THE HAMMOND ORGAN

GENERAL DESCRIPTION
OPERATING INSTRUCTIONS
AND
CIRCUIT DIAGRAMS

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1/59

THEORY OF OPERATION

The console of the Hammond Organ contains the entire tone-producing mechanism, which is completely electrical in operation. Within it are produced all the tones and tone combinations of the organ. The electrical waves are made audible, as music, by one or more tone cabinets containing suitable amplifiers and loud speakers. The block diagrams (Figures 13 and 14) show the chief components of the instrument.

Electrical impulses of various frequencies are produced within a unit known as the "tone generator", containing a number of "phonic wheels" or "tone wheels" driven at predetermined speeds by a motor and gear arrangement. Each phonic wheel is similar to a gear, with high and low spots, or teeth, on its edge. As the wheel rotates these teeth pass near a permanent magnet, and the resulting variations in the magnetic field induce a voltage in a coil wound on the magnet. This small voltage, when suitably filtered, produces one note of the musical scale, its pitch or frequency depending on the number of teeth passing the magnet each second.

A note of the organ, played on either manual or the pedal keyboard, generally consists of a fundamental pitch and a number of harmonics, or multiples of the fundamental frequency. The fundamental and eight harmonics available on each playing key are individually controllable by means of drawbars and preset keys or buttons. By suitable adjustment of these controls the player is enabled to vary the tone colors at will.

The resulting signal passes through the expression or volume control and through the preamplifier (where vibrato is introduced) to the tone cabinet. Here reverberation is added electrically and a power amplifier feeds the signal into loud speakers.

DESCRIPTION

A Hammond Organ console (Fig. 2) includes two manuals or keyboards: the lower, or Great, and the upper, or Swell, and a pedal keyboard of 25 keys. The concert models have a 32-key pedalboard and are constructed to A.G.O. specifications. Various controls have appeared on different models. The operation of these controls is covered in the following paragraphs.

STARTING THE ORGAN

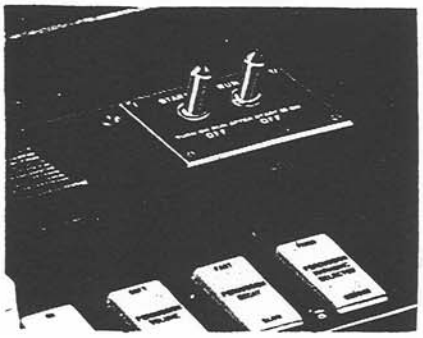


FIGURE 1

To start the organ, hold the "start" switch (Fig. 1) in "on" position for approximately eight seconds. Still holding it, push the "run" switch to "on" position. After leaving both switches on for about four seconds, release the start switch to return to its normal position.

If the console is very cold, or if a frequency regulator is used, it may be necessary to hold the start switch slightly longer.

THE
CONCERT MODEL
HAMMOND
ORGAN

THE
HOME MODEL
HAMMOND
ORGAN

FIGURE 2

PRESET KEYS

At the left end of each manual are twelve keys identical to the playing keys except reversed in color. (Fig. 3). These are replaced by twelve numbered buttons on the Model E console.

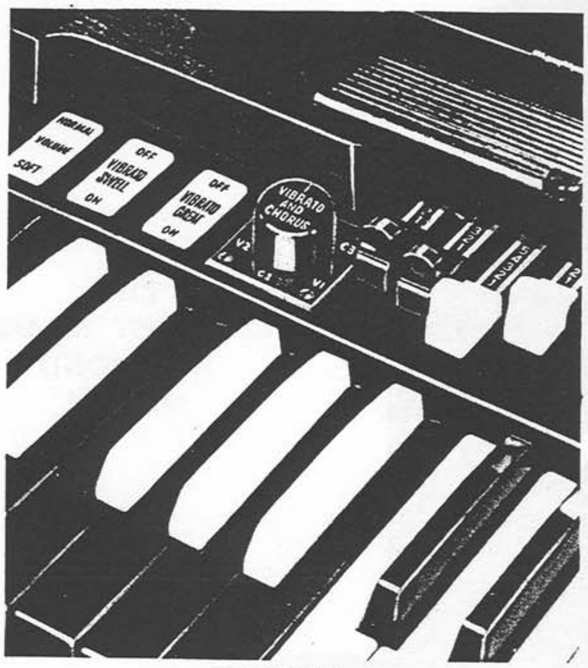


FIGURE 3

When a preset key is depressed it locks down and is released only when another is depressed. The exception to this is the cancel key at the extreme left, which serves only to release any key which may be locked down. Only one preset key is used at one time. If by mistake two are depressed and locked, they may be released by means of the cancel key.

Each preset key, with the exception of the cancel key and the two adjust keys at the extreme right of the group, makes available a different tone color which has been set up on the preset panel located inside the console. These tone colors are set up at the factory in accordance with a standard design which has been found to best meet the average organist's requirements. They may be changed, if desired, by removing the back of the console and changing the preset panel connections in accordance with instructions on a card located near the preset panel.

When either adjust key is depressed, the organ speaks with whatever tone color is set up on the harmonic drawbars associated with that key. The percussion effect on Models B-3, C-3, RT-3 is introduced when the upper manual 'B' preset key is depressed (see "percussion" also).

HARMONIC DRAWBARS

Each console has four sets of harmonic drawbars, two for each manual. Figure 4 shows one group of harmonic drawbars, by which the organist is enabled

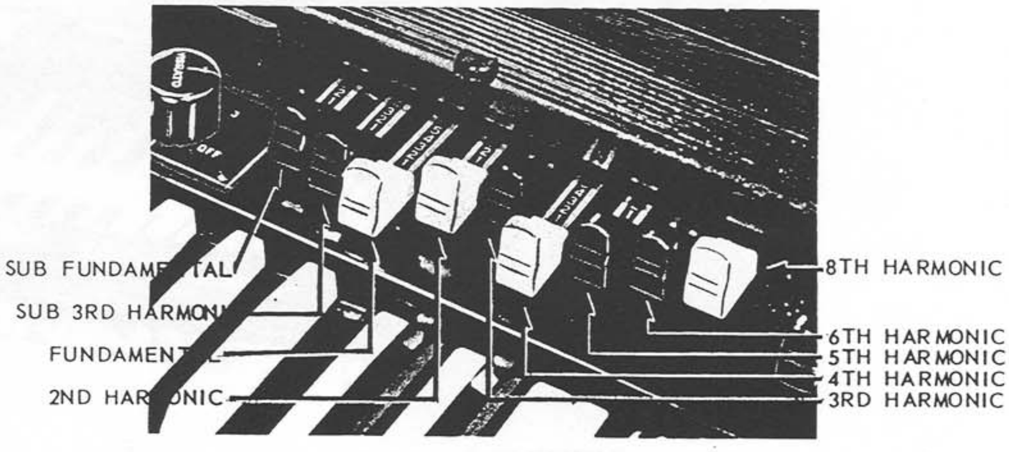


FIGURE 4 ONE HARMONIC DRAWBAR GROUP

to mix the fundamental and any, or all, of eight different harmonics in various proportions. The third bar from the left controls the fundamental, and each of the other bars is associated with a separate harmonic. If a drawbar is set all the way in, the harmonic it represents is not present in the mixture.

Each drawbar may be set in eight different positions by the organist in addition to the silent position. Each position, as marked on the drawbars, represents a different degree of intensity of the harmonic it controls. When drawn out to position 1, the harmonic it represents will be present with minimum intensity, when drawn out to position 2, with greater intensity, and so on up to position 8.

A tone color is logged by noting the numerical position of the various drawbars. For instance, the tone set up on Figure 4 is known as tone 34 630 5210. After a tone is so logged it may be made available again by setting the harmonic drawbars to that number.

The drawbars in earlier consoles have distinct intensity positions with silent spots between them. Later consoles are equipped with "continuous contact" drawbars which move smoothly with no interruption in tone.

HARMONIC DRAWBARS FOR THE PEDALS
(All models except Model M series)

In the pedals the harmonic resources have been combined into two drawbars which may be used separately or in combinations. When the left drawbar is used emphasis is given to the lower harmonics, and similarly the higher harmonics are emphasized when the right drawbar is used. The pedal drawbars are located between the two sets of manual drawbars.

PEDAL TOE PISTONS - MODEL E CONSOLE

FIGURE 5

Four pedal toe pistons are located to the left of the expression pedals. Numbers one and two of these pistons are pedal presets. The third is a Great-to-Pedal coupler, which makes the pedals speak with whatever 8 foot tone is set up on the Great manual. The left pedal drawbar may be used with the coupler to add 16 foot tone. The fourth piston connects the pedals to the two pedal drawbars.

Lighted piston indicators are provided on the left side of the console just above the Swell manual. Each time a toe piston is depressed, the proper indicator is automatically illuminated so the organist always knows which toe piston is depressed.

PEDAL SOLO UNIT - MODELS RT, RT-2 AND RT-3

A pedal solo unit is incorporated in the concert Models with prefix "RT" to provide a series of bright pedal solo tones in addition to the usual pedal accompaniment tones available on other models. The pedal solo tones, generated by a vacuum tube oscillator circuit, are controlled by a volume control knob and eight tilting stop tablets located at the right end of the Great manual (Fig. 5). One tablet turns all the pedal solo tones on or off and the others provide various pitch registers and tone colors. The pedal solo unit is independent of the electromagnetic tone generator and can be turned off without affecting the remainder of the organ.

NORMAL - SOFT VOLUME CONTROL
(Models B-2, B-3, C-2, C-3, RT-2, RT-3)

This control (Fig. 3) is a tilting tablet which supplements the action of the expression pedal. In "soft" position it reduces the volume of the whole instrument. It is particularly useful when playing in a small room or when the organist wishes to practice without disturbing others.

CHORUS CONTROL
(Models BC, BCV, D, DV, E)

On these models an extra generator known as a chorus generator will be found. To use the tones generated by this unit at will, one extra black drawbar has been added which operates a switch located on the generator. The drawbar labeled "chorus" is located at the right-hand end of the console. (Fig. 6)

When the organ is played with the chorus drawbar pushed in (the "off" position) it operates in exactly the same way as though no chorus were included. Pulling the drawbar out (to the "on" position) instantaneously adds the ensemble or chorus effect to whatever is being played. Actually it adds a series of slightly sharp and slightly flat tones to the true tones produced by the main generator. The resulting electrical wave contains a complex series of undulations which enhance the pleasing effect of many tone qualities, notably string and full organ combinations.

The chorus control should not be confused with the "vibrato chorus" effect, described under "vibrato". The two effects are similar musically, but are produced by completely different means.

EXPRESSION OR SWELL PEDAL

The swell pedal, located in the customary position, is operated by the right foot and with it the volume of the organ may be controlled over a wide range. It operates on the two manuals and pedals equally; that is to say, once the manuals and pedals are balanced, they retain their relative balance over the entire swell pedal range.

Two expression pedals are provided for the Model E Console. Both are equipped with adjustable clamps to regulate the tension and the distance through which they move. Adjustable pedal indicators, operated by wires from the rheostat box, are located at the extreme right side of the console above the Swell manual.

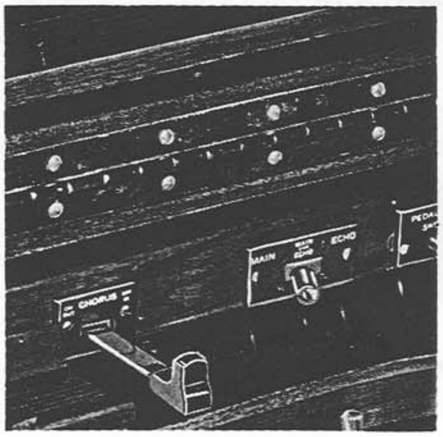


FIGURE 6

ECHO SWITCH

Located above the starting and running switches on some consoles is the "echo switch" (Fig. 6). With this switch it is possible to use two tone cabinets and have either cabinet or both speak, depending on the position of the switch. Generally one tone cabinet is placed rather distant from the console and is called the "echo organ". This feature can be added to a Hammond Organ by installation of an "Echo switch kit".

TREMULANT

The tremulant or tremolo is a periodic variation in intensity of all tones without change in pitch. It is produced by a variable resistance driven by the motor of the main tone generator, and is controlled by a variable resistor in shunt. When the tremulant control is turned as far as possible to the left, the tremulant is entirely off. As it is turned to the right (clockwise) the degree of tremolo gradually increases until it reaches a maximum at the extreme right position. The white dot marker on the knob indicates at a glance the degree of tremolo present. Two tremulant controls are used on the Model E console, one for each manual. These are controlled by separate levers located on the console.

The tremulant is not incorporated in models having vibrato.

VIBRATO

FIGURE 7

The vibrato effect is created by a periodic raising and lowering of pitch, and thus is fundamentally different from a tremolo, or loudness variation. It is comparable to the effect produced when a violinist moves his finger back and forth on a string while playing, varying the frequency while maintaining constant volume.

The vibrato mechanism includes an electrical time delay line, which shifts the phase of all tones fed into it. A rotating scanner, mounted on the main tone generator, picks up successive signals from various line sections. These signals represent various amounts of phase shift, and the combination of signals produces a continuous frequency variation.

When the "vibrato chorus" switch (Fig. 7) (Models AV, BV, BCV, CV, DV, and RT) is pushed to the left, normal vibrato is obtained with the vibrato switch in positions 1, 2, or 3. When the lever is pushed to the right a chorus or ensemble effect, combining foundation organ tone with vibrato tone, is obtained. The center position of this switch is not intended to be used. No harm will result from leaving the switch in this position, but reduced volume will be obtained.

Models B-2, B-3, C-2, C-3, RT-2 and RT-3 have the "selective vibrato" feature which makes the vibrato effect available on either manual separately or on both together. Two tilting tablets (Figure 3) control the vibrato for the two manuals, while the rotary switch selects the degrees of vibrato or vibrato chorus effect. The "Great" tablet controls the vibrato for the pedals as well as for the Great manual.

The vibrato is not present on models having the tremulant.

PERCUSSION

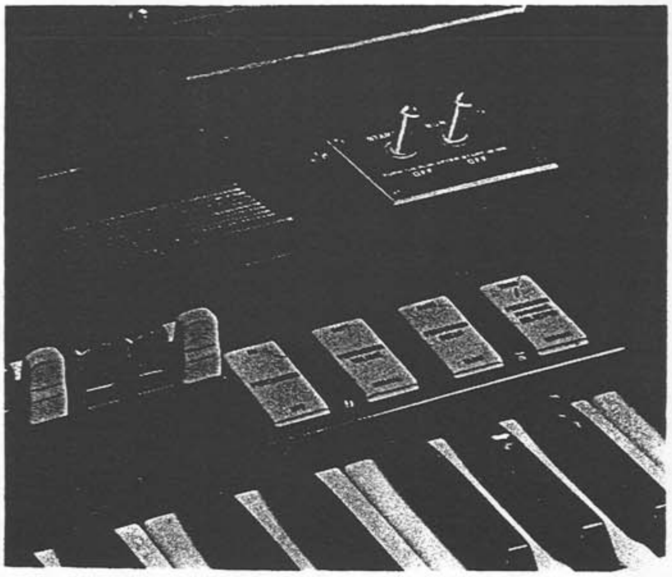


FIGURE 8

The Percussion feature (Models B-3, C-3 and RT-3) is controlled by four tilting tablets (Fig. 8) at the upper right side of the manuals. Percussion is available only on the upper manual and only when the 'B' preset key is depressed. The four tablets (from left to right) select Percussion on or off, normal or soft Volume, fast or slow Decay, and second or third Harmonic tone quality.

Percussion tones are produced by borrowing the second or third harmonic signal from the corresponding manual drawbar, amplifying it, returning part of the signal to the same drawbar, and conducting the balance of the signal through push-pull control tubes where its decay characterics are controlled.

The Percussion signal is then combined with the signal from the manuals after the vibrato but before the expression control. The control tubes are keyed through the eighth harmonic key contacts and busbar.

TONE GENERATOR

The main tone generator furnishes 82 or 91 different musical frequencies, depending on the console model. It includes a tone wheel, magnet, and coil for each frequency. Mounted on top of the generator are tuned filters to insure purity of the tones.

PREAMPLIFIER

The preamplifier is located in the console. Several types have been used in the various console models. Some obtain their plate voltage from the power amplifier through the console-to-cabinet cable, while others have a self-contained power supply.

TONE CABINETS

Tone cabinets are made in a number of models differing in size, finish, and power output. The numbers 20 and 40 in the model designations indicate the nominal power output in watts. Each tone cabinet includes one or two power amplifiers and two or more speakers.

Cables of special design are used to connect the console to the tone cabinet or cabinets.

REVERBERATION CONTROL

Tone cabinets having the letter R within the model designation are equipped with the Hammond Reverberation Control. This is an electro-mechanical device designed to supply reverberation for installations that are accoustically "dead" or have insufficient natural reverberation. A portion of the musical signal is delayed by passing through fluid-damped coil springs and then combined with the direct signal. By adjustment of the amount of delayed signal the reverberation characteristics of large or small enclosures may be simulated. A tone cabinet having this unit must be handled in accordance with directions on the instruction card in order to avoid damaging the unit or spilling the fluid.

ROTOR TREMULANT

Tone cabinets having the letter X in their model designation contain a drum rotor mounted above the speakers and driven by a small motor. Rotating in the path of sound from the loud speakers, it produces the effect of a periodic volume and pitch variation in all tones of the organ.

A switch for controlling its operation can be mounted on the tone cabinet, or an additional cable with a switch located at the console may be used.

When a console having the Hammond Vibrato is connected to this type cabinet, use of the rotor tremulant is not recommended.

WIRING DIAGRAMS

Figures 9 through 12 are rear views of typical console models, showing the locations of components.

Figures 15 to 25 show circuits and details of electrical connections for various models.

INSTALLATION AND MAINTENANCE

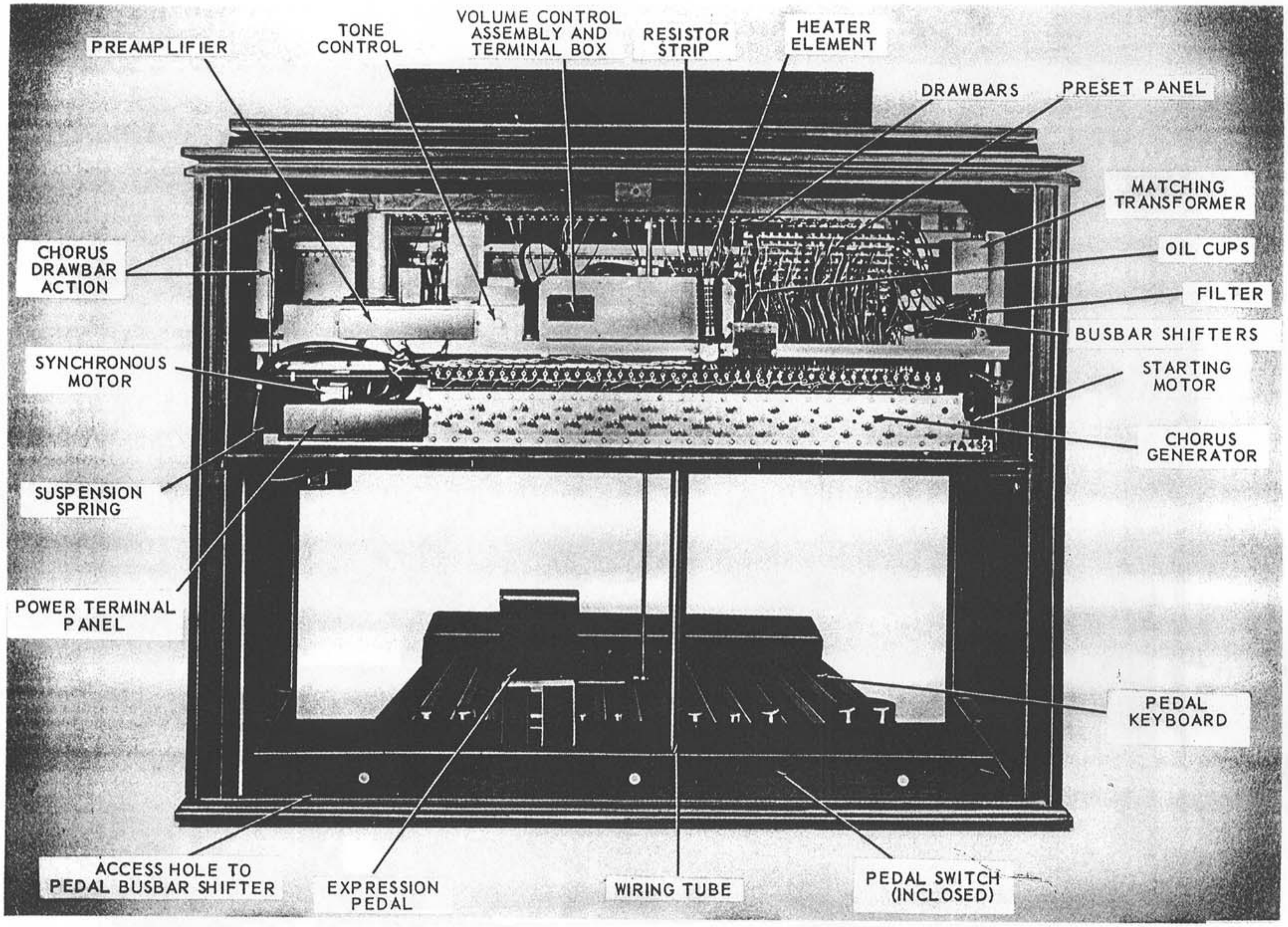
The organ must be connected to a regulated-frequency source of the voltage and frequency specified on the name plate. If the frequency is not regulated the pitch of the organ will be irregular.

When a console is set up for operation the anchoring must be loosened so that the generator will float freely on its spring suspension system. No damage will result if this is not done, but the console will sound noisy, and the same is true if the anchoring is loosened but the console is not level. If the console is to be moved a long distance the anchoring should be tightened during such moves.

Several different types of anchoring have been employed and instructions for loosening and tightening the generator in any particular console are given on the instruction card contained in the bench which accompanied that console.

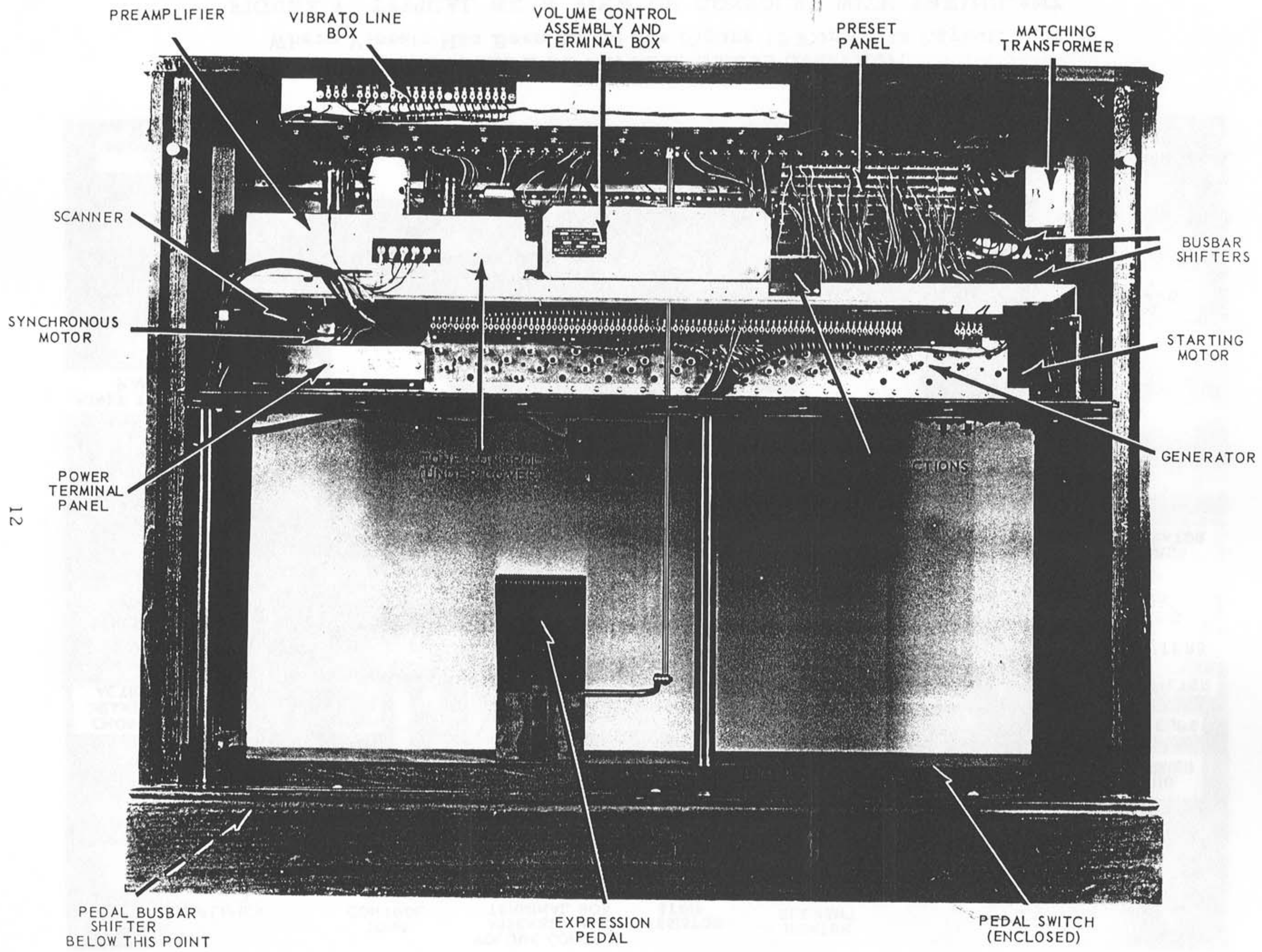
Each power amplifier has anchoring which should be loosened on installation and tightned for shipping. If the cabinet has a reverberation unit, it should be locked before moving the cabinet and the fluid should be removed as instructed on the card attached to the tone cabinet.

The tone generator is lubricated by putting oil into cups inside the console. It is recommended that each cup be filled three-fourths full, (1 tablespoon) once a year, using only the oil recommended for this purpose.



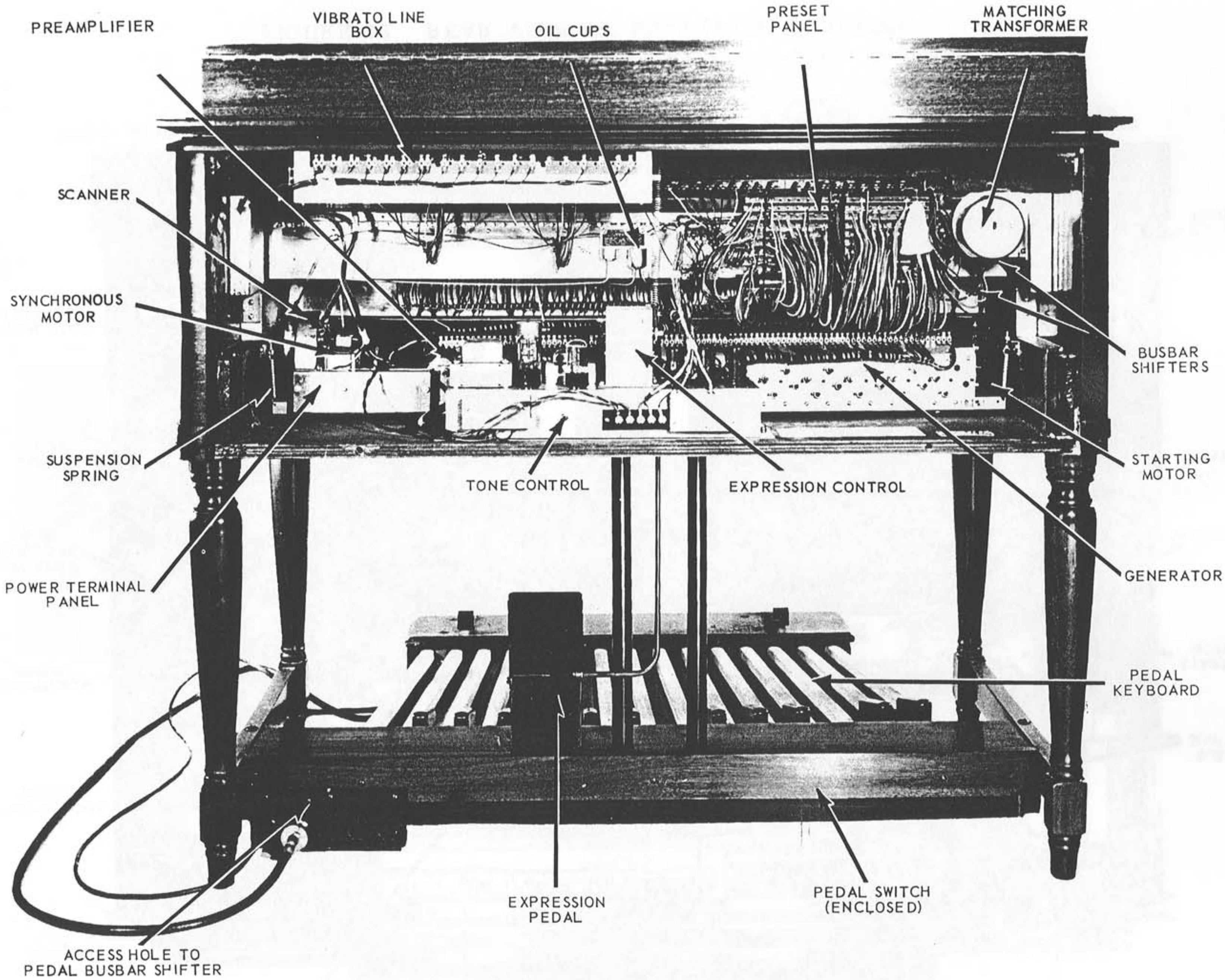
Models A and B Do Not Have Chorus Generator.
Where Vibrato Has Been Added See Figure 10 For Parts Layout.

