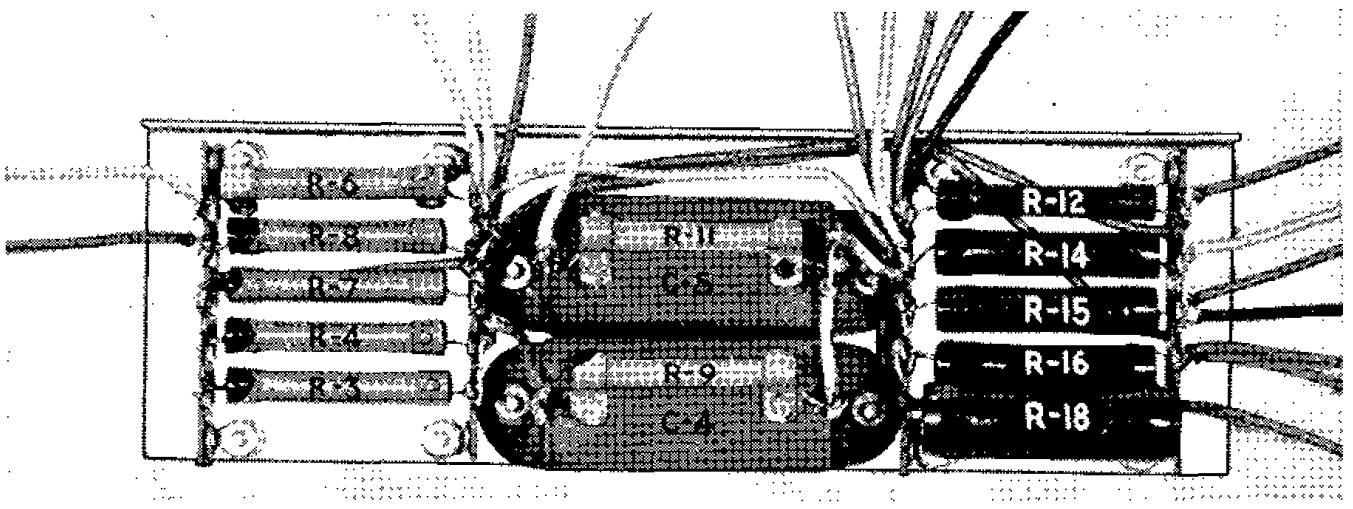
Both 6F6; 3, 270V; 4, 282V; 8, 17½V.

Junction, R-18 and T-5753, 310 volts.

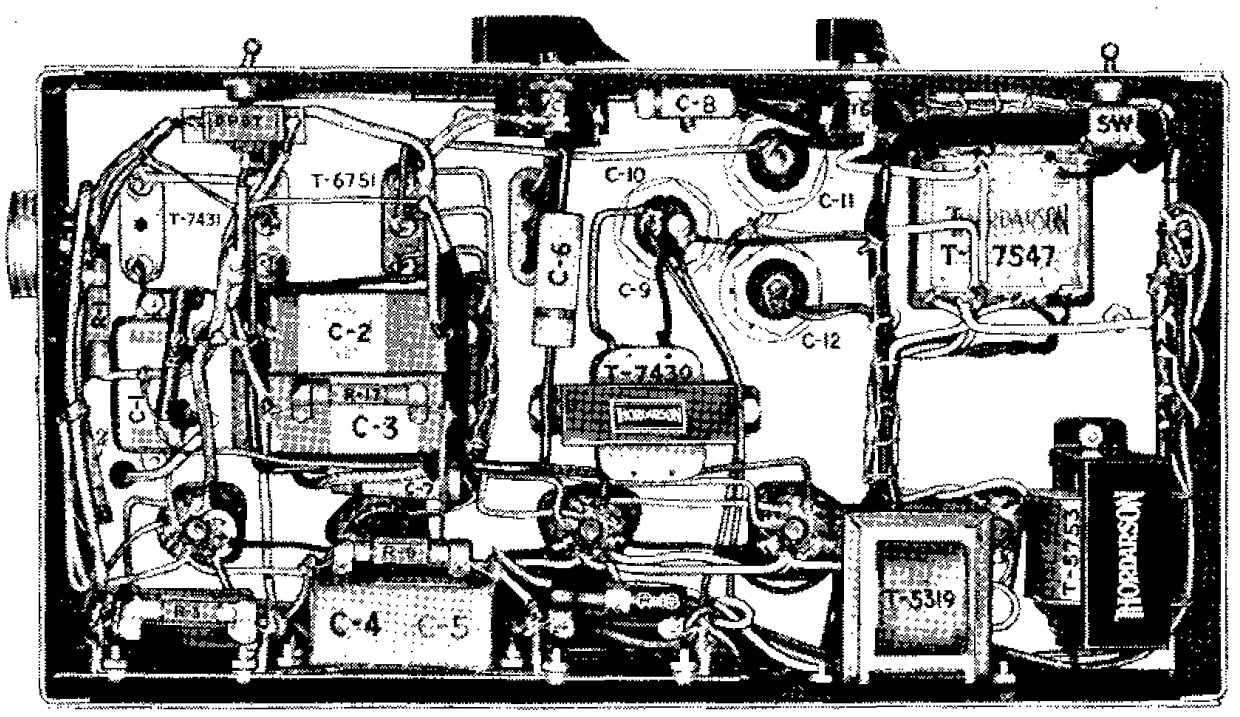
Junction, T-5753 and T-5319, 285 volts.

Junction of T-5319 and T-7430, 268 volts,

Junction of R-3 and R-4, 3.5 volts without a microphone and not less than 2 volts with a good carbon microphone.



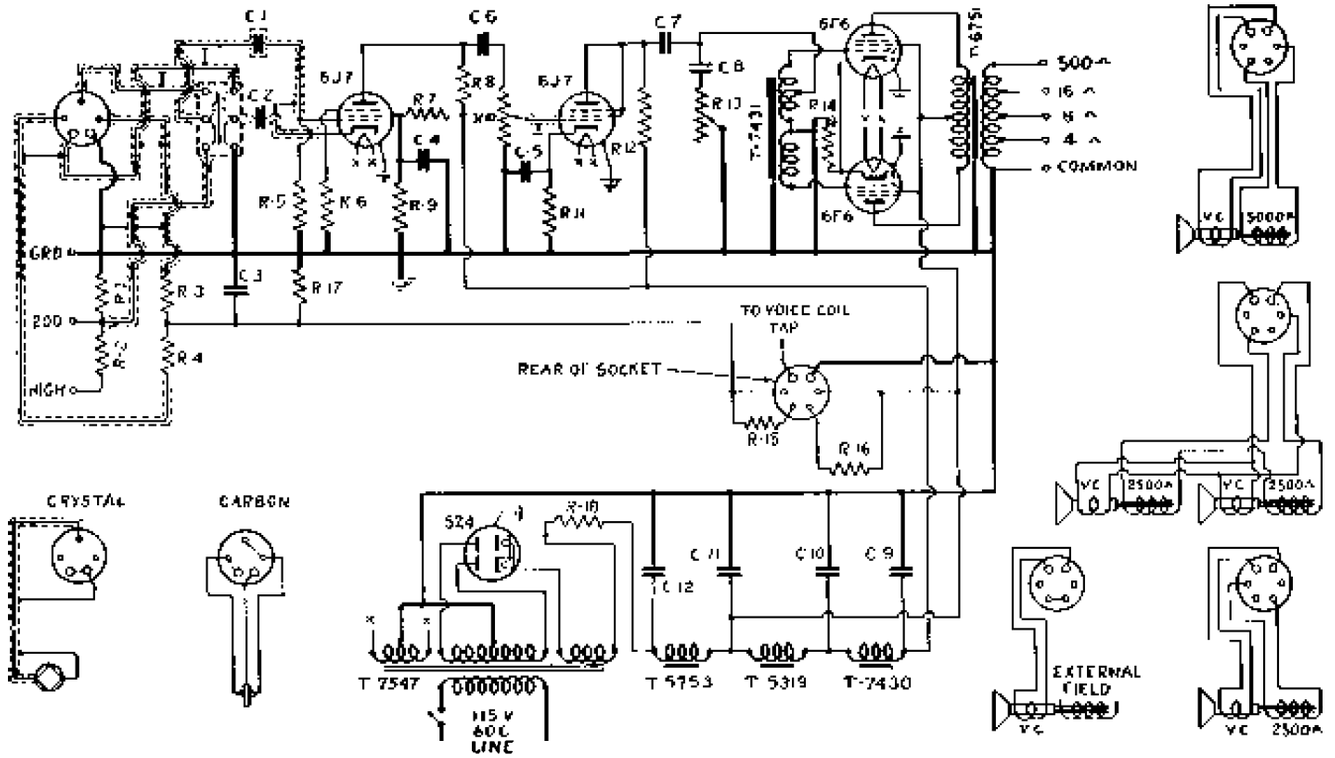
T-7506-M—Sub-Assembly



T-7506-M—Underside View

T-7506-M 6F6 Amplifier

6 WATT



PARTS LIST

THORDARSON Foundation Unit

1 Chassis Base 8" deep, 15" wide, and 3¼" high, with all mounting holes drilled and seven sockets mounted in place.

1 Sub-assembly base and 4 res. mtg. strips.

1 Each, input and output terminal strips.

Complete instructions, diagrams and assembly plans.

All above items in one T-7506-M Unit.

THORDARSON Transformers and Chokes

1 T-7547 Power Transformer.
1 T-6751 Output Transformer.
1 T-7431 Tapped Input Impedance.
1 T-7430 Filter Choke.
1 T-5753 Filter Choke.
1 T-5319 Filter Choke.

RESISTORS (Wire-wound resistors recommended for values under 25,000 ohms):

Diagram Number	Ohms	Watts
R-1	200	1
R-2	10,000	1
R-3	200	1
R-4	200	1
R-5	5,000,000	1
R-6	2,250	1
R-7	100,000	1
R-8	250,000	1
R-9	20,000	1
R-10	250,000	Volume Control
R-11	2,250	1
R-12	50,000	1
R-13	250,000	Tone Control
R-14	200	10
R-15	2,500	10
R-16	5,000	10
R-17	100	1
R-18	300	25

CONDENSERS

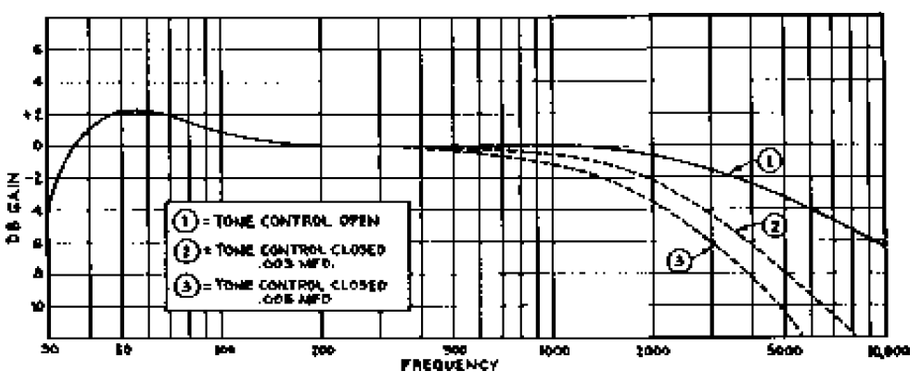
Diagram Number	Capacity in Mfds.	Working Voltage	Type
C-1	0.1	400	Metal Case
C-2	25	25	Electrolytic
C-3	25	25	Electrolytic
C-4	8	200	Electrolytic
C-5	25	25	Electrolytic
C-6	0.1	400	Tubular
C-7	0.1	400	Tubular
C-8	0.003	400	Tubular
C-9, C-10	6—6	450	Electrolytic
C-11	8	450	Electrolytic
C-12	8	450	Electrolytic

TUBES

2 Type 6J7.
2 Type 6F6
1 Type 5Z4

MISCELLANEOUS PARTS

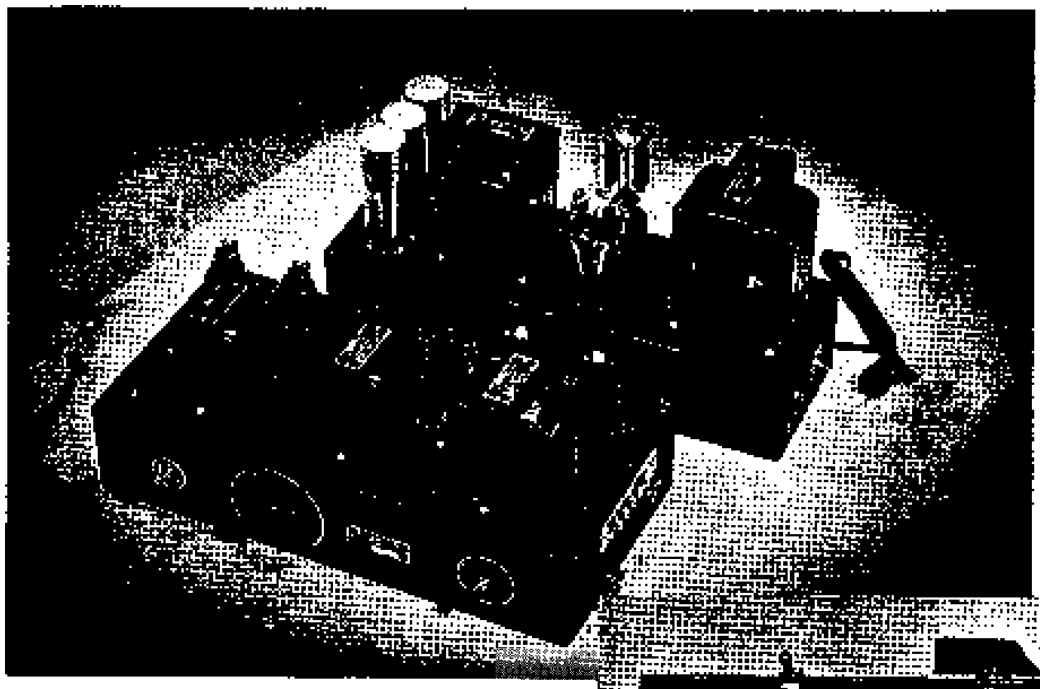
1 Double-pole double-throw toggle switch.
1 Single-pole single-throw toggle switch.
1 2½" bar knob, ¼" shaft.
1 1¼" bar knob, ¼" shaft.
1 3" Crowe #261 dial plate.
1 Crowe tone control dial.
5 ft. Shielded cable.
5 ft. Primary cord and soft rubber plug.
Hookup wire, nuts, bolts, etc.



THORDARSON

T-7518-M 6F6 Amplifier

18 WATT



Technical Data

Power Output—18 watts or +34.9 d b referred to a zero d b level of 6 milliwatts.
Gain—119.11 d b from crystal microphone input at 100,000 ohms.
92 d b from 200-ohm input (line or carbon microphone).
74.8 d b from 10,000-ohm input (high impedance pick-up or radio tuner).
Hum Level— −13.3 d b or 41.6 d b down from rated output or 0.1 milliwatt.
Over-all Frequency Response—±2 d b from 35 to 6500 c.p.s. ±3 d b from 32 to 8500 c.p.s.
Tubes—6J7 pentode, 6J7 triode, push-pull 6C5 drivers, and push-pull 6F6 Class AB output, 83 and 82 rectifiers.
Field Supply—25 watts, 70 M.A. at 350 volts, 2 2500-ohm fixed bleeder resistors.
Microphone Current—for double-button carbon microphone. **Average 10 mils per button.**
Output Impedances—500, 15, 8, or 4 ohms.
Two-unit Base—amplifier on one; power supply on other; may be mounted on standard relay rack. Amplifier and power supply can be coupled together into single unit or separately mounted to fit available space.
Bases furnished complete with sockets and terminal strips.

The class AB operation of power triodes or **pentodes is becoming popular and is used extensively in public address amplifiers. Efficiency approaches that of class B and high quality can be maintained.**

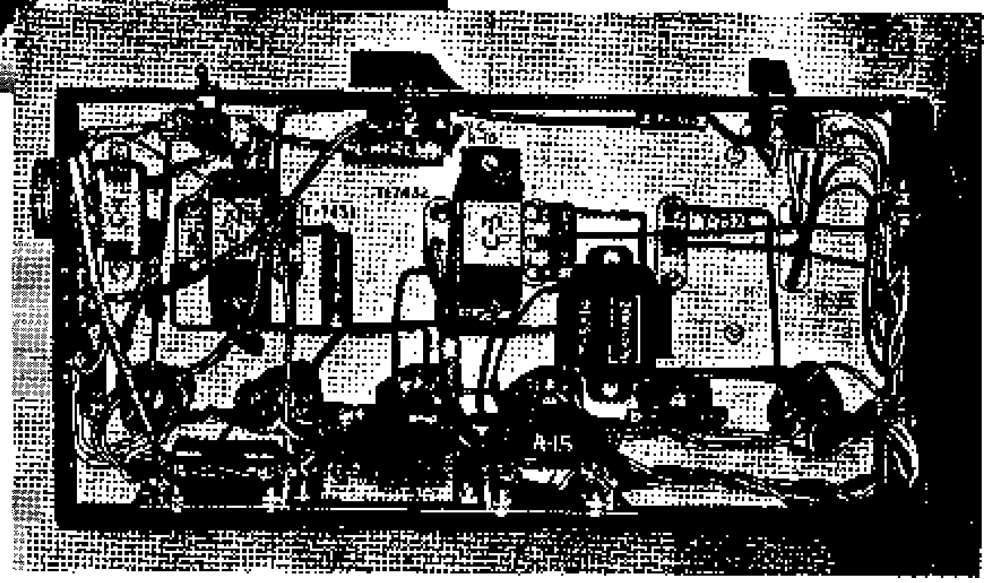
The Thordarson T-7518-M amplifier employs **type 6F6 pentodes operating in class A-B.** Fixed bias is provided by a separate 82 rectifier tube making possible high output with little **distortion. Push-pull 6C5 drivers supply** adequate power and regulation to the 6F6 grids.