FIGURE 9 TYPICAL REAR VIEW OF CONSOLES WITH TREMULANT.



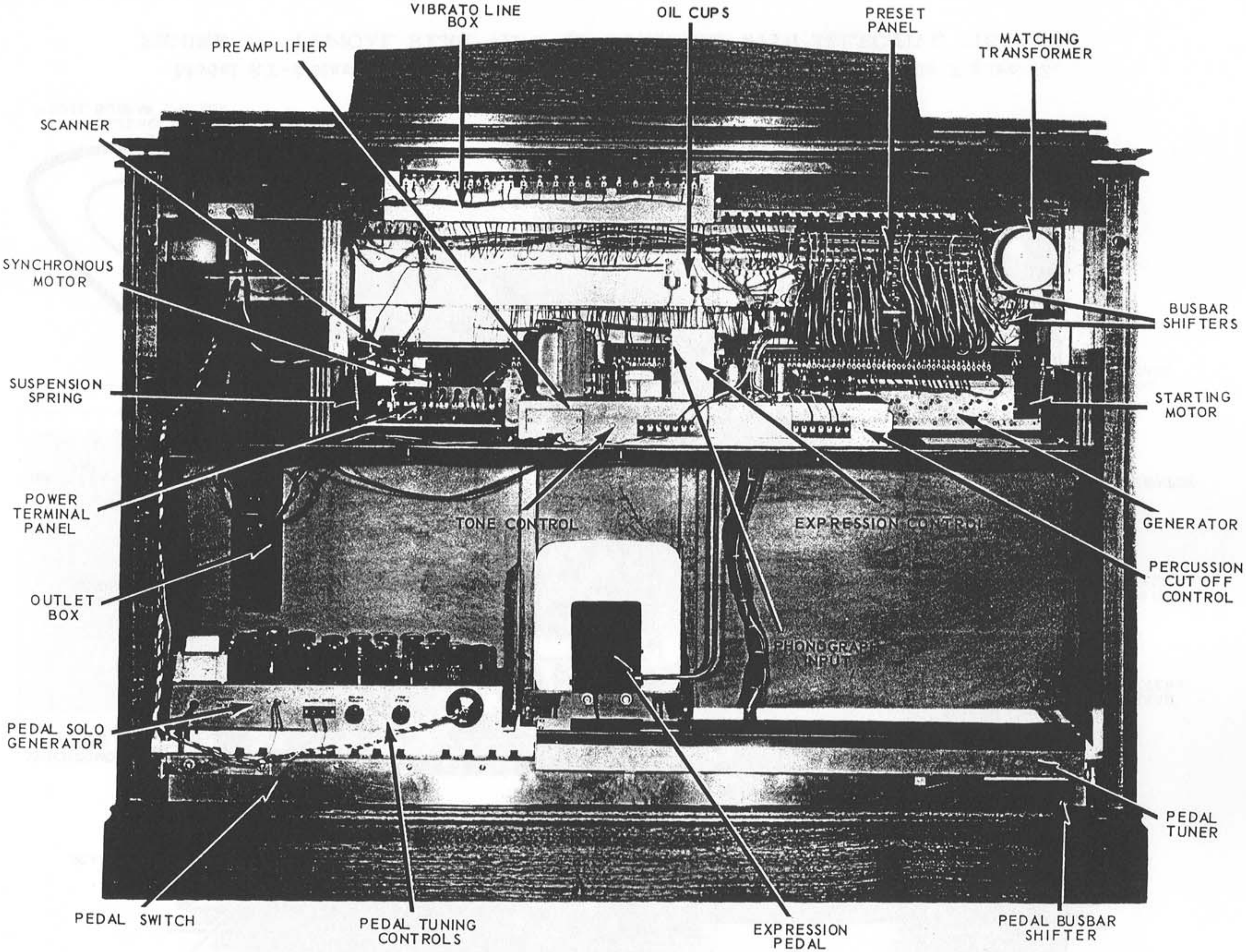
Model RT Has Wider Case, 32 Pedals and Pedal Solo Shown In Figure 12.

FIGURE 10 TYPICAL REAR VIE" OF CONSOLES WITH VIBRATO.



Model RT-2 Has Wider Case, 32 Pedals and Pedal Solo Unit Shown In Figure 12.

FIGURE 11 TYPICAL REAR VIEW OF CONSOLES WITH SELECTIVE VIBRATO.



Models B-3 and C-3 Have Narrower Cases, 25 Pedals, No Pedal Solo.

FIGURE 12 REAR VIEW OF RT-3 (WITH PERCUSSION).

THE HAMMOND ORGAN

The Amplification System

HAMMOND ORGAN COMPANY
4200 West Diversey Avenue
Chicago 39, Illinois

THE AMPLIFICATION SYSTEM

The electrical impulses which produce the tones of the Hammond Organ are given their original amplification by a preamplifier located in the console, and are then transmitted to the power amplifiers which are located in the tone cabinets. It will be noted that no power transformer is included in the preamplifiers shown in figures 1 through 9, the required plate current being supplied by the power amplifier in the first tone cabinet. Later models of preamplifiers have a complete power supply incorporated within them.

A tone control is included in all preamplifiers whereby the relative intensity of the high and low frequencies may be changed to suit acoustical conditions by varying the amplitude of the higher frequencies. On tremulant equipped consoles this control will be found under a screw cap located toward the right end of the chassis, while on consoles equipped with the Hammond Vibrato this tone control will be found under the cap marked "HI IMP INPUT." Selective vibrato consoles have the tone control located midway on the preamplifier chassis.

A microphone or phonograph pickup may be used with the organ if special circumstances make it desirable. On tremulant type consoles the input terminal, marked "P" on the preamplifier, goes through a screen by-pass condenser to the screen of the input tube. This terminal is normally grounded, and the input device should have an impedance of 500 ohms or less in order not to reduce the volume of the organ. A signal level of a volt or more is required to drive this point, and therefore it is suggested that the microphone or phonograph be connected through a suitable preamplifier having an output impedance of about 200 ohms.

On vibrato consoles the input terminal, located under the cap marked "HI IMP INPUT" on the preamplifier, goes to the grid of one input tube. This circuit has an input of 1 megohm impedance and requires an input signal of about 60 millivolts maximum.

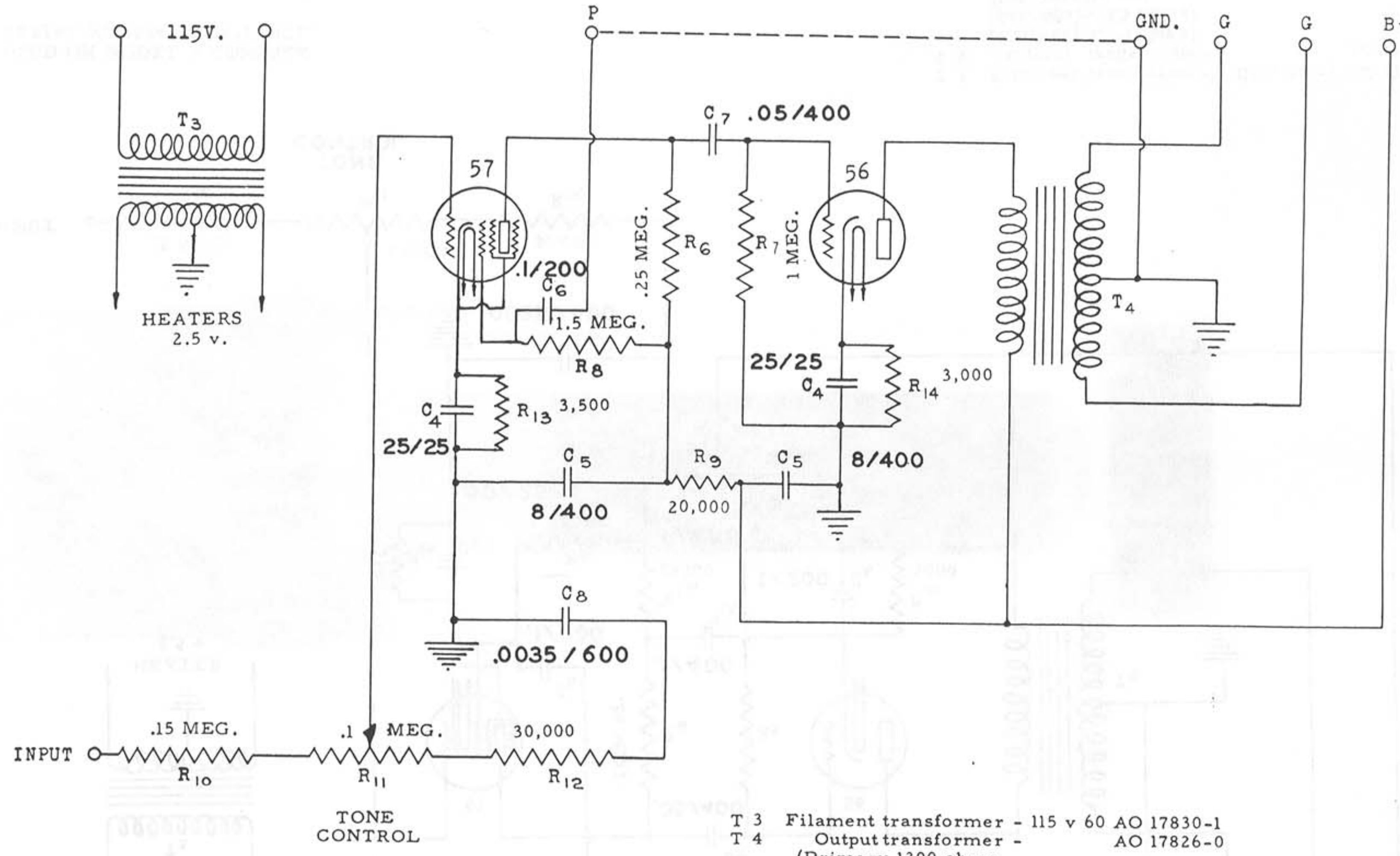
Most preamplifiers used on selective vibrato type consoles are equipped with a standard phonograph input jack. The input impedance is approximately 1 megohm and the circuit requires a maximum input signal of about 1/2 volt.

The push-pull signal line from the preamplifier output transformer to the tone cabinets has a total impedance of approximately 200 ohms. As it is connected directly to the grids of the power amplifier input tubes, practically any number of power amplifiers may be connected in parallel.

The section on cables and plugs shows methods of connecting amplifiers to the console.

Replacement parts, with the exception of resistors, condensers, and tubes, which are standard items and may be purchased from a radio supplier, should always be ordered from Hammond Organ Company. When ordering, specify the type and serial mumber of the console or tone cabinet.

When making tube replacement, output tubes in the amplifier should be checked for similar plate current readings. If tubes have been in service for a considerable length of time it is usually advisable to change all tubes at one time rather than to try to match new tubes to the old ones.



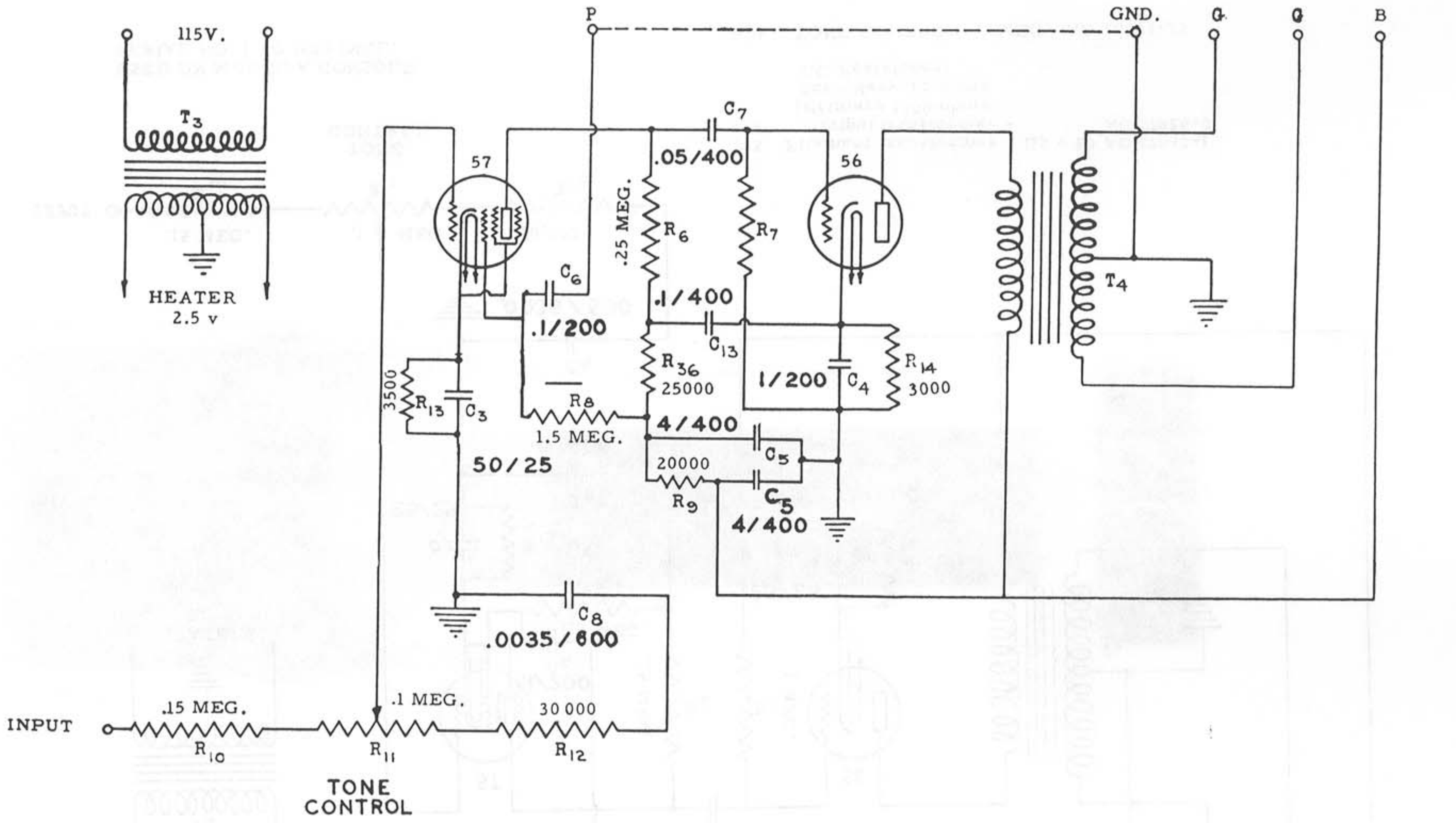
USED ON MODEL A CONSOLE
SERIAL NO. 1 TO 1573 INCL.

T 3 Filament transformer - 115 v 60 AO 17830-1
T 4 Output transformer - AO 17826-0
(Primary 1300 ohms
Secondary 1 5 ohms
DC Resistance)

R 11 TONE CONTROL .1 MEG. AO 20293-23

PRE-AMPLIFIER

FIGURE 1



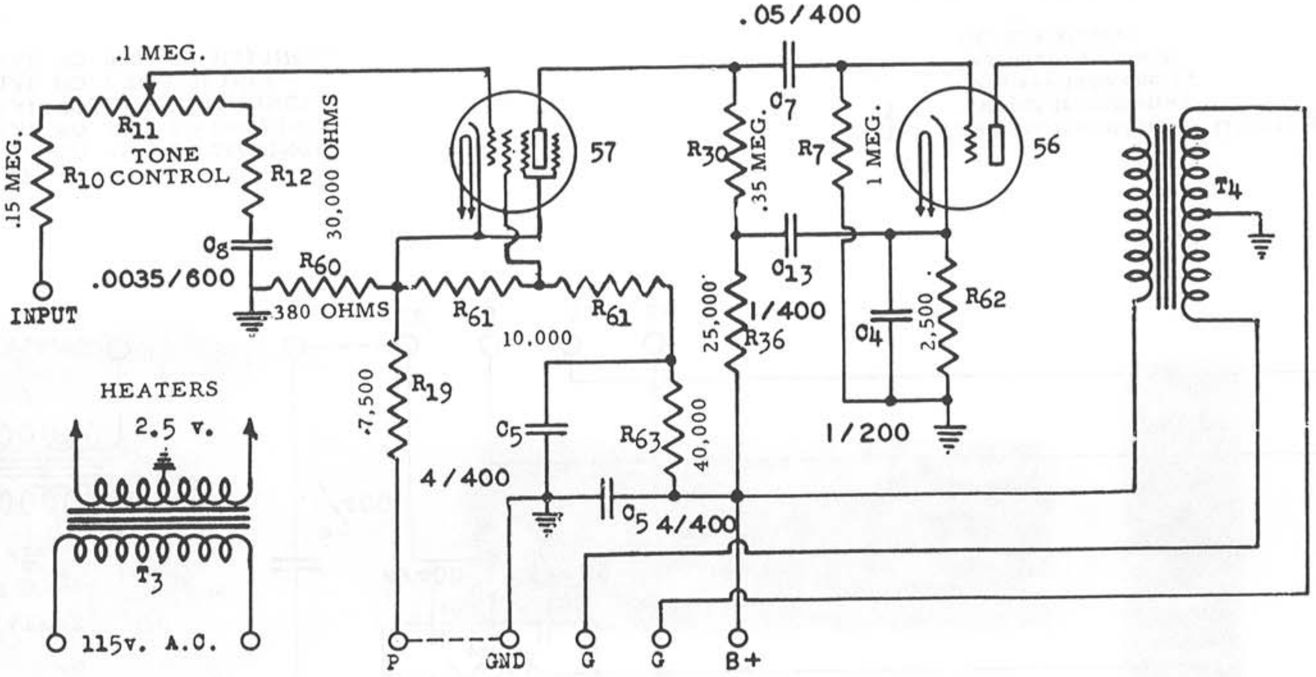
USED ON MODEL A CONSOLE
SERIAL NO.1574 TO 2451 INCL.

USED ON MODEL B CONSOLE
SERIAL NO. 4000 TO 5539 INCL.

-PRE-AMPLIFIER-
FIGURE 2

T 3 Filament transformer - 115 v 60 cy AO 17830-1
T 4 Output transformer - AO 17826-0
(Primary 1300 ohms)
(Secondary 15 ohms)
(DC Resistance)

R11 TONE CONTROL .1 MEG. AO 20293-23



USED ON MODEL A CONSOLE
SERIAL NO. 2452 TO 2559 INCL.

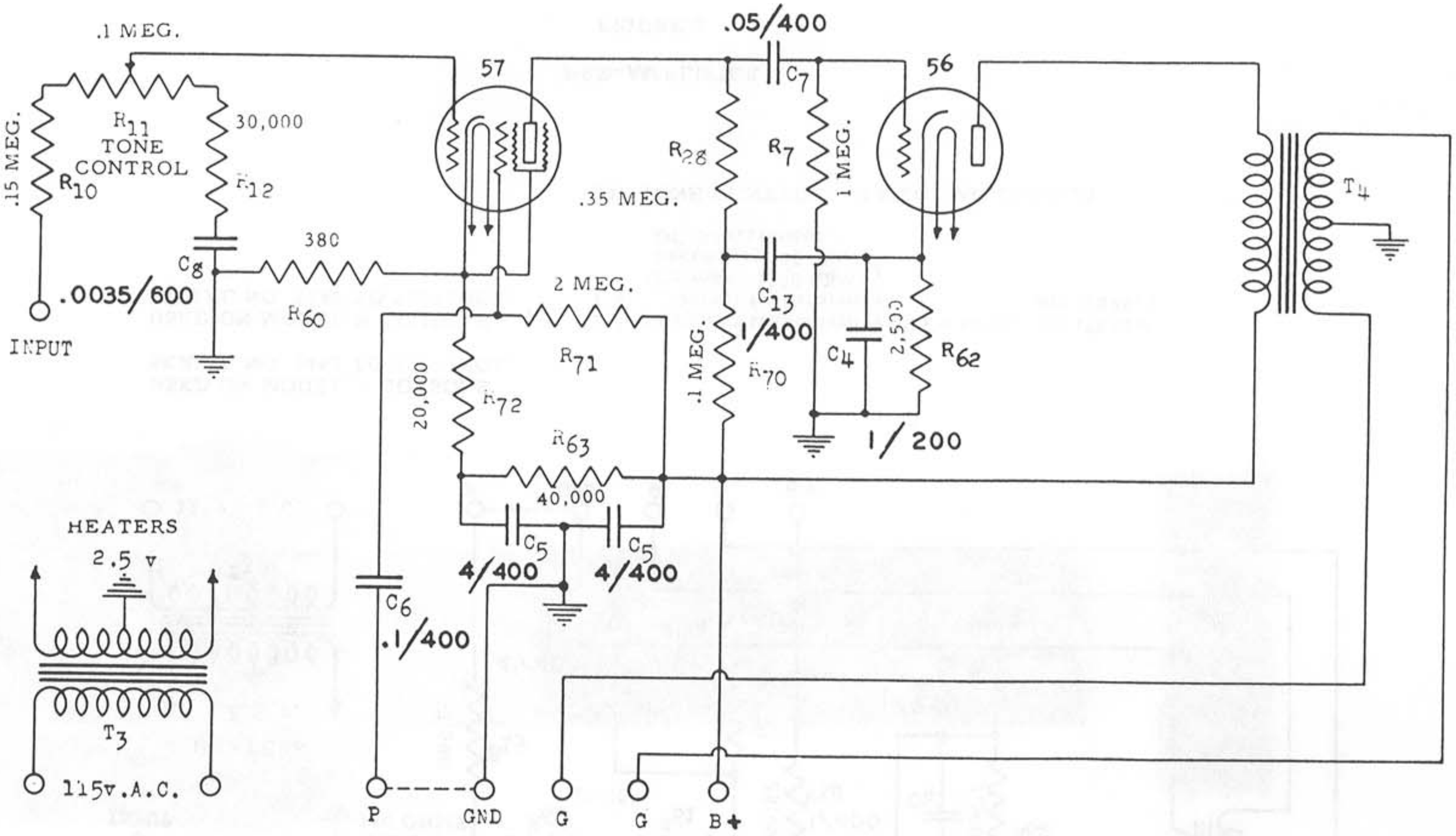
USED ON MODEL B CONSOLE
SERIAL NO. 5540 TO 5939 INCL.

T 3 Filament transformer 115 v 60 cy AO 17830-1
T 4 Output transformer AO 17826-0
(Primary 1300 ohms,
Secondary 15 ohms
DC Resistance)

R11 TONE CONTROL .1 MEG. AO 20293-23

PRE-AMPLIFIER

FIGURE 3

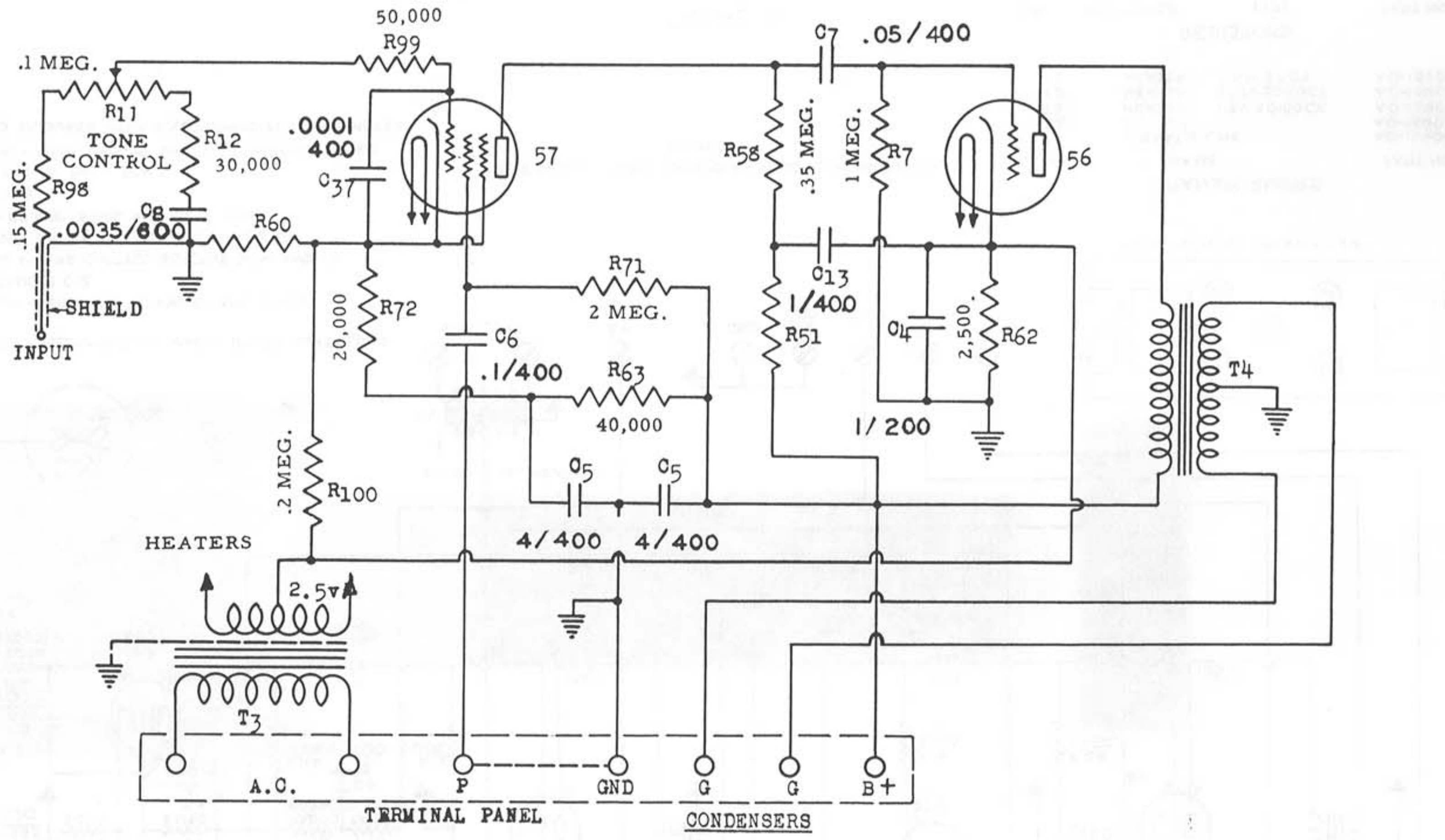


USED IN CONSOLES
MODEL A SERIAL NO. 2560 TO 2646 INCL.
MODEL B SERIAL NO. 5940 TO 10032 INCL.
MODEL C SERIAL NO. 1203 TO 1212 INCL.
MODEL D SERIAL NO. 1 TO 1208 INCL.
PLAYER SERIAL NO. 9000 TO 9123 INCL.