Two chassis, one for the amplifier proper and one for the plate, bias and filament supply has **several advantages for portability or rack and** panel mounting. Also if mobile or portable battery operation is required, a separate power supply can be built, using a gen-e-motor for B supply. Since the tubes used in the amplifier have 6.3 volt heaters, no changes are necessary **for battery operation, except to connect to the** proper power supply. Full details for 6-volt **operation of this amplifier are given on page 15.**

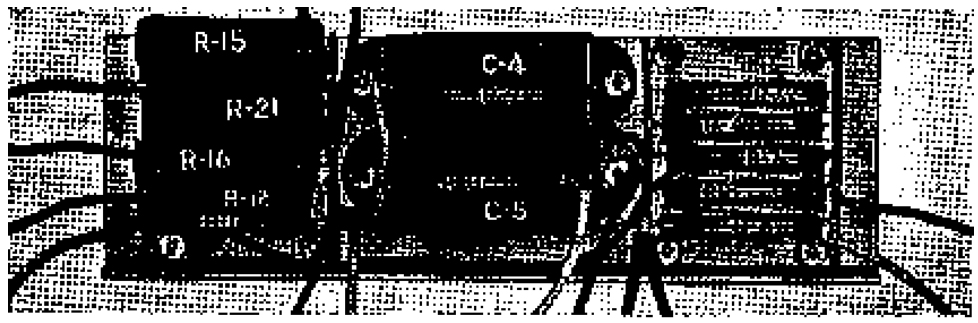
Speaker field excitation (25 watts) may be taken from the power supply and will handle one 5000, two 2500, or four 1250 ohm fields. The diagram inserts indicate how different fields **are connected to the output plug.**

The high gain of the amplifier is sufficient for **either crystal or high impedance velocity microphones. Current is supplied by the** amplifier for a double button carbon microphone **eliminating the need for a separate battery. A switch is provided for changing from microphone to phono or line. The mixer described on page 14 may be incorporated in this amplifier with slight circuit alterations.**

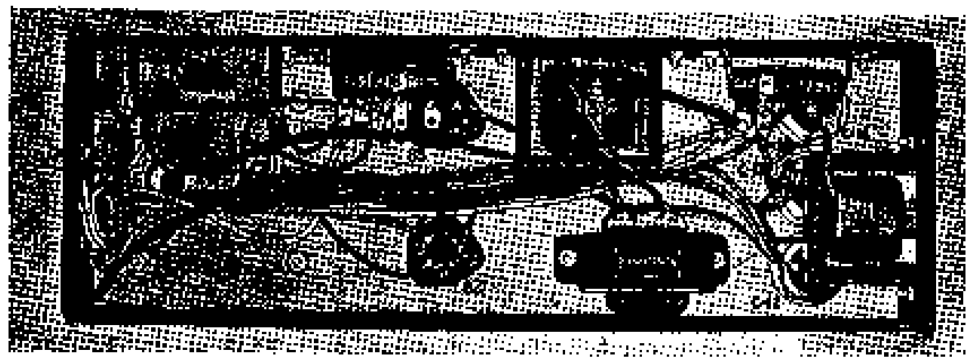
THORDARSON FOUNDATION UNIT T-7518-M is available for this **amplifier as detailed in the parts list. If glass tubes are desirable (6C6's, 76's,** 42's, 82, 83) use foundation unit T-7518 **instead.**



T-7518-M Underside View



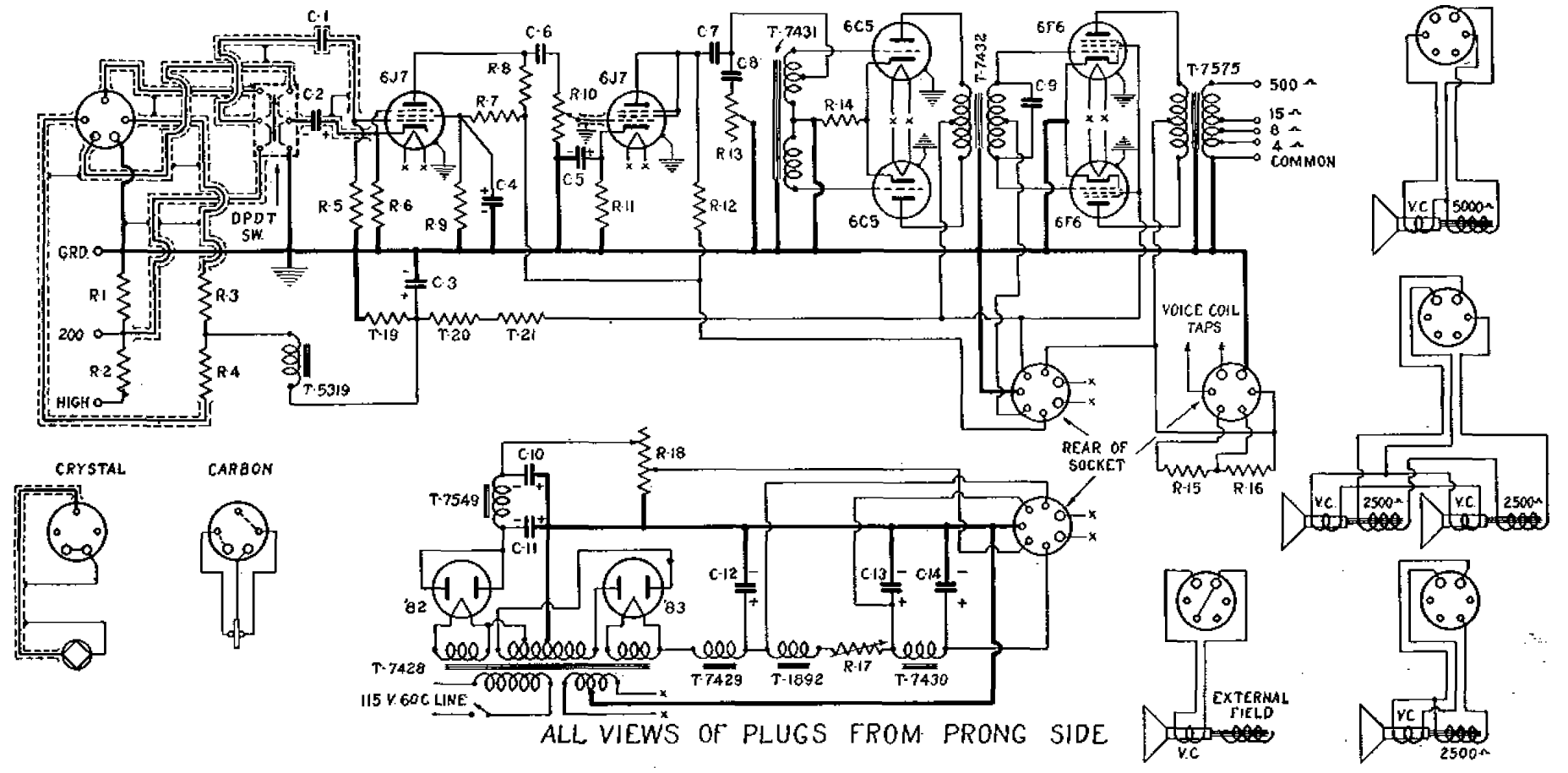
Sub-Assembly



Power Supply—Underside View

T-7518-M 6F6 Amplifier — 18 WATT

THORDARSON



ALL VIEWS OF PLUGS FROM PRONG SIDE

PARTS LIST

THORDARSON Foundation Unit

1 Amplifier base with 9 sockets mounted.
1 Power supply base with 3 sockets mounted.
1 Sub-assembly base and 4 res. mtg. strips.
1 Each, input and output terminal strips.
Complete instructions, diagrams, and assembly.
All above items in one T-7518-M Unit.

THORDARSON Transformers and Chokes

1 T-7428 Power Transformer.
1 T-7429 Power Choke.
1 T-7430 Filter Choke.
1 T-7431 Tapped Input Impedance.
1 T-7432 Push-Pull Interstage Transformer.
1 T-1892 Choke.
1 T-5319 Choke.
1 T-7549 Choke.
1 T-7575 Output Transformer.

RESISTORS (Wire-wound resistors recommended for values under 25,000 ohms):

Diagram Number	Ohms	Watts
R-1	200	1
R-2	10,000	1
R-3	200	1
R-4	200	1
R-5	5,000,000	1
R-6	2,250	1
R-7	100,000	1
R-8	250,000	1
R-9	20,000	1
R-10	250,000	Volume Control
R-11	2,250	1
R-12	50,000	1
R-13	250,000	Tone Control
R-14	500	1
R-15	2,500	25
R-16	2,500	25
R-17	5,000	25 Semi-Variable
R-18	1,500	25 Semi-Variable
R-19	1,250	1
R-20	5,000	10
R-21	5,000	10

1 additional slider for R-18.

CONDENSERS

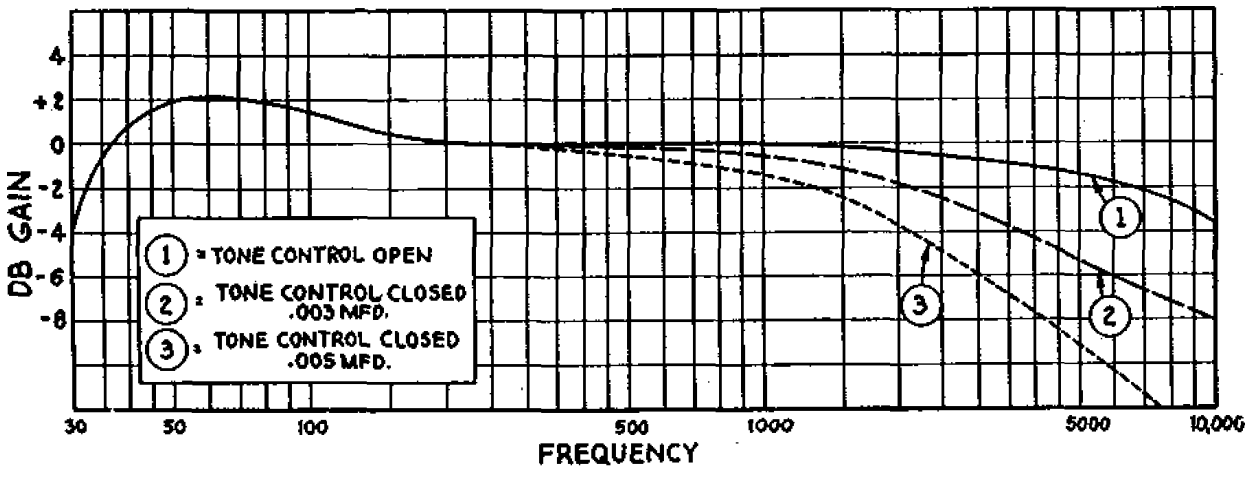
Diagram Number	Capacity in Mfds.	Working Voltage	Type
C-1	0.1	400	Metal cased paper
C-2	25	25	Electrolytic
C-3	25	25	Electrolytic
C-4	8	200	Electrolytic
C-5	25	25	Electrolytic
C-6	0.1	400	Tubular paper
C-7	0.1	400	Tubular paper
C-8	0.003	400	Tubular paper
C-9	0.001	600	Tubular paper
C-10	8	200	Electrolytic
C-11	8	200	Electrolytic
C-12	8	450	Electrolytic
C-13	8	450	Electrolytic
C-14	8	450	Electrolytic

TUBES

2 Type 6J7
2 Type 6C5
2 Type 6F6
1 Type 83
1 Type 82

MISCELLANEOUS PARTS

1 Double-pole double-throw toggle switch.
1 Single-pole single-throw toggle switch.
1 2½" bar knob, ¼" shaft.
1 1¼" bar knob, ¼" shaft.
1 3" Crowe 261 dial plate.
1 Crowe tone control dial.
5 ft. Shielded cable.
Hookup wire, nuts, bolts, etc.



Voltage Analysis

Supply Voltage: 60 cycle, 115 Volts.

All readings of D.C. taken with a 0-50-250-500 volt (1000-ohm per volt) meter. Deviations of 10% in specified voltages are tolerable. R.M.A. standard system of tube terminal numbers used. See THORDARSON Servicing Guide #342 or any R.M.A. tube chart. All measurements from tube terminals to ground.

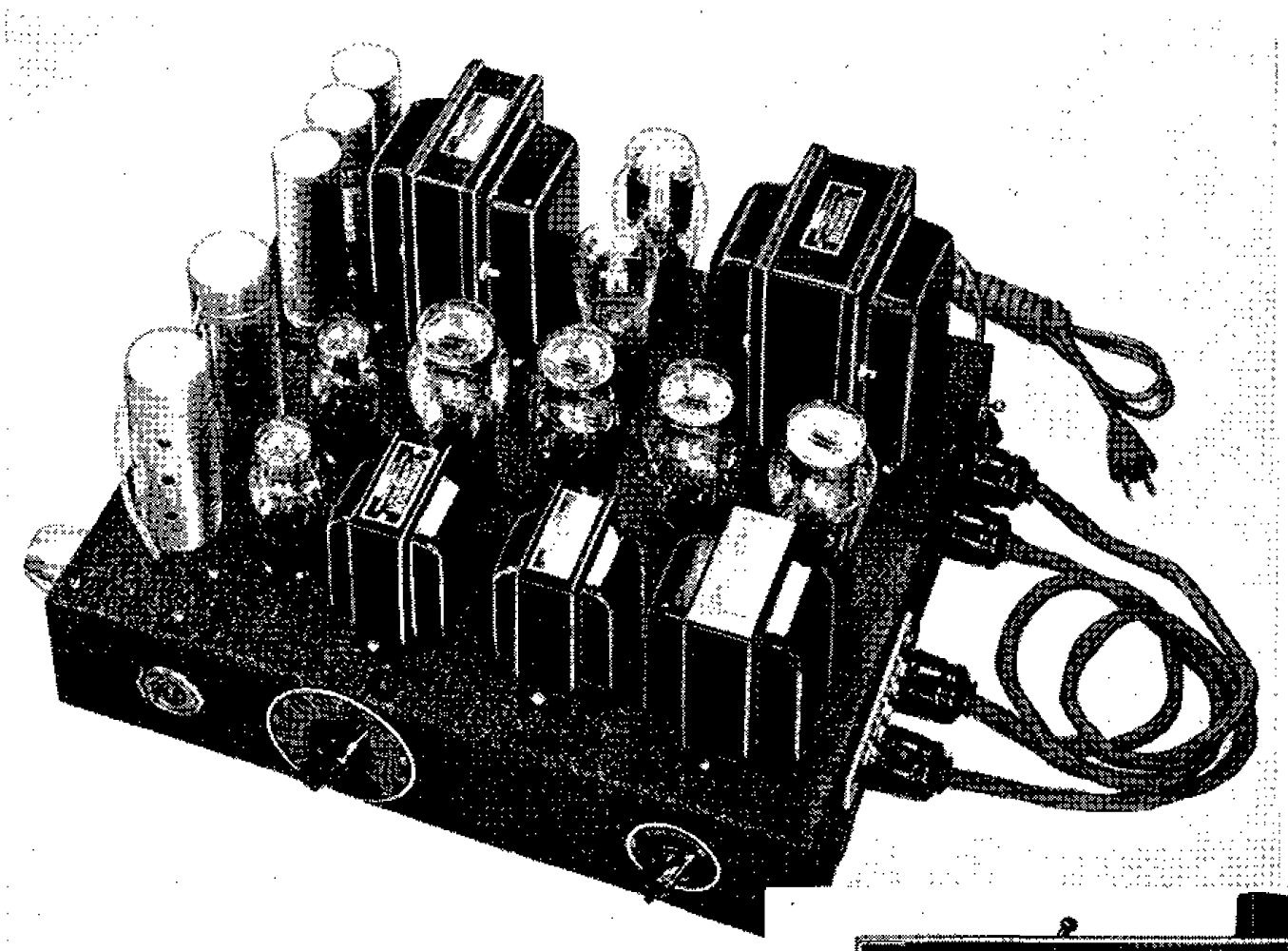
1st 6J7; 3, 62V; 4, 44V; 5, 1.9V; 8, 1.9V; Grid, 0.
2nd 6J7; 3, 130V; 4, 130V; 5, 130V; 8, 5V; Grid, 0.
Both 6C5; 3, 253V; 5, 0; 8, 7.5V.
Both 6F6; 3, 353V; 4, 264V; 5, —26V; 8, 0.
82; 2, —60V; 3, —60V.
83; 1, 390V; 4, 390V.

Junction, R-17 and T-7430—adjust R-17 to 264V. Adjust slider on R-18 connecting to T-7549 to read —38 volts from slider to ground. Adjust slider connecting to 7-prong power plug to read —26 volts from slider to ground on 50 volt scale. Junction R-3 and R-4 with no microphone plugged in, is 25 volts; with double-button carbon microphone in, about 2 volts. Junction R-15 and R-16, 180 volts.

THORDARSON

T-7530 2A3 Amplifier

30 WATT



Technical Data

Power Output—30 watts or +36.99 d b referred to a zero d b level of 0.006 watts.

Gain—118.4 d b from crystal microphone input at 100,000 ohms.

91.1 d b from 200-ohm input (line or carbon microphone).

74.3 d b from 10,000-ohm input (high impedance pickup or radio tuner).

Hum Level—47.2 d b down from maximum level.

Over-all Frequency Response—±2½ d b from 30 to 7,000 cycles.

Tubes—6C6 pentode, 6C6 triode, 2 push-pull 76 drivers, and 4 push-pull parallel 2A3 tubes.

Field Supply—30 watts, 100 M.A. at 300 volts. 3 1000-ohm bleeder resistors to dissipate field supply when it is not needed for speakers.

Microphone Current—for double-button carbon microphone. Average 10 mils per button.

Two-unit Base—amplifier on one; power supply on other. Mounts on standard relay rack. Amplifier and power supply can be coupled together into a single unit or mounted to fit available space. Chassis dimensions: 15" wide, 3¼" high (8" over-all height). Amplifier, 7½" deep. Power supply, 5" deep.

Bases furnished complete with sockets and terminal strips.

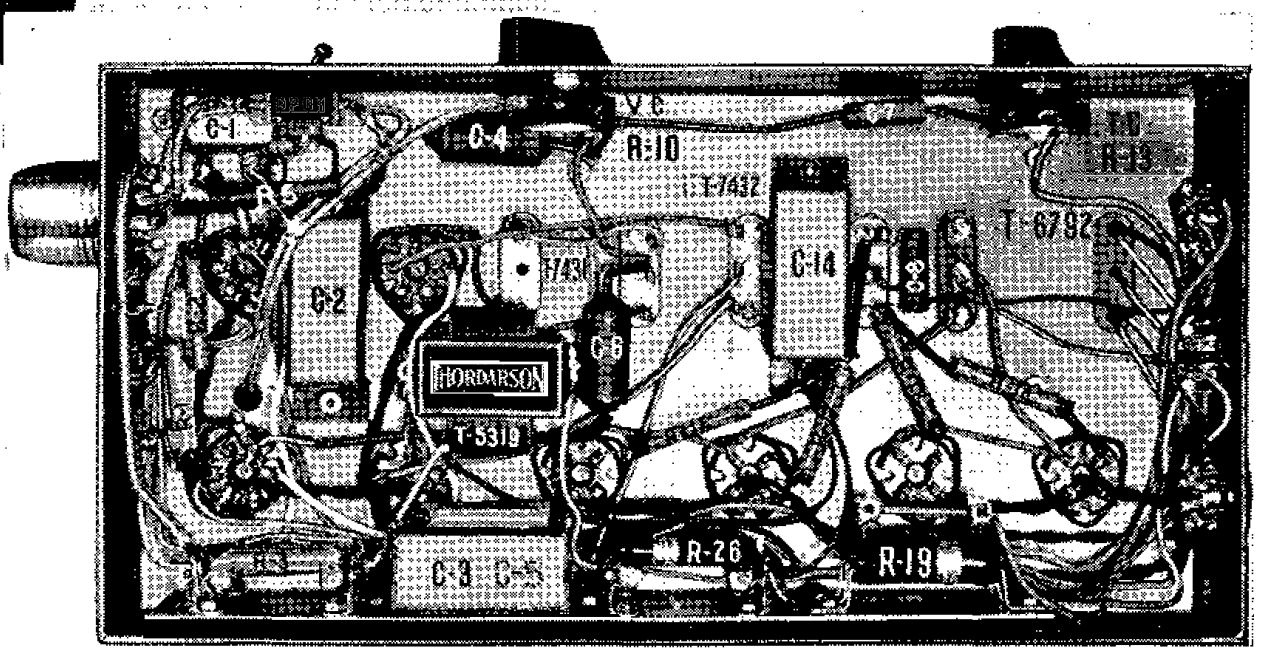
The 30-watt undistorted output of this amplifier is sufficient for 90% of the sound engineers' installations. Reproduction is excellent at any output level up to 30 watts as indicated by the frequency response curve.

Two unit construction is preferred for larger amplifiers inasmuch as one chassis can be mounted above the other. Hum can be kept to a minimum when the power supply is separated from the amplifier proper.

The output stage uses four type 2A3 tubes in push pull parallel class AB. Fixed bias is provided by a separate 82 rectifier tube. Since the 2A3 grids are not driven positive at 30 watts output, driving power is unnecessary. However, push-pull 76 tubes are used with a stepdown coupling transformer preventing distortion on output peaks and permitting higher peak power. The 76's are fed from a triode connected 6C6 by means of a tapped grid impedance. Excellent quality is possible with this method of coupling. High gain is provided by a resistance coupled 6C6 pentode stage. The volume control follows the first stage to reduce control noise and hum.

Either high impedance velocity, crystal or a double button carbon microphone may be connected to the input plug. A terminal strip is provided for 200 ohm line or pickup or high impedance pickup. The DPDT switch permits changing from microphone to phono. If a mixer control is desirable full instructions are given on page 14.

A THORDARSON T-7530 FOUNDATION UNIT is available for this amplifier, making its construction simply a matter of assembly and assuring excellent results.



T-7530—Underside View

Voltage Analysis

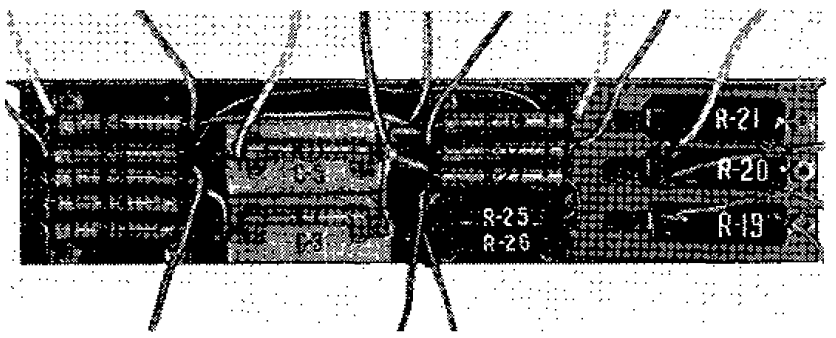
All readings of D.C. taken with a 0-50-250-500-volt (1000-ohm per volt) meter. Deviations of 10% in specified voltages are tolerable. R.M.A. standard system of tube terminal numbers is used. See THORDARSON Servicing Guide No. 342 or any R.M.A. tube chart. All measurements from point designated to ground. Supply Voltage: 60 cycle, 110-120 volts A.C. 1st 6C6; 2, 45V; 3, 42V; 4, 2V; 5, 2V; Grid, 0.