T 3 Filament transformer 115 v 60 cy AO 17830-1
T 4 Output transformer AO 17826-1
(Primary 1300 ohms,
Secondary 15 ohms
DC Resistance)

R 11 TONE CONTROL .1 MEG. AO 20293-23

PRE-AMPLIFIER
FIGURE 4



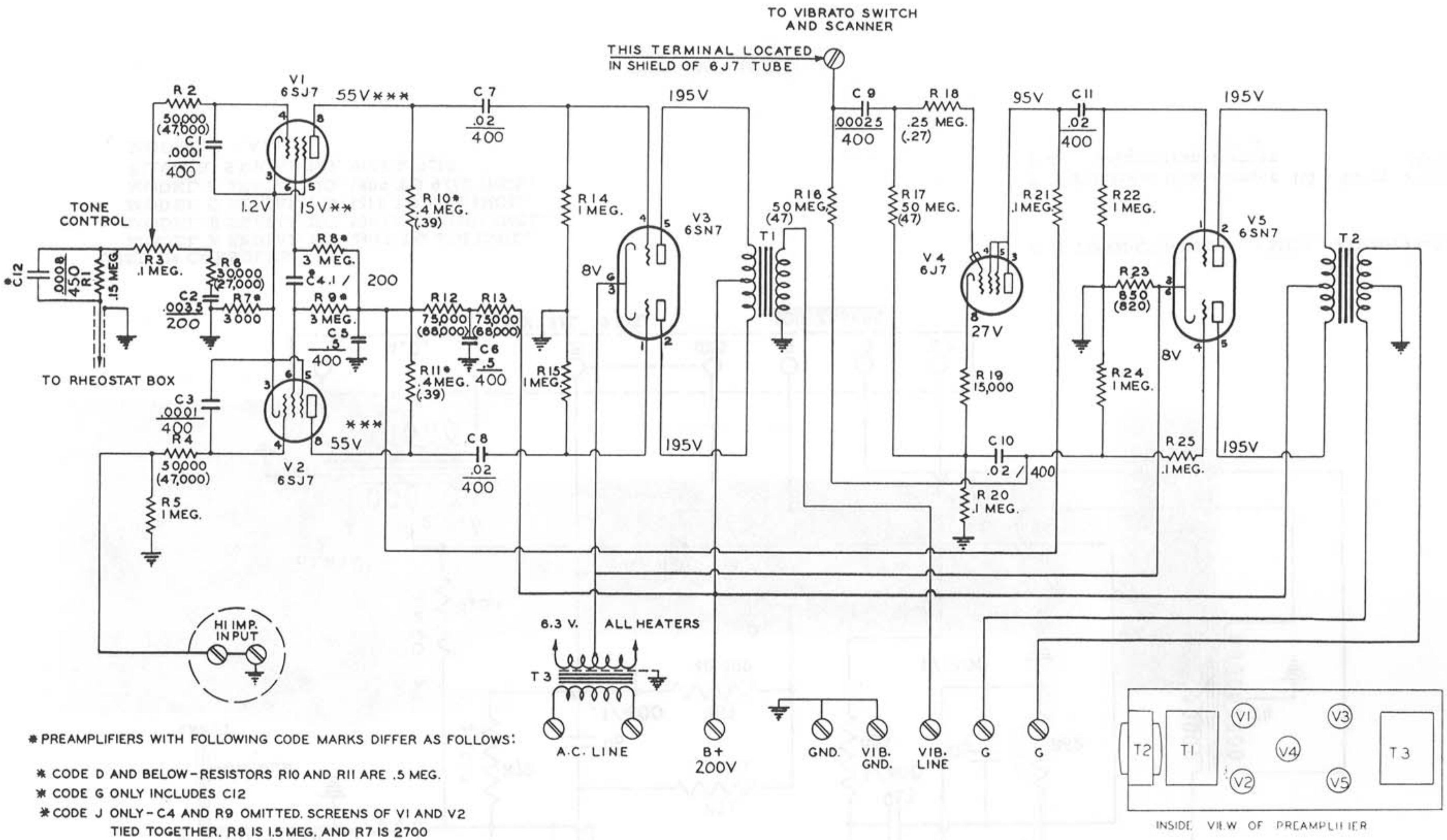
USED IN CONSOLES
MODEL A SERIAL NO. 2647 TO 2711 INCL.
MODEL B SERIAL NO. 10033 TO 11205 INCL.
MODEL C SERIAL NO. 1213 TO 1298 INCL.
MODEL D SERIAL NO. 1809 TO 9268 INCL.
PLAYER SERIAL NO. 9124 & 9210
MODEL G - ALL

R 11 TONE CONTROL .1 MEG. AO 20293-23

T 3 Filament transformer 115 v 60 cy AO 17830-1
T 4 Output transformer AO 17826-1

PRE-AMPLIFIER

FIGURE 5



* PREAMPLIFIERS WITH FOLLOWING CODE MARKS DIFFER AS FOLLOWS:

* CODE D AND BELOW-RESISTORS R10 AND R11 ARE .5 MEG.

* CODE G ONLY INCLUDES C12

* CODE J ONLY-C4 AND R9 OMITTED. SCREENS OF V1 AND V2 TIED TOGETHER. R8 IS 1.5 MEG. AND R7 IS 2700

* CODE K-R8 AND R9 ARE 1.8 MEG. AND R7 IS 3300

** CODE K ONLY 25V

*** CODE K ONLY 30V ON 250V SCALE

ALL VOLTAGES ARE + FROM GROUND UNLESS OTHERWISE NOTED

ALL DC VOLTAGES MEASURED WITH 20,000 OHMS-PER-VOLT METER

USED IN ALL VIBRATO CONSOLES, MODELS AV, BV, BCV, CV, DV, AND RT

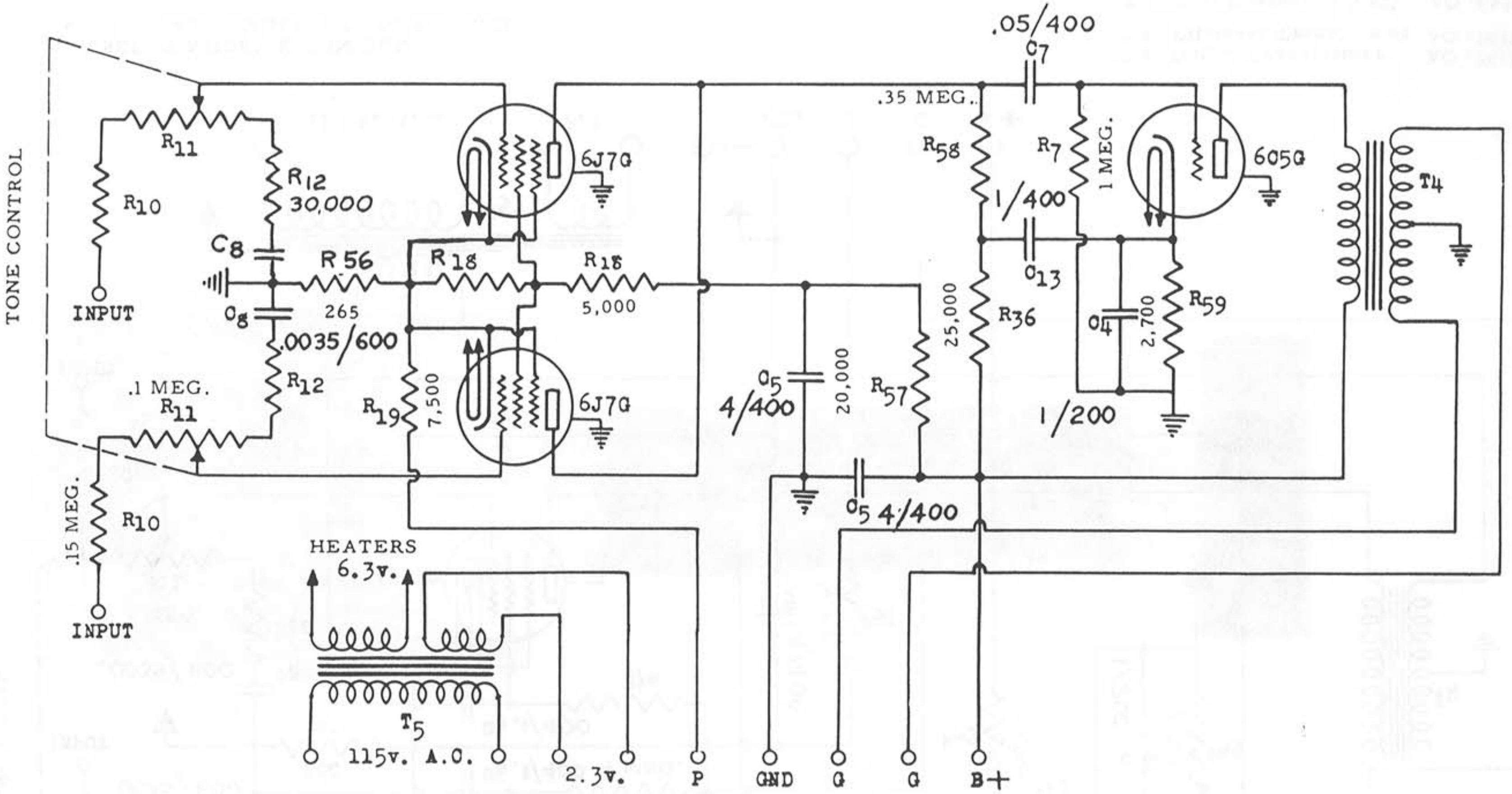
FIGURE 6

TRANSFORMERS

NO.	NAME		PART NO.
T1	VIBRATO LINE		AO-16906-1
T2	OUTPUT		AO-16906-2
T3	HEATER	115V. 50-60CY.	AO-16907-1
T3	HEATER	230V. 50-60CY.	AO-16907-2
T3	HEATER	115 V. 25CY.	AO-16907-3

RESISTORS

NO.	RESISTANCE	TYPE	PART NO.
R3	.1 MEG.	VARIABLE	AO-16532-0

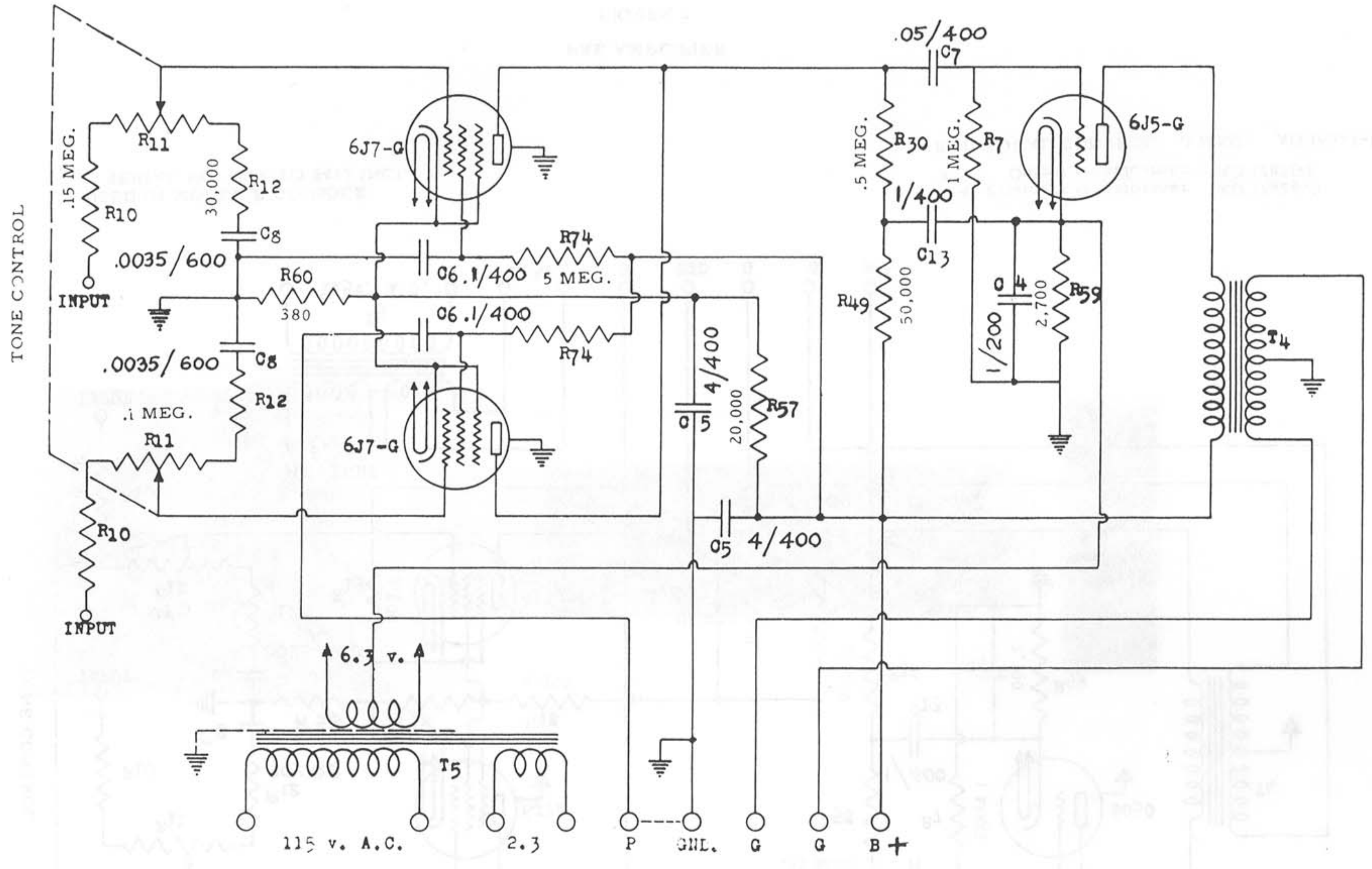


USED IN MODEL E CONSOLE
SERIAL NO. 8000 TO 8472 INCL.

T 4 Filament transformer AO 17826-0
T 5 Output transformer AO 17831-1
R 11 DUAL CONTROL .1 MEG. AO 16533-0

PRE AMPLIFIER

FIGURE 7

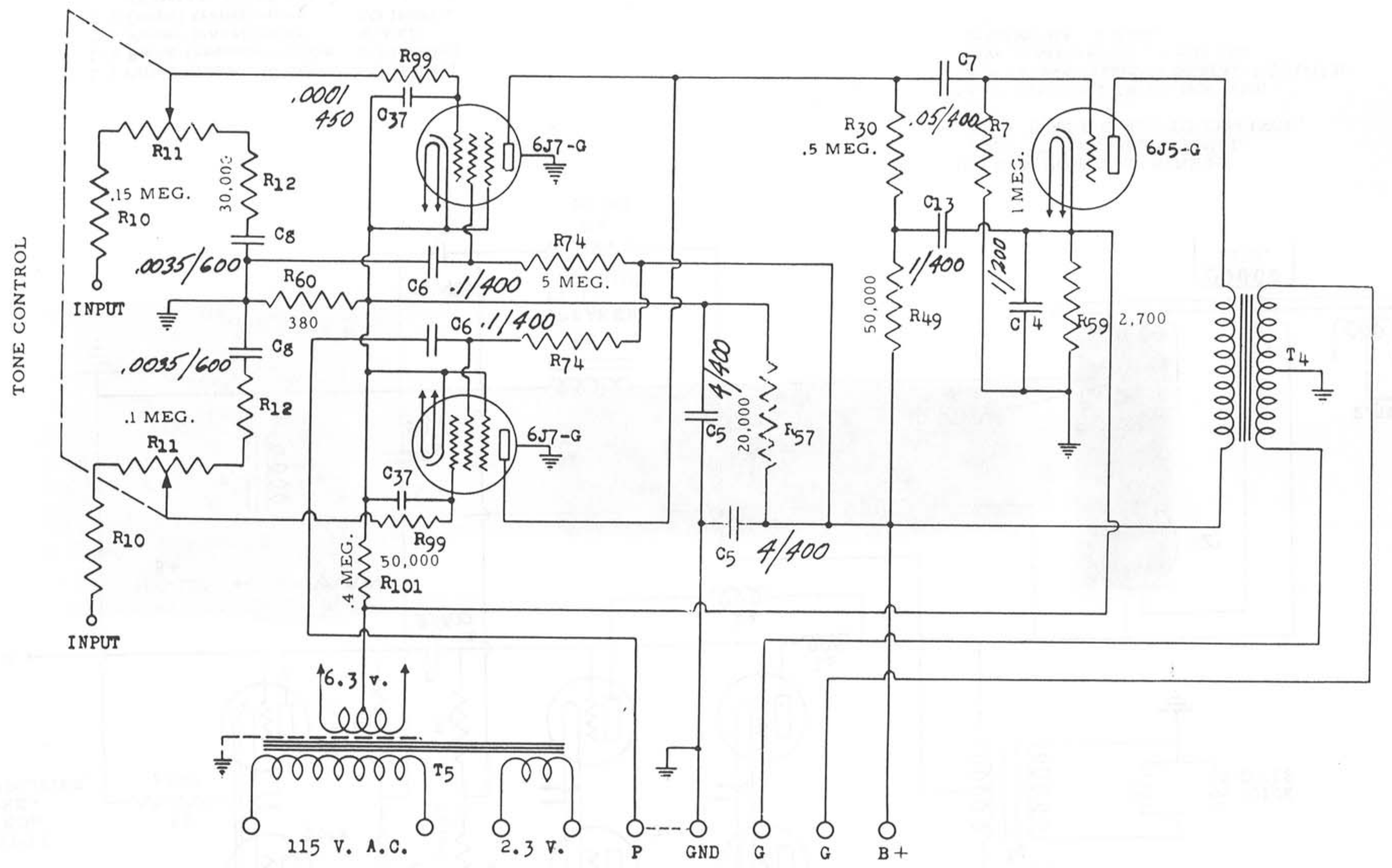


USED IN MODEL E CONSOLE
SERIAL NUMBER 8473 TO 8561 INCL.

T 4 Output Transformer AO 17826-0
T 5 Filament Transformer AO 17831-1
R 11 Dual Control .1 MEG. AO 16533-0

PRE AMPLIFIER

FIGURE 8

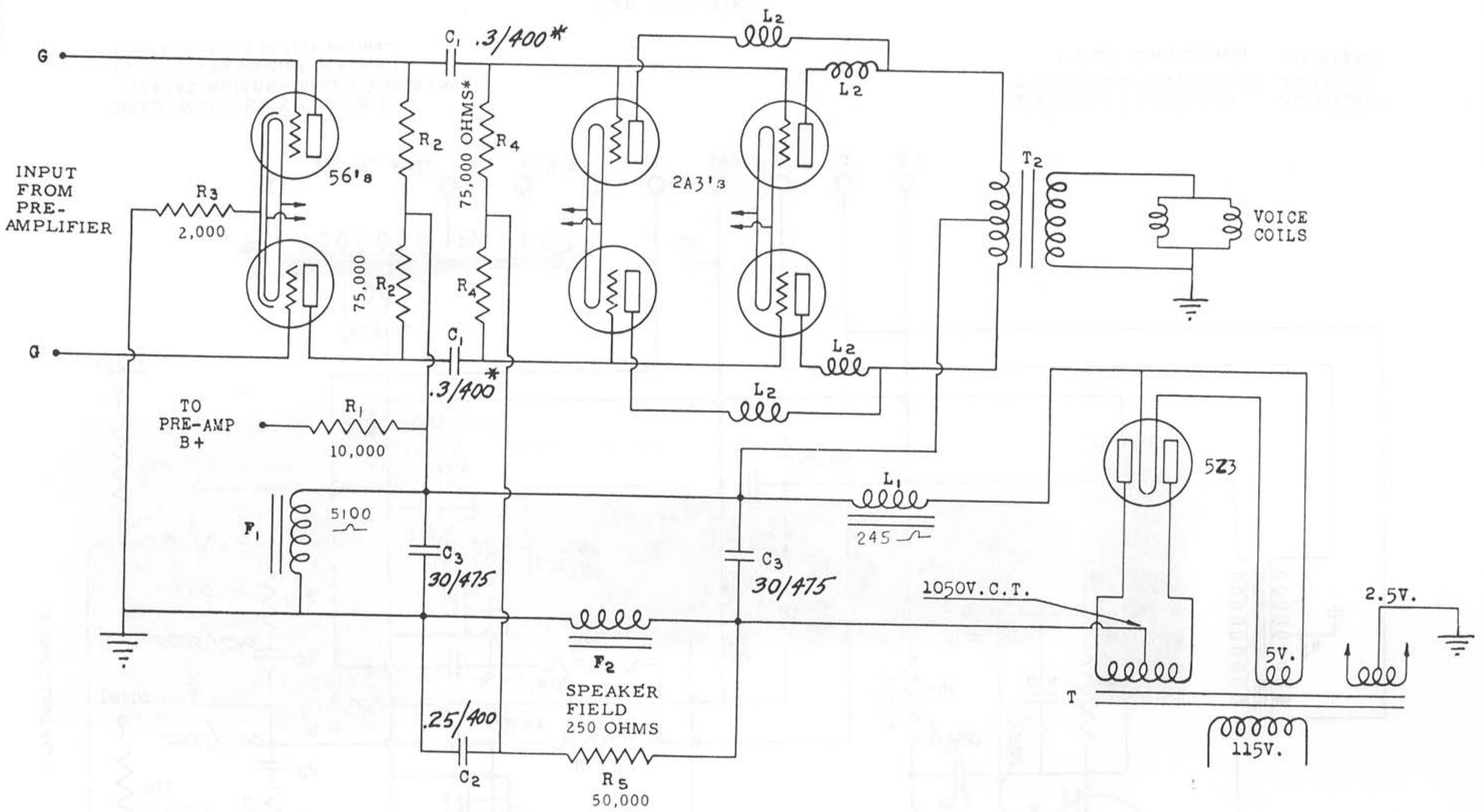


USED IN MODEL E CONSOLE
SERIAL NUMBER 8562 TO 8739 INCL.
(C 37 & R 99 omitted in early)
(pre amplifiers of this series.)

T 4 Output Transformer	AO 18726-0
T 5 Filament Transformer	AO 17831-1
.1 MEG. Dual Control	AO 16533-0

PRE AMPLIFIER

FIGURE 9



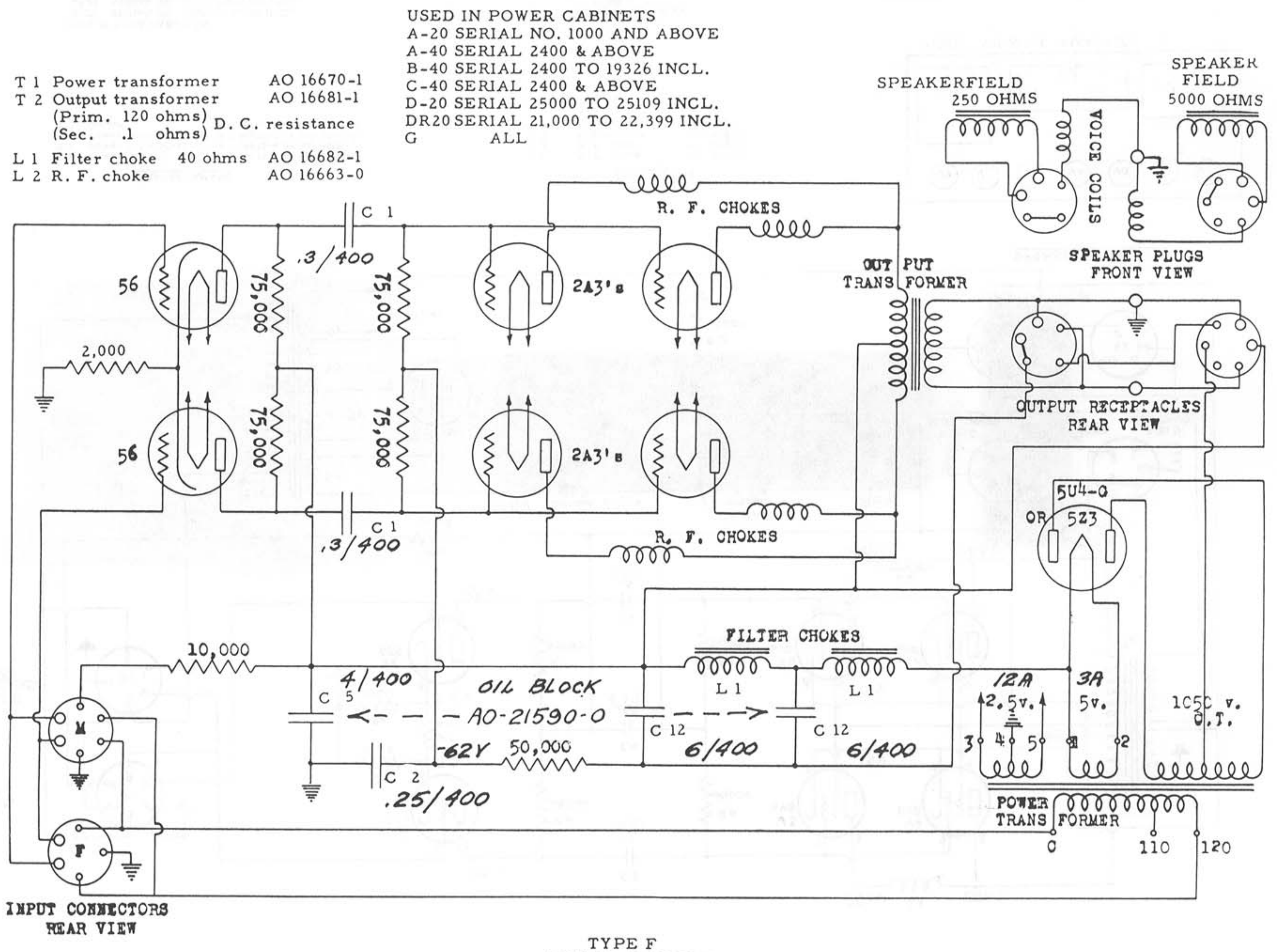
USED IN POWER CABINETS
A-20 SERIAL 1 TO 999 INCL.
A-40, B-40 & C-40 1 TO 2399 INCL.

*A-20 cabinets SERIAL NO. 1-601
A-40 & B-40 cabinets SERIAL NO. 1-1731
have condenser C1 .1 mfd and
resistor R4 .2 MEG.