2nd 6C6; 2, 135V; 3, 135V; 4, 135V; 5, 5V; Grid, 0.

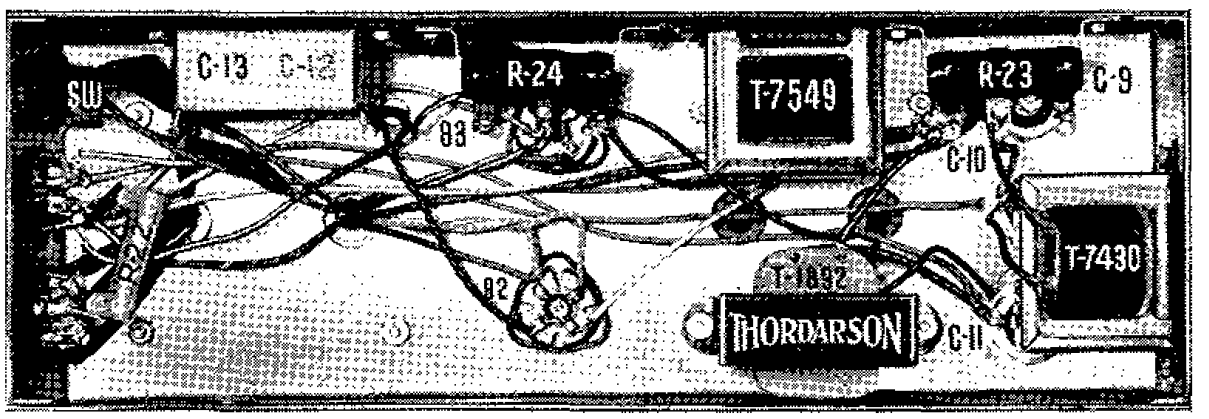
Both 76; 2, 265V; 3, 0; 4, 15V.

All 2A3; 2, 300V; 3, —54V; 4, 8V; 1, 8V.

Junction of T-7551 and T-1892, 300V. Junction of R-23 and T-7430, adjust R-23 to secure 268V. Junction R-24 and T-7549, adjust R-24 to secure —55V. R-3 and R-4, with no microphone plugged in, is 25V; with double-button carbon microphone in, about 2V. Junction R-8 and R-9, 252V.



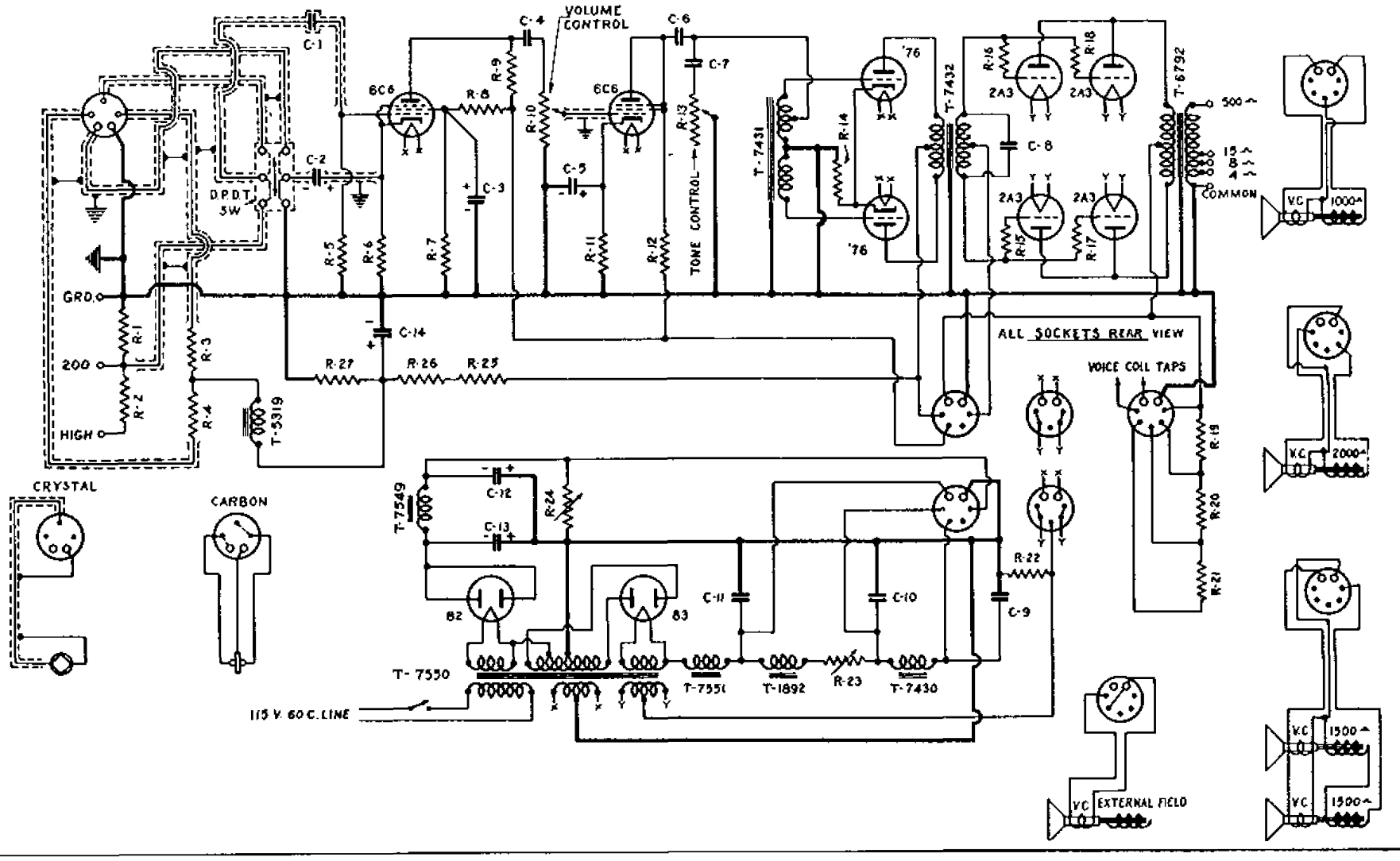
Sub-Assembly



Power Supply—Underside View

T-7530 2A3 Amplifier — 30 WATT

THORDARSON



PARTS LIST

THORDARSON Foundation Unit

1 Power supply base with 4 sockets mounted.
1 Amplifier base with 12 sockets mounted.
1 Sub-assembly base and 4 res. mtg. strips.
1 Each, input and output terminal strips.
Complete instructions, diagrams, and assembly plans.
All above items in one T-7530 Unit.

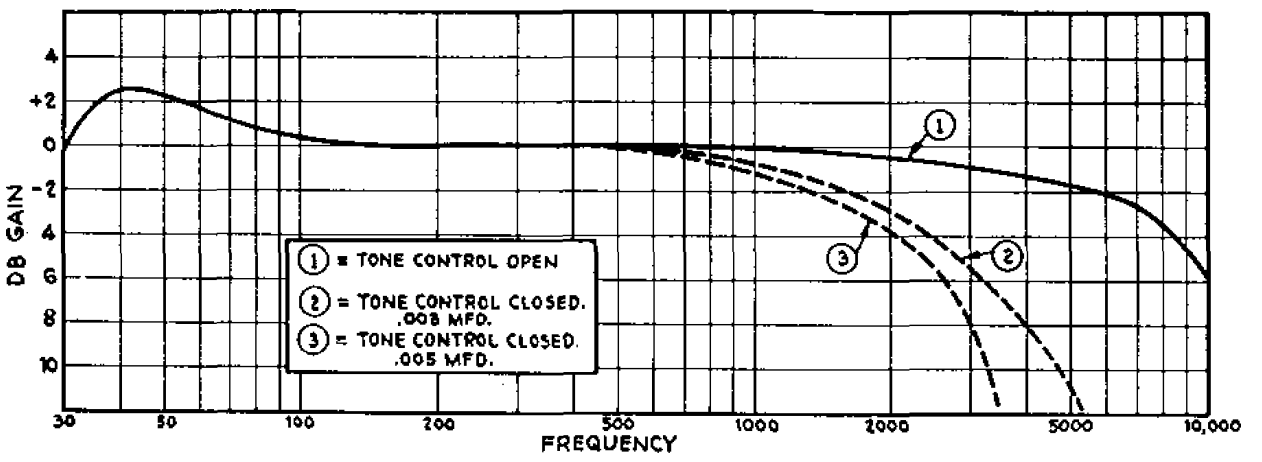
THORDARSON Transformers and Chokes

1 T-7550 Power Transformer.
1 T-7551 Filter Choke.
1 T-1892 Filter Choke.
1 T-7430 Filter Choke.
1 T-5319 Choke.
1 T-7549 Choke.
1 T-7431 Tapped Input Impedance.
1 T-7432 Push-pull Interstage Transformer.
1 T-6792 Output Transformer.

RESISTORS

(Wire-wound resistors recommended for values under 25,000 ohms):

Diagram Number	Ohms	Watts
R-1	200	1
R-2	10,000	1
R-3	200	1
R-4	200	1
R-5	5,000,000	1
R-6	2,250	1
R-7	20,000	1
R-8	100,000	1
R-9	250,000	1
R-10	250,000	Volume Control
R-11	2,250	1
R-12	50,000	1
R-13	250,000	Tone Control
R-14	1,500	1
R-15	100	1
R-16	100	1
R-17	100	1
R-18	100	1
R-19	1,000	25
R-20	1,000	25
R-21	1,000	25
R-22	50	10
R-23	1,500	25 Semi-Variable
R-24	2,500	25 Semi-Variable
R-25	5,000	10
R-26	5,000	10
R-27	1,250	1



CONDENSERS

Diagram Number	Capacity in Mfds.	Working Voltage	Type
C-1	0.1	400	Metal Cased Paper
C-2	25	25	Electrolytic
C-3	8	200	Electrolytic
C-4	0.1	400	Tubular
C-5	25	25	Electrolytic
C-6	0.1	400	Tubular
C-7	0.005	400	Tubular
C-8	0.001	400	Tubular
C-9	8	450	Electrolytic Cyl.
C-10	8	450	Electrolytic Cyl.
C-11	8	450	Electrolytic Cyl.
C-12	8	200	Electrolytic
C-13	8	200	Electrolytic
C-14	25	25	Electrolytic

TUBES

2 Type 6C6
2 Type 76
4 Type 2A3
1 Type 83
1 Type 82

MISCELLANEOUS PARTS

1 Double-pole double-throw toggle-switch.
1 Single-pole single-throw toggle-switch.
2 Tube shields, 1⅝" diameter.
1 2½" bar knob, ¼" shaft.
1 1¼" bar knob, ¼" shaft.
1 3" Crowe #261 dial plate.
1 Crowe tone control dial.
3 ft. 7-wire cable.
3 ft. 6-wire cable.
2 7-prong plugs.
2 6-prong plugs.
1 5-prong microphone plug.
6 ft. Power cord and rubber fixture plug.
5 doz. ½" 6-32 round head machine screws.
8 doz. 6-32 hex. nuts.
1 gross shake-proof lock washers.
Hookup wire, shielded wire, solder, etc.

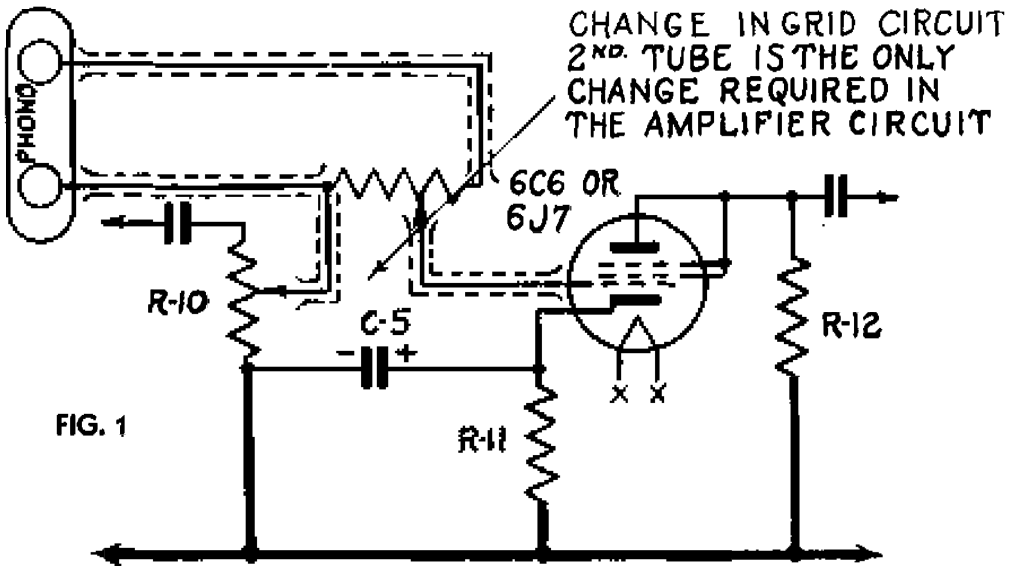


FIG. 1

Due to the many requests for information and circuit data on an additional input source and mixing system for the T-7506, T-7518, and T-7530 amplifiers, the following method is suggested. It allows for adding another input source at the grid of the second stage and provides for mixing this input with the inputs already on the amplifier.

The only circuit change necessary in the amplifier is opening the grid circuit of the second 6C6 (or 6J7 in T-7506-M and T-7518-M) for the connection of the new potentiometer to the amplifier circuit. (See Figure 1.) It is important to note that neither terminal of this new input is grounded; if an input with a grounded side must be accommodated, as may be the case with some radio inputs, an isolating audio transformer ahead of the input terminals and external to the amplifier must be used. See the suggested methods for connecting these inputs. (Figure 2.)

The mechanical changes in the amplifier to accommodate this new source are comparatively simple. A new 3/8" hole for the regular volume control should be drilled 1/2" to the left of the regular hole; the dial plate will cover the old hole. A 3/8" hole 4" to the right of this new hole should be drilled for the new potentiometer. It will be necessary to remove the name plate in order to accommodate this control. Of course, if the pickup or input source already has a volume control, which can be used conveniently, it is not essential to add the new control. In this case the leads from the new input terminals will go directly to the grid circuit of the second 6C6 (or 6J7), one to the grid itself and the other to the center lug of the regular volume control; a .1 megohm or 1/4 megohm resistor should also be connected across these input terminals at the amplifier so that the grid return circuit will not have to be completed through the leads of this input source. There is ample space on the input end of the amplifiers opposite the MIC sockets for mounting either the twin binding posts (or jacks) or installing another shielded input socket. The former is the most convenient, as only small holes will be required in the base. The input socket requires a 1 3/16" hole.

The wiring procedure for this change is very simple. After the regular volume control has been moved to its new position and the new potentiometer installed, disconnect the shielded grid lead from the center lug of the regular volume control and solder it to the center lug of the new potentiometer; if this lead is not long enough, it is better to use a whole new lead rather than try to splice the old one. Connect a new shielded lead from the center lug of the regular volume control to the zero position lug on the new potentiometer (this will be the lug on the left as you look at the rear of the control with the lugs to the top). Another new shielded lead should be connected from this same lug to one of the new input terminals. The other input terminal is then connected, also by a shielded lead, to the remaining free terminal on the new potentiometer (this will be the one on the right as you look at the rear of the control with the lugs at the top). Now when all the shielding is properly grounded (by wire connection to the input GRD lug on the terminal strip) the amplifier is ready to operate.

• PARTS LIST •

1 100,000 ohm Potentiometer.
1 3" Crowe #261 Dial Plate.
1 2 1/2" Bar Knob 1/4" shaft.
1 Phono type insulated twin binding posts (or twin jacks if phone tips are to be used). There is room for another shielded socket similar to the MIC input socket if that type of plug-in connection is desired.
3 ft. Shielded hookup wire.
1 Input matching transformer if low impedance source is to be used.

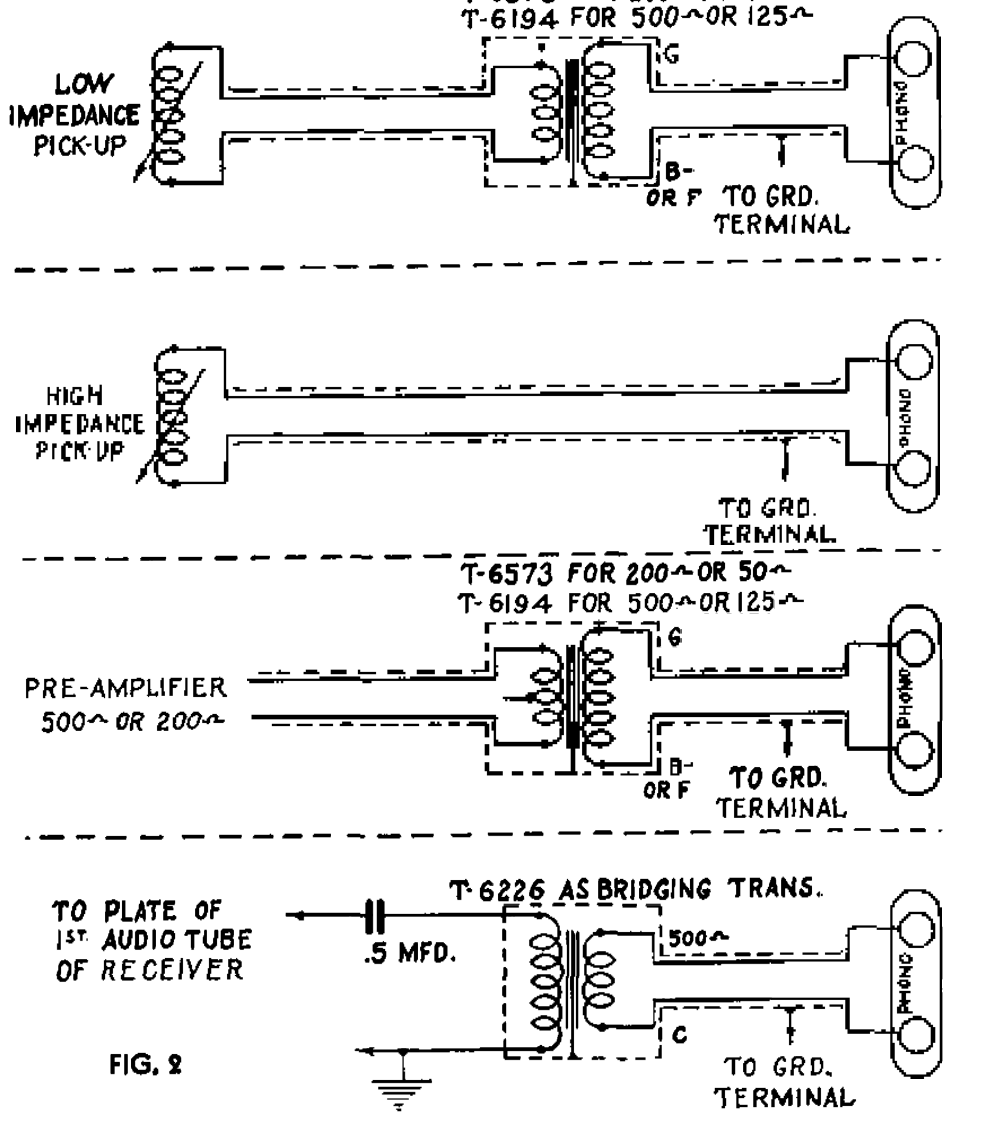
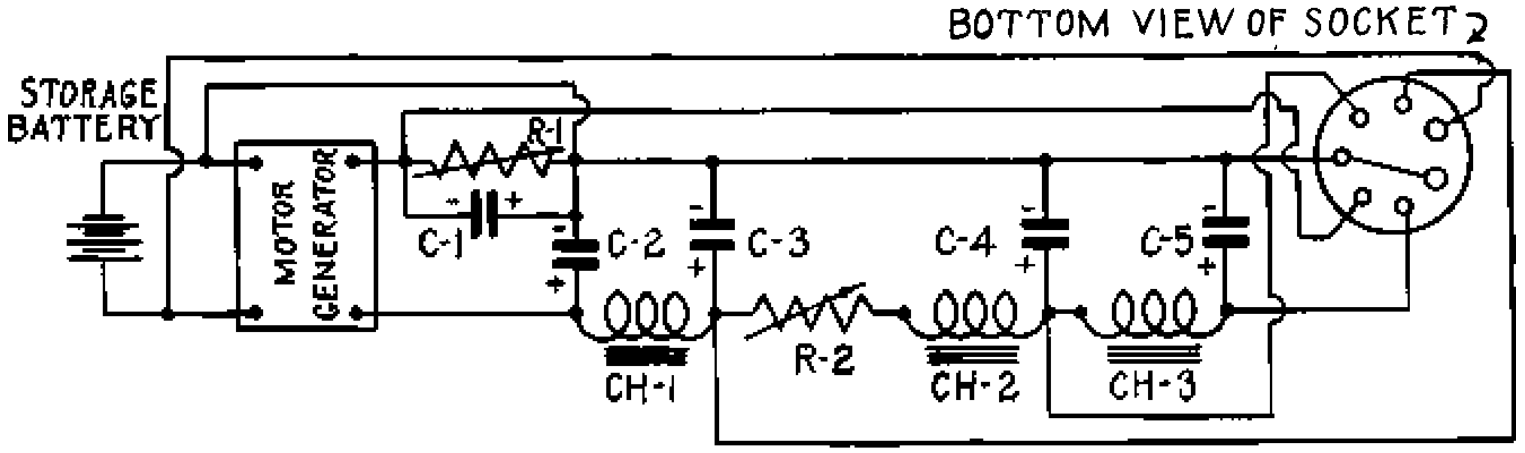


FIG. 2

Mobile Operation with T-7518—T-7518-M



Adjust R-1 to 26 volts drop with 6F6 tubes in T-7518 M amplifier or 38 volts with 42's in T-7518 amplifier.