L 1	Filter choke 40 ohms	AO 16682-1
L 2	Radio frequency choke	AO 16663-0
T 1	Power transformer	W 3162
T 2	Output transformer	AO 16681-1

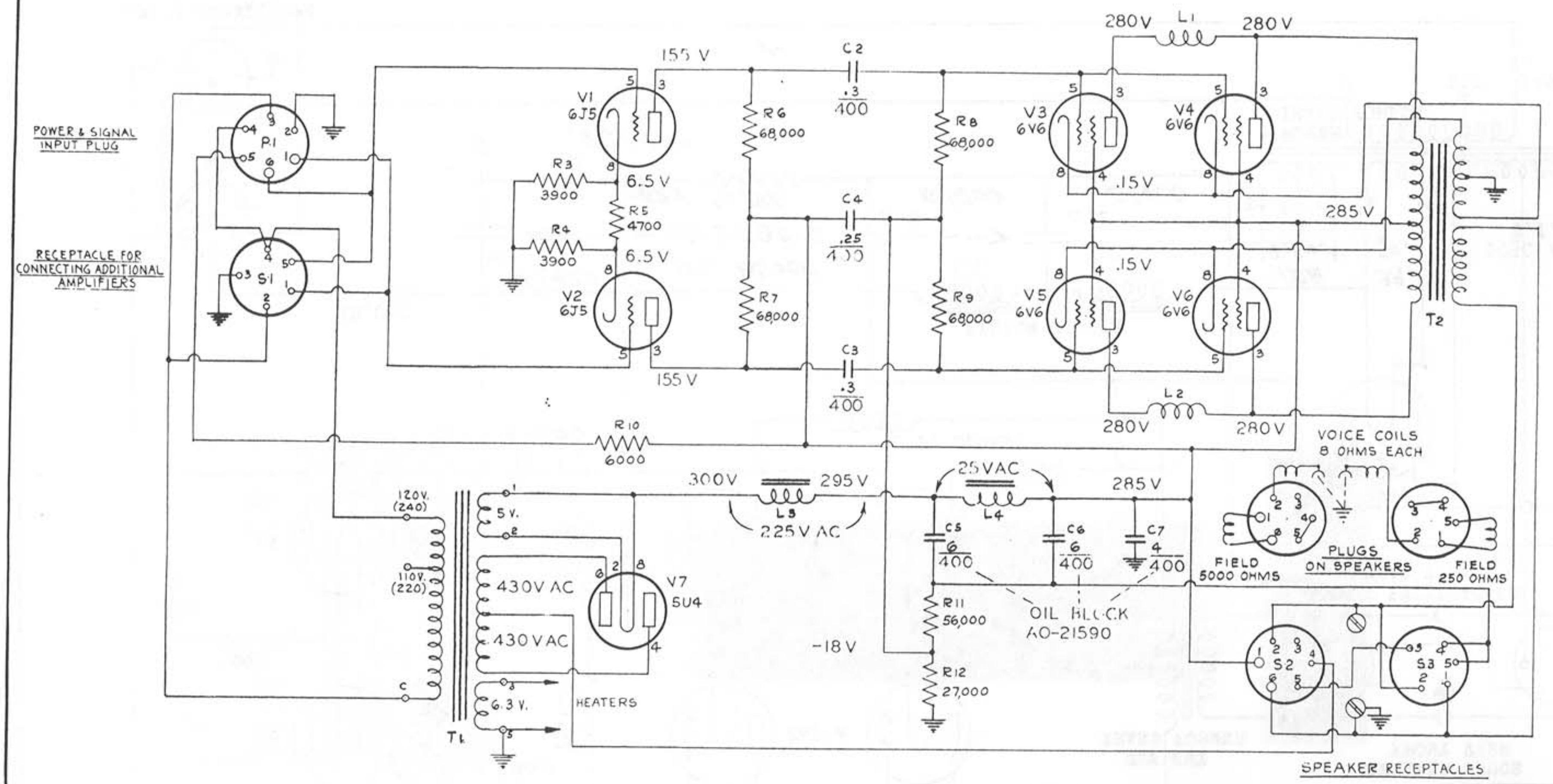
(Primary 120 ohms)
(Secondary 1/10 ohm) } DC RESISTANCE

PRE AMPLIFIER
FIGURE 10



TYPE F
POWER AMPLIFIER

FIGURE 11

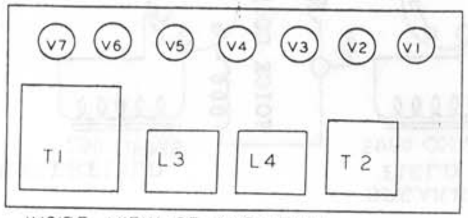


TRANSFORMERS

T 1	Power (115 v 60 cy)	AO 16670-5 or AO 20181-1
T 1	Power (115 v 50-60 cy)	AO 16670-6 or AO 20181-2
T 1	Power (230v 50-60 cy)	AO 16670-7 or AO 20181-3
T 2	Output	AO 16681-2 or AO 20182-1

CHOKE COILS

L 1	R. F. Choke	PO-16663-0
L 2	R. F. Choke	PO-16663-0
L 3	Filter Choke	AO-16682-1
L 4	Filter Choke	AO-16682-1



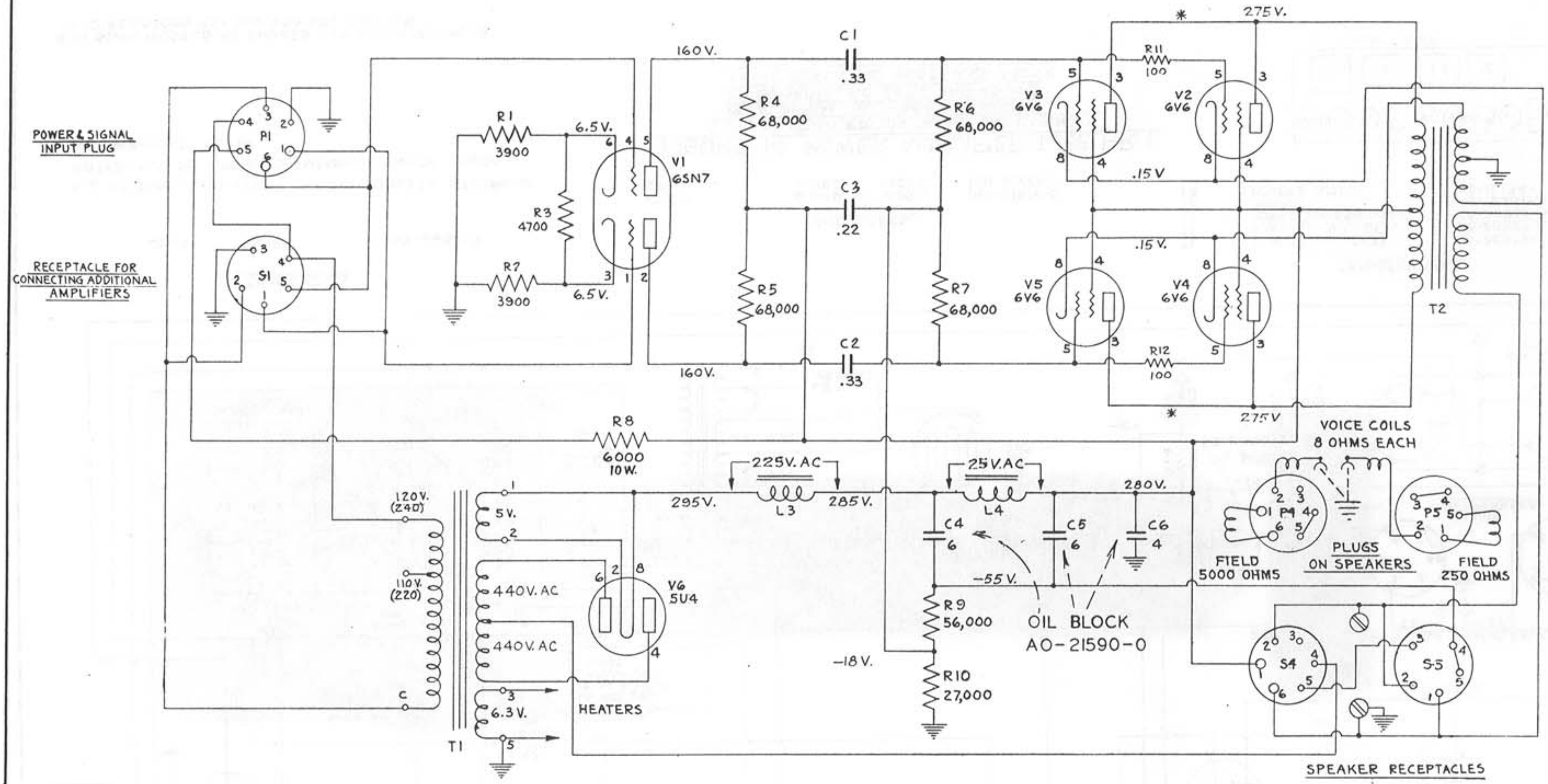
INSIDE VIEW OF AMPLIFIER

USED IN TONE CABINETS
D 20 SERIAL NO. 25110 TO 26968 INCL.
DR20 SERIAL NO. 22400 TO 35303 INCL.
B 40 SERIAL NO. 19327 TO 19841 INCL.
ER20 SERIAL NO. 27001 TO 28709 INCL.
FR40 SERIAL NO. 35001 TO 35623 INCL.
(SOME FR40 ALSO HAVE AMPLIFIER SHOWN IN FIGURE 15)
F40 SERIAL NO. 37001 TO 37659 INCL.

POWER AMPLIFIER
TYPE G

FIGURE 12

ALL VOLTAGES ARE + FROM GROUND UNLESS OTHERWISE NOTED. ALL DC VOLTAGES MEASURED WITH 20,000 OHM - PER-VOLT METER.

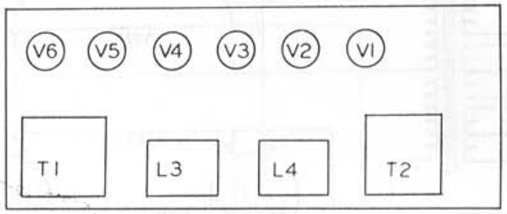


TRANSFORMERS

T1	POWER (115 V. 60 CY.)	AO-20927-1
T1	POWER (115 V. 50-60 CY.)	AO-20927-2
T1	POWER (230 V. 50-60 CY.)	AO-20927-3
T2	OUTPUT	AO-16681-4

CHOKE COILS

L3, L4	FILTER CHOKE	AO-16682-2



INSIDE VIEW

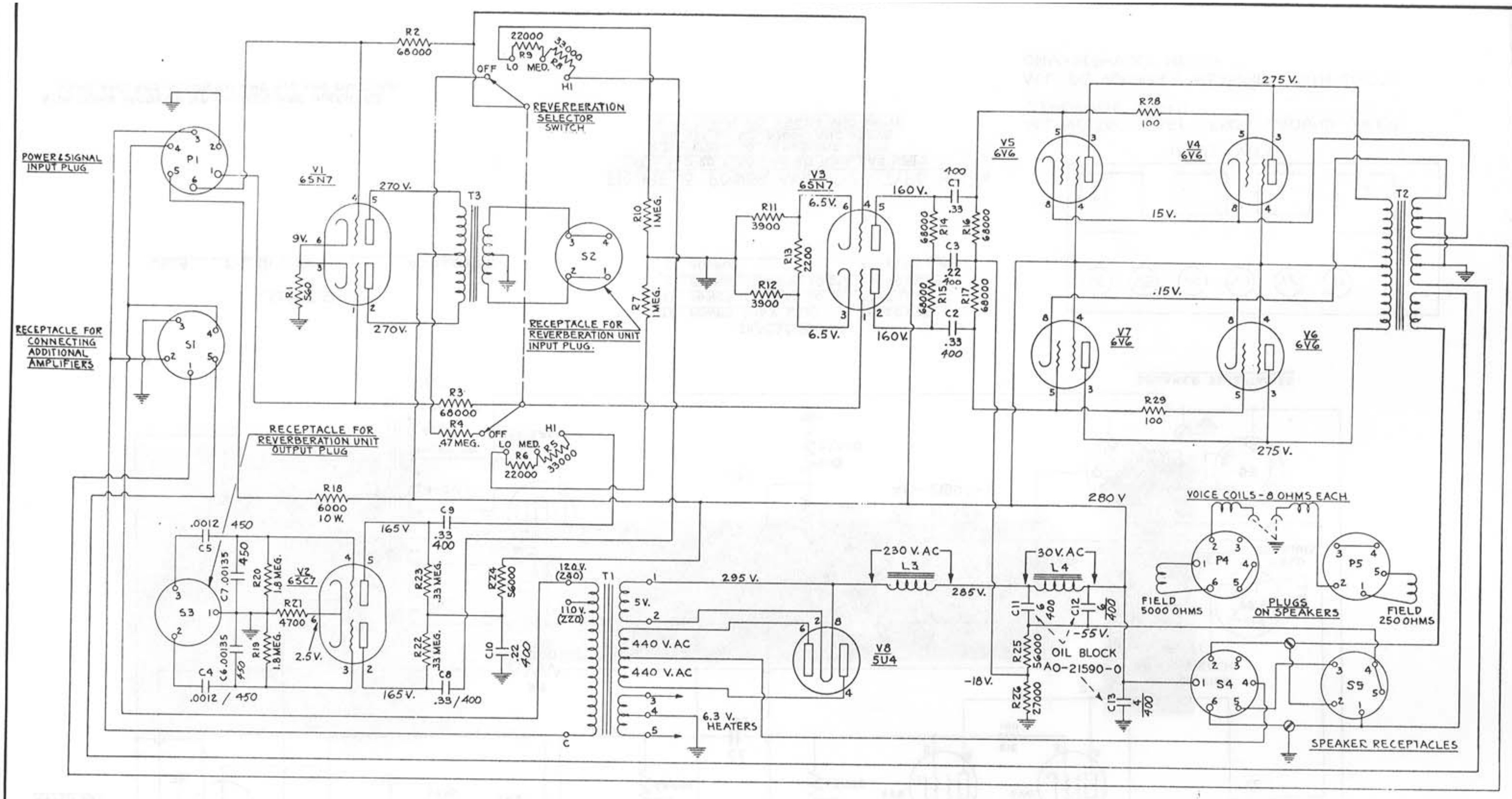
ALL VOLTAGES ARE + FROM GROUND UNLESS OTHERWISE NOTED.

ALL DC VOLTAGES MEASURED WITH 20,000 OHM-PER-VOLT METER

FIGURE 13 POWER AMPLIFIER TYPE H-1-A

USED IN D-20, F-40 & FR-40 TONE CABINETS
D-20 SERIAL NO. 26969 AND ABOVE
F-40 SERIAL NO. 37660 AND ABOVE
FR-40 SERIAL NO. 35624 AND ABOVE

* IN SOME MODELS RF CHOKES ARE INSERTED HERE AND RESISTORS R11 AND R12 ARE OMITTED.



CHOKE COILS

L3,L4	FILTER	A0-16682-2

CONDENSERS

C11,C12	6 MFD.	400 V.	A0-21574-2
C13	4 MFD.	400 V.	OIL BLOCK

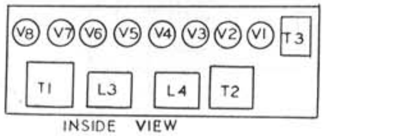
TRANSFORMERS

T1	POWER (115 V. 60 CY)	A0-20927-1
T1	POWER (115 V. 50 CY)	A0-20927-2
T1	POWER (230 V. 50-60 CY)	A0-20927-3
T2	OUTPUT	A0-16681-3
T3	REVERB. OUTPUT	A0-16134-1

ALL VOLTAGES ARE + FROM GROUND UNLESS OTHERWISE NOTED. ALL DC VOLTAGES MEASURED WITH 20000 OHM-PER-VOLT METER

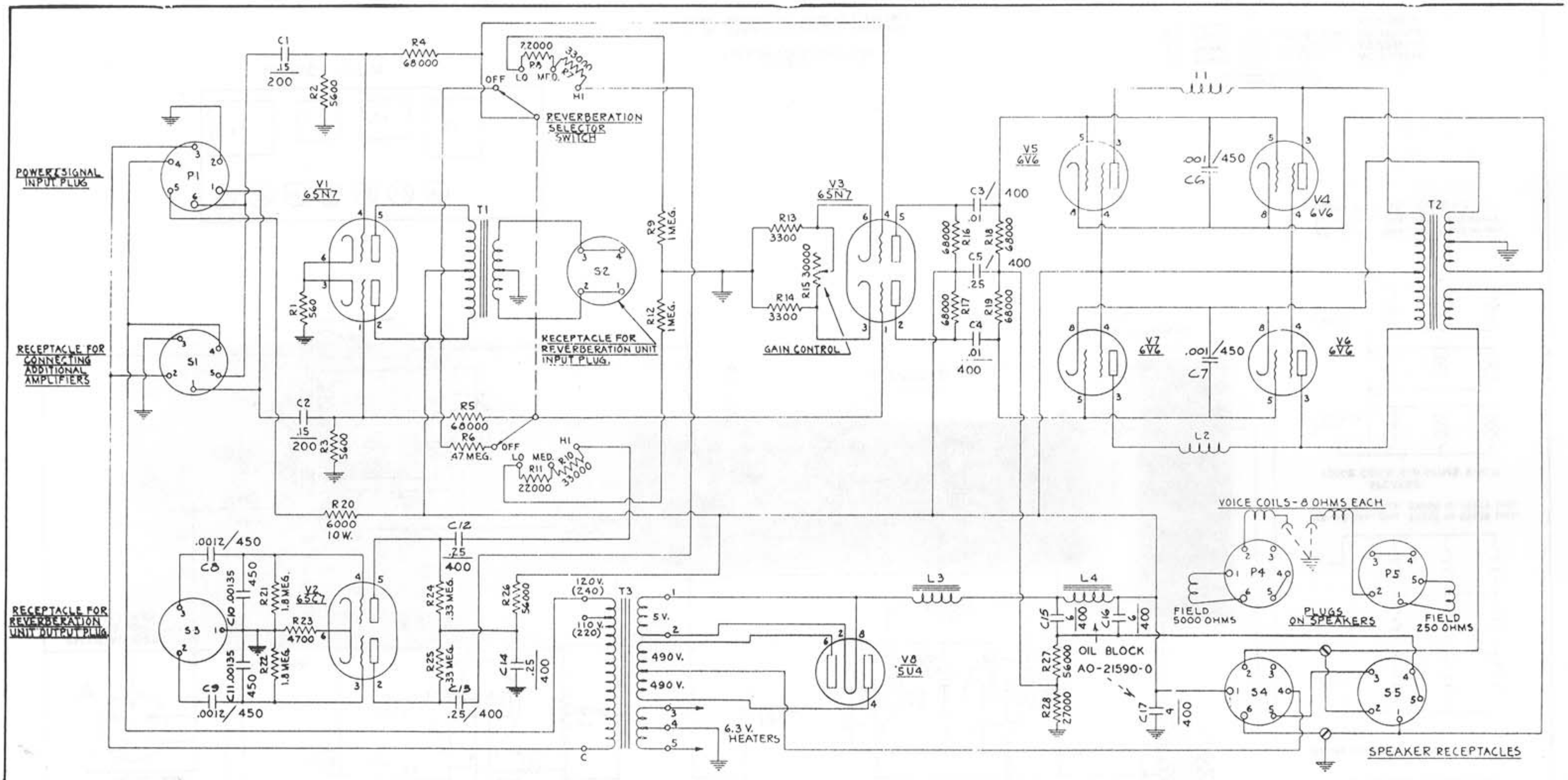
FIGURE 14 POWER AMPLIFIER TYPE HR-1

USED IN DR-20, ER-20 & FR-40 TONE CABINETS
DR-20 SERIAL NO. 35304 AND ABOVE
ER-20 SERIAL NO. 28710 AND ABOVE
FR-40 SERIAL NO. 35425 AND ABOVE



INSIDE VIEW

* IN SOME MODELS RF CHOKES ARE INSERTED HERE AND RESISTORS R28 AND R29 ARE OMITTED.



TRANSFORMERS

T 1	Reverb. Output	AO 16134-1
T 2	Output	AO 16681-5
T 3	Power (115 v 60 cy)	AO 20927-1
T 3	Power (115 v 50-60 cy)	AO 20927-2
T 3	Power (230 v 50-60 cy)	AO 20927-3

CHOKE COILS

L 1, 2	R. F. Choke	PO 16663-0
L 3, 4	Filter	AO 16682-2

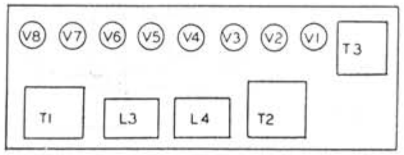
POTENTIOMETER

R 15	30,000 OHMS	AO 20293-24

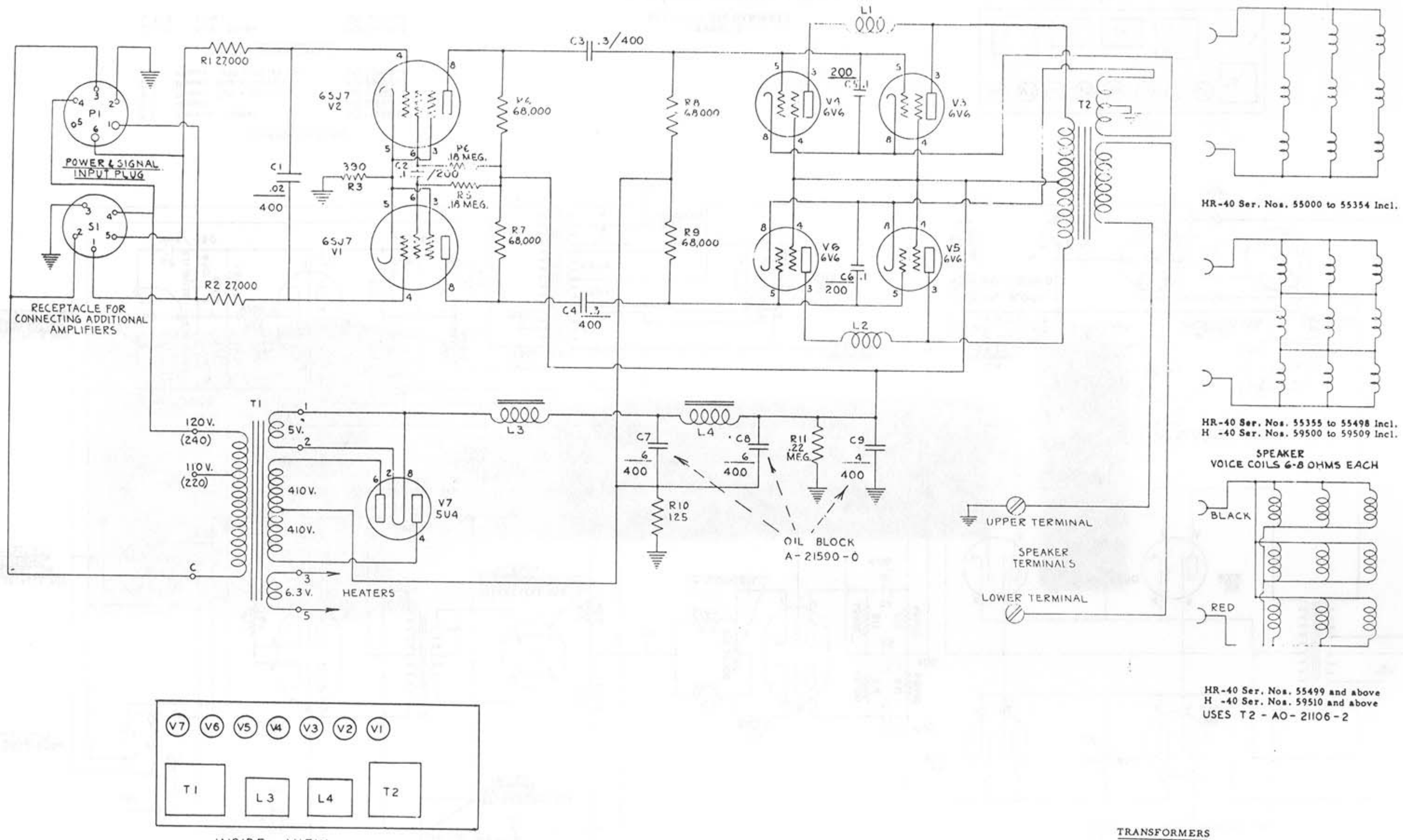
TYPE JR
USED IN TONE CABINETS

H 40 SERIAL NO. 55002 to 59999 incl.
HR40 SERIAL NO. 55002 to 56499 incl.

FIGURE 15



INSIDE VIEW



TYPE K
USED IN TONE CABINETS

H 40 SERIAL NO. 50002 to 59999 incl.
HR40 SERIAL NO. 50002 to 56499 incl.

TRANSFORMERS

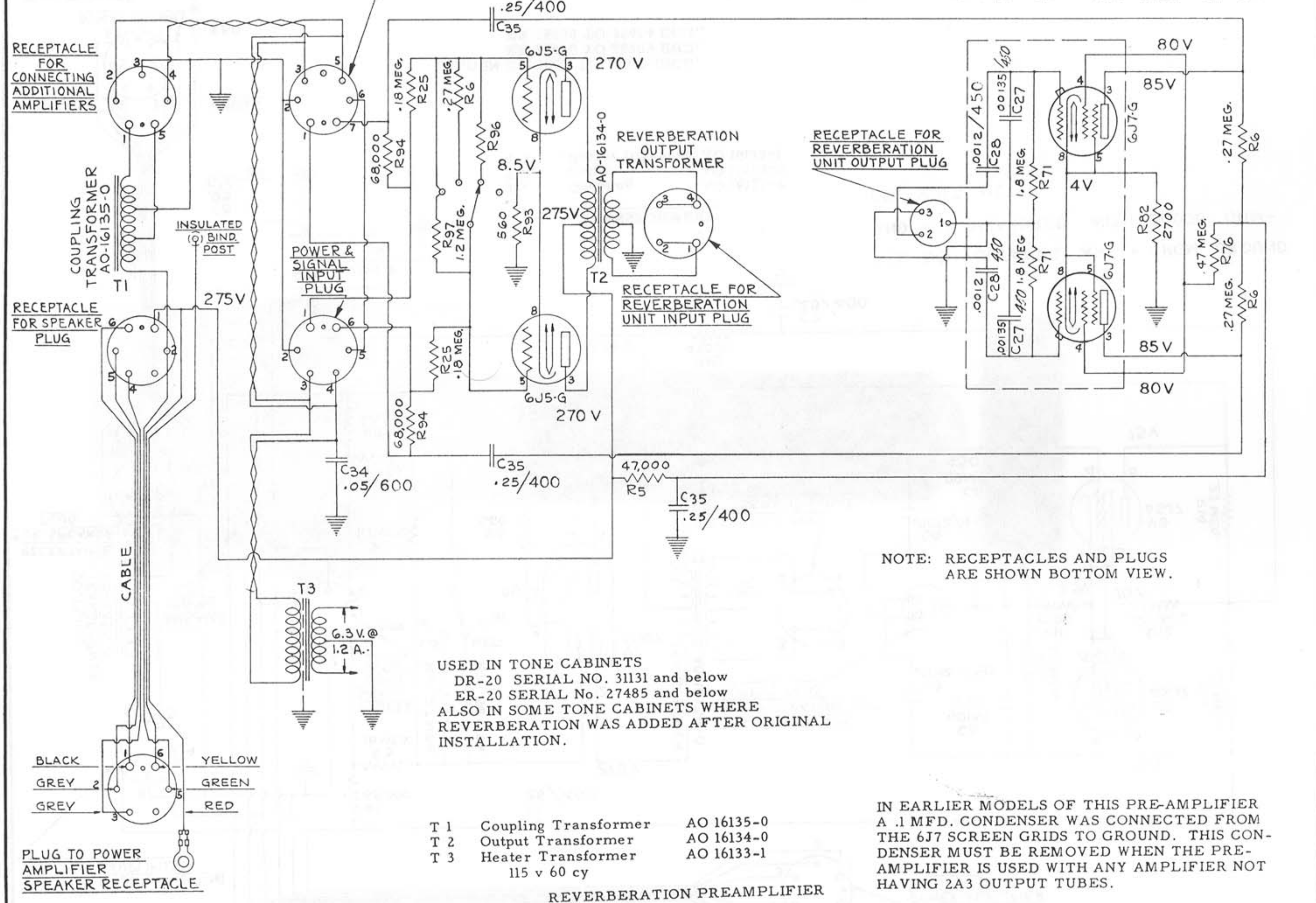
T 1	Power	(115 v 60 cycle)	AO 20927-4
T 1	Power	(115 v 50-60 cycle)	AO 20927-5
T 1	Power	(230 v 50-60 cycle)	AO 20927-6
T 2	Output		AO 21106-1

CHOKE COILS

L 1, L 2	R. F. Choke	PO 16663-0
L 3, L 4	Filter Choke	AO 16682-2

FIGURE 16

ALL DC VOLTAGES ARE + FROM GROUND AND ARE MEASURED WITH 20 000 OHM - PER - VOLT METER



NOTE: RECEPTACLES AND PLUGS ARE SHOWN BOTTOM VIEW.

USED IN TONE CABINETS
DR-20 SERIAL NO. 31131 and below
ER-20 SERIAL No. 27485 and below
ALSO IN SOME TONE CABINETS WHERE REVERBERATION WAS ADDED AFTER ORIGINAL INSTALLATION.

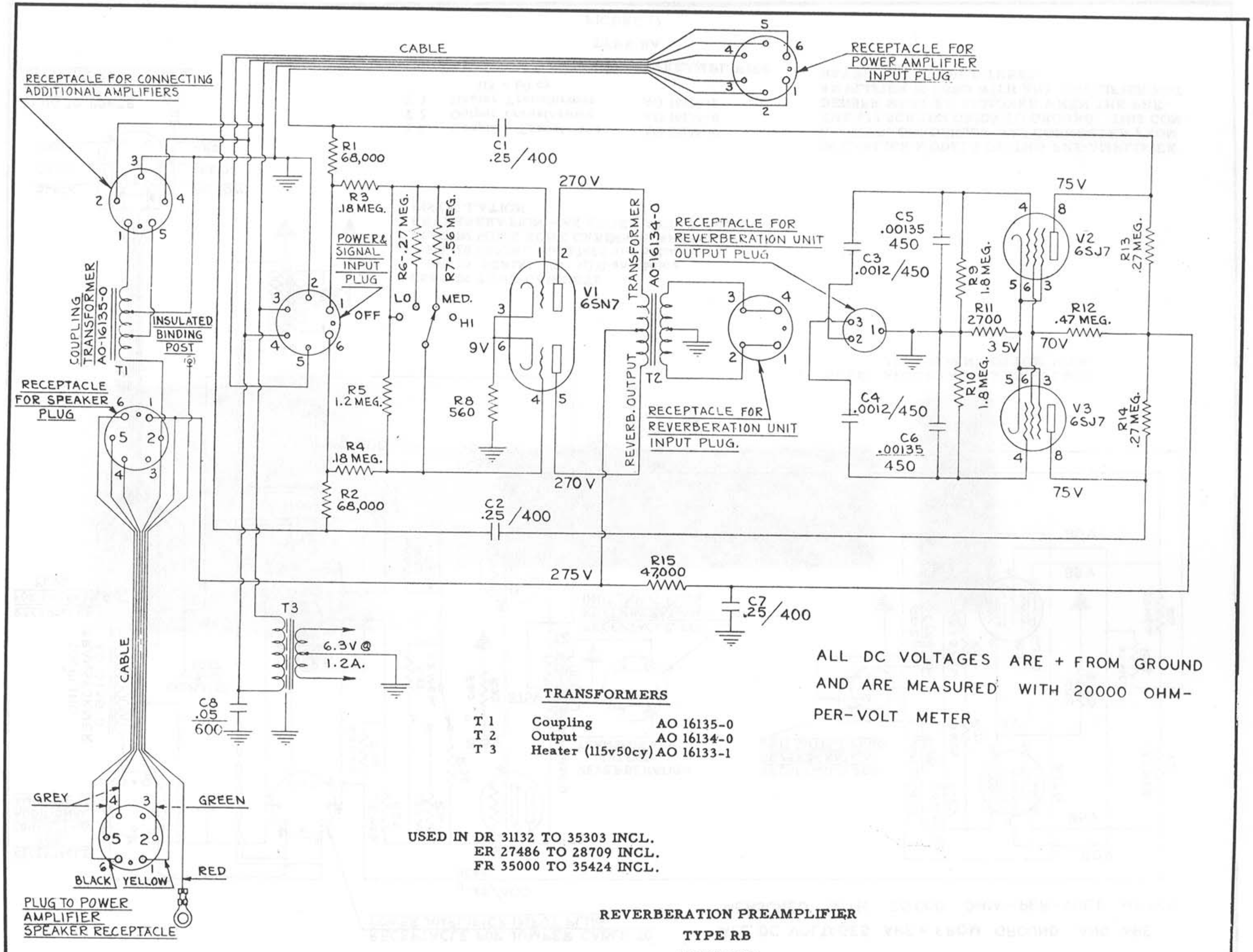
T 1	Coupling Transformer	AO 16135-0
T 2	Output Transformer	AO 16134-0
T 3	Heater Transformer 115 v 60 cy	AO 16133-1

IN EARLIER MODELS OF THIS PRE-AMPLIFIER A .1 MFD. CONDENSER WAS CONNECTED FROM THE 6J7 SCREEN GRIDS TO GROUND. THIS CONDENSER MUST BE REMOVED WHEN THE PRE-AMPLIFIER IS USED WITH ANY AMPLIFIER NOT HAVING 2A3 OUTPUT TUBES.

REVERBERATION PREAMPLIFIER

TYPE RA

FIGURE 17



TRANSFORMERS

T 1	Coupling	AO 16135-0
T 2	Output	AO 16134-0
T 3	Heater (115v50cy)	AO 16133-1

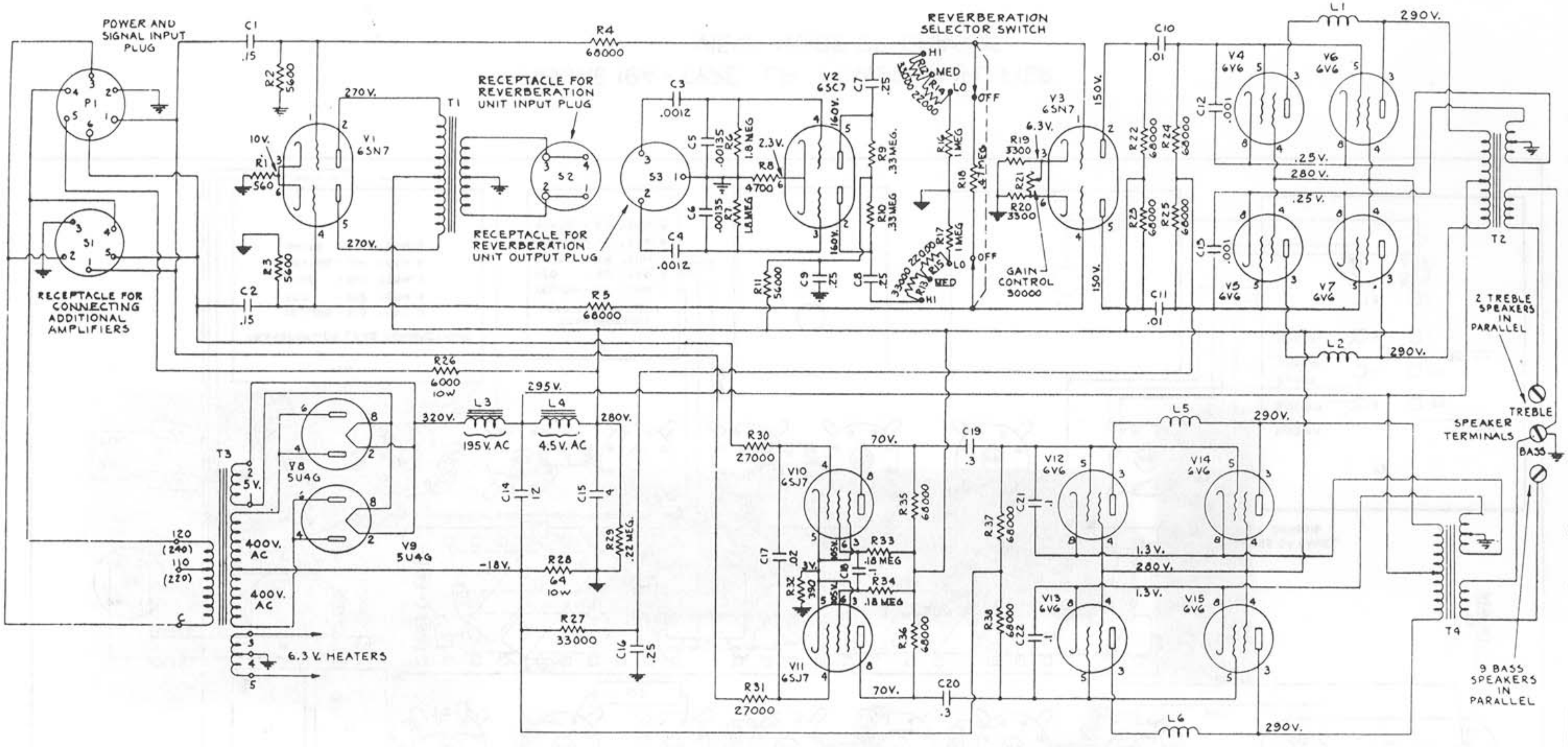
ALL DC VOLTAGES ARE + FROM GROUND AND ARE MEASURED WITH 20000 OHM-PER-VOLT METER

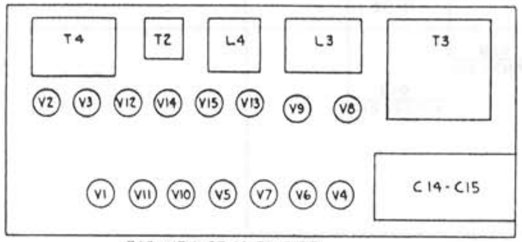
USED IN DR 31132 TO 35303 INCL.
ER 27486 TO 28709 INCL.
FR 35000 TO 35424 INCL.

REVERBERATION PREAMPLIFIER

TYPE RB

FIGURE 18





TOP VIEW OF AMPLIFIER

FIGURE 19 - POWER AMPLIFIER TYPE LR

USED IN H-40 AND HR-40 TONE CABINETS

HR 40 56500 and above
H 40 60000 and above

TRANSFORMERS

T1	REVERB. OUTPUT	AO-16134-2
T2	TREBLE OUTPUT	AO-21264-0
T3	POWER (115V 60CY)	AO-20927-7
T3	POWER (115V 50-60CY)	AO-20927-8
T3	POWER (230V 50-60CY)	AO-20927-9
T4	BASS OUTPUT	AO-21106-3

CHOKE COILS

L1, L2, L5, L6	R.F.	PO-16663-0
L3	6 HENRY INPUT	AO-21268-0
L4	18 HENRY OUTPUT	AO-16682-3

VARIABLE RESISTOR

R21	30,000 OHMS	AO-20293-24

DC VOLTAGES MEASURED WITH 20000 OHMS-PER-VOLT METER
ALL VOLTAGES ARE + FROM GROUND UNLESS OTHERWISE NOTED.

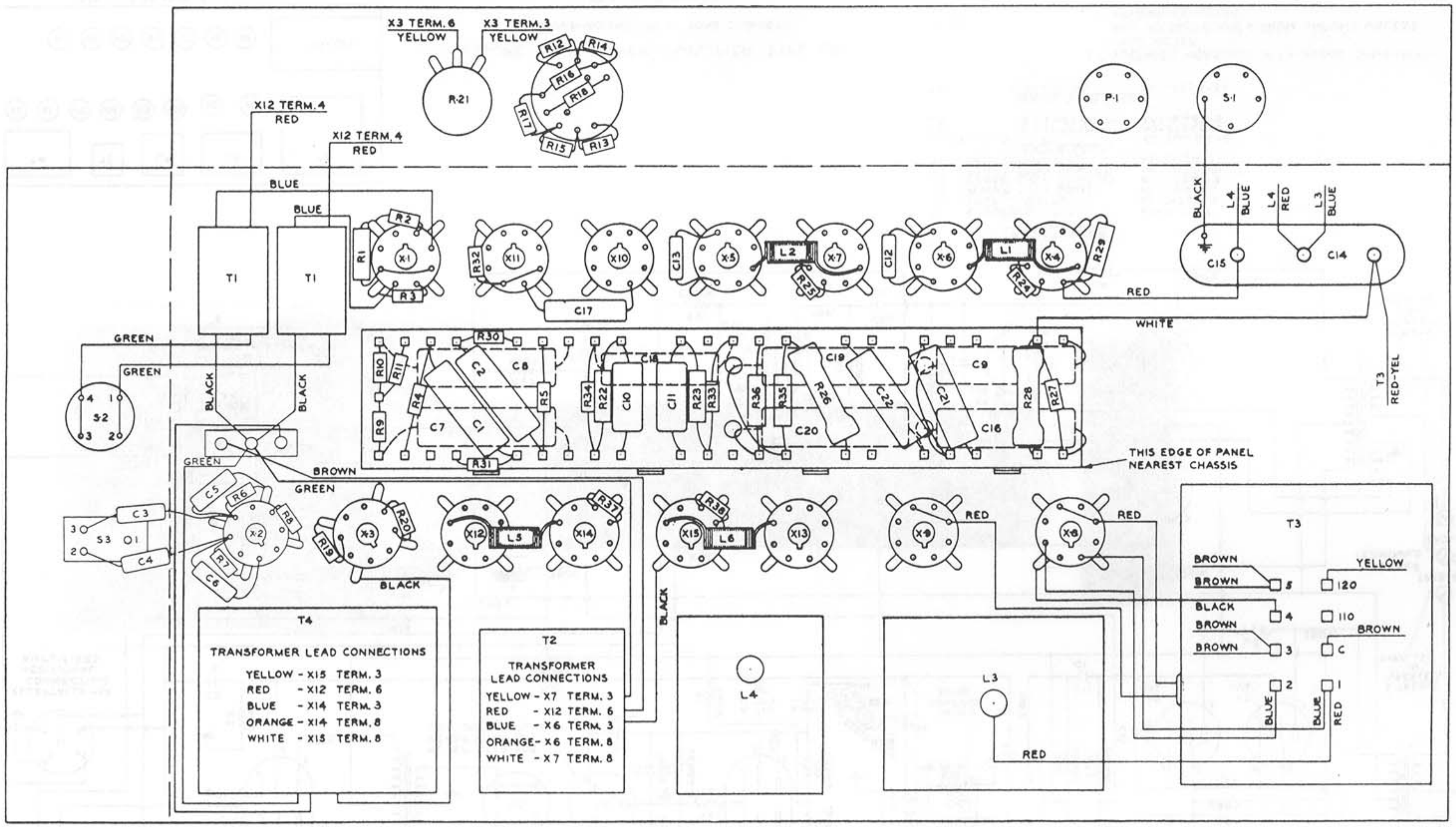
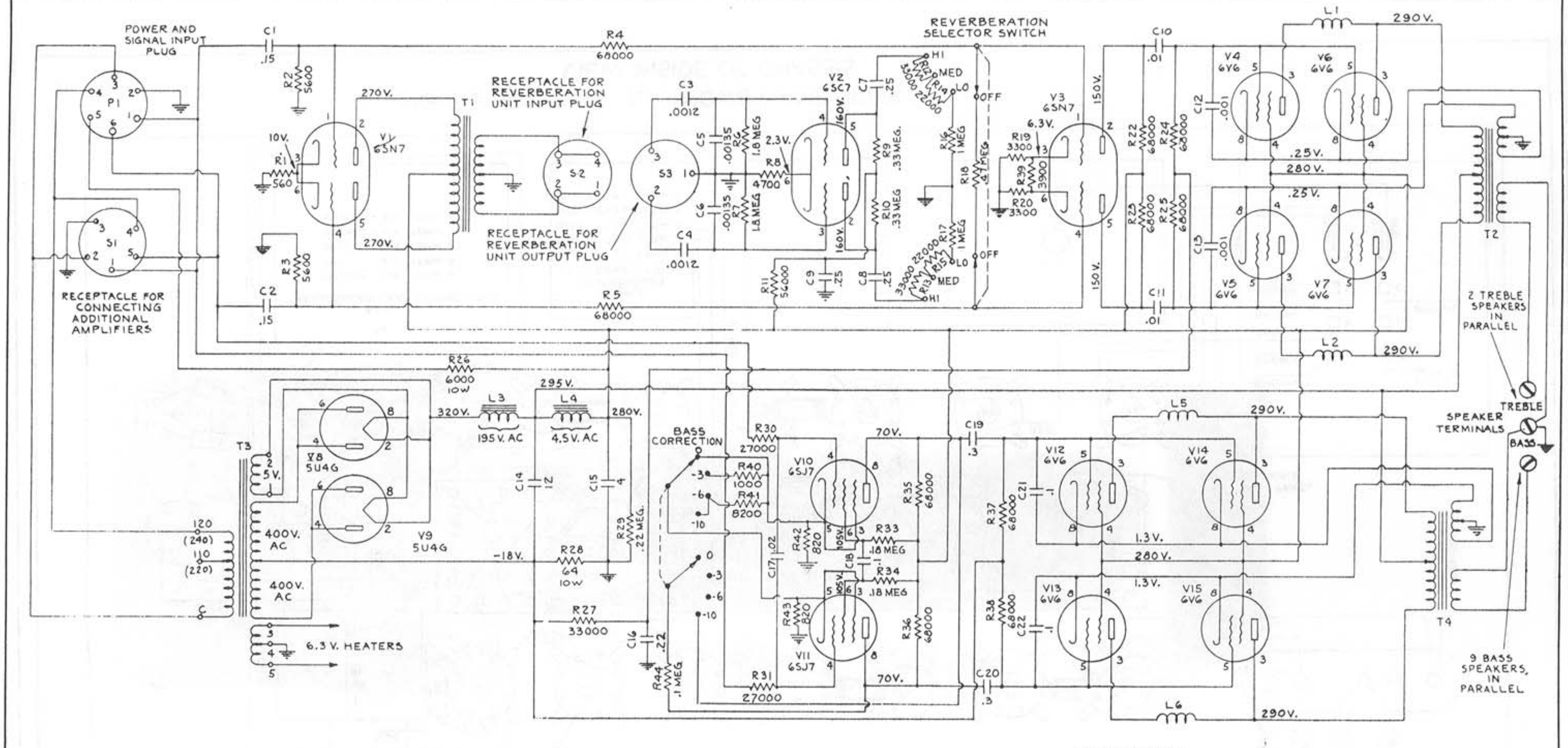
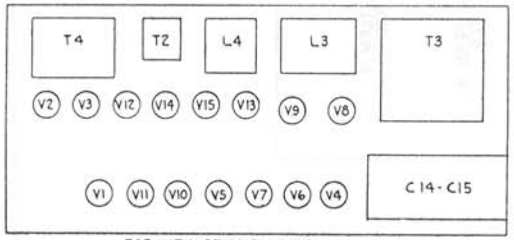


FIGURE 19A - TYPE LR POWER AMPLIFIER
VIEW INSIDE OF CHASSIS





TOP VIEW OF AMPLIFIER

FIGURE 19B POWER AMPLIFIER TYPE LR

USED IN H-40 AND HR-40 TONE CABINETS
CODE B AMPLIFIER- H-40 #60660 AND ABOVE
HR-40 #80061 AND ABOVE.

TRANSFORMERS

T1	REVERB. OUTPUT	AO-16134-2
T2	TREBLE OUTPUT	AO-21264-0
T3	POWER (115V 60CY)	AO-20927-7
T3	POWER (115V 50-60CY)	AO-20927-8
T3	POWER (230V 50-60CY)	AO-20927-9
T4	BASS OUTPUT	AO-21106-3
	CHOKE COILS	
L1, L2, L5, L6	R.F.	PO-16663-0
L3	6 HENRY INPUT	AO-21268-0
L4	18 HENRY OUTPUT	AO-16682-3

D.C. VOLTAGES MEASURED WITH 20000 OHMS-PER-VOLT METER.
ALL VOLTAGES ARE + FROM GROUND UNLESS OTHERWISE NOTED.

BASS CORRECTION

The "Bass Correction" switch on the amplifier is used to compensate for variations in room size. When this cabinet is used in a small room, the switch should be adjusted to reduce the volume of the bass tones for best tonal balance. Approximate settings for rooms with average furnishings will be as follows:

Volume of Room	Switch Position
Over 16,000 cubic feet	0
8,000 to 16,000 cubic feet	−3
4,000 to 8,000 cubic feet	−6
2,000 to 4,000 cubic feet	−10

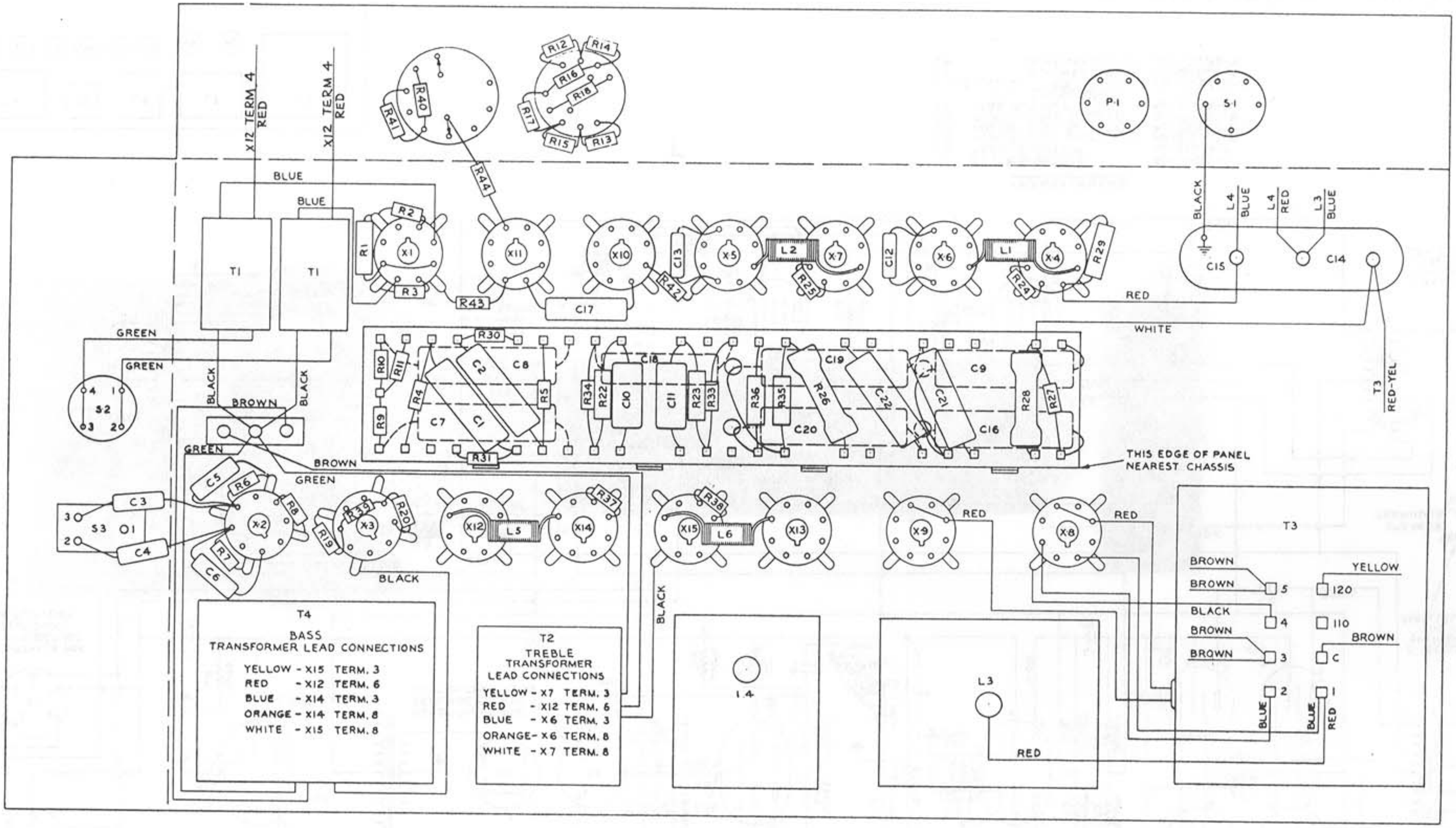
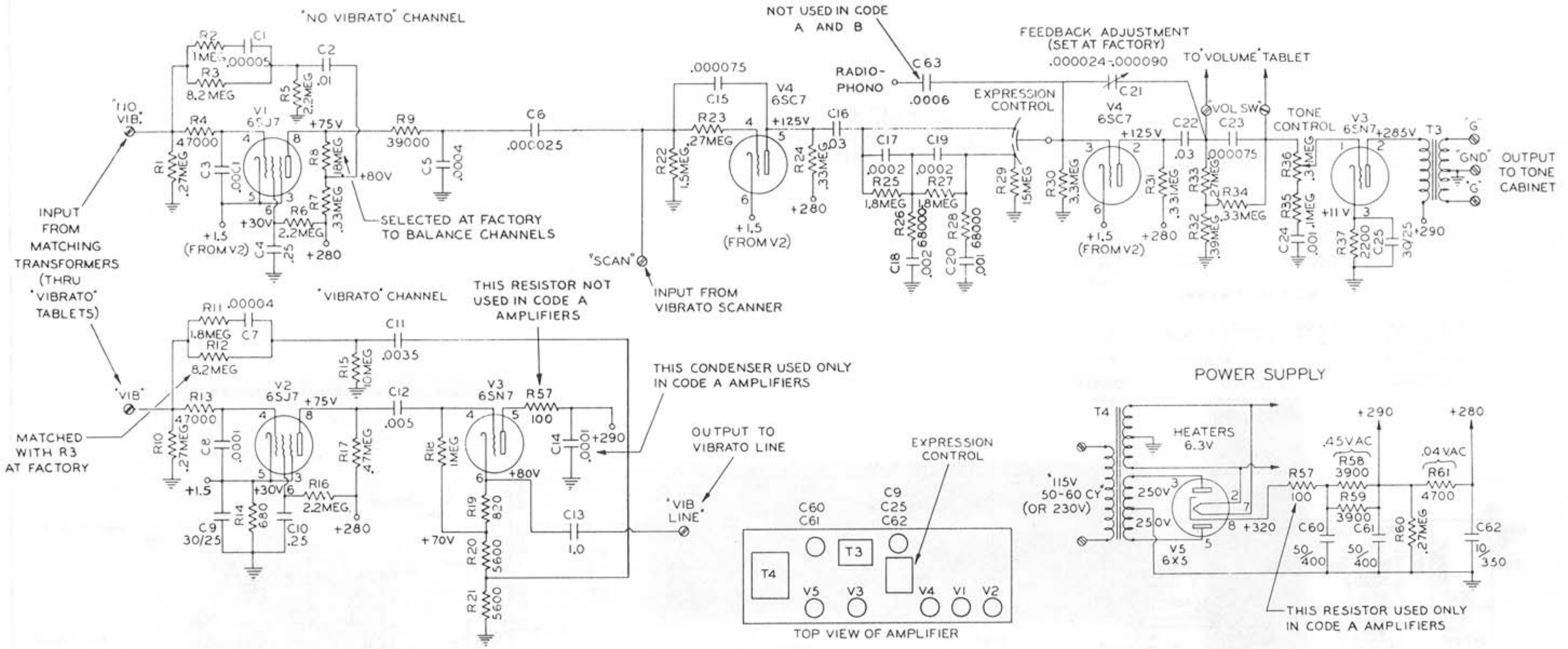


FIGURE 19C - TYPE LR POWER AMPLIFIER
VIEW INSIDE OF CHASSIS.



CONSOLE SERIAL NUMBERS:

CODE A
MODEL B-2 #35000-36187
MODEL C-2 #35000-35699
MODEL RT-2 #1300 - 1504

CODE B
MODEL B-2 #36188-39868
MODEL C-2 #35700-39407
MODEL RT-2 #1505-2056

CODE C
MODEL B-2 #39869-42635
MODEL C-2 #39408-42874
MODEL RT-2 #2057-2380

TRANSFORMERS

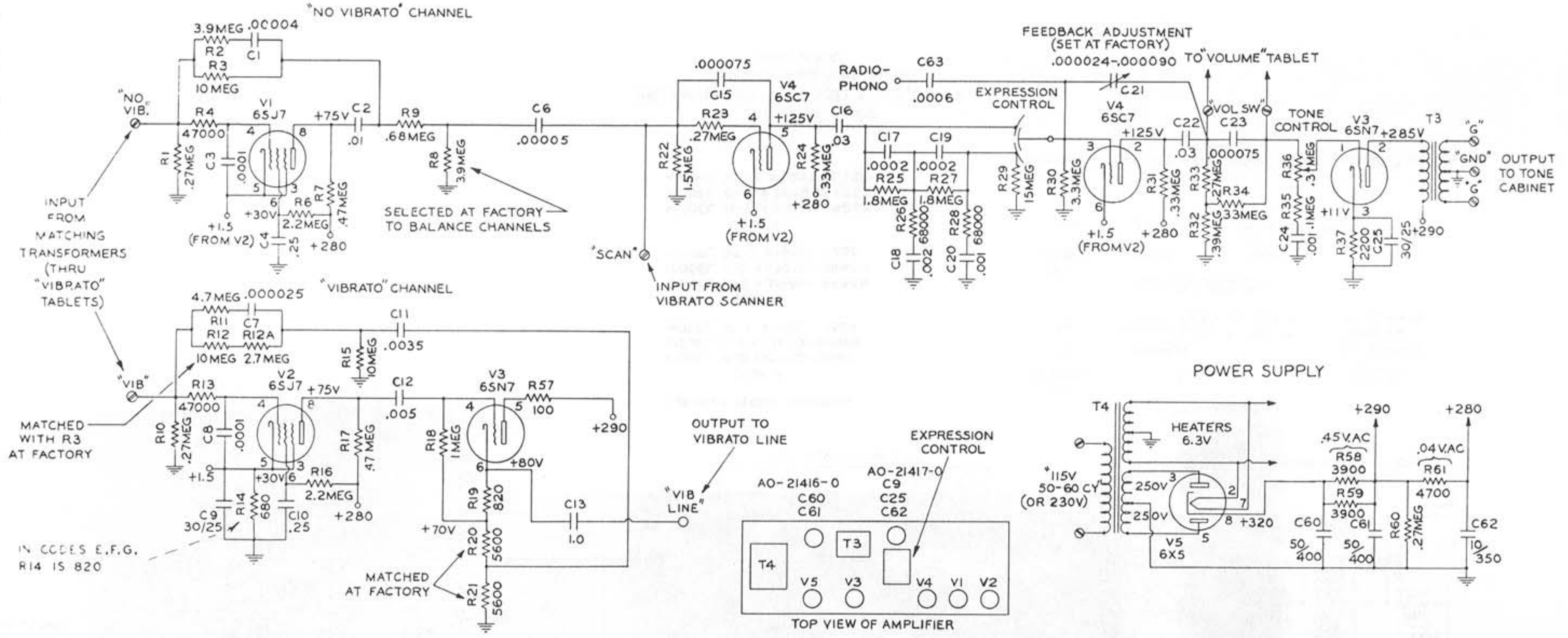
REF. SYMBOL	FUNCTION	PART NO
T3	OUTPUT	AO-21415-0
T4	POWER { 115V. 50-60 CY.	AO-21414-1
	{ 230V. 50-60 CY.	AO-21414-2

VARIABLE RESISTOR

REF. SYMBOL	OHMS	PART NO
R36	.3 MEG.	AO-20293-26

VOLTAGES MEASURED WITH 20000-OHMS-PER-VOLT METER.