One of the reasons for choosing the 6.3 volt tubes and a high efficiency Class AB output stage for the T-7518 and T-7518-M amplifiers was to make them convertible to 6 volt D. C. operation. This can be accomplished by merely plugging the power cable into a suitably wired motor-generator power supply unit, no change of any kind being necessary on the amplifier unit proper. The two circuits given show possible assemblies of a motor-generator unit and associated filter for this purpose.

The first circuit shows a self-bias method for obtaining bias for the output stage. The voltage obtained is, of course, subtracted from the total "B" voltage generated by the M-G unit. For this reason the second circuit showing "C" battery bias is recommended. In the regular A-C power supply a fixed bias is provided for by an extra rectifier tube. To furnish an extra M-G unit for purposes of bias is obviously out of the question. Therefore, one of the two above methods must be used in the 6 volt power unit. The motor-generator used in the above tests is rated at 350 volts 100 m.a. Because voltage is at a premium, "C" battery bias is desirable. There being no drain from this battery, frequent replacement is unnecessary.

Ordinarily there would not be so much filtering necessary with an M-G unit as is shown in these circuits. The reason for it in this instance is the high gain of the amplifier; the least amount of ripple reaching the first stage of the amplifier will result in appreciable hum in the output. The main trouble that will be met with in this connection is noise generated by the brushes of the motor-generator. This seems to be carried at R. F. and to be radiated from the unit rather than carried by the wiring. Additional filtering in the "B" supply circuits, either audio or R. F., has little effect in eliminating this noise. However, when the brushes of the generator are held tightly against the commutator (manually) the noise is almost eliminated. This plainly indicates the source of the noise and definitely predicates the necessity of keeping the commutators clean and the brush tension good on these units. A good connection of the M-G case to ground is essential. The amplifier and the M-G power supply should not be too close together.

No provisions are made for obtaining field supply from the unit. Either 6 volt speaker fields should be used, connected directly to the storage battery, or new type permanent magnet dynamic units.

In wiring the speakers to the amplifier only voice coil connections should be made. The jumper wire shown in the plug connections of a speaker with external field supply should be omitted. Therefore, resistors R-15 and R-16 will not be connected. If R-15 and R-16 were used as a bleeder, the M-G would be overloaded.

OPERATING CONDITIONS

	Self Bias		Fixed Bias	
	No Signal	Max. Signal	No Signal	Max. Signal
Volts at M-G Pri.	6.3	6.3	6.3	6.3
Battery Amps.	10.0	12.5	11	14.5
B plus V. at M-G	360	330	345	305
Total B drain	65 m.a.	100 m.a.	80 m.a.	120 m.a.
Watts output		12.5		20.0

NOTE: Above data taken with 6.3 V. adjusted at M-G terminals.

● ● PARTS LIST ● ●

CHOKES

CH-1 T-7429
CH-2 T-1892
CH-3 T-7430

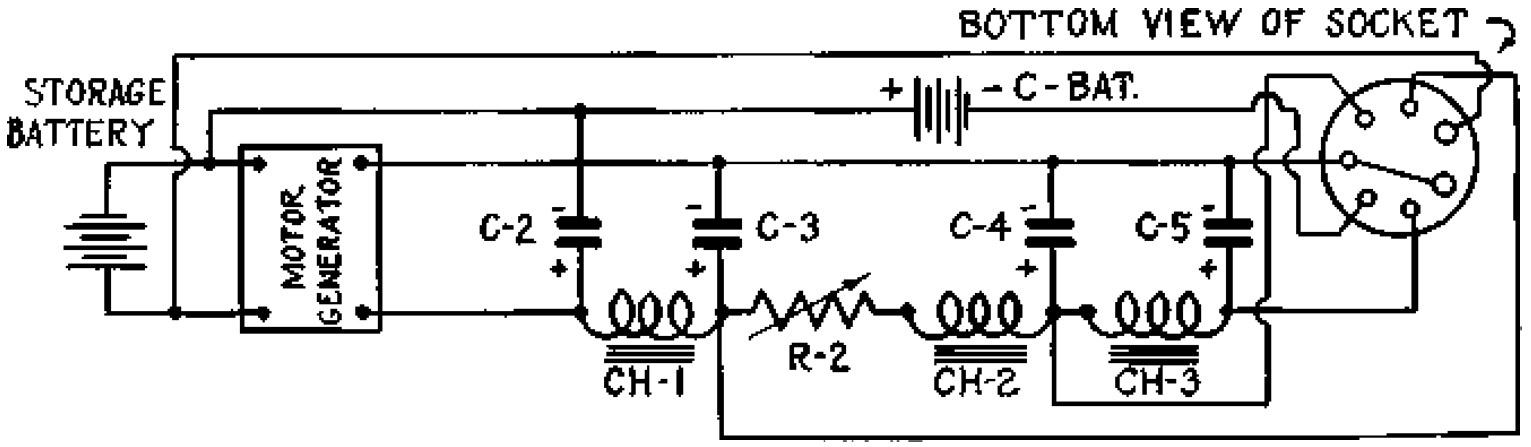
RESISTORS

Diagram Number	Ohms	Watts
R-1	1000	30 Variable
R-2	5000	30 Variable

CONDENSERS

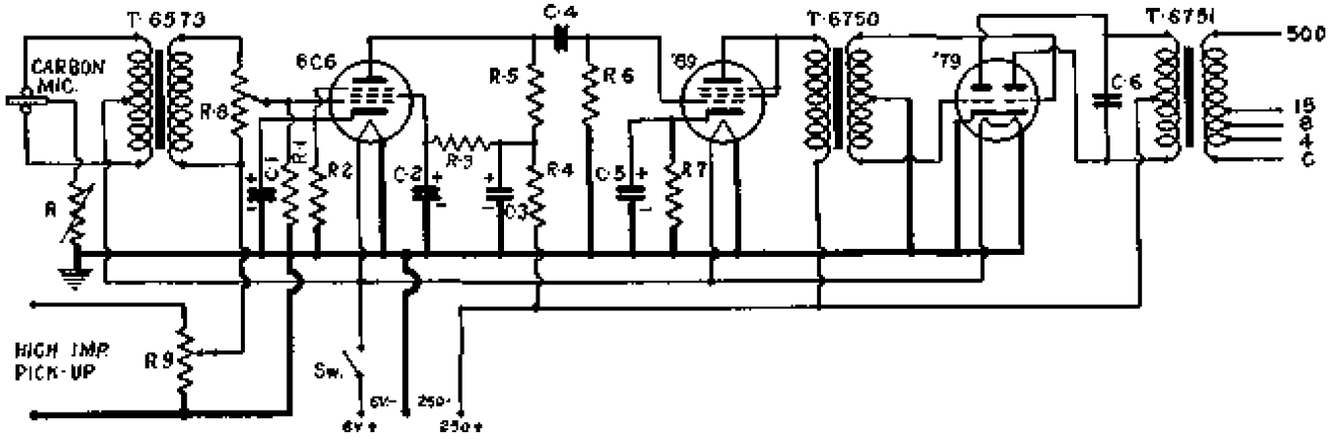
Diagram Number	Capacity in Mfds.	Working Voltage	Type
C-1	8.	200	Electrolytic
C-2	8.	450	Electrolytic
C-3	8.	450	Electrolytic
C-4	8.	450	Electrolytic
C-5	8.	450	Electrolytic

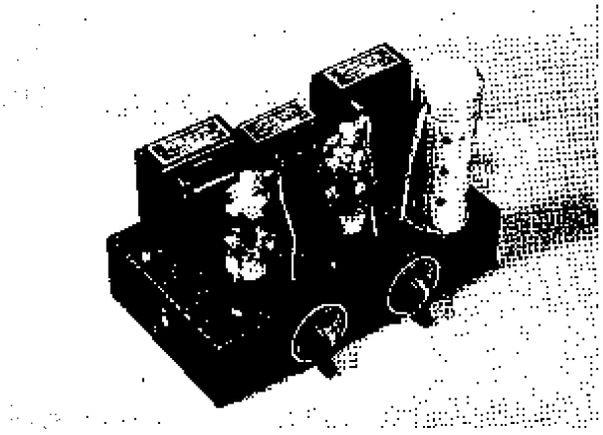
1 Gen-e-motor 350 volts 100 m.a.
1 Chassis, 15" long, 5" wide, 3" high.



C battery should be 26 volts with 6F6 tubes in T-7518-M amplifier or 38 volts with 42's in T-7518 amplifier.

Battery Operated Low Power Amplifier





The important requisite of a battery operated amplifier is that power consumption be held at a minimum.

The circuit illustrated uses three tubes. A 6C6 pentode provides high gain and is resistance coupled to a triode connected 89 which is used as a driver. The output tube is a 79 consisting of two high mu triodes in one envelope, operating in Class B. With 250 volts of B battery, the power output is 8 watts. This is sufficient to operate one or two dynamic speakers at a fairly high level. If this much power is not required, the "B" voltage may be reduced. About 5 watts output is possible with a 180 volt B battery.

A 6 volt battery should be used for the heater supply. The current drain is 1.3 amperes. Medium or heavy duty "B" batteries will provide plate voltage and have a fairly long life. If desired, a genemotor may be used instead of "B" batteries, providing it contains an efficient filter.

Two input circuits are provided and may be mixed together. A carbon microphone is used, since its level is quite high. Lower level microphones, crystal microphones, for example, require more gain necessitating another tube which would draw more current from the battery. Either a high impedance magnetic, crystal, or radio pickup may be coupled to the other input for music amplification.

To further conserve the batteries it is advisable to use the new permanent magnet dynamic speakers. Their efficiency is comparable to the electro-dynamic type which requires a field supply. Electro-dynamic speakers for operation from a 6 volt battery require 1 to 1½ amperes, depending upon their size and field resistance, which usually is 4 to 6 ohms.

In wiring the amplifier it may be desirable to incorporate two switches, one for the 6 volt heater circuit, and another for the "B" batteries. This makes it possible to conserve the "B" batteries during intermissions by turning off the "B" supply, allowing the heaters to remain on ready for immediate operation.

• • PARTS LIST • •

THORDARSON EQUIPMENT

T-6573 Microphone Transformer.
T-6750 Driver Transformer.
T-6751 Output Transformer.

RESISTORS

Diagram Number	Ohms	Watts	Type
R	1,000	..	Rheostat
R-1	100,000	1	Carbon
R-2	2,250	1	Wire-wound
R-3	100,000	1	Carbon
R-4	10,000	1	Wire-wound
R-5	50,000	1	Carbon
R-6	500,000	1	Carbon
R-7	1,000	10	Wire-wound
R-8	500,000	..	Volume Control
R-9	100,000	..	Volume Control

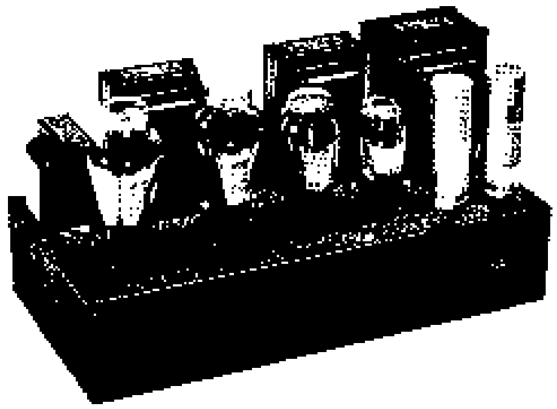
CONDENSERS

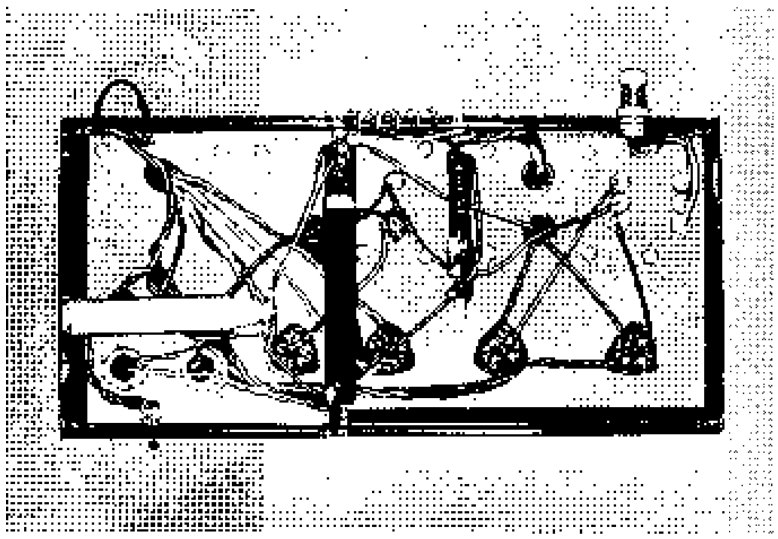
Diagram Number	Capacity in Mfds.	Working Voltage	Type
C-1	25.	25	Electrolytic
C-2	5.	450	Electrolytic
C-3	8.	450	Electrolytic
C-4	.25	400	Paper
C-5	25.	25	Electrolytic
C-6	.005	400	Paper

1 Chassis, 9" long, 5" wide, 2" high.

Push-Pull 50 Amplifier — 40 WATT

THORDARSON





Bottom View

Because of their reliability, type 50 output tubes are popular with a great many experimenters and sound men. This power stage uses 50's in a Class AB circuit delivering about three times as much power as the conventional Class A system. Approximately 40 watts of audio power is available with negligible distortion.

A 500 ohm input transformer is used for coupling to an existing amplifier capable of delivering at least 5 watts of undistorted audio. This arrangement is desirable since high power output may be had at a reasonable cost by using the power stage in conjunction with a low power amplifier to provide the additional gain required. The output transformer is tapped at 4, 8, 15 and 500 ohms for convenient matching to a loud speaker system.

Plate, bias and filament voltages are supplied by a single power transformer T-8382. Choke input is used in the filter with an 83 rectifier to provide good regulation. This is very desirable where fluctuating plate current exists. The potential applied to the type 50 tube plates is 600 volts. A type 82 tube is used as the rectifier tube for the bias supply and receives voltage from a tap on the high voltage secondary. The bias bleeder resistor is variable and is adjusted until each of the type 50 tubes draw 40 m.a. plate current. At this plate current the bias potential will measure about 130 volts negative. It is advisable to adjust the bias voltage to this value before inserting the type 50 and 83 tubes in the amplifier to prevent damage that would result if turned on without bias on the 50 grids.

• • PARTS LIST • •

THORDARSON EQUIPMENT

T-8321 Input Transformer
T-8384 Output Transformer
T-8382 Power Transformer
T-7429 Filter Choke
T-1607 Filter Choke

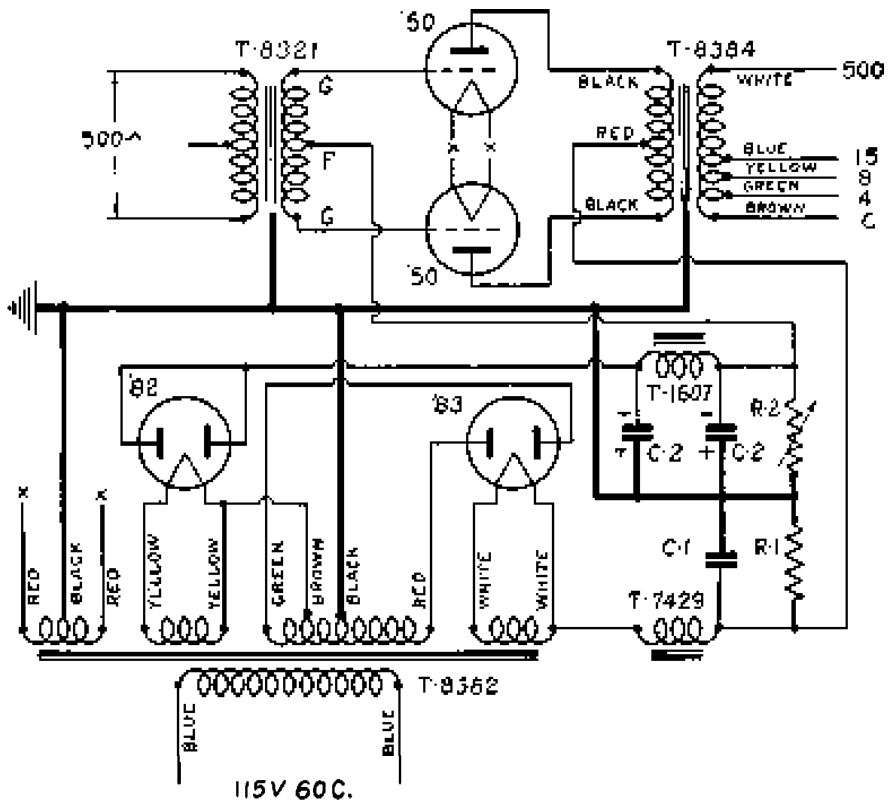
RESISTORS

Diagram Number	Ohms	Watts	Type
R-1	20,000	50	Wire-wound
R-2	2,500	30	Wire-wound Semi-Variable

CONDENSERS

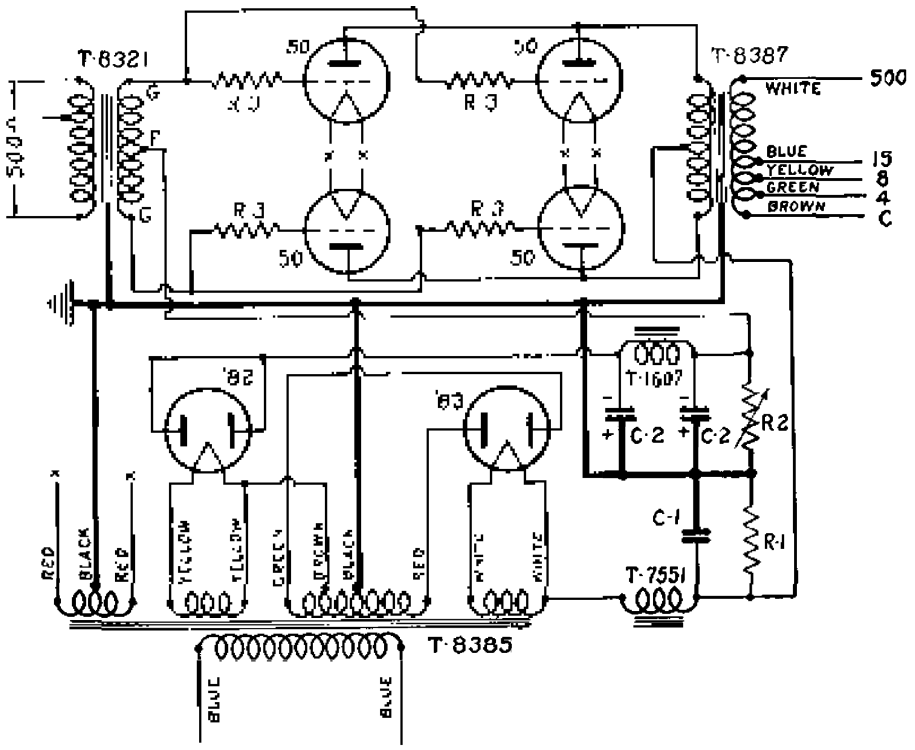
Diagram Number	Capacity in Mfds.	Working Voltage	Type
C-1	2.	1000	Paper
C-2	8.	450	Electrolytic
C-2	8.	450	Electrolytic

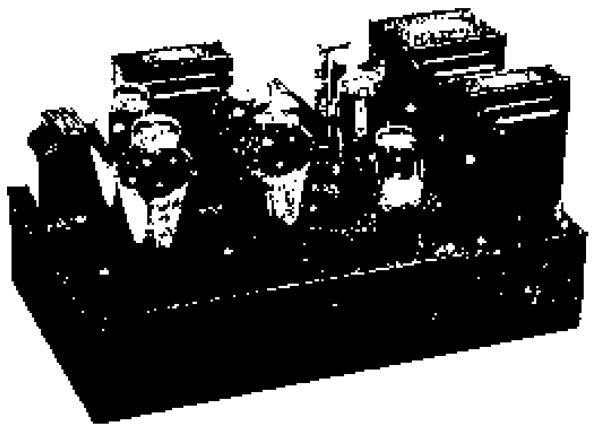
Chassis, 16½" long, 8¼" wide, 3½" high.