FIGURE 20
PREAMPLIFIER - MODELS B2, C2, RT-2
(PREAMPLIFIER TYPE AO-10)
CODE A.B.C



USED WITH REVISED MATCHING TRANSFORMERS

TRANSFORMERS

REF. SYMBOL	FUNCTION	PART NO
T3	OUTPUT	AO-21415-0
T4	POWER { 115V. 50-60 CY.	AO-21414-1
	230V. 50-60 CY.	AO-21414-2

VARIABLE RESISTOR

REF. SYMBOL	OHMS	PART NO
R36	.3 MEG.	AO-20293-26

VOLTAGES MEASURED WITH 20000-OHMS-PER-VOLT METER.

FIGURE 20A
PREAMPLIFIER - MODELS B2, C2, RT-2
(PREAMPLIFIER TYPE AO-10)
CODE D.E.F.G

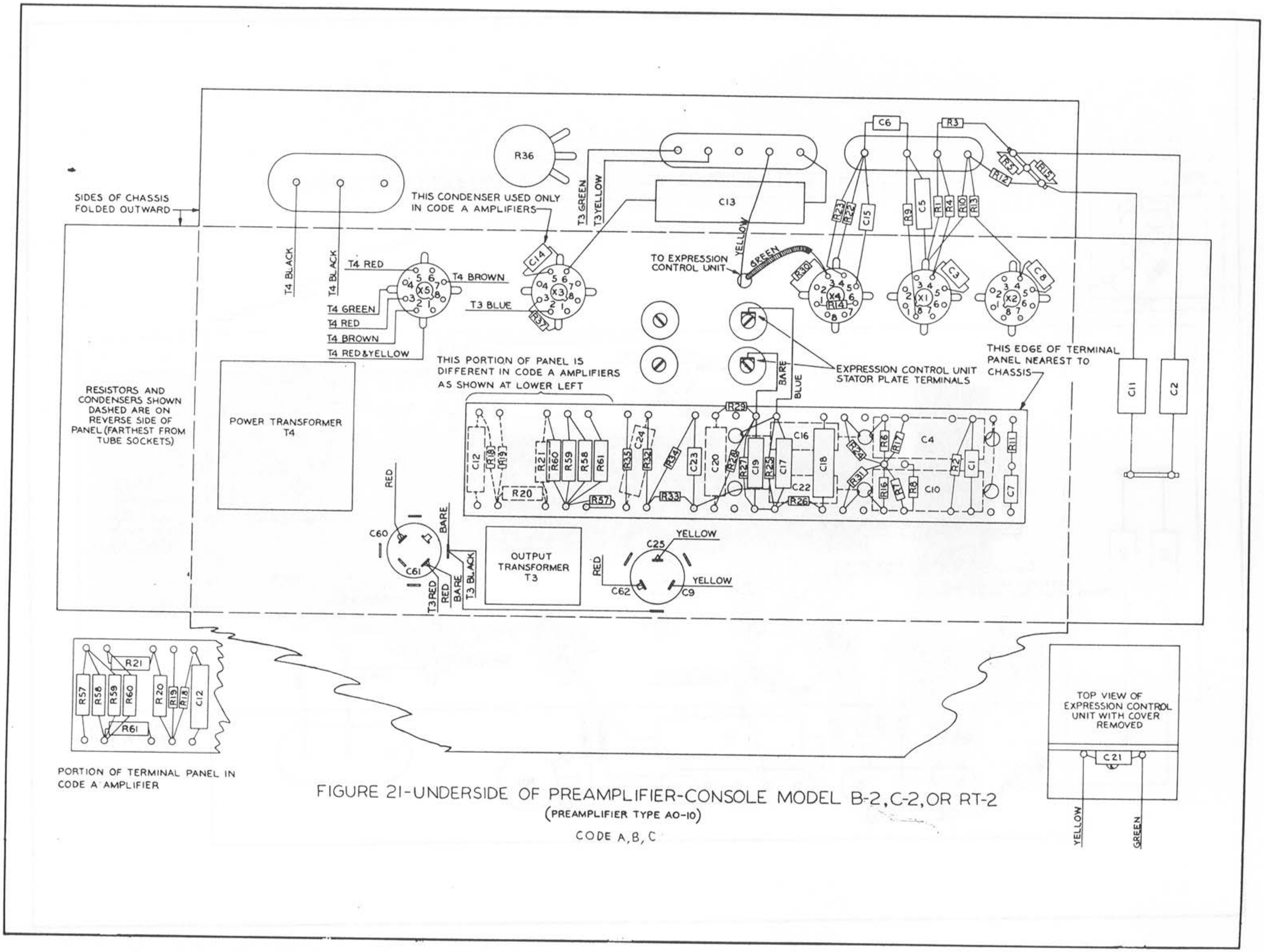


FIGURE 21-UNDERSIDE OF PREAMPLIFIER-CONSOLE MODEL B-2, C-2, OR RT-2

(PREAMPLIFIER TYPE AO-10)

CODE A, B, C

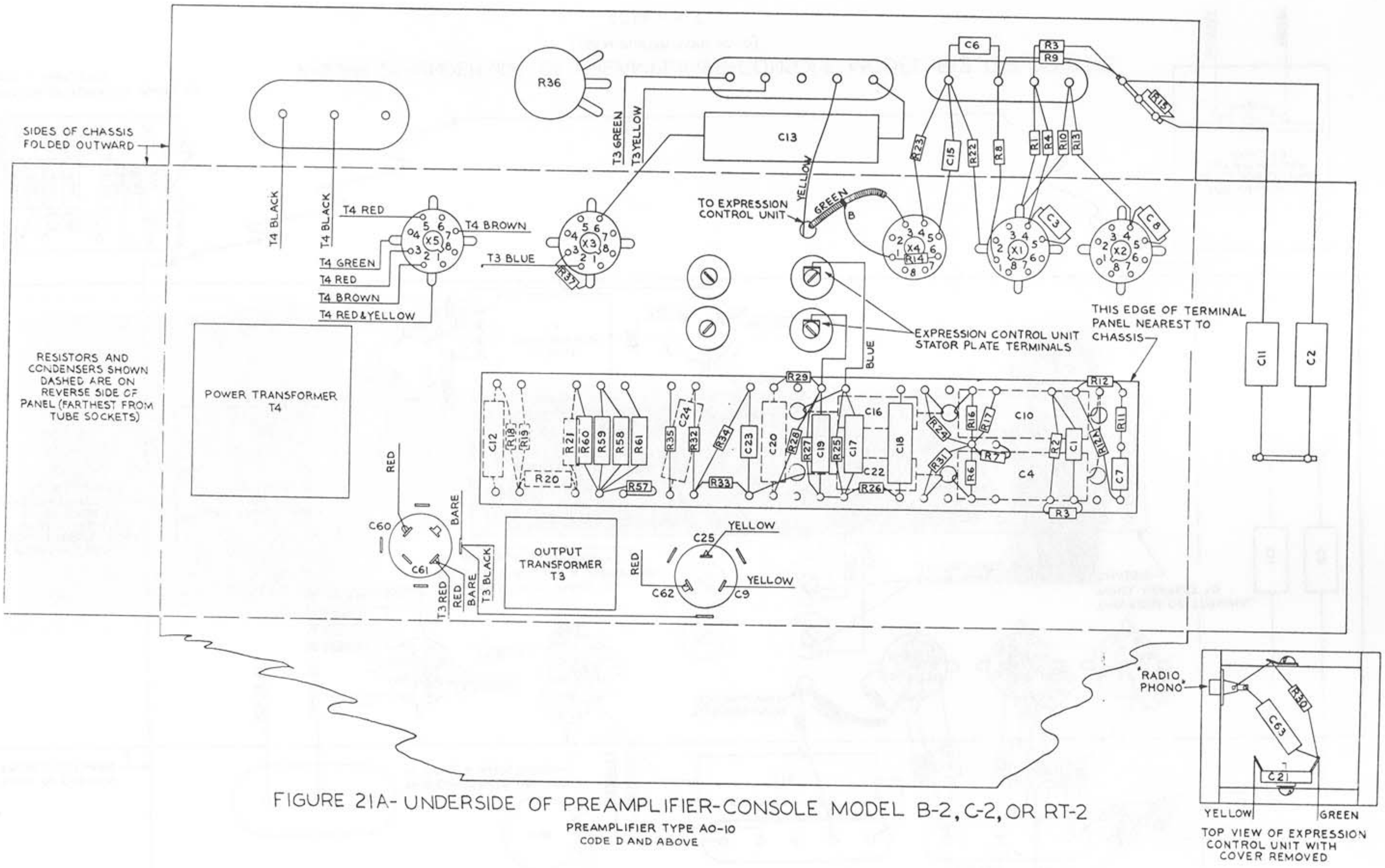


FIGURE 21A- UNDERSIDE OF PREAMPLIFIER-CONSOLE MODEL B-2, C-2, OR RT-2

PREAMPLIFIER TYPE AO-10
CODE D AND ABOVE

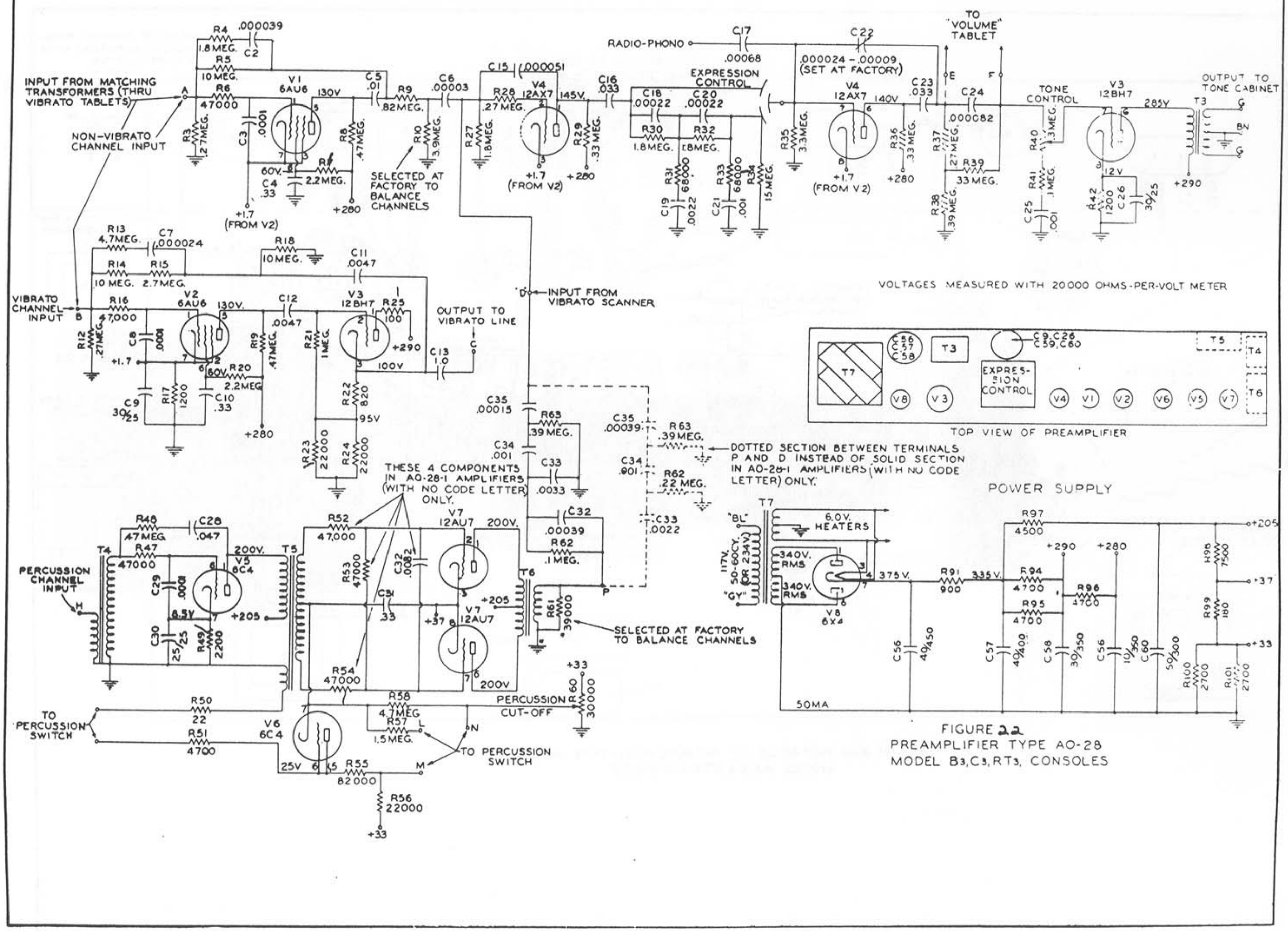


FIGURE 22
PREAMPLIFIER TYPE AO-28
MODEL B3, C3, RT3, CONSOLES

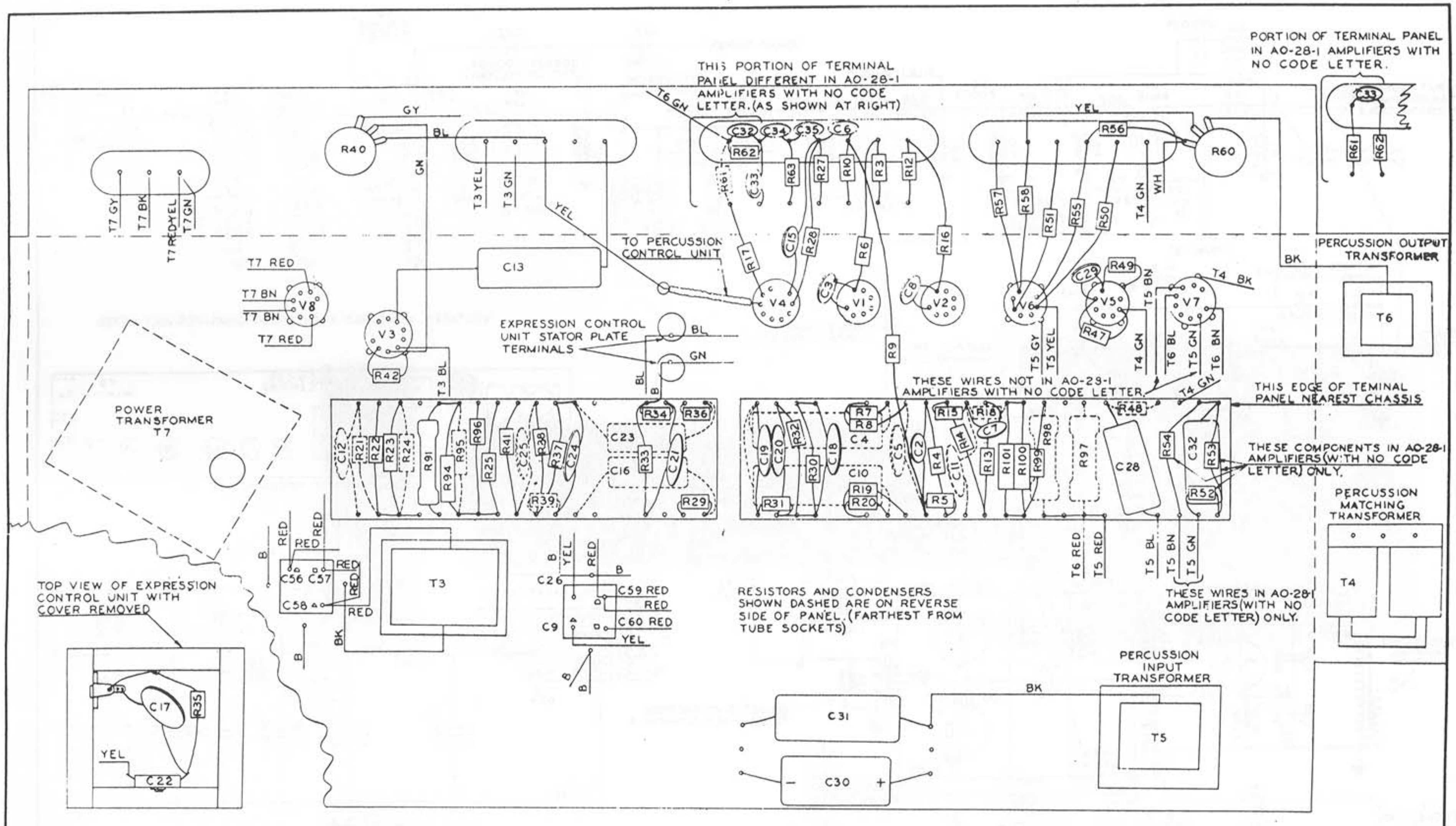


FIGURE 22A UNDERSIDE OF PREAMPLIFIER-TYPE AO-28
MODEL B3, C3, RT3 CONSOLES

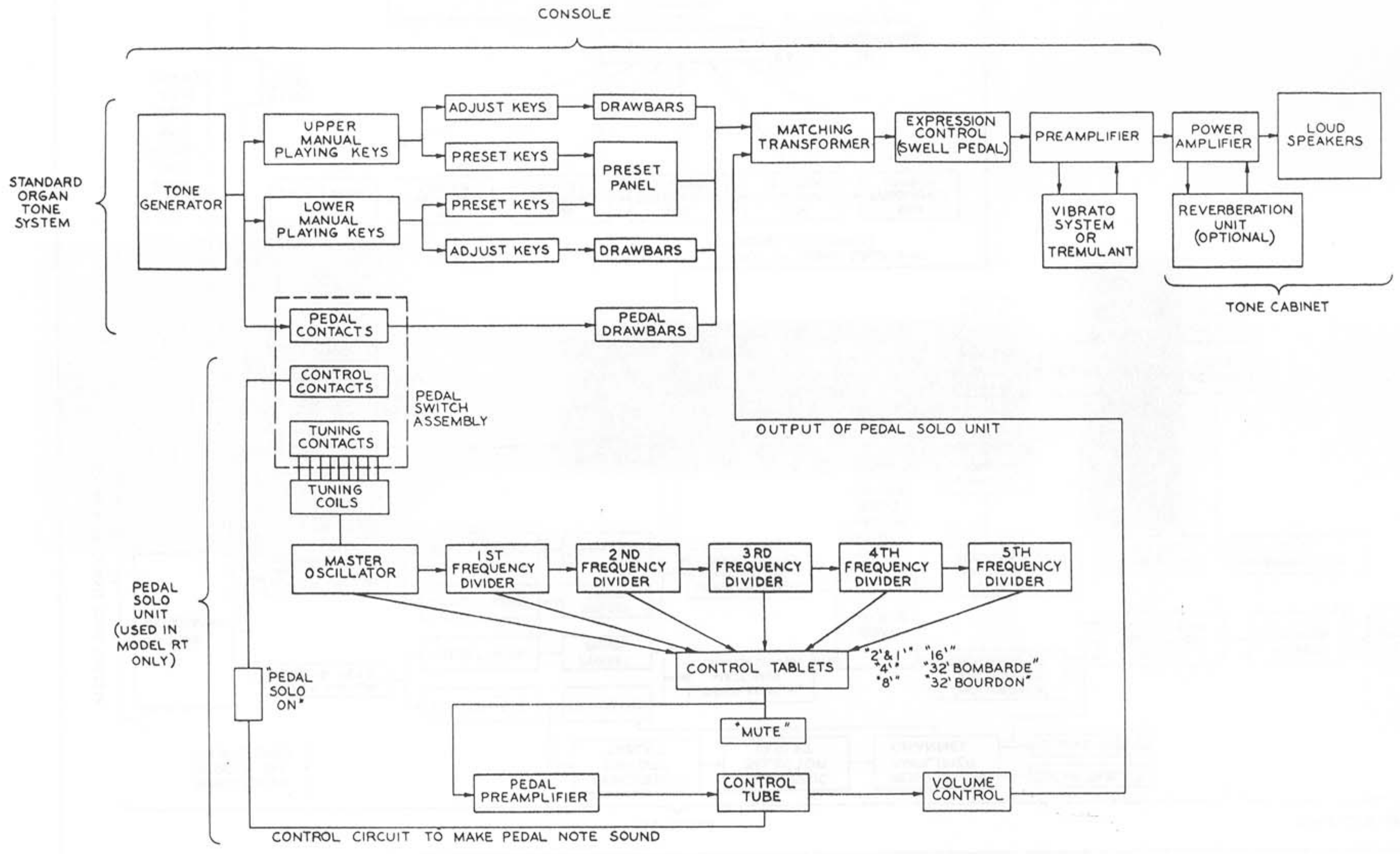


FIG. 23 – BLOCK DIAGRAM OF HAMMOND ORGAN
MODEL A, B, BC, BCV, BV, C, CV, D, DV, G, RT

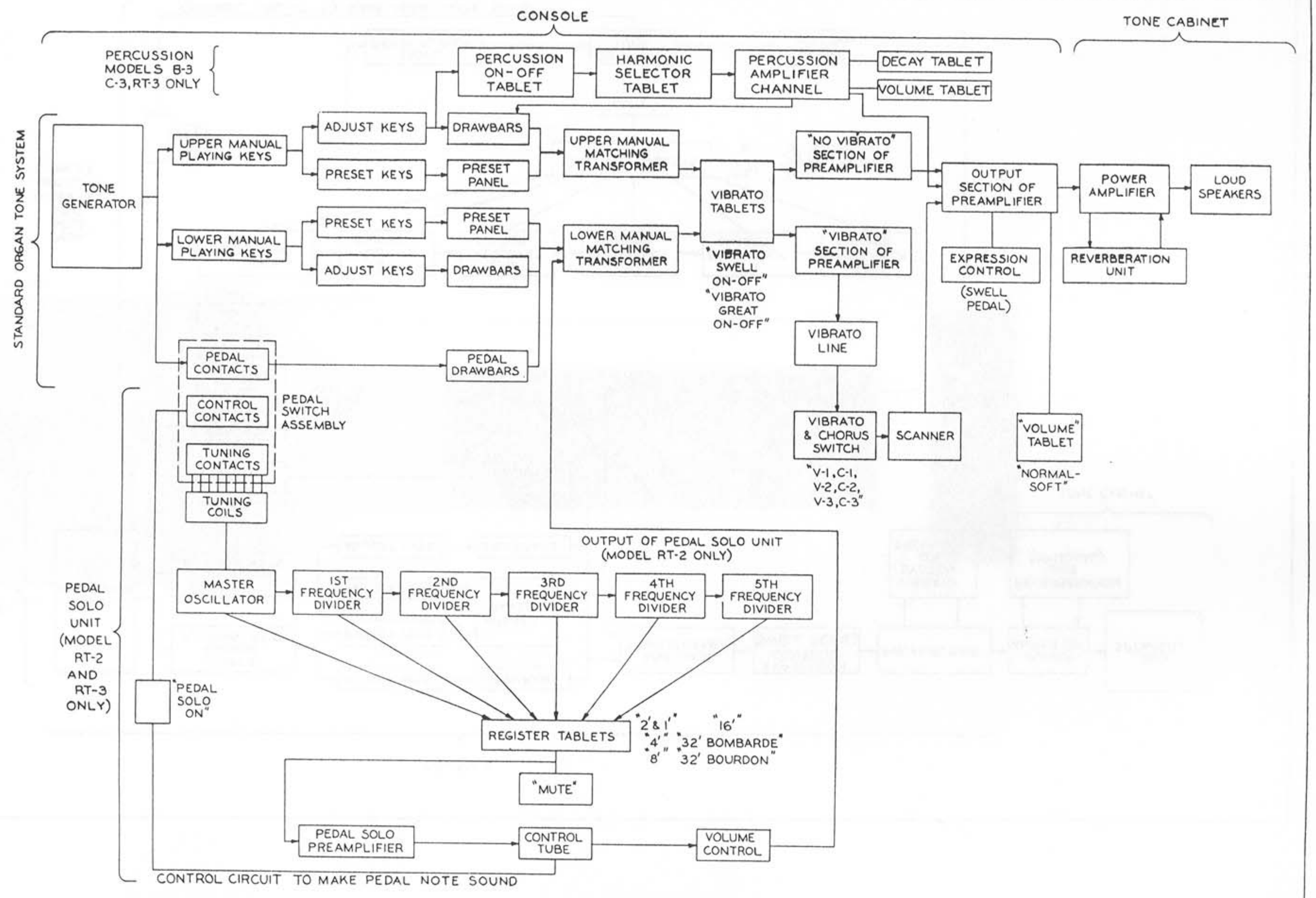


FIGURE 24-BLOCK DIAGRAM OF ORGAN MODEL B-2, B-3, C-2, C-3, RT-2, OR RT-3 WITH SELECTIVE VIBRATO SYSTEM

(B AND C MODELS DO NOT HAVE PEDAL SOLO UNIT)

THE HAMMOND ORGAN

- ACOUSTICS -

The Part They Play in
Hammond Organ Installations

HAMMOND ORGAN COMPANY
4200 West Diversey Avenue
Chicago 39, Illinois

ACOUSTICS - THE PART THEY PLAY IN HAMMOND ORGAN INSTALLATIONS

INSTALLATIONS IN GENERAL

The proper installation of a Hammond organ requires the careful observance of four primary rules:

1. The organ should furnish AMPLE POWER.
2. The sound energy from the organ should be EVENLY DISTRIBUTED.
3. The console and tone cabinets should be so located in relation to each other and to the audience, choir, soloist, etc., that a PROPER TONAL BALANCE is accomplished.
4. The organ tone should be PROPERLY REVERBERATED.

The observance of these rules with due consideration to the particular use for which the instrument is required will insure the best possible installation in any type of enclosure. These rules will be discussed in detail in the following pages.

POWER

There are so many factors which have a bearing on the amount of power or sound energy necessary for best musical results in a given enclosure that an accurate formula for determining the required power in all cases would be too cumbersome for everyday use. Experience has shown that it is very seldom that too many tone cabinets are specified. Therefore, if there is doubt as to the sufficiency of tone cabinets for any installation it is reasonably safe to double this amount. This will greatly improve the musical quality of the instrument and eliminate overloading of the speakers. Some of the factors which have a bearing on the amount of tone cabinet equipment required in any enclosure are the size and shape of the enclosure, placement of tone cabinets, amount and location of sound-absorbing materials including persons present in the enclosure. The use for which the organ is desired also has a bearing on requirements; for example, an organ to be used primarily to support congregational singing would require more tone cabinets than one that is to be used mainly for accompaniment of soloists or light entertainment.

The following conditions in an enclosure, therefore, usually indicate that more than an average installation may be required:

1. When the area of the boundaries of the enclosure is great in proportion to the volume of the enclosure. Thus, an enclosure of irregular shape having numerous alcoves, etc., would require more tone cabinets than one of cubical shape.
2. When the tone cabinets are located in a position where considerable sound absorption takes place before the music reaches the listener. A poorly designed or constructed organ chamber is an example.
3. When acoustical correction materials are used on walls or ceiling, when heavy drapes are present and carpets are used for floor covering.
4. When seating capacity is high for the size of the enclosure. For practical purposes an open window is considered as an area of 100 percent absorption of sound. A single person absorbs about as much sound as four square feet of open window. Therefore, an audience of 1,000 people will have the effect on music volume of an open window area of 4,000 square feet as compared with the volume heard when the enclosure is empty. To offset this absorption, a disproportionately greater amount of tone cabinet equipment must be used.

DISTRIBUTION

The sound energy from the organ should be distributed as evenly as possible throughout the enclosure. In order that this may be accomplished, it is important that the sound be distributed in the auditorium above the listeners and that a large percentage of the sound reaching the listener is by numerous reflections from the walls and ceiling. Direct projection as well as direct reflection from the speakers should not reach the listener. Focusing effects of curved surfaces such as barreled ceilings often cause difficulty in sound distribution unless the tone cabinet is so located as to reduce the direct sound energy that reaches these surfaces.

It must be remembered that although sound is reflected in a manner similar to light, the reflecting surface must be large in relation to the wave length of the sound. Therefore, a reflecting surface of a given size will reflect sounds above a certain frequency, while sounds of lower frequency will be diffracted or spread out. To reflect fully the lower tones of the organ a reflector thousands of square feet in area is necessary. This, together with the fact that different materials absorb sounds of certain frequencies more than others explains why identical tone colors produced in different enclosures will sound very different to the ear.