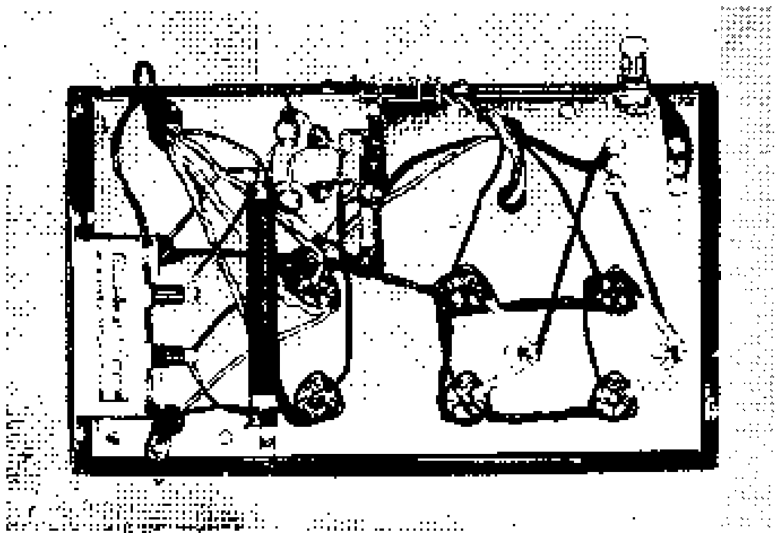


Push-Pull Parallel 50 Amplifier

80 WATT







Bottom View

Four type 50 power tubes are used in this high power booster amplifier. The unit is complete in itself with plate, bias, and filament supply on one chassis. Driving power is required and should be supplied by an amplifier (preferably Class A) capable of an undistorted output of about 10 watts. Most sound men have an amplifier of this type with suitable input and mixer facilities, or one can be constructed specially for the application.

Since most amplifiers which can be used to drive the booster stage are made to operate into a 500 ohm line in addition to speaker voice coils, Input Transformer T-8321 was selected. Should it be desirable to operate directly from the plates of driver tubes, such as 2A3's, T-8386 may be substituted with equal results.

The 50's are operated in Class AB, which requires fixed bias for high power output with minimum distortion. The high voltage winding of the power transformer is tapped to provide proper voltage for the 82 bias rectifier tube. Bias voltage is adjusted to 130 volts by means of a semi-variable bleeder resistor. Excellent regulation is provided by this method. If metal encased filter condensers are used in the bias supply, care should be taken to insulate them from the chassis. The positive terminal is grounded instead of the negative, as is customary in the "B" supply.

The plate voltage applied to the 50's is 600 volts D.C. This requires a 1000 volt paper filter condenser rather than the electrolytic type. Class AB operation is characterized by changing plate current in accordance with the signal being amplified. The 83 rectifier and choke input filter provide good regulation and prevent distortion, which would result if the plate voltage fluctuated greatly.

Before operating the amplifier insert the 82 rectifier and adjust the bias voltage to 130 volts as measured from the center tap of the 7.5 volt filament winding to the grid contacts of the type 50 tube sockets. With all tubes inserted and the amplifier turned on, further adjust the bias resistor until the power tubes draw a total of 160 m.a., or about 40 m.a. per tube.

• • P A R T S L I S T • •

THORDARSON EQUIPMENT

T-8321 Input Transformer.
T-8387 Output Transformer.
T-8385 Power Transformer.
T-7551 Filter Choke.
T-1607 Filter Choke.

RESISTORS

Diagram Number	Ohms	Watts	Type
R-1	20,000	50	Wire-Wound
R-2	2,500	30	Wire-Wound Semi-Variable
R-3	100	1	Carbon

CONDENSERS

Diagram Number	Capacity in Mfds.	Working Voltage	Type
C-1	2	1000	Paper
C-2	8	450	Electrolytic
C-2	8	450	Electrolytic

Chassis, 16½" long, 10¼" wide, 3½" high.

845 Booster Amplifier

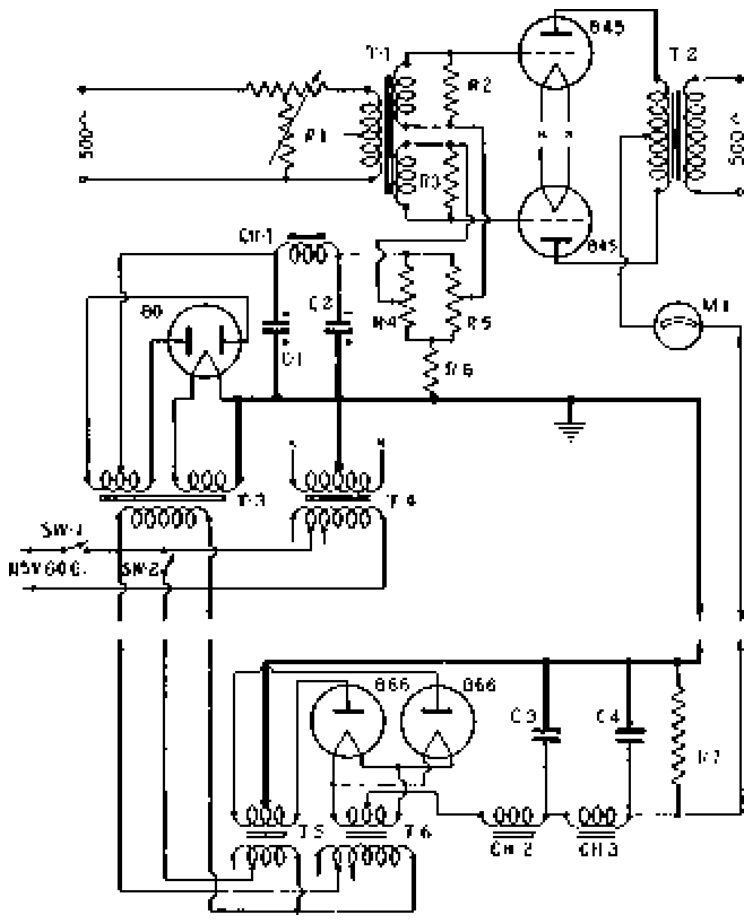
100 WATT

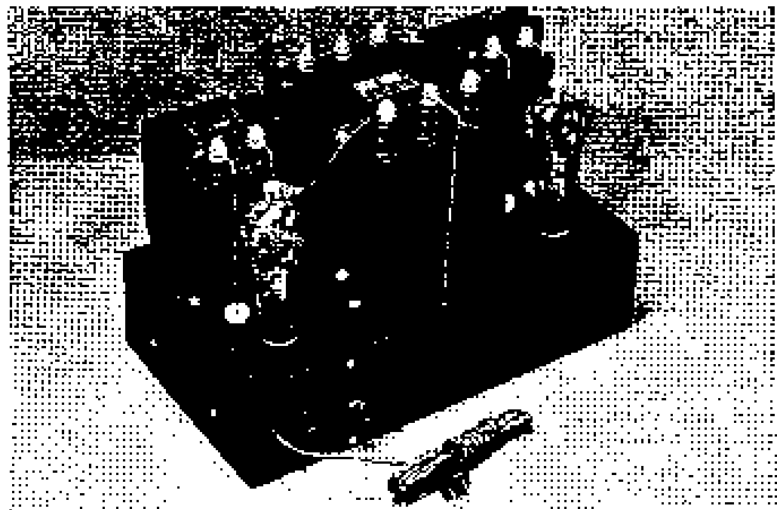
THORDARSON

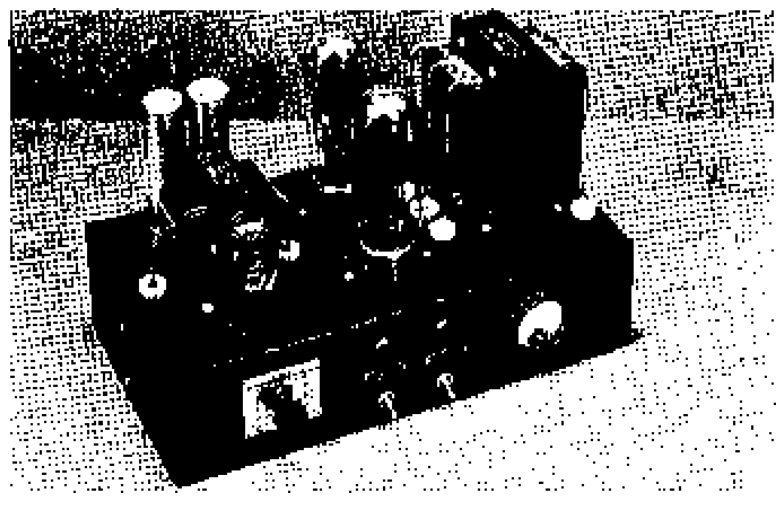
The 845 Class AB Booster Amplifier consists of a push-pull output stage with its plate, filament, and fixed bias supplies. The type 845s are operated under their 1250 volt plate supply rating, with a fixed bias of approximately —225 volts. Under these conditions they will develop a maximum output of approximately 100 watts with negligible distortion. Individual bias adjustment is provided for each tube so that differences in tube characteristics may be compensated for; and the second harmonic distortion that would be generated as a result of these differences is eliminated. Two on-and-off switches, one to turn on the filaments of all tubes and the bias supply for the 845s, the second to turn on the high voltage plate supply, are provided. They are so arranged that unless the filament and bias supply switch is closed the plate supply switch is not effective. A plate milliammeter is used as an indicator, both for making bias adjustments and as a check that the tubes are operating properly—it also provides a rough indication of volume level.

The input to the 845 stage is 500 ohms and is fed either directly to the primary of the input transformer or through a 2 watt 500 ohm T-pad if volume control at this unit is desired. The input transformer is of the terminated type and will reflect the proper load to the line whether or not the T-pad is used. A maximum power input of 2 watts is necessary from the driving source to drive the 845s at full output. As noted above, the 845s are operating under Class AB conditions, but no grid current flows during any portion of the signal cycle; so that no power is taken by the grids. The 2 watts noted above are necessary so that the proper signal voltage will appear across the terminating resistors on the secondary of the input transformer. The output transformer has a 500 ohm secondary, but this could be replaced by one with other secondary values or by a modulation transformer if desired.

It is suggested that this amplifier and its power supply be built up on a double base, with the parts distributed on the two as the circuit diagram indicates. The input and output transformers, T-1 and T-2, can be mounted on top of the main amplifier base, together with the two type 845s, the type 80, and the bias supply condensers, C-1 and C-2. T-3, T-4, CH-1 and all resistors in this section of the unit can be mounted beneath the panel. The plate transformer and two large chokes (T-5, CH-2, CH-3) can be mounted on top of the main power supply base with the two type 866 rectifiers, while the filament transformer, T-6, and the balance of the power supply section can be mounted underneath. A three-wire service cord and three-pole plug on the power supply base, together with a three-pole line receptacle mounted on the amplifier base, provide A.C. line connections between the units. A two-wire cord with socket type receptacles and plugs provide for the high voltage D.C. connection between the chassis.







● ● P A R T S L I S T ● ●

THORDARSON EQUIPMENT

Diagram Number	
T-1	T-9312 High Level Line to Push-Pull Grids.
T-2	T-6167 Output Transformer.
T-3	T-6049 Plate and Filament Transformer.
T-4	T-6414 Filament Transformer.
T-5	T-6411 Plate Transformer.
T-6	T-6433 Filament Transformer.
CH-1	T-1892 Choke.
CH-2	T-6315 Input Choke.
CH-3	T-6408 Filter Choke.

RESISTORS

Diagram Number	Ohms	Watts		
*R-1	500	2	T-Pad	
R-2, R-3	25,000	10	Wire-wound	
R-4, R-5	5,000	10	Wire-wound	Potentiometers
R-6	5,000	25	Wire-wound	
R-7	50,000	75	Wire-wound	

CONDENSERS

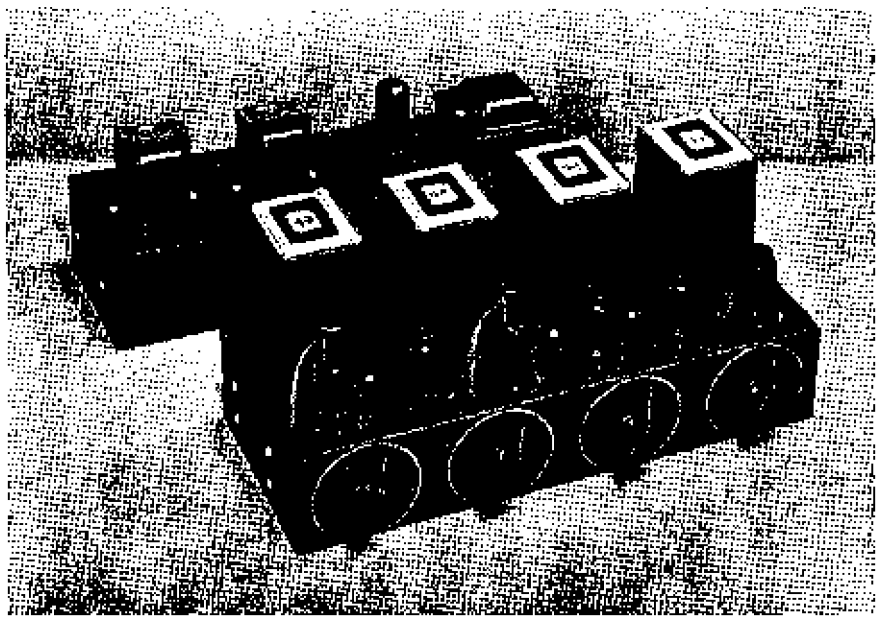
Diagram Number	Capacity in Mfds.	Working Voltage	Type
C-1, C-2	8	450	Electrolytic
C-3, C-4	2	2000	Paper

MISCELLANEOUS PARTS

2 Chassis bases—each 16½" long, 9" wide, 4" high.
SW-1 SW-2 Heavy duty line switches (6 amperes).
M-1 0-300 Milliammeter.

*This T-Pad Control may be eliminated if there is adequate and convenient level control available at the driving amplifier; however, if the booster amplifier is operated at some distance from the driving source, or if more than one booster amplifier is operated from the same driving source and an individual level control is desired, then the T-Pad is necessary.

Electronic Mixer and Pre-Amplifier



Electronic mixing has become very popular due to the simplicity and economy of construction. The unit described here has four separate channels, any of which may be mixed together. Two low level channels are provided with a switching arrangement, permitting direct connection to the grid, as required with crystal microphone, or through an input transformer for 200 ohm velocity or dynamic microphones. The third channel has an input transformer for low impedance pickup, condenser microphone or line, and the fourth channel is high impedance for crystal pickup, radio or high impedance magnetic pickup.

The input connectors are wired universal so that either low impedance or grid input is possible with one fitting. For instance, the plug on a crystal microphone cable is wired so that connection is made with the ground and grid terminals. A velocity or other low level source has the cable plug wired to contact the transformer primary and ground. Switches SW-1 and SW-2 must be thrown to the proper position, depending upon which input is in use.

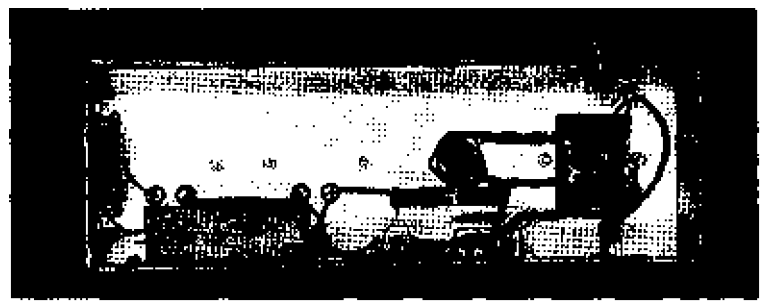
As noted in the schematic diagram, all connections ahead of the first input tubes are well shielded. This is necessary because of the extremely low signal level accommodated. Grid resistors R-1 and R-7 are ½ watt size to facilitate shielding. They should first be insulated by a wrapping of varnished cambric, or inserted into a piece of ¼ inch spaghetti tubing before covering with the braided shield.

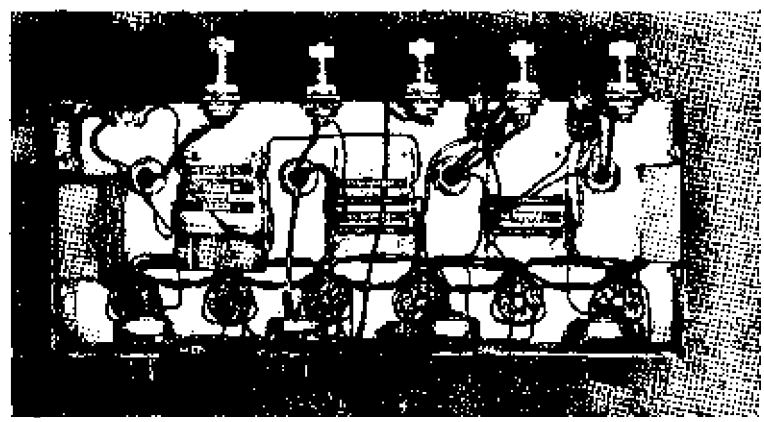
The output is coupled through a tube to line transformer that may be worked into Thordarson amplifiers or any system having a low impedance input circuit.

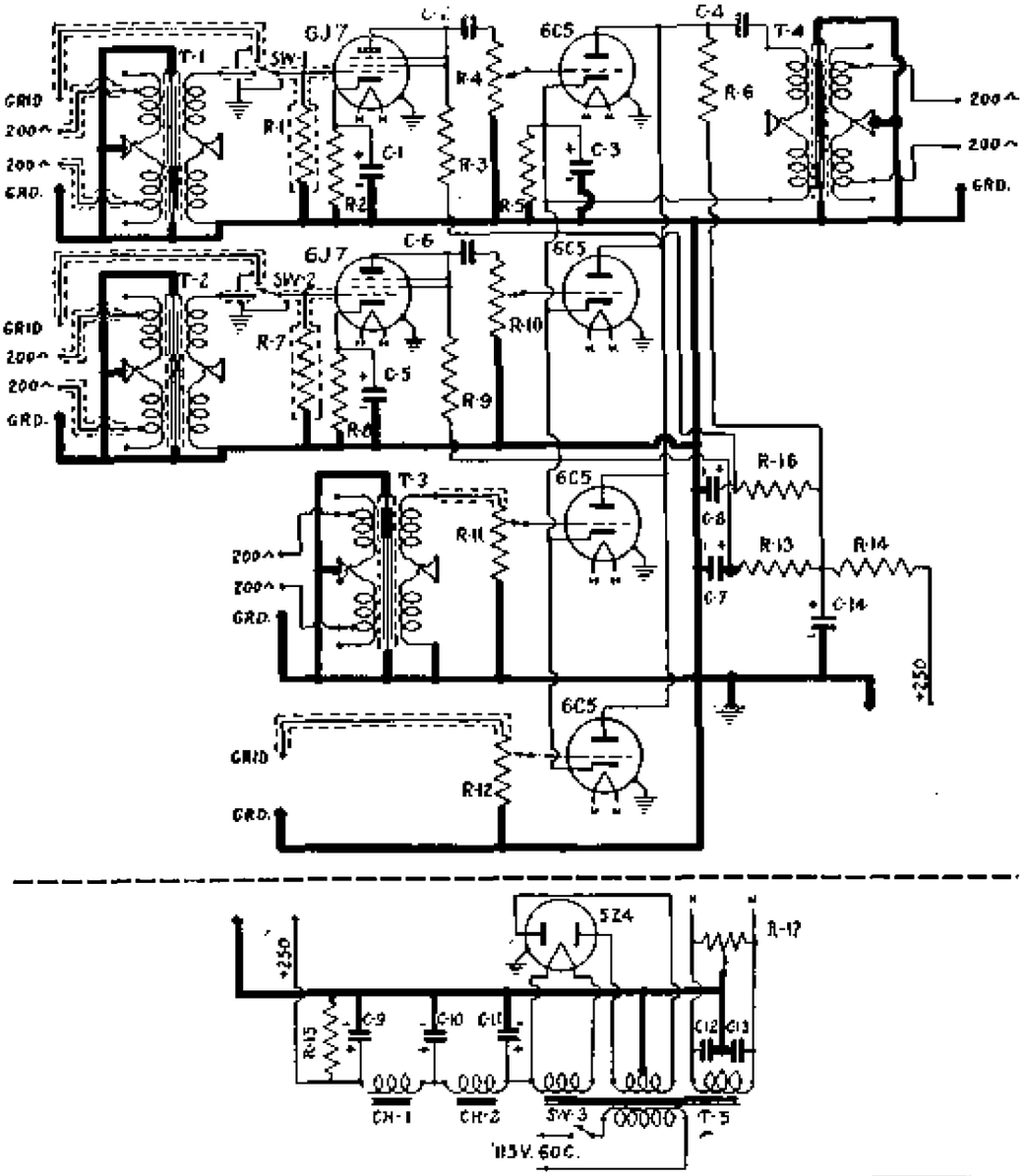
Metal tubes are used throughout, eliminating the necessity of separate tube shields.