BALANCE

The placement of console and tone cabinets should be carefully planned so that the following conditions are fulfilled:

1. The organ should sound as loud or slightly louder to the organist at the console than it does to the audience. This allows the organist to accurately judge the musical effect he is producing and make any necessary corrections before the audience appreciates the need for them. It also reduces the tendency of playing too loud which is usually evident when the organist hears the organ at a lower level than the audience.
2. The organist should hear the organ and the choir with the same relative loudness that the audience hears them, otherwise a perfect tonal balance between organ and choir from the organist's point of hearing will result in an unbalanced effect as heard by the audience. When we refer to the choir we also include instrumental groups or soloists who may have occasion to perform in conjunction with the organ.
3. The tonal equipment of the organ should be so located that the choir, while singing, has adequate support from the organ when played at accompaniment volume. They should not, however, hear the organ so loudly as to have difficulty in singing with it. Good tonal balance and ease of performance should result if the average distance between choir and tone cabinets is about the same distance as between tone cabinets and organist.
4. The audience should hear the choir and the organ as a balanced ensemble, and the tone cabinets should be so placed that the choir voices will not be obscured by the organ tones.

REVERBERATION

Reverberation is the prolongation or persistence of sound by reflection, what we usually mean by "echo". It is measurable by the interval of time required for the sound to decay to inaudibility after the source of the sound has been stopped. It is present in a varying degree in all enclosures and most types of music are more pleasing to the ear when accompanied by a certain amount of reverberation. It is also the most important single factor to be considered in planning an organ installation as proper reverberation makes it easier to attain all of the other requirements necessary for a perfect installation.

In a Hammond organ installation, the proper amount of reverberation may be secured in three ways:

1. By the successive reflections of the sound by the boundaries of the auditorium.
2. By the Hammond Reverberation Control.
3. By placing the tone cabinets in a chamber, the boundaries of which cause the organ tones to reverberate before reaching the auditorium.

REVERBERATION IN THE AUDITORIUM

The reverberation that results from the successive reflections of sound back and forth by the boundaries of the auditorium itself is most desirable from the installation engineer's point of view. (By auditorium we mean any audience room such as a church or concert hall.)

In a reverberant auditorium less power is necessary and problems of sound distribution are greatly simplified and, therefore, the best possible musical results are usually obtained as a matter of course. Unfortunately, however, the reverberation characteristics of an auditorium usually are not alterable by the installation engineer, and he must accept them, good or bad as the case may be.

A reverberation time of one second when a two-thirds capacity audience is present is usually sufficient if reasonable care is taken in locating the organ equipment for proper distribution and balance although a slightly longer reverberation time is often desirable. It must be remembered that the reverberation time in any enclosure is greatly reduced when an audience is present. In general, the higher the ceiling of the auditorium, the less effect the presence of an audience has on the reverberation time; however, this effect is always considerable. If the natural reverberation in the auditorium is insufficient for best musical results from the organ, another method must be used to properly reverberate the organ tones.

HAMMOND REVERBERATION CONTROL

The Hammond Reverberation Unit provides an effective means of securing proper reverberation in all types of installations where the natural reverberation in the auditorium is insufficient. Experience has shown that best installations in homes, radio studios, mortuaries, and small churches include a tone cabinet equipped with reverberation control. It may also be used to improve the effectiveness of the organ in auditoriums where considerable natural reverberation is present, but where this natural reverberation is characterized by an objectionable echo occurring after the organ tones have seemingly ceased. The Hammond Reverberation Unit will not eliminate an echo or reduce the natural reverberation time, but will often make this natural reverberation more pleasing to the ear by "filling in" that period between the time the organ tones seem to cease and the echo occurs. The Hammond Reverberation Unit will not add to the reverberation time in auditoriums already having excessive natural reverberation. As the reverberation unit is connected to the electrical system of the organ and provides reverberation at the source of sound rather than after the sound comes from the speakers, it allows the installation engineer to place the tone cabinets for best results in balance and distribution without the necessity of compromise for reverberation considerations. The use of this device also eliminates the necessity of costly reverberation chambers, and by allowing the tone cabinets to be so located as to minimize sound energy losses, a saving in the amount of necessary power equipment is often effected. A further advantage is that the reverberation time may be regulated for best musical results after the organ is installed.

With the use of the Hammond Reverberation Unit a good organ installation should always result if the tonal equipment is placed to give even distribution and proper tonal balance.

REVERBERATION CHAMBERS

When it is desired to conceal the organ tone cabinets and there is adequate space available, a properly designed reverberation chamber may be very effective in supplying reverberation for the organ tones. In many cases, however, the space allotted for use as a reverberation chamber is anything but ideal, and often, because of structural limitations, little can be done to improve the effectiveness of the chamber other than to make minor corrections. The following principles of reverberation chamber design are given for guidance in properly evaluating the good and bad characteristics of a given chamber and in making such changes as will improve the effectiveness of the chamber as much as possible.

SIZE

As the reverberation time increases as the size of the chamber increases, the chamber should be as large as possible. Experience has shown that practically the only exceptions to this rule are when the shape of the chamber may be improved by reducing its size or when the tone opening cannot be made large enough in proportion to the size of the chamber. For best musical results the chamber should be at least 800 cubic feet in volume. The dimensions of the chamber are in most cases ideal if they are in the ratio of approximately 2 : 3 : 4 1/2. A chamber of equal volume but more cubical in form would have a longer reverberation time, while a chamber of less cubical form would have a shorter reverberation time; however, dimensions in the above ratio usually are most desirable. Chambers of complex shape or chambers of regular shape whose greatest dimension is more than three times the least dimension should be avoided .

CHART SHOWING SIZE OF TONE OPENING REQUIRED
FOR REVERBERATION TIME OF ONE SECOND
FOR CHAMBERS WITH DIMENSIONS IN RATIO OF 2 : 3 : 4.5

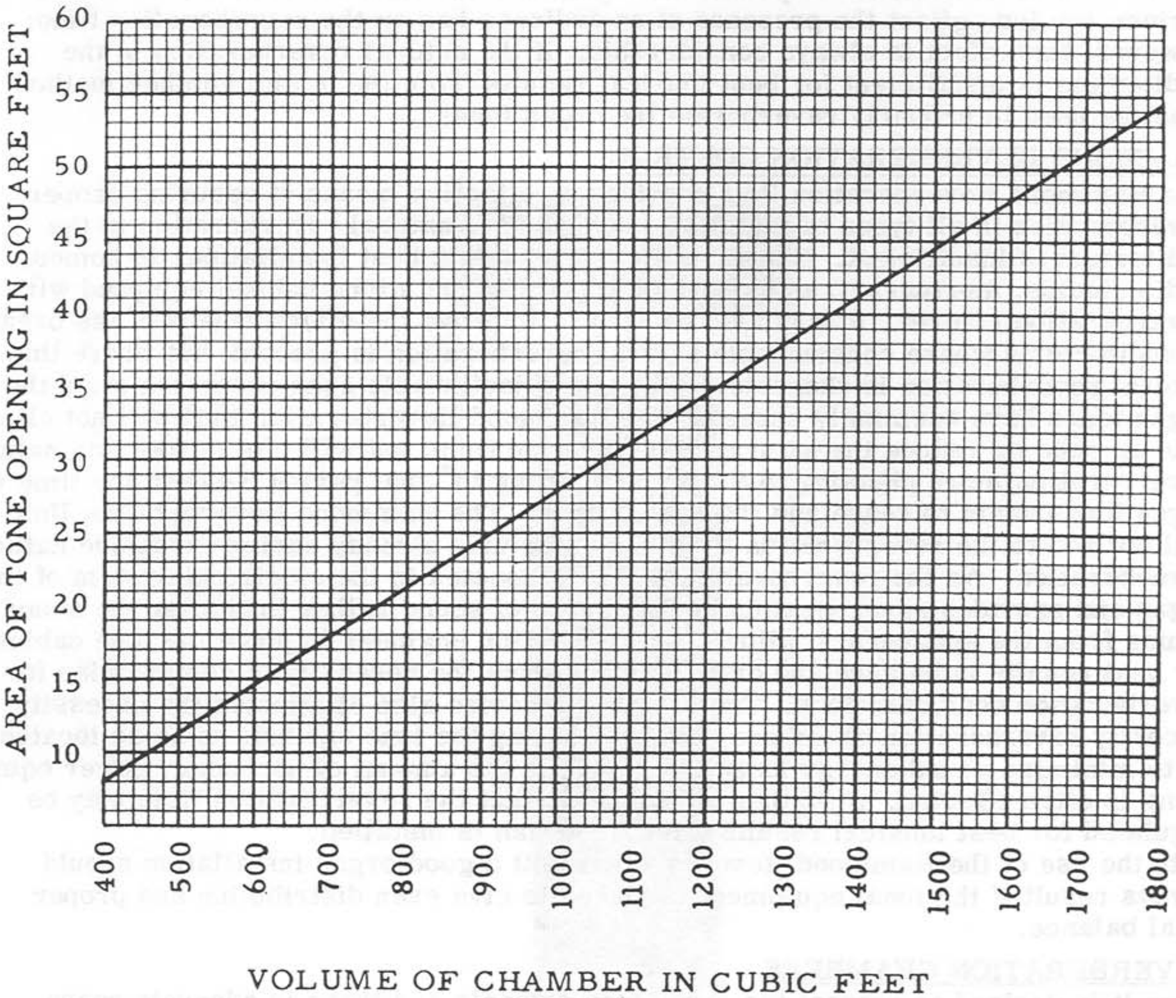


FIGURE 1.

CONSTRUCTION AND FINISH

All boundaries of a reverberation chamber should be of exceptionally rigid construction. Concrete or heavy tile is ideal. If the chamber is to be of frame construction the studs should not be over fourteen inches on centers. Lath should be very securely nailed and the plaster should be hard and given a smooth finish coat.

TONE OPENINGS

The reverberation time of an organ chamber is greatly influenced by the size of the tone opening. For a chamber of given dimensions, the reverberation time is increased as the area of the tone opening is reduced. A large chamber, therefore, may have a large tone opening and still furnish sufficient reverberation, whereas a small chamber might require a very small opening. A chart is shown in Figure 1, giving the area of tone opening required to furnish one second reverberation time when the volume of the chamber is known. This chart is for chambers with dimensions in the ratio of 2 : 3 : 4 1/2 only; however, in practice the areas of tone opening shown are generally satisfactory.

The tone opening should be located in the largest wall surface of the chamber if possible, and preferably near the center of the wall area.

HAMMOND ORGAN COMPANY
4200 West Diversey Ave., Chicago 39, Illinois

THE HAMMOND ORGAN

Main Generator

HAMMOND ORGAN COMPANY
4200 West Diversey Avenue
Chicago 39, Illinois

7/58

TECHNICAL SECTION

MAIN GENERATOR - GENERAL DESCRIPTION

Each Hammond Organ console has a main generator within it, and in some cases, depending on the model, a chorus generator. This section describes the main generator, illustrated below.

The main generator assembly consists of the generator proper, a shaded pole induction motor for starting, a non-self-starting synchronous motor for driving the unit after it is started, and either a tremulant switch mechanism or a Vibrato Scanner mounted on the synchronous motor. The entire assembly is mounted on two long steel angles which also provide the means of mounting the tone generator in the console. The method of mounting is such as to minimize the transmission of vibration from the tone generator to the console.

A drive shaft, resiliently coupled to the synchronous running motor, extends the entire length of the generator. Twenty-four driving gears, two each of twelve sizes, are mounted on this shaft, and the drive shaft itself is divided into several sections connected by flexible couplings. The starting motor is mounted at the end of this drive shaft, opposite the synchronous motor. Section 7 describes the starting procedure.

The main generator proper is a long structure in which are mounted 48 rotating assemblies, each consisting of a shaft and two discs known as tone or phonic wheels. These assemblies are coupled resiliently to the drive shaft. Each of the driving gears engages two bakelite gears associated with opposite rotating assemblies (See Figure 2). These bakelite gears rotate freely on the shafts with the tone wheels, and are coupled to their respective assemblies by a pair of coil springs. There are 12 sizes of bakelite gears, corresponding to the 12 sizes of driving gears. Thus 4 of the tone wheel assemblies, each with 2 tone wheels, run at each of 12 speeds.

Each tone wheel is a steel disc about 2 inches in diameter, accurately machined with a definite number of high and low points on its edge (See Figure 3). Each high point on a tone wheel is called a tooth. The number of teeth on each of these tone or phonic wheels, in conjunction with the speed at which the tone wheel is revolving, determines the frequency of the tone generated.

Each driving gear, with its two bakelite gears and four tone wheels, runs in a separate compartment magnetically shielded from the rest by steel plates which divide the generator into a series of bins.

All four tone wheels in any one compartment run at the same speed. The individual tone wheel shafts are mounted in bearings made of a special porous bronze and each of these bearings is connected to the oiling system by a cotton thread from the oil trough. Thus, oil from the trough is carried by capillary action to all bearings, penetrating them and lubricating the actual bearing surface. The drive shaft and both motors are lubricated in a similar manner. It is very important to use the recommended grade of oil regularly, as it is essential to the proper operation of the organ that the generator be well lubricated. If oil of varying grades is used, it is likely that the generator may be sluggish in starting, and in time the threads may gum up and prevent the proper flow of oil.

The two spring couplings on the motor shaft, the flexible couplings between sections of the drive shaft, and the tone wheel spring couplings all contribute to absorbing variations in motor speed. The synchronous motor does not deliver absolutely steady power, but rather operates with a series of pulsations, one with each half cycle. If the tone wheels were rigidly coupled to the motor, this slight irregularity would carry extra frequencies into each tone wheel. In addition, "hunting" is suppressed by the resilient couplings and inertia members of the synchronous motor proper.

Associated with each tone wheel is a magnetized rod about 1/4 of an inch in diameter and 4 inches in length, with a coil of wire wound near one end (See Figure 3). The tip of the magnet at the coil end is ground to a sharp edge and mounted near the edge of the tone wheel. Each time a tooth passes this rod it causes a change in the magnetic field which induces a small voltage in the coil, the frequency being determined by the number of teeth and the wheel speed.

Small coils are used on the higher frequency magnets and larger coils on the lower frequencies. It is found that large pole pieces are needed on the low frequency magnets to give good frequency output, but it is necessary to use smaller ones on the high frequencies to prevent excessive iron losses.

Some of the coils have copper rings mounted on them for the purpose of reducing harmonics. As these are used only on fairly low frequency coils, the eddy current loss in such a ring is small for the fundamental frequency of that coil, but high for its harmonics. This has the effect of reducing the relative intensities of any harmonics which may be produced by irregularities in the tone wheels. The wheels are cut so to give as nearly a sine wave as possible, but the generated voltage seldom reaches that ideal condition, since even a change in the air gap will change the wave form. The tip of each magnet, as well as the edge of each tone wheel, is coated with lacquer to prevent corrosion, for, should oxidation set in, the change in tooth shape would introduce irregular frequencies.

Locations of the various magnet and coil assemblies are shown in Figure 4. They are identified by their frequency numbers, and the broken line between any two numbers indicates that these two frequencies are supplied by one tone wheel assembly.

Each magnet is set at the factory with the set screw partially loosened, while observing an output meter. Experience has shown that the magnets seldom need adjustment and that setting them without proper equipment involves danger of damaging both magnet and wheel. Therefore it is not recommended that the service man attempt this adjustment.

As a means of eliminating any vagrant harmonics that may be present, there are filters consisting of small transformers and condensers associated with certain frequencies. The transformers have a single tapped winding, and this tap is grounded, so one side, which is connected to the corresponding magnet coil through a condenser, forms a resonant circuit for the fundamental frequency of that coil. This tends to emphasize the fundamental and suppress harmonics.

Locations of these transformers are shown in Figure 5 and 6. They are also shown in schmotics in section 2.

These transformers and condensers are mounted on the top of the generator assembly. The transformers are mounted at an angle, thus minimizing interference between them. The cores of the transformers are made of a special iron, and the number of laminations used is adjusted to secure the proper inductance. Wires from the magnet coils connect to the transformers, and wires from the transformers lead to the terminal strip on the generator.

This terminal strip carries the output frequencies of the generator, which are arbitrarily numbered from 1 to 91 in order of increasing frequency. This frequency numbering is continued throughout the instrument. In some models the frequencies are not in order on the terminal strip, and Figures 5 and 6 indicate the arrangement for different models. Several terminals at the right end are grounded to the generator frame and serve to ground the manuals and pedals.

Transformers and condensers are not used below frequency 44, but a length of resistance wire shunts each generator. Frequencies 44 to 48 have transformers only, while both transformers and condensers are used for frequencies 49 to 91 except in the case of Model A consoles numbered below 2179, which do not have condensers for frequencies 49 to 54 inclusive.

Two condenser values are used - 0.255 mfd for frequencies 49 to 54, and 0.105 mfd for frequencies 55 to 91. The transformers are all different. Each transformer is matched to its condenser and any replacements are supplied as matched pairs by the factory.

There are several types of generators in use and the following information will aid the service technician in identifying the console on which work is being performed.

<u>91 Frequency Generator</u>

Model A serial No. 1	- 2676	Model D serial No. 1	- 3143
Model B serial No. 4000	- 10,549	Model E serial No. 8000	- 8663
Model C serial No. 1	- 1247	Player consoles serial No. 9000	- 9209

The number of tone wheels on the above models is 91, and 5 blank wheels are used to maintain the balance of the rotating units. There are twelve wheels with two teeth, one to operate at each of twelve speeds, and similarly twelve have four teeth, twelve have eight teeth, twelve have sixteen, twelve have thirty-two, twelve have sixty-four, twelve have one hundred and twenty-eight and seven have one hundred ninety-two. An assembly with a two-tooth wheel also has a thirty-two tooth wheel which generates a frequency four octaves above the other. The four and sixty-four tooth wheels go together, as do the eight and one hundred twenty-eight tooth wheels. The twelve sixteen tooth wheels are mounted with seven one hundred ninety-two tooth wheels and the five blank wheels. In this last group the high frequency is not four octaves above, but is four octaves less five semi-tones above the lower.

This arrangement gives a total of 91 frequencies that are connected to corresponding terminals on the generator, and then to the manuals and pedal switch. In all cases, as mentioned above, the generator must be used with corresponding manuals and pedal switches and other types of generators cannot be substituted.

82 Frequency Generator

Model A serial No. 2677 - 2711

Model B serial No. 10,550 - 17,074

Model C serial No. 1248 - 17,074

Model D serial No. 3144 - 17,074

Model E serial No. 8664 - 8739

Model G serial No. 4101 - 7349

Player consoles serial No. 9210 only.

In the above consoles, frequencies #1 to 9 have been omitted from the generator, and only 82 generator terminals are used. Similarly, there are only 82 tone wheels and magnets in the generator instead of 91. Blank wheels replace the nine two-tooth tone wheels formerly used to produce frequencies 1 to 9.

This generator change accompanies a wiring revision in the manual and pedal switches which makes the frequencies from 1 to 9 unnecessary. Generators having but 82 frequencies are easily identified by a blank space on the terminal strip at the left of the ground terminals. The first terminal at the left of this space is terminal #10.

91 Frequency Generator with Complex Tone Wheels

Model BV serial No. 17075 - 29737

Model CV serial No. 17075 - 30287

Model RT serial No. 1001 - 1201

Model B-2 serial No. 35000 - 40303

Model C-2 serial No. 35001 - 40459

Model RT-2 serial No. 1300 - 2150

In the above consoles, the original two-tooth wheels in the generator have been replaced with twelve two-tooth complex tone wheels, which supply a fundamental tone that is enriched with the odd-number harmonics. Both manuals and pedal switch are wired differently and are therefore not interchangeable with earlier models.

91 Frequency Generator with complex tone wheels and narrow cover

Model B-2, C-2, RT-2 (Except those listed in prior paragraph) and all B-3, C-3, and RT-3

This generator has twelve complex tone wheels and is identical to the one above except for the generator cover. Because the output terminals of this cover are not in order of frequency (See Figure 6) this type of generator is not interchangeable with the one above.

Tone Generator For Spinet Models

The generator used in Spinet Models has 86 tone wheels and differs from other models in several other respects. The twelve complex-tone wheels are different in shape from those used in other models, and the generator-to-manual cable connects directly to the filter transformer terminals.
For details, see Service Manual covering specific Models.

ORDERING INFORMATION

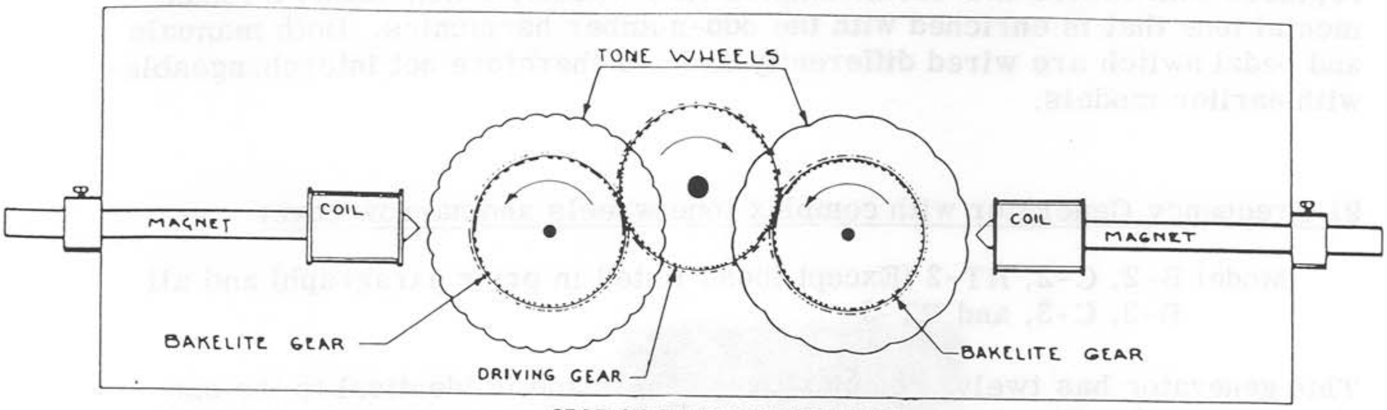
When ordering replacement generators be sure to state model and serial number of consoles, as generators are not interchangeable.

Note: Consoles have been made equipped with 115 volt 25 or 50 or 60 cycle and 230 volt 50 or 60 cycle generators. If the owner is contemplating moving to a location having a different frequency of current, the complete generator must be changed. Where voltage changes only are encountered, step-up or step-down transformers will be necessary.

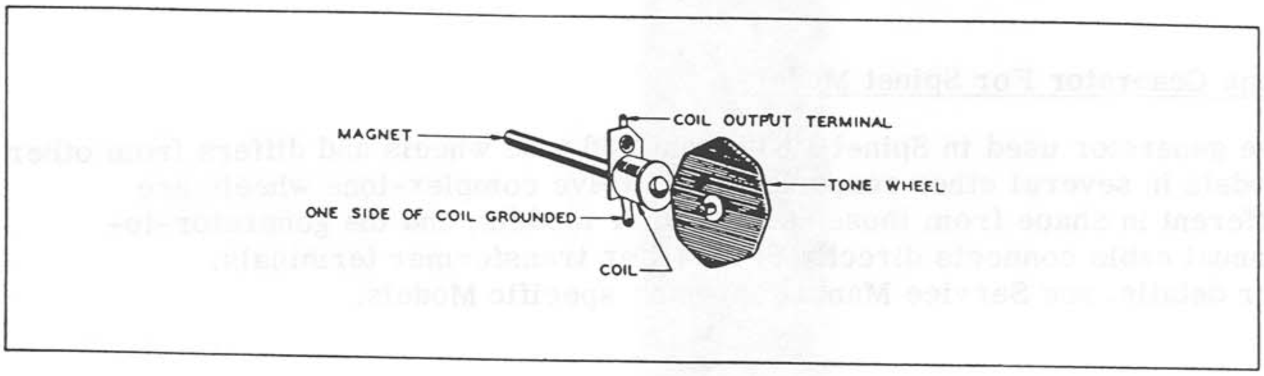
Generator Anchoring

When a console is set up for operation the anchoring must be loosened so that the generator will float freely on its spring suspension system. No damage will result if this is not done, but the console will sound noisy, and the same is true if the anchoring is loosened but the oonsole is not level. If the console is to be moved a long distance the anchoring should be tightened during such moves.

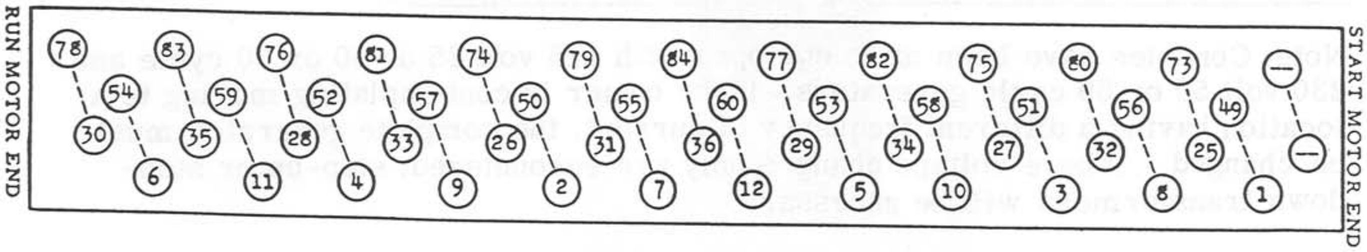
Several different types of anchoring have been employed and instructions for loosening and tightening the generator in any particular console are given on the instruction card contained in the bench which accompanied that console.