The power supply was constructed separately to prevent hum pickup by the low level input transformers. The units are coupled together with a four wire cable several feet long.

Both chassis are 15 inches long and 3 inches high; the amplifier section is 6 inches wide; the power supply 5 inches wide.







P A R T S L I S T

THORDARSON EQUIPMENT

Diagram Number	
T-1	T-9000 Input Transformer
T-2	T-9000 Input Transformer
T-3	T-9000 Input Transformer
T-4	T-9002 Tube to Line Transformer
T-5	T-7020 Power Transformer
CH-1	T-6808 Filter Choke
CH-2	T-6808 Filter Choke

RESISTORS

Diagram Number	Ohms	Watts	Type
R-1	5 Megohm	½	Carbon
R-2	2,500	1	Wire-wound
R-3	50,000	1	Carbon
R-4	½ Megohm	..	Volume Control
R-5	500	1	Wire-wound
R-6	25,000	2	Carbon
R-7	5 Megohm	½	Carbon
R-8	2,500	1	Wire-wound
R-9	50,000	1	Carbon
R-10	½ Megohm	..	Volume Control
R-11	½ Megohm	..	Volume Control
R-12	½ Megohm	..	Volume Control
R-13	25,000	1	Carbon
R-14	10,000	10	Wire-wound
R-15	25,000	25	Wire-wound
R-16	25,000	1	Carbon
R-17	50	..	Potentiometer

CONDENSERS

Diagram Number	Capacity in Mfds.	Working Voltage	Type
C-1	10.	25	Electrolytic
C-2	.1	400	Paper
C-3	50.	25	Electrolytic
C-4	1.	400	Paper
C-5	10.	25	Electrolytic
C-6	.1	400	Paper
C-7, C-8	8.—8.	450	Electrolytic
C-9	8.	450	Electrolytic
C-10, C-11	8.—8.	450	Electrolytic
C-12, C-13	.1—.1	200	Paper
C-14	8.	450	Electrolytic

SWITCHES

Diagram Number	
SW-1, SW-2	Single-pole, double-throw, toggle Switch.
SW-3	On-Off A.C. Switch.

Very often it is necessary to provide amplifying systems with more than one input connection. Also, it is desirable to mix the inputs so that one source may be imposed upon another. Several popular methods of mixing are described on these pages.

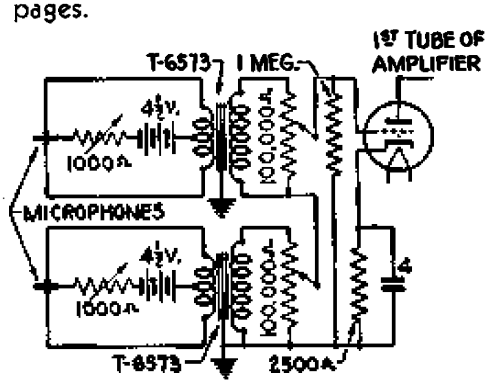


FIG. 1

TWO MICROPHONE MIXER

The most simple mixer circuit is the series type operating directly into the first tube grid. Figure 1 shows two carbon type microphones connected in a two circuit series mixer. Two microphone to grid transformers and two volume controls are required. It is preferable to use tapered controls so that the sound output of the system is proportional to the control knob rotation. The 1000 ohm rheostats control the microphone battery current. It is often desirable to keep watch of this current so that it is within the rating of the microphone, as specified by the manufacturer. This may be accomplished by inserting a 0-50 milliammeter in series with the battery. Most double button carbon microphones require 20 to 30 m.a. total current.

Figure 3 illustrates the same type of mixer except that high impedance velocity microphones are used. Because this type microphone is designed to operate directly into the grid of a tube, the input transformers are not needed. The output of velocity microphones is low level. This requires extreme care in shielding of all leads and controls up to the grid of the tube.

MICROPHONE AND PHONO MIXER

Sometimes it is desired to have a background of music imposed upon the voice picked up by the microphone. The circuit in Figure 2, which is essentially the same as described above, accomplishes this. Only one microphone is used, the other circuit being connected to a phonograph pickup or radio. Either the high impedance magnetic or crystal type pickup, both of which are very popular, may be used. For radio operation a blocking condenser could be connected from

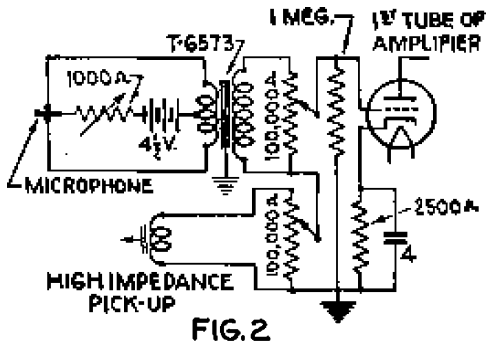


FIG. 2

the detector plate to the lower mixer control. The grounded side of the control would be connected to the ground circuit of the radio.

THREE CIRCUIT PARALLEL MIXER

In broadcasting and recording it is common practice to mix input at low impedance. This method is superior inasmuch as both sides of the

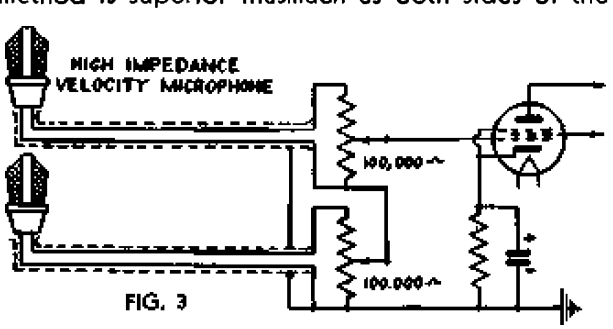


FIG. 3

input line can be balanced with respect to ground. A minimum pickup of hum or other disturbance results. Also, long, low impedance lines will not cause serious loss of signal or attenuation of the high audio frequencies. Figure 4 is a popular parallel mixer with three input circuits. Since each input is balanced to ground without individual transformers this is well adapted to portable amplifiers. If balanced lines are not required, "T" pads may be used instead of the balanced "H" pads indicated. In this case a 112 ohm resistor is inserted in the side above ground instead of the 56 ohm resistor on each side of the line. The insertion loss in this mixer is approximately 8 d b. Only sources having 200 ohms can be used unless matching transformers are provided.

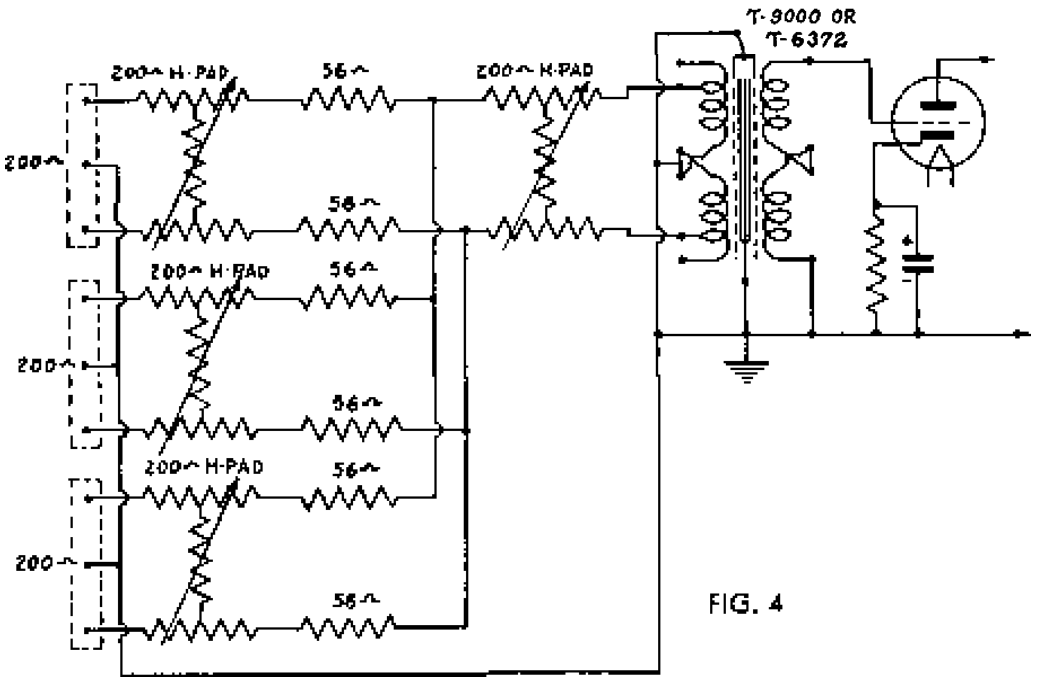


FIG. 4

FOUR CIRCUIT SERIES MIXER

The most popular low impedance mixer circuit is the series type illustrated in Figure 5. The insertion loss in this type is somewhat less than the parallel mixer, being 5 d b with four input circuits. Balanced "H" pads are not required since a line to mixer transformer is used in each circuit. These transformers all have universal secondaries connected for 50 ohms. The primaries may be of any impedance to match the input source which must be accommodated.

ELECTRONIC MIXING

The reader is referred to pages 20 and 21, which describe an effective electronic mixer. The new Thordarson amplifiers on pages 6, 7, 8 and 9 incorporate electronic mixing and fading by means of a special control circuit.

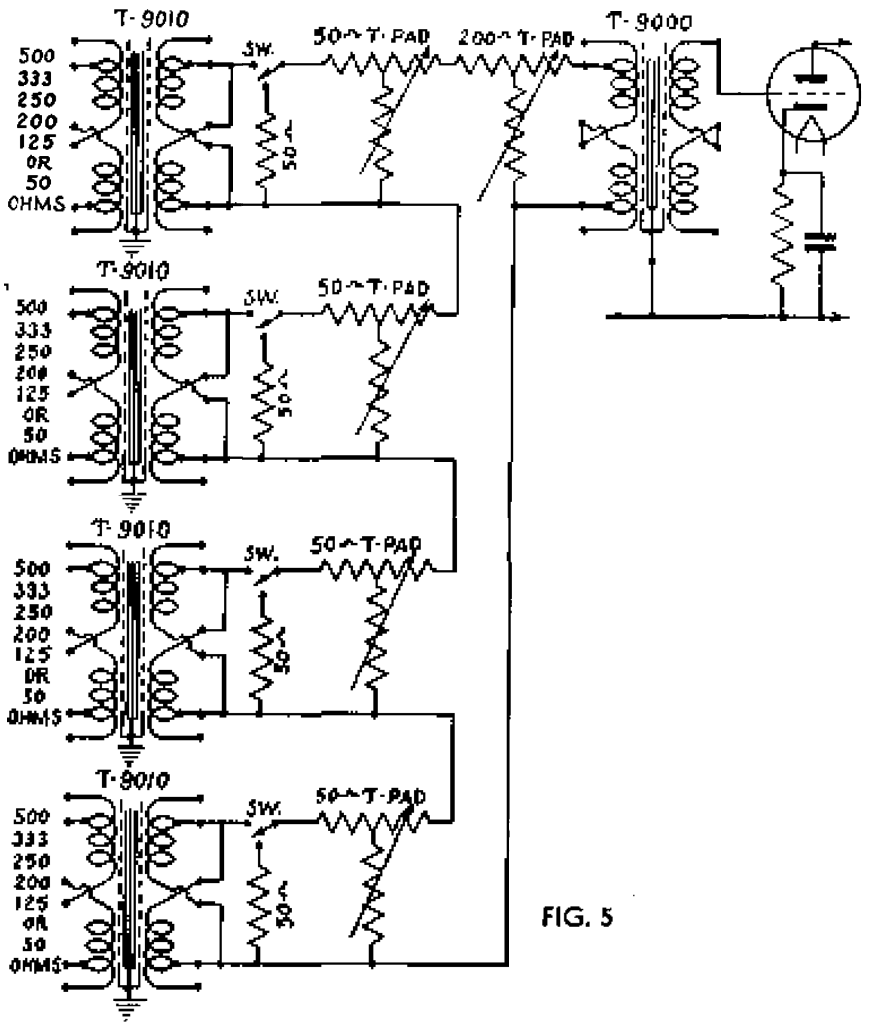
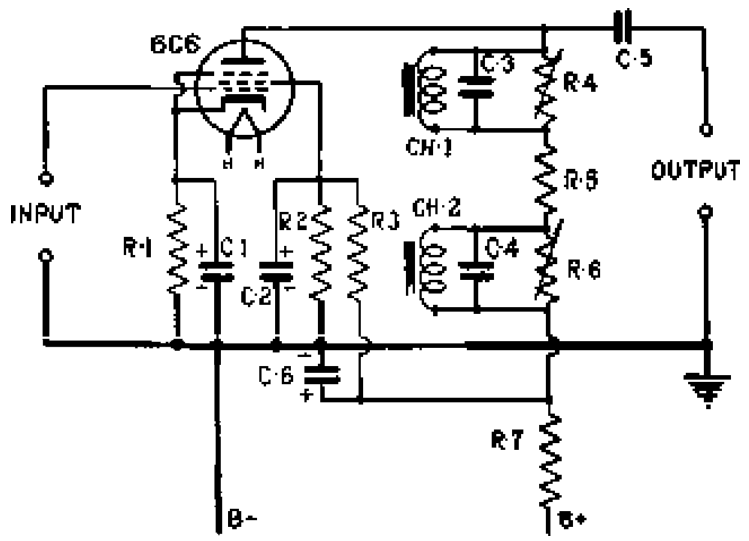


FIG. 5

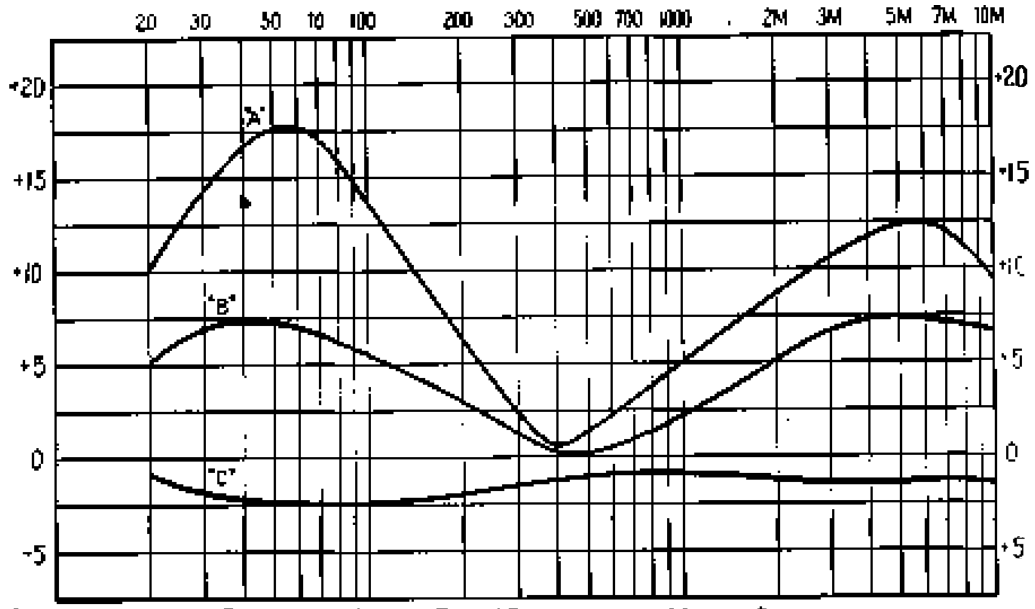
THORDARSON **Audio Compensating System**

It is often desirable to have an easily accessible control of the low frequency and high frequency characteristics of an amplifier. Such a control permits adjusting the amplifier characteristic to secure the desired type of reproduction in any particular service.

One of the most useful applications of this system will be where, perhaps for economical reasons, the audio components employed in an amplifier are of such a grade that either the high frequency or low frequency response or both is deficient. This circuit will provide compensation for these deficiencies, and in addition will allow for emphasis at the resonant frequencies if the deficiencies are not too great. Other applications of this type of compensation system are: (1) Compensation of the usual deficiencies of different types of microphones and phonograph pickups; (2) Compensation of response deficiencies



Db. vs Frequency—Response Curve



Curve "A"—Maximum Compensating Action—Control Potentiometers in Maximum Position.
Curve "B"—Intermediate Compensating Action—Control Potentiometers Advanced to Approximately 20% of Resistance Value.
Curve "C"—Minimum Compensating Action—Control Potentiometers at Zero Resistance Setting.

of loud speakers and losses at low frequencies due to insufficient baffle area; (3) Altering the type of sound reproduction to that most suitable for the particular acoustical characteristics of a particular hall or auditorium.

The audio compensation system shown schematically consists essentially of two parallel tuned circuits arranged in series with a fixed resistor, the whole combination placed in the plate circuit of a type 6C6, pentode operated, audio stage. One of these tuned circuits can be tuned in the low frequency range of approximately 30 to 120 cycles; the other in the high frequency range of approximately 2000 to 7000 cycles. The values of 60 cycle and 5000 cycle for the low and high frequency resonant points respectively were selected for response curve purposes as being the most representative of desirable compensation frequencies. The resonant frequency of either tuned circuit may be changed within the limits mentioned above, using the same choke units, by changing the value of the tuning condenser. The amplitude of the compensation action is controlled by adjustment of the shunting potentiometers (connected as rheostats).

Although the 6C6 is connected as a high gain audio pentode, it should not be counted on for gain, since under some conditions of adjustment the gain will be negligible; therefore when the installation of this stage is contemplated, there should be adequate gain available from the rest of the amplifier. This stage should be operated at a relatively low level, although it is not recommended that it be placed at the head end of a high gain amplifier. The best position would be the stage ahead of the driver stage—i.e., the second stage ahead of the output.

This compensator is effective only when used in the plate circuit of a high mu tube such as 6C6 pentode, resistance coupled to the following stage. The d b gain at resonance with a low mu triode, such as 76, etc., will be insufficient for most purposes.

• • PARTS LIST • •

CHOKES

Diagram Number	
CH-1	T-8115
CH-2	T-9320

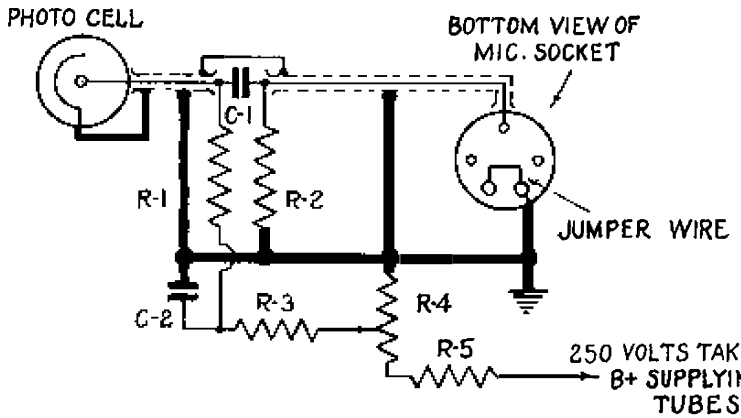
RESISTORS

Diagram Number	Ohms	Watts	Type
R-1	2,250	1	Wire-wound
R-2	20,000	1	Wire-wound
R-3	100,000	1	Carbon
R-4	50,000	..	Potentiometer
R-5	5,000	1	Wire-wound
R-6	50,000	..	Potentiometer

CONDENSERS

Diagram Number	Capacity in Mfds.	Working Voltage	Type
C-1	25	25	Electrolytic
C-2	8	200	Electrolytic
C-3	.002	1000	Mica (for 5000 cycles resonance)
	.006	1000	Mica (for 3000 cycles resonance)
C-4	.03	600	Paper (for 60 cycles resonance)
	.06	600	Paper (for 40 cycles resonance)
	.01	600	Paper (for 120 cycles resonance)
C-5	.1	400	Paper
C-6	8	450	Electrolytic

Photo Electric Cell Circuits



Thordarson 6, 18, and 30 watt High Gain Amplifiers have ideal characteristics when used in conjunction with photo-cells for portable or theater sound on film reproduction.

A circuit is shown with a single cell as is generally used with portable equipment. The cell voltage is controlled by a 100,000 ohm potentiometer.

In larger installations two projectors are generally used. A potentiometer is required for each photo-cell to provide independent voltage control so as to have equal volume from each projector. The more voltage supplied to the cell, the greater is the audio output. However, care must be taken not to exceed the manufacturer's rating, which usually is 90 volts maximum with gas filled cells.

The diagrams show how connections are made to the input socket of T-7506-M, T-7506, T-7518-M, T-7518, and T-7530 amplifiers without altering the original amplifier circuit whatsoever.

If the amplifier is to be used only with the photo-cell input, the regular microphone and switching circuit may be eliminated, connections being made directly to the grid and ground of the first 6C6 or 6J7 tube. The photo-cell resistors and condensers can then be mounted in the amplifier chassis, and the photo-cell connected to the chassis with a shielded cable and plug. This cable must be low capacity and not over 3 or 4 feet long.

Where the amplifier will be used with microphones and other sources of input, it is best to build the photo cell equipment in a separate small case. This includes all the parts shown in the schematic diagrams. Connections can be made to the amplifier with a short piece of single wire shielded cable and plug, using the same circuit as shown for the crystal microphone. The 250 volt "B" plus lead will be taken out separately and connected to the lead supplying the 6C6 or 6J7 tubes.

If quiet operation is to be expected, care must be taken to use shielded wire where shown. If the photo-cell parts are not built into the amplifier, they must be mounted in a metal case to provide shielding.

Sound-on-film reproduction is not always satisfactory when the amplifier has linear characteristics. On page 24 is described a tone compensation circuit that can be incorporated and adjusted to fit almost any requirements. High frequency accentuation is usually desirable because of loss in film, optical system, and auditorium acoustics.

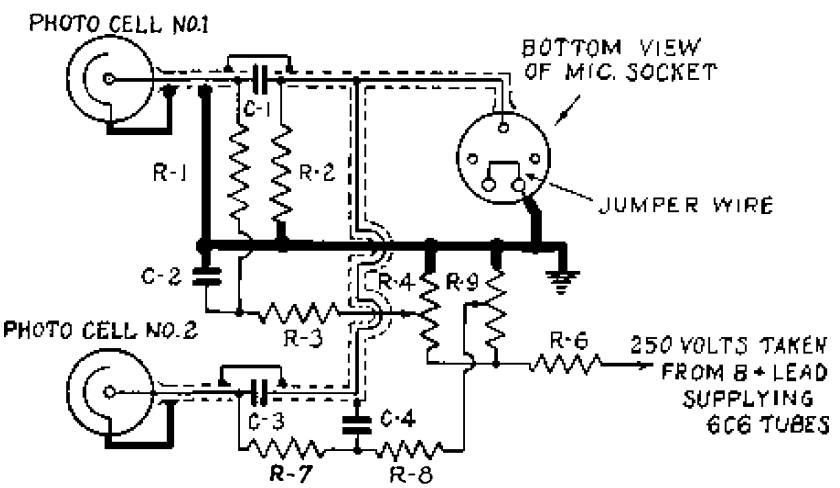
• • PARTS LIST • •

RESISTORS

Diagram Number	Ohms	Watts	Type
R-1	1 Megohm	½	Carbon
R-2	500,000	½	Carbon
R-3	100,000	1	Carbon
R-4	100,000	..	Potentiometer
R-5	150,000	1	Carbon
R-6	75,000	1	Carbon
R-7	1 Megohm	½	Carbon
R-8	100,000	1	Carbon
R-9	100,000	..	Potentiometer

CONDENSERS

Diagram Number	Capacity in Mfds.	Type
C-1	.01	Mica
C-2	1.	400 Volt Paper
C-3	.01	Mica
C-4	1.	400 Volt Paper



Speaker Coupling Circuits

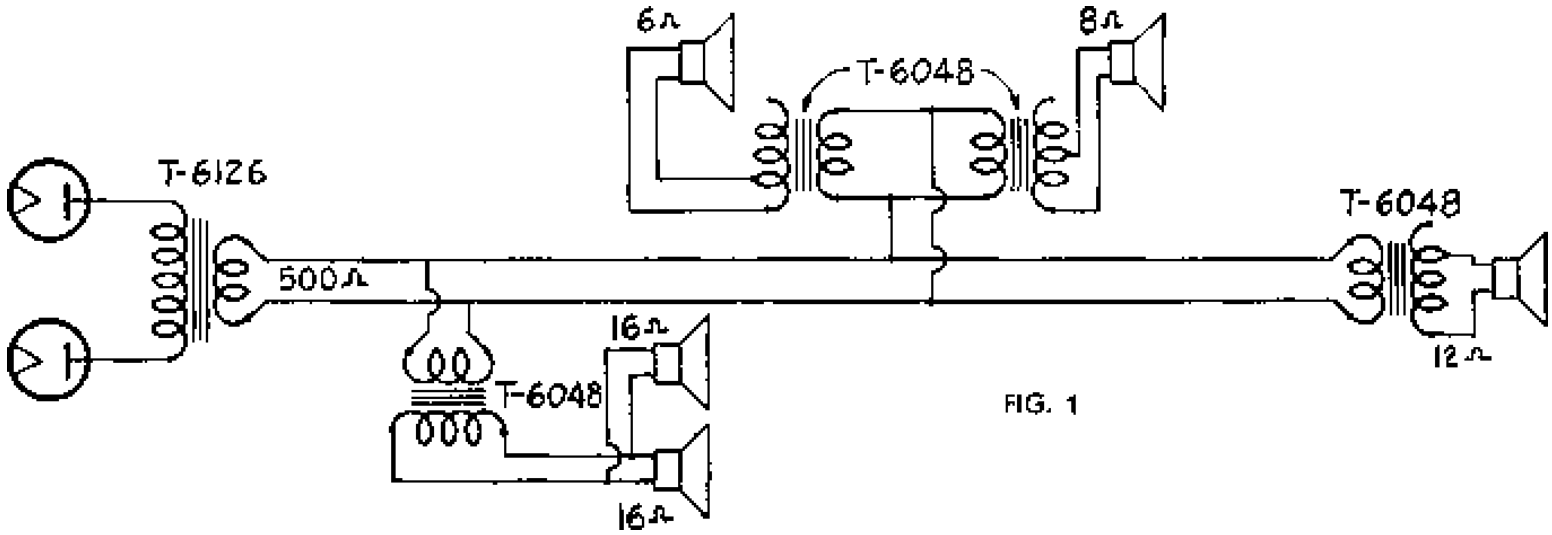


FIG. 1

For amplifier installations where some, or all, of the speakers are to be located at a distance from the amplifier, experience has shown that the installation of a 500 ohm transmission line offers greatest economy of sound energy, maximum ease of securing accurate impedance matches, and freedom from attenuation of any desired signal frequencies.

Most amplifiers are provided with 500 ohm output terminals in addition to the low impedance voice coil terminals for this purpose.

THORDARSON engineers have developed an unusual system for setting up 500 ohm transmission lines, and a series of tube-to-line and line-to-speaker transformers that eliminate the guesswork which existed previously in working out complicated speaker systems. Fig. 1 shows a typical multiple speaker installation employing dynamic units of varying impedances, all operated from a single amplifier through a 500 ohm line. In this case, a perfect impedance match has been secured at all points, both between line and amplifier, line and output transformers, and between the transformers and dynamic speaker voice coils.

Such simplified output circuits have been made possible by the development of the THORDARSON T-6048 Universal Line-to-Speaker Transformer. The primary has high inductance so that up to six transformers may be connected in parallel across the line, and by proper selection of terminals, a perfect impedance match with the line can be maintained. Then by proper selection of secondary terminals, any dynamic speaker with voice coil impedance from .1 to 48 ohms may be properly matched to the 500 ohm line.

The accompanying table shows the wide range of dynamic speaker voice coil impedances that may be matched with this transformer.

A common method of proportioning the sound energy between speakers is shown in Fig. 2. Here is represented a typical large auditorium installation where two speakers are to be located near the stage and operated at half power, and two more are to be placed toward the rear of the room to be operated at full power.

The speakers "A" have 8 ohm voice coils while the two marked "B" are 12 ohms each. By using three of the THORDARSON T-6048 Line-to-Speaker Transformers, all transformers present the same impedance to the line and the power will be divided equally among the three. However, the speakers "A" divide the power from a single transformer and, therefore, have half the power of each of the other two speakers.

Where there are a number of speakers

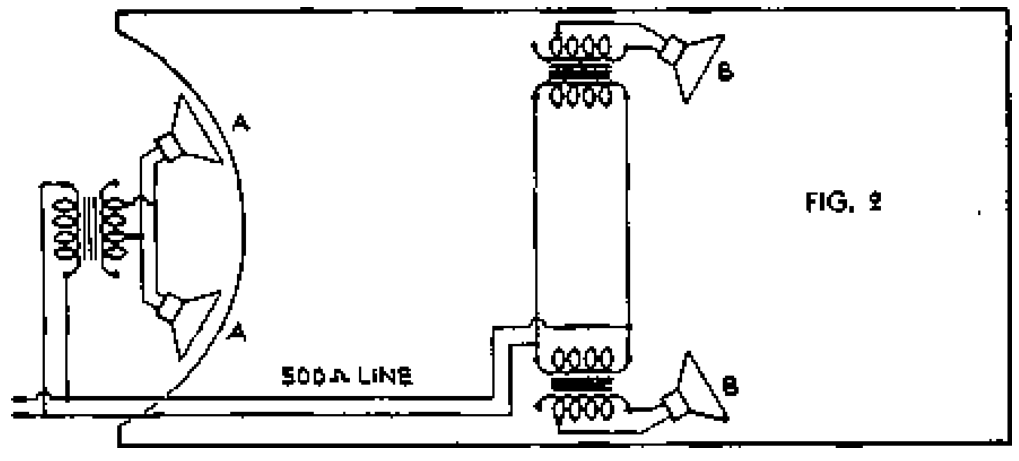


FIG. 2

which already have 500 ohm input transformers to be connected to a 500 ohm line a matching transformer must be used. Fig. 3 shows how a number of 500 ohm speakers connected in parallel may be matched to the 500 ohm amplifier output with T-7674 matching autotransformer. This unit provides five impedances in addition to the original 500 ohms—250, 166, 125, 100, and 84 ohms. These values are the result of connecting 2, 3, 4, 5, or 6, 500 ohm speakers in parallel.

The circuit shows two 500 ohm speakers connected in parallel which reflect an impedance of 250 ohms. Connections are made to the common terminal #7 and terminal #5. If three speakers are used, the reflected impedance will be 166 ohms, in which case the common terminal and terminal #4 are used.

THORDARSON transformer T-5381 will couple a 500 or 250 ohm line to voice coils having 4, 8, or 15 ohms impedance. If desired, two of these transformers may be connected to a 500 ohm line by using a series connection and the 250 ohm tap. It is also possible to connect several speaker voice coils to one of the T-5381 transformers. If the voice coils have 15 ohms impedance each, two of them could be connected in parallel to the 8 ohm tap. Four 15 ohm voice coils can be wired in series parallel to the 15 ohm tap or in parallel to the 4 ohm tap.

If it is impossible to make the impedances match, it is advisable to work into a load of a higher rather than a lesser impedance. For instance, if 4 and 8 ohm taps are available on the output transformer and the

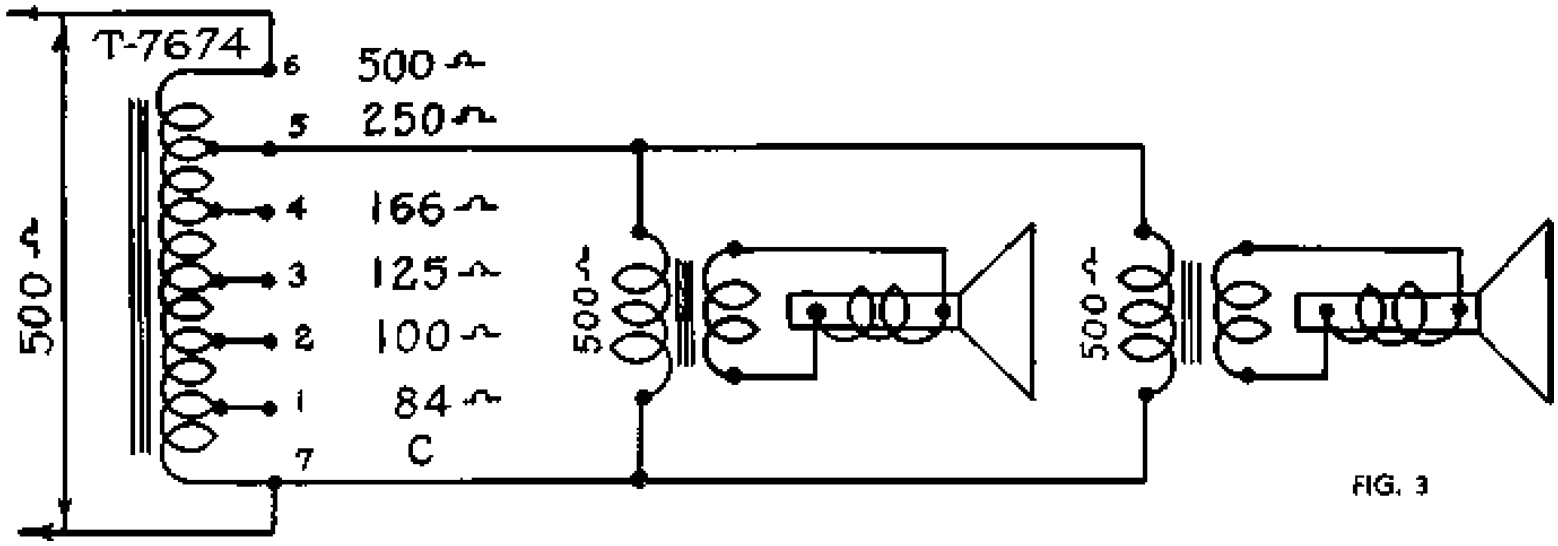


FIG. 3

speaker impedance is 6 ohms, the 4 ohm tap should be used. This will result in only slight loss of power, whereas if the 8 ohm tap had been used, the peak current of the power tubes would be excessive, and distortion would result.

The wires connecting the transformer to the speaker coil should not be any longer than necessary. Long voice coil leads result in loss of power and low frequencies. Heavy wire should be used if the transformer is separated from the speaker more than a foot or so.

Where a group of speakers are operated relatively close together it is not uncommon to use only one voice coil transformer. This requires that the speakers are connected to properly match the transformer secondary which usually is 4, 8, and 15 ohms impedance.

The series connection of voice coils is not recommended unless absolutely necessary. This is because the resonance of two speakers very seldom occurs at the same frequency. This not only allows the normal response of the speakers to be affected by the resonance of other units, but may result in voice coil burn-out if the system is operating near the maximum speaker capacity. In matching series connected speakers, the transformer impedance should be equal to the sum of voice coil impedances. The voice coil impedance of each speaker should be alike to have an equal distribution of power. If one speaker is 4 ohms and the other 8 ohms, the sum would be 12 ohms and would match a 12 ohm transformer. However, the 8 ohm speaker will receive twice as much power as the 4 ohm unit.

It is advisable, where possible, to connect the voice coils of speakers or input transformers in parallel for reasons described above. If two 16 ohm voice coils are connected in parallel, the net impedance will be 8 ohms, and each will receive the same amount of power. However, if one voice coil is 16 ohms and the other 8 ohms, the one of lesser impedance will receive twice as much power as the other. Formulas for determining the approximate net impedance of voice coils are given below.

Voice coils in series:

$$\text{Total impedance in ohms} = Z_1 + Z_2 + Z_3$$

Two voice coils in parallel:

$$\text{Total impedance in ohms} = \frac{Z_1 Z_2}{Z_1 + Z_2}$$

More than two voice coils in parallel:

$$\text{Total impedance in ohms} = \frac{1}{\frac{1}{Z_1} + \frac{1}{Z_2} + \frac{1}{Z_3}}$$

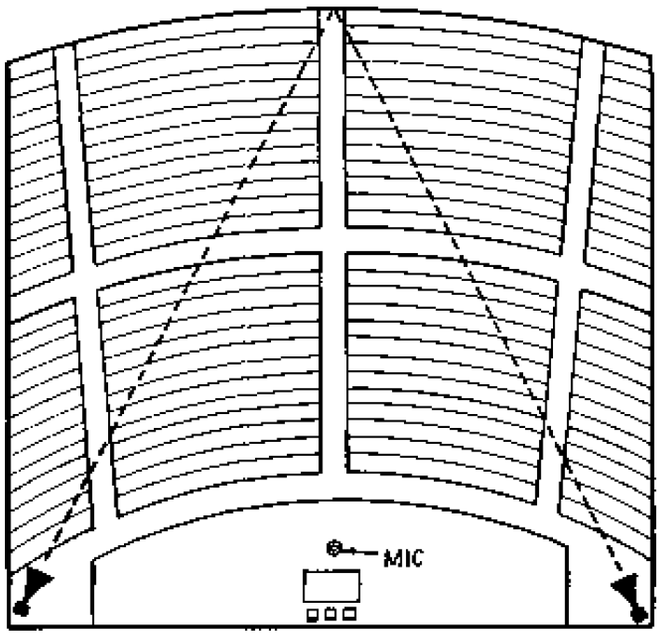
Voice coils in series parallel:

$$\text{Total impedance in ohms} = \frac{1}{\frac{1}{Z_1 + Z_2} + \frac{1}{Z_3 + Z_4}}$$

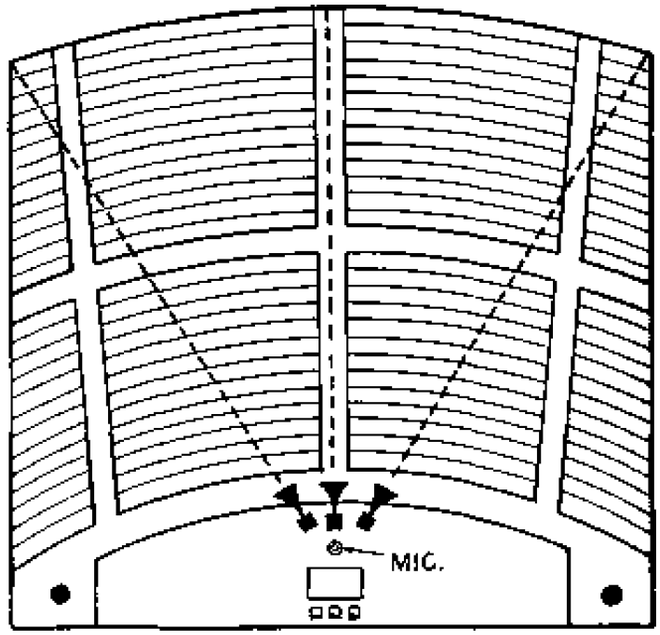
Table for Connecting Dynamic Speakers of Various Impedances in Same Output System

Secondary Matching Impedance T-6048 Transformer

Secondary Terminals	No. of Transformers in Parallel Across 500-ohm Line					
	1	2	3	4	5	6
2 - 4	.06	.1	.2	.2	.3	.4
5 - 6	.1	.2	.4	.5	.6	.7
2 - 5	.2	.4	.7	.9	1.1	1.3
4 - 6	.3	.6	1.0	1.3	1.6	1.9
3 - 6	.4	.7	1.1	1.4	1.8	2.1
2 - 6	.6	1.2	2.0	2.7	3.4	4.0
6 - 7	.7	1.4	2.2	2.9	3.6	4.3
1 - 2	1.3	2.7	4.	5.4	6.8	8.1
1 - 3	1.7	3.3	5.	6.7	8.4	10.
1 - 4	2.	4.0	6.	8.	10.	12.
3 - 7	2.4	4.8	7.2	9.6	12.	14.4
1 - 5	2.6	5.3	8.	10.6	13.3	16.
2 - 7	2.8	5.6	8.4	11.2	14.	16.8
1 - 6	4.	8.	12.	16.	20.	24.
1 - 7	8.	16.	24.	32.	40.	48.



Speakers at both sides of microphone



Speakers above microphone

SPEAKER PLACEMENT AND AUDIO POWER REQUIRED

Placement of speakers plays an important part in the successful operation of public address equipment. Regardless of the quality of microphone, amplifier, or speakers used, there is a possibility of acoustical feedback occurring before a satisfactory level is reached for full distribution of sound.

The directional characteristics of trumpet horns permit unusually good coverage before acoustical feedback occurs. This is because the sound can be directed entirely away from the microphone. For outdoor work the 6-foot trumpet is recommended, whereas the 3½ and 4½ foot models are better indoors.

Trumpet horns are very efficient and provide maximum sound output for a given amplifier power input. Either the permanent magnet dynamic or electro-dynamic units may be used. There is some advantage in the permanent magnet type since no field exciter is required, and the unit is considerably lighter.

The use of directional baffle, rather than flat baffle cone type speakers, will often reduce feedback. The speaker unit may be entirely enclosed where unusual conditions exist, leaving only the cone exposed to emit sound through the horn.

Loud speakers should be placed as far ahead of the microphone as conditions permit, and higher. Placing speakers higher makes it possible to direct them down toward the audience. This not only improves audibility but reduces feedback by means of absorption.

Best indoor results are obtained with two speakers. The illustrations on this page show conventional methods of placing speakers in a hall or auditorium. If non-directional or flat baffles are used with cone speakers, it may be necessary to locate the speakers further toward the rear of the room.

The following data, based on experience and theory, should prove helpful in determining what size amplifier is required. Installations may vary somewhat due to the difference in the efficiency of speakers used and in the noise level which the system must over-ride.

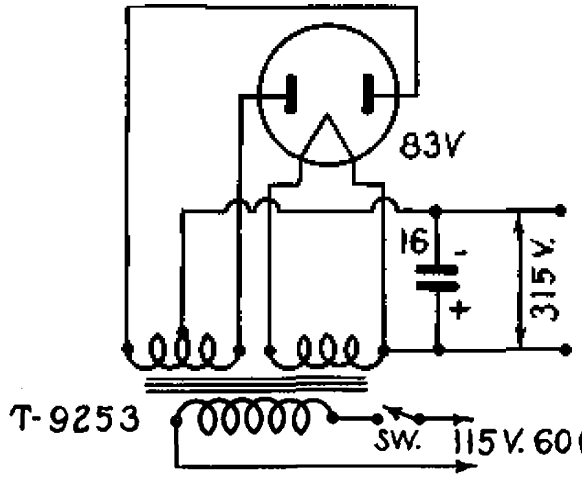
In obtaining the information, 12-inch electro-dynamic speakers with 15 to 20 watts of field excitation and directional baffle horns, were used. Flat or box type baffles require approximately three times as much audio power. Likewise, if the noise level is high, as in dance halls, etc., it will be necessary to use three times as much power.

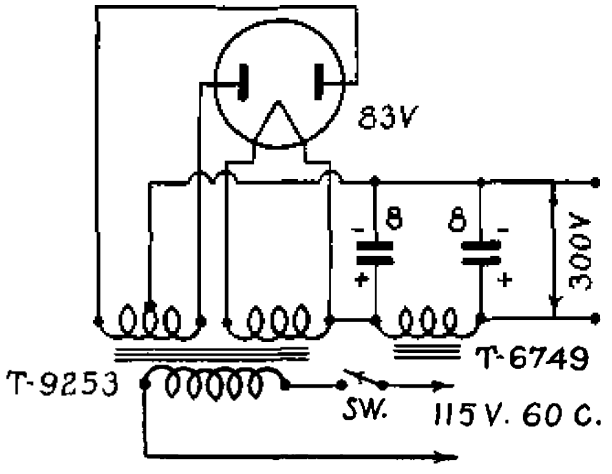
After determining the required power estimate that each speaker will receive about 5 watts. Therefore, if 30 watts are required for the installation, six speakers should be used and so placed that the sound will be evenly distributed.

Outdoor coverage is based on the number of square feet of ground and it has been determined that 1 watt of audio power will cover 1,000 square feet. For example, if we have a park 300 ft. long and 150 ft. wide, or 45,000 square feet, 45 watts are required and 9 speakers should be used.

Indoors it is necessary to estimate the cubic content of the room or hall. Following is a table showing what size rooms may be covered with a given amount of audio power:

ELECTRICAL WATTS	VOLUME OF ROOM IN CUBIC FEET
2	25,000
4	60,000
8	150,000
12	350,000
20	700,000
30	1,000,000
40	1,500,000



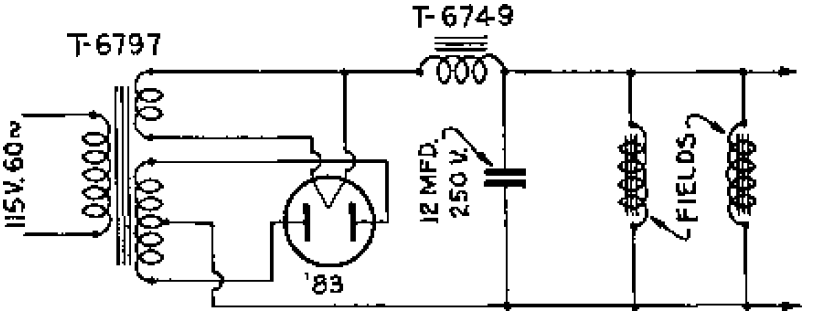


Two speaker field supplies are shown on this page, one rated to deliver 300 volts D.C. at 200 m.a. or 60 watts, and the other 115 volts D.C. at 250 m.a. or 30 watts.

The tables below the schematic diagrams indicate the number and rating of speaker fields that may be accommodated with a parallel connection. Many other combinations can be worked out by using either a series or series parallel connection. When other fields than those indicated in the tables are used, care should be taken not to exceed the current rating of the transformer. This may be checked after final connections are made by inserting a 0-300 milliammeter in the lead wired to the power transformer center tap.

It should be noted that the field wattage is specified in the tables. This is important, inasmuch as a speaker field may be damaged if seriously overloaded. Usually 25% above or below the normal operating wattage, as rated by the speaker manufacturer, is tolerable.

1 to 7	300 volt	9 to 10 watt fields	10,000 ohms each
1 to 3	300 volt	18 to 20 watt fields	5,000 ohms each
1 or 2	300 volt	30 watt fields	3,000 ohms each
1	300 volt	60 watt field	1,500 ohms



1 to 6	115 volt	5 watt fields	2,500 to 3,000 ohms each
1 to 4	115 volt	8 watt fields	1,800 to 2,500 ohms each
1 to 3	115 volt	10 watt fields	1,400 to 1,800 ohms each
1 or 2	115 volt	15 watt fields	950 to 1,400 ohms each
1	115 volt	30 watt field	450 to 950 ohms

The Thordarson power transformers used in these supplies are fully shielded and are universal to satisfy any mounting conditions.

Two diagrams are shown for the 300 volt 60 watt supply. The difference is that a filter choke is incorporated in one, assuring an absolute minimum of ripple or speaker hum. This method is desirable when supplying speakers installed in places having an unusually low noise level. Noisy installations, such as dance halls, ball parks, etc., do not require as much filtering of the field supply and the choke can be eliminated. An 83-V rectifier tube provides good efficiency and regulation.

The 115 volt 30 watt supply is capable of furnishing power to speaker fields designed for operation on 115 volts D.C. Low voltage field supplies usually require a larger filter than one of higher voltage. A choke and condenser are used to insure freedom of ripple in the direct current, which might cause objectionable hum. The power transformer is designed to have exceptionally good regulation so the voltage will not drop below 115 volts when the maximum current is taken from the supply.

ELIMINATING HUM

The most difficult problem in the designing and building of amplifiers is the elimination of hum, or its reduction to a satisfactory value. Since the introduction of dynamic, velocity, and crystal microphones, which have outputs of comparatively low level, higher gain amplifiers are necessary. An amplifier having low level input is likely to pick up stray magnetic fields, or amplify ripple caused by an insufficiently filtered plate supply, unless extreme care was taken in its design and construction.

Hum from the plate supply is quite easily corrected by the insertion of an additional choke and filter condenser in the B plus lead supplying the low level stages. If for any reason a choke cannot be used a resistor may be substituted with fairly good results. Oftentimes it is desirable to insert a resistance filter in the plate circuit of the first and second stages. This not only reduces hum but eliminates common coupling between stages which causes feedback. The resistor values might be from 10,000 to 50,000 ohms, depending upon the allowable voltage drop.

Any ripple in the plate supply will appear across the bias resistor. In push-pull circuits this cancels out and is not usually audible in the loud speaker. In the first or second stage ripple developed in the cathode circuit is fully amplified by the tube. The use of a large cathode resistor bypass condenser (25. mfd) will lower the impedance, resulting in a minimum of ripple developing at this point.

Power transformers, filament transformers, and filter choke coils (especially with choke input) set up strong magnetic fields. Audio transformers within the field will have a voltage induced in their windings. If there is sufficient amplification following the transformer, objectionable hum will be emitted from the loud speaker. Output and driver transformers do not usually pick up enough to be noticeable. Most trouble occurs with the input and interstage transformers. For this reason it is desirable to construct the power supply separate from the amplifier. However, when both are mounted on one chassis, rotating the transformers to a minimum hum position will be necessary. The new Thordarson Tru-Fidelity units have several interesting features incorporated to prevent magnetic hum pickup. Special core and coil construction cancels the hum within its windings. The case shields the entire unit, both statically and magnetically. Any residual hum may be eliminated by rotating, which is easily done because of single stud mounting.

Connecting cables from microphones, pickups, etc., should be shielded and the shield connected to the amplifier, which is grounded. When long cables are used, shielding is not always effective. It may be necessary to use balanced lines. This is similar to the three wire system where the outside wires are balanced to ground. With transformer input the primary is center tapped and grounded to the amplifier and cable shield. A balanced line from crystal microphones requires a two wire shielded cable and push-pull input tubes. With this method any disturbance is impressed on both sides of the line equally and cancels as in a balanced bridge circuit.

The wiring of high gain amplifiers is quite important. Filament or heater leads usually carry fairly high alternating currents and set up strong magnetic fields. The usual practice is to twist the leads connecting to tube sockets. This tends to reduce the field. The current travels in opposite directions in the wires and the lines of force set up around one wire cancel those of the other wire. The 6.3 volt tubes are more satisfactory than 2.5 volt types for high gain stages because the heater current is only ¼ to ⅓ as great.

Usually the first tube of a high gain A.C. amplifier is responsible for hum after all other causes have been eliminated. The tube selected should be of the 6.3 volt type and have its grid connection on top. If only low gain is required from the first stage the tube should be a pentode, triode connected, rather than a triode with the grid lead out the base. The close proximity of the grid prong to the heater prongs of the tube base is responsible for hum trouble, especially where the grid of the tube is operated at a high impedance. The grid lead connecting to the tube grid cap should be shielded and of low capacity.

MICROPHONES

There are many types of microphones available today that are adaptable to sound amplifier systems. Some types are more suitable than others for public address work.

The crystal microphone has become popular because of its simplicity in connecting to the amplifier system and also because of its small size. Two types are available, namely the Cell Type and Diaphragm Type. The Cell Type has good frequency characteristics but low output. The diaphragm Crystal Microphone has higher output which compensates for cable loss; however, the cable should be as short as possible for best operation. Crystal microphones having larger capacity in mfds. are less affected by cable length. Cell types usually have larger capacity than the Diaphragm type, since the Cell is directly excited by sound and must be large to be affected. However, cable length should be held to a minimum because of the low output. Crystal microphone cable should have very low capacity. Long cables do not affect the frequency response but result in loss of power. Where it is necessary to locate the crystal microphone some distance from the amplifier, a transformer may be used having a 200 or 500 ohm secondary. This requires an input transformer at the amplifier with the same input impedance.

The dynamic or moving coil microphone is undoubtedly one of the most satisfactory for all-around pickup. Since it does not require exciting voltage or an associate amplifier, the unit is small and easily handled. The output impedance is low and the signal level fairly high so that a few hundred feet of cable may be used without serious loss of power or high frequencies. Close talking, which is necessary with public address systems, does not cause blasting or boominess. Most models are not affected by temperature, humidity or wind.

Velocity microphones, while ideal for broadcasting or recording, are not designed for close talking such as is necessary with public address. In broadcasting or recording, the artist or announcer may stand away from the microphone and take advantage of its frequency characteristics. This is impractical in most P.A. installations due to acoustical feedback. Close talking is necessary and results in unnatural boominess or a predomination of the lower frequencies. The Velocity is primarily a studio microphone.

The condenser microphone is capable of high quality reproduction and for many years was considered the choice of broadcast engineers. Its frequency response compares to that of the better type dynamic units, but the output level is considerably lower. This low output requires an associated pre-amplifier (usually two or three stages) which makes the microphone bulky and hard to handle. The battery supply necessary for operation is also objectionable.

Double button carbon microphones are very seldom used with modern sound systems. An exciting voltage is required and the microphone is inherently noisy. The reasons for their use are reasonable cost and high output. This is an advantage where a system must be inexpensive.

Of the above types, the crystal and dynamic microphones are most suitable and adaptable for public address installations. Their use is recommended wherever possible.

Where the microphone is subject to considerable handling while in operation a cushion mounting should be used between the microphone and microphone stand. This feature is incorporated in the design of some of the better type microphones, making an additional cushion unnecessary. Noise and disturbance, brought about by moving the microphone or adjusting the stand, are eliminated when a satisfactory cushion mounting is provided.

DECIBEL (db) TABLE

The decibel (d b) is accepted as the standard unit of measurement indicating power loss or gain. Zero d b (or level) is referred to as .006 milliwatts. When an amplifier is said to have an overall gain of 130 d b and a power output of +30 d b, full output will be delivered with an input of —100 d b. If the input level is somewhat greater, say, —80 d b, the d b gain of the amplifier is reduced by means of the volume control. Since all microphones, pickups, etc., are rated in d b, it is possible for the sound engineer to determine what gain is necessary in an amplifier for a specified power output by referring to the table below.

Power Level d b	Power* Ratio to 0 d b	Power Watts 6 Mw.=0 d b	Volts Across 500 Ohms	Power Level d b	Power* Ratio to 0 d b	Power Watts 6 Mw.=0 d b	Volts Across 500 Ohms
—10	0.1000	0.0006000	0.5477	20	100.000	0.60000	17.3205
— 9	0.1259	0.0007553	0.6145	21	125.89	0.75535	19.434
— 8	0.1585	0.0009509	0.6895	22	158.49	0.95093	21.805
— 7	0.1995	0.0011972	0.7737	23	199.53	1.19716	24.466
— 6	0.2512	0.0015071	0.8681	24	251.19	1.50713	27.451
— 5	0.3162	0.0018975	0.9740	25	316.23	1.89747	30.801
— 4	0.3981	0.0023886	1.0928	26	398.11	2.38865	34.559
— 3	0.5012	0.0030071	1.2262	27	501.19	3.0071	38.776
— 2	0.6310	0.0037857	1.3758	28	630.96	3.7857	43.507
— 1	0.7943	0.0047660	1.5437	29	794.33	4.7660	48.816
0	1.0000	0.0060000	1.7321	30	1000.00	6.0000	54.772
1	1.2589	0.0075535	1.9434	31	1258.9	7.5535	61.455
2	1.5849	0.0095093	2.1805	32	1584.9	9.5093	68.954
3	1.9953	0.0119716	2.4466	33	1995.3	11.9716	77.368
4	2.5110	0.0150713	2.7451	34	2511.9	15.0713	86.808
5	3.1623	0.0189747	3.0801	35	3162.3	18.9747	97.400
6	3.9811	0.0238865	3.4559	36	3981.1	23.8865	109.285
7	5.0119	0.030071	3.8776	37	5011.9	30.071	122.620
8	6.3096	0.037857	4.3507	38	6309.6	37.857	137.582
9	7.9433	0.047660	4.8816	39	7943.3	47.660	154.369
10	10.0000	0.060000	5.4772	40	10000.0	60.000	173.205
11	12.589	0.075535	6.1455	41	12589.2	75.535	194.34
12	15.849	0.095093	6.8954	42	15848.9	95.093	218.05
13	19.953	0.119716	7.7368	43	19952.6	119.716	244.66
14	25.119	0.150713	8.6808	44	25118.9	150.713	274.51
15	31.623	0.189747	9.7400	45	31622.8	189.747	308.01
16	39.811	0.238865	10.9285	46	39810.7	238.865	345.59
17	50.119	0.30071	12.2620	47	50118.7	300.71	387.76
18	63.096	0.37857	13.7582	48	63095.7	378.57	435.07
19	79.433	0.47660	15.4369	49	79432.7	476.60	488.16
				50	100000.0	600.00	547.72

* Voltage Ratio is equal to the square root of the power ratio.

Tru-Fidelity

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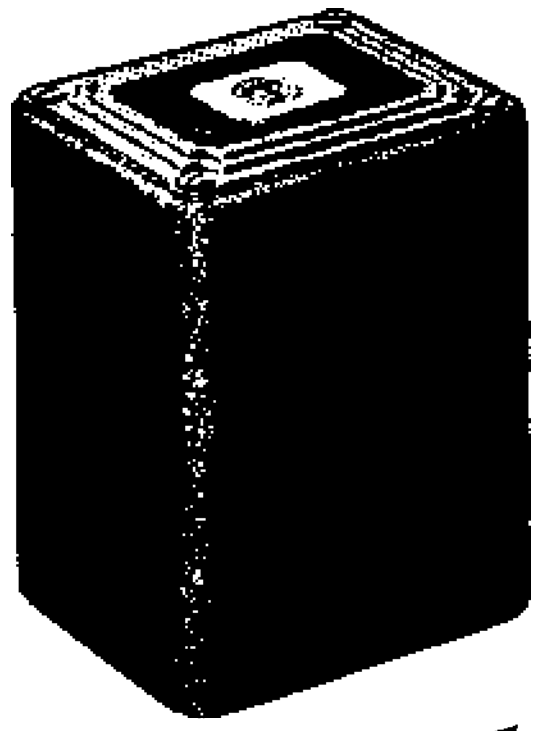

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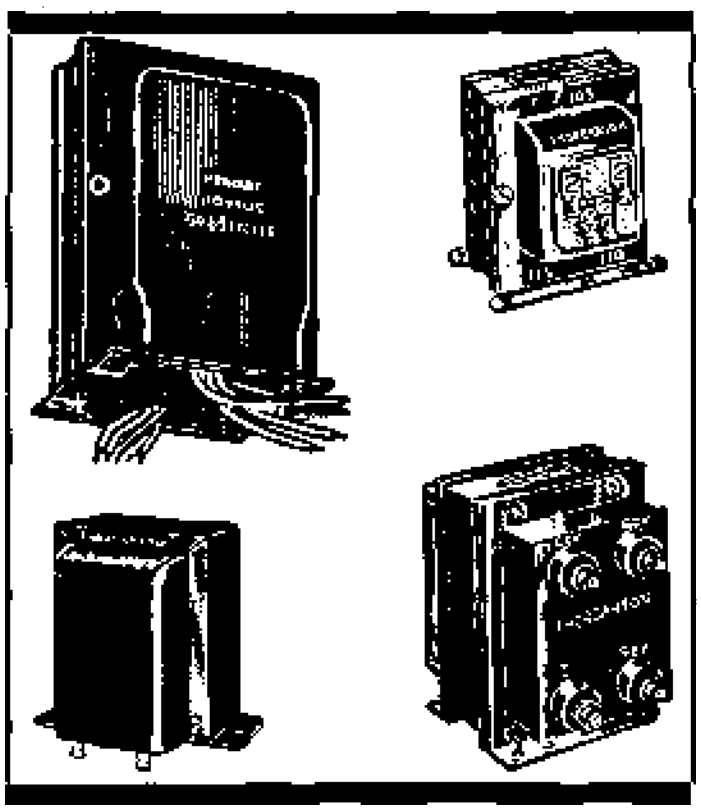

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