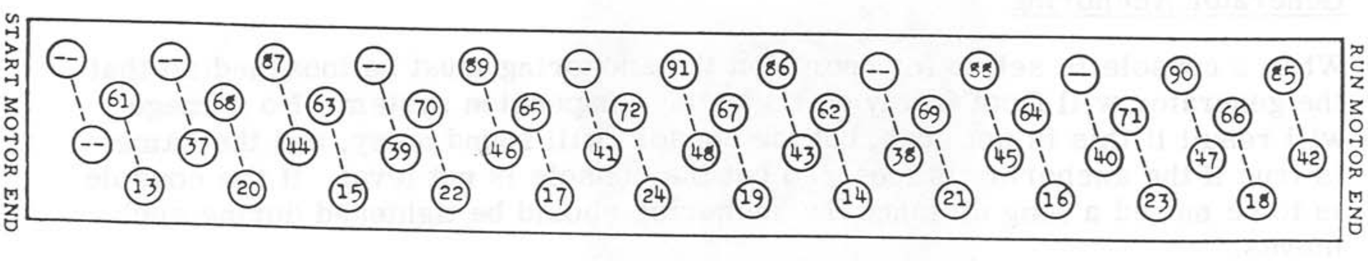
SECTION OF MAIN GENERATOR



TONE GENERATOR



BACK VIEW OF MAIN GENERATOR



FRONT VIEW OF MAIN GENERATOR

GENERATOR MAGNET LOCATIONS

(Numbers shown are frequency numbers)

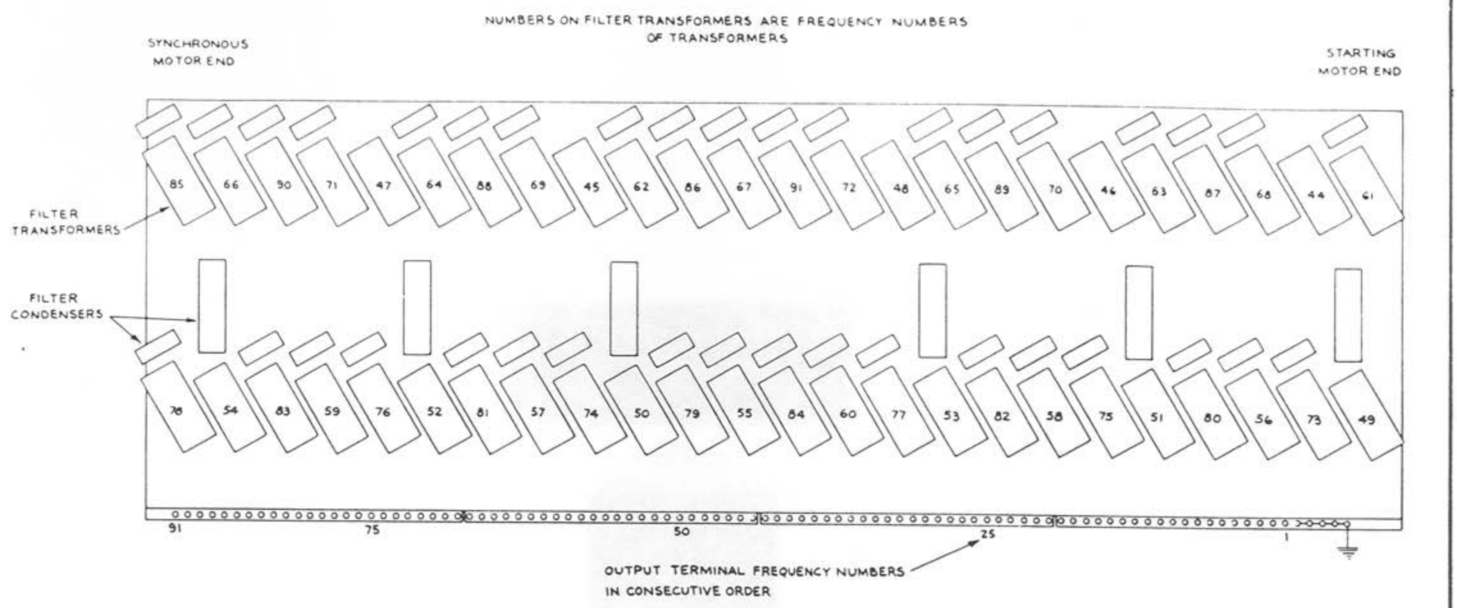


FIGURE 5 - MAIN GENERATOR COVER
MODELS A, B, BC, BV, C, CV, D, DV, E, AND RT
MODEL B-2 SERIAL NUMBERS BELOW 40304
MODEL C-2 SERIAL NUMBERS BELOW 40460
MODEL RT-2 SERIAL NUMBERS BELOW 2151

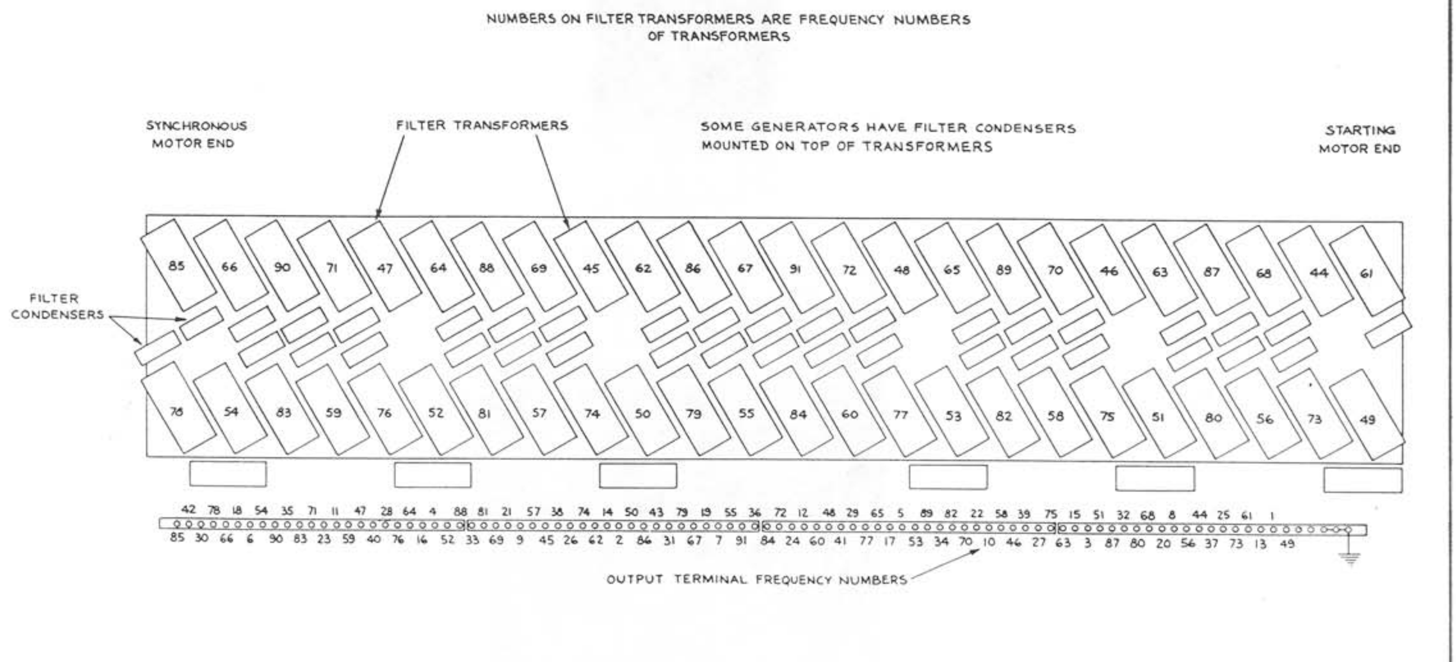


FIGURE 6 - MAIN GENERATOR COVER
MODEL B-2 SERIAL NUMBER 40304 AND ABOVE
MODEL C-2 SERIAL NUMBER 40460 AND ABOVE
MODEL RT-2 SERIAL NUMBER 2151 AND ABOVE
ALL B-3 C-3 AND RT-3 CONSOLES

VIBRATO,
SELECTIVE VIBRATO,
TOUCH RESPONSE
PERCUSSION

HAMMOND ORGAN COMPANY
4200 West Diversey Avenue
Chicago 39, Illinois

12/59

THE HAMMOND VIBRATO

Hammond Organ consoles equipped with vibrato differ from tremulant models in the omission of the tremulant switch, tremulant control, and non-vibrato preamplifier, and in the addition of the vibrato line box, scanner, vibrato switch, and vibrato preamplifier. Three degrees of vibrato are available and also a different degree of chorus or celeste effect with each of the three degrees of vibrato. Console models with the suffix "2" and "3" in their model designation have the selective vibrato feature, with tilting control tablets permitting the player to place the vibrato effect on either manual or both.

PRINCIPLE OF OPERATION

The vibrato effect is created by a periodic raising and lowering of pitch, and thus is fundamentally different from a tremolo, or loudness variation. It is comparable to the effect produced when a violinist moves his finger back and forth on a string while playing, varying the frequency while maintaining constant volume.

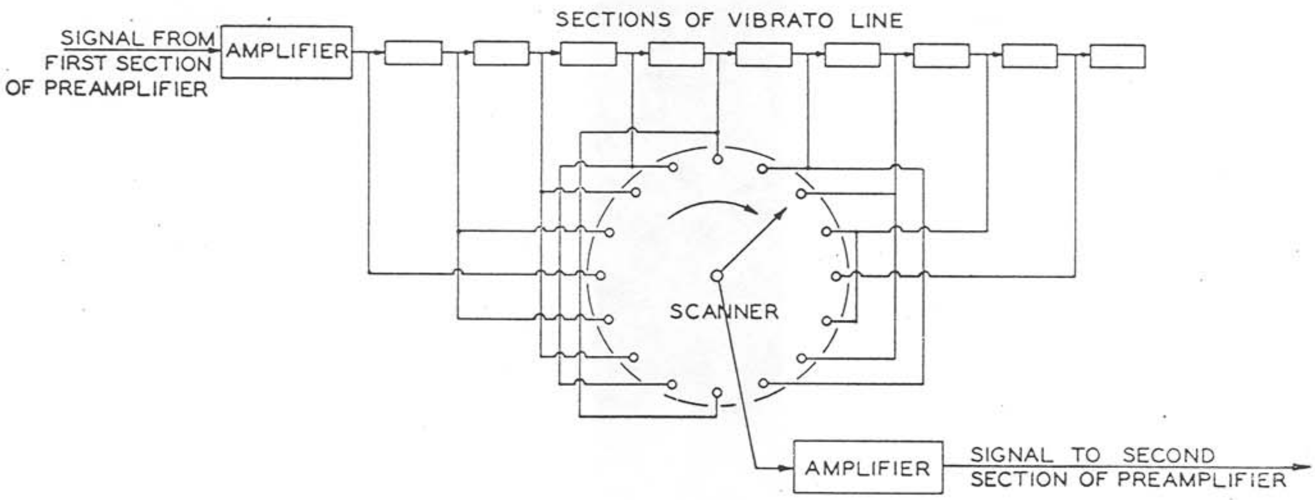


Fig. 1 - FUNDAMENTAL DIAGRAM OF VIBRATO EQUIPMENT.

The Hammond Organ vibrato equipment (see simplified block diagram, Fig. 1) varies the frequency of all tones by continuously shifting their phase. It includes a phase shift network or electrical time delay line, composed of a number of low pass filter sections, and a capacity type pickup or scanner, which is motor driven so that it scans back and forth along the line.

Electrical waves fed into the line are shifted in phase by each line section (the amount per section being proportional to frequency), so that at any tap on the line the phase is retarded relative to the previous tap.

The scanning pick-up traveling along the line will thus encounter waves increasingly retarded in phase at each successive tap, and the signal it picks up will continuously change in phase. The rate at which this phase shift occurs will depend on how many line sections are scanned each second.

Since a cycle is equivalent to 360 electrical degrees, a frequency shift of one cycle occurs for each 360 electrical degrees scanned per second. For example if the scanner passes over the line at such a rate that 3600 electrical degrees are scanned each second, there will be a frequency change of 10 cycles.

For the widest vibrato, the whole line is scanned from beginning to end in about 1/14 second, and this rate of change of phase causes about 1-1/2% decrease in frequency. Note that the frequency remains constantly 1-1/2% low as long as the moving pick-up retards the phase at a constant rate.

Since the pick-up sweeps from start to end of the line and then back, it increases the frequency by an equal percentage on its return trip, the average output frequency remaining equal to the input frequency. The exact amount of frequency shift depends not only on the amount of phase shift in the line but also on the scanning rate. This rate, however, is constant because the scanner is driven by the synchronous running motor of the organ.

The degree of vibrato (or amount of frequency shift) may be varied by a switch (not shown in Fig. 1) which causes the whole line to be scanned for #3 (wide) vibrato, about half of it for #2, and about one third for #1.

A vibrato chorus effect, similar to the effect of two or three slightly out-of-tune frequencies mixed together, is obtained when the vibrato output signal is mixed with a portion of signal without vibrato. For vibrato chorus, part of the incoming signal appears across the vibrato line and the rest across a resistor in series with the line. As the vibrato effect is applied to the part of the signal appearing across the line but not to the part appearing across the resistor, the combination produces a chorus effect. For normal vibrato, this resistor is short-circuited.

In "selective vibrato" consoles the vibrato effect can be applied to either manual separately or to both at once.

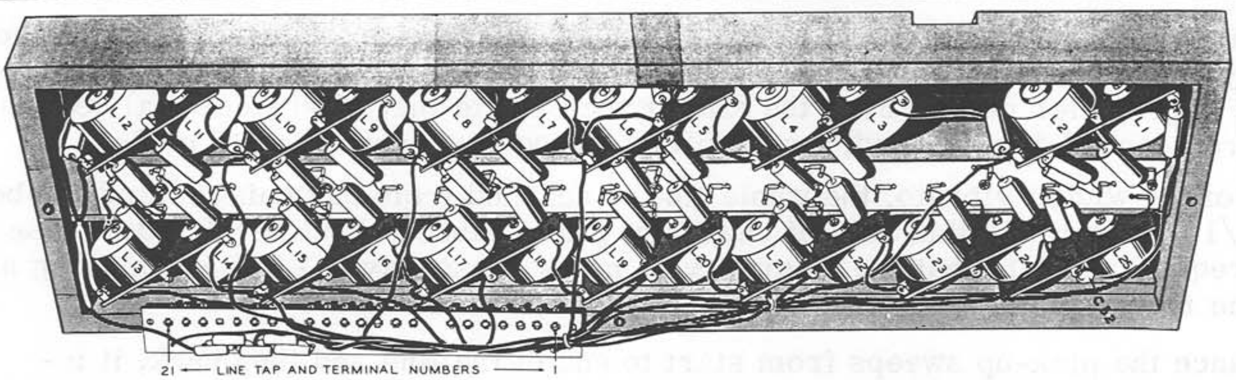
CONSTRUCTION OF COMPONENTS

Figures 2 and 3 show different models of the vibrato line box. Each of the air core inductance coils is connected with one or more condensers to form one filter section.

Figure 4 shows the construction of a typical vibrato switch. Some models differ in wiring and number of contacts, but all are similar in mechanical arrangement.

The scanner (fig. 5) is mounted on the main generator synchronous motor and driven at 412 revolutions per minute. It is a multi-pole variable condenser with 16 sets of stationary plates and a rotor whose plates mesh with the stationary ones. In figure 5B two sets of plates have been removed to show the rotor.

Signals coming from the line through the vibrato switch appear on the stationary plates and are picked up, one at a time, by the rotor. Connection to the rotor is made by carbon brushes as shown in figure 5A. Two brushes touch the sides of the contact pin and a third presses on the end, in order to eliminate the possibility of contact failure.



(TERMINAL PANEL FOLDED OUT TO SHOW CONNECTIONS)

FIG. 2
VIBRATO LINE BOX
USED WITH CIRCUITS SHOWN IN FIGURES 6, 7, 8

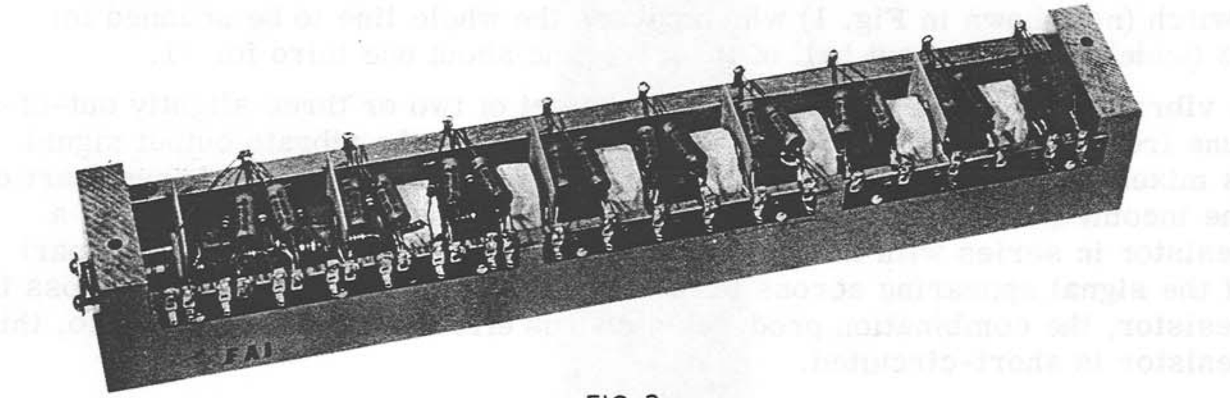


FIG. 3
VIBRATO LINE BOX
USED WITH CIRCUIT SHOWN IN FIGURE 9

SCHEMATIC DIAGRAMS

Figures 6, 7, 8 and 9 show four different vibrato circuits which have been used in various models. As the components of different types are generally not interchangeable, it is important that model and serial number be furnished when ordering replacement parts.

Non-Selective Vibrato

Figure 6, used in all consoles with "V" in the model designation, has a 25 section vibrato line. It is wired (to minimize the number of compensated take-off points) so that the last part of the line is used for #1 vibrato. The vibrato switch has positions for three degrees of vibrato (V1, V2 and V3) with three "off" positions between them, and there is a separate vibrato chorus switch. A resistor connected to the "off" side of the chorus switch serves to maintain constant volume for the two switch positions. The switch is not intended to be left in its middle position.

The preamplifier used with this circuit is actually two separate cascaded amplifiers on one chassis, with the vibrato system connected between them. The first section drives the vibrato line, and the second section amplifies the signal picked up by the scanner. The "vibrato off" contact in the vibrato switch carries non-vibrato signal directly to the second section of the preamplifier. The complete schematic circuit of a console of this type is shown in Figure 7 of section 2, and preamplifier in Figure 6 of section 11.

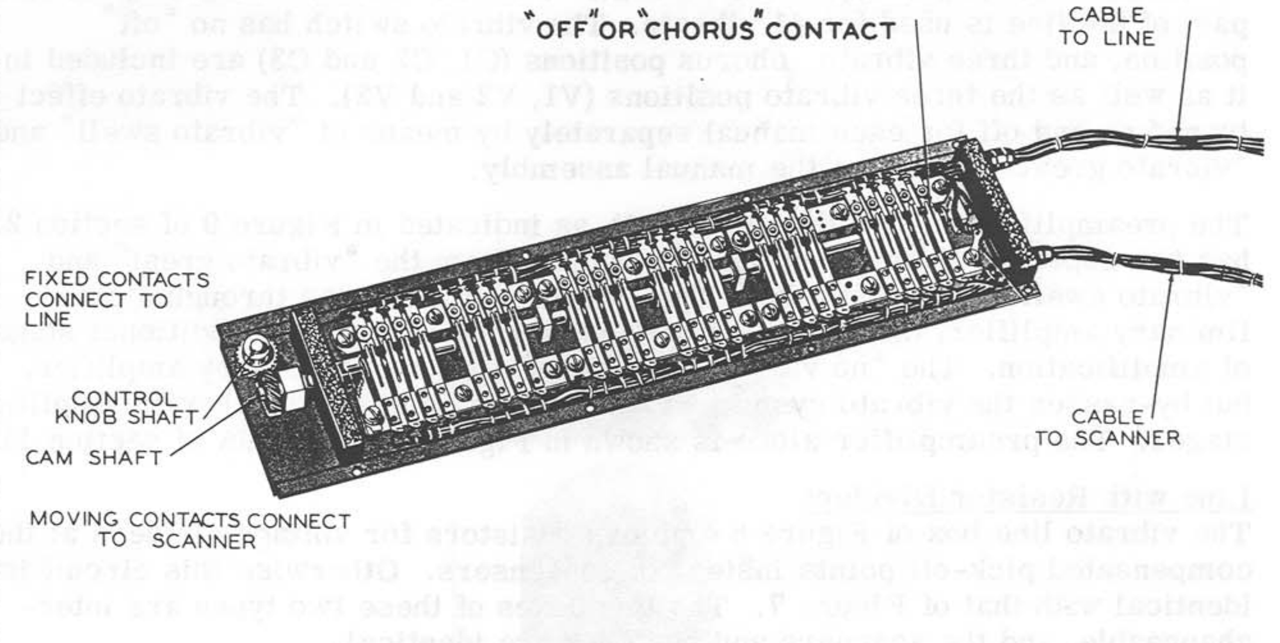
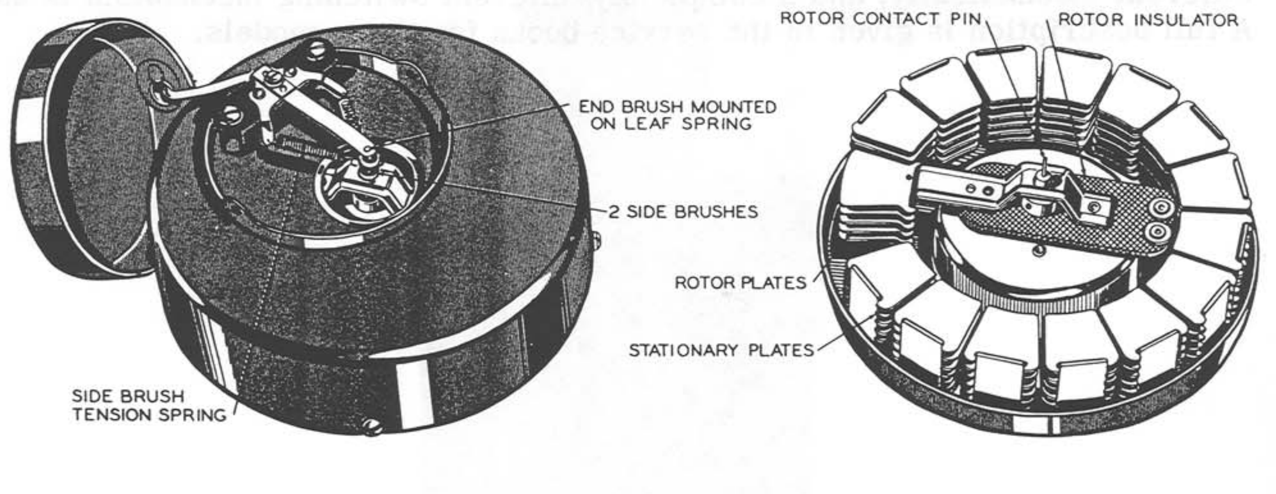


FIG.4 VIBRATO SWITCH
(BOTTOM VIEW WITH COVER REMOVED)



A-BRUSH COVER REMOVED TO SHOW BRUSHES

B-VIEW WITH SCANNER COVER REMOVED
(2 SETS OF PLATES REMOVED TO SHOW ROTOR)

FIG. 5 SCANNER

Selective Vibrato

Figure 7, used in early selective vibrato consoles, also has a 25 section line. To obtain correct phasing of the "vibrato" and "no vibrato" channels, the first part of the line is used for #1 vibrato. The vibrato switch has no "off" position, and three vibrato chorus positions (C1, C2 and C3) are included in it as well as the three vibrato positions (V1, V2 and V3). The vibrato effect is turned on and off for each manual separately by means of "vibrato swell" and "vibrato great" tablets on the manual assembly.

The preamplifier used with this circuit, as indicated in Figure 9 of section 2, has two separate channels into which signals from the "vibrato great" and "vibrato swell" tablets are fed. The "vibrato" signal goes through a preliminary amplifier, through the vibrato system, and then into additional stages of amplification. The "no vibrato" signal also has a preliminary amplifier, but by-passes the vibrato system and goes directly into the following amplifier stages. The preamplifier alone is shown in Figures 20 and 20A of section 11.

Line with Resistor Dividers

The vibrato line box of Figure 8 employs resistors for voltage dividers at the compensated pick-off points instead of condensers. Otherwise this circuit is identical with that of Figure 7. The line boxes of these two types are interchangeable, and the scanners and switches are identical.

Coupled Line

Figure 9 shows the coupled-coil type of vibrato line box. It is smaller in size and requires only 18 sections to give the same amount of vibrato effect as the 25 sections previously used. The switch has one less contact in each position, and so neither the vibrato line nor the vibrato switch is interchangeable with earlier types. The preamplifiers are the same as those used with the circuits of Figures 7 and 8. The scanner has somewhat different wiring harness.

MODEL "M" VIBRATO SYSTEM

The vibrato system in the Spinet Model M Series is somewhat different from those described above. The line box is slightly smaller, the scanner is slightly different mechanically, and a completely different switching mechanism is used. A full description is given in the service books for these models.

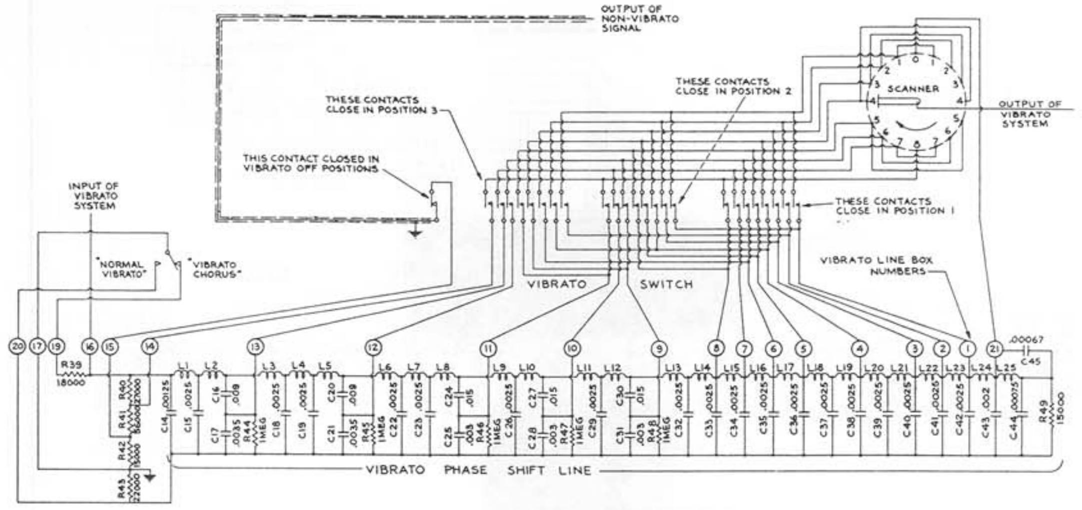


FIGURE 6 - VIBRATO SYSTEM

.SED IN ALL MODEL AV, BV, BCV, CV, DV, AND RT CONSOLES

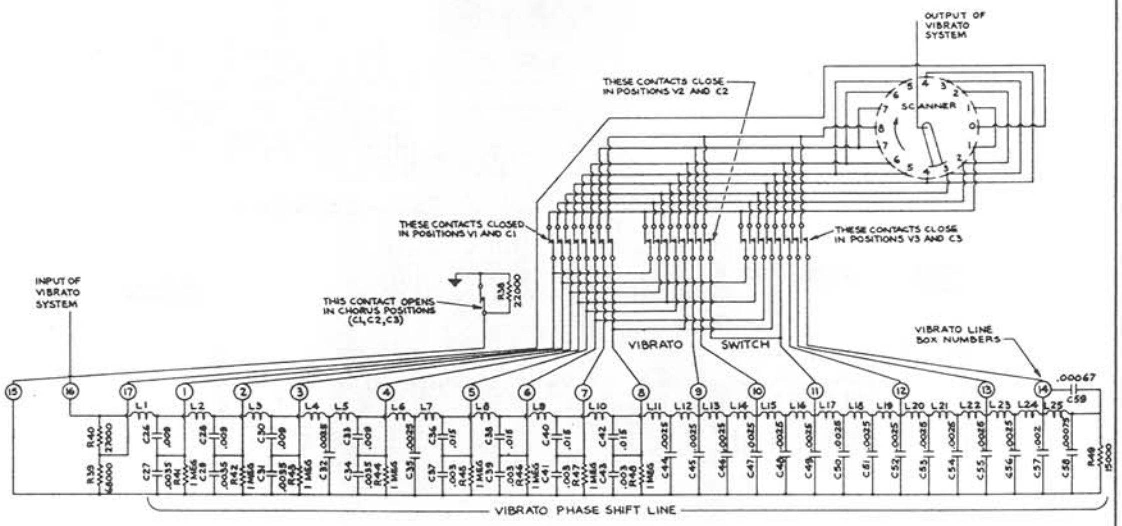


FIGURE 7 - VIBRATO SYSTEM

MODEL B-2 CONSOLES BELOW SERIAL NUMBER 37305
MODEL C-2 CONSOLES BELOW SERIAL NUMBER 38728
MODEL RT-2 CONSOLES BELOW SERIAL NUMBER 2051

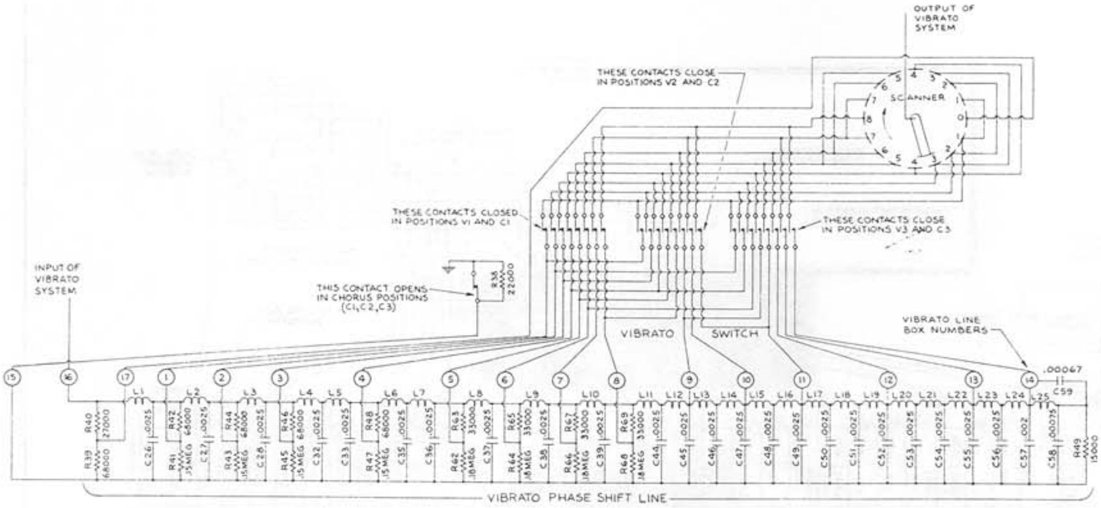


FIGURE 8 - VIBRATO SYSTEM

MODEL B-2 CONSOLES SERIAL NUMBER 37305 TO 45900, AND 46101 TO 46154
MODEL C-2 CONSOLES SERIAL NUMBER 38728 TO 46961
MODEL RT-2 CONSOLES SERIAL NUMBER 2031 TO 2735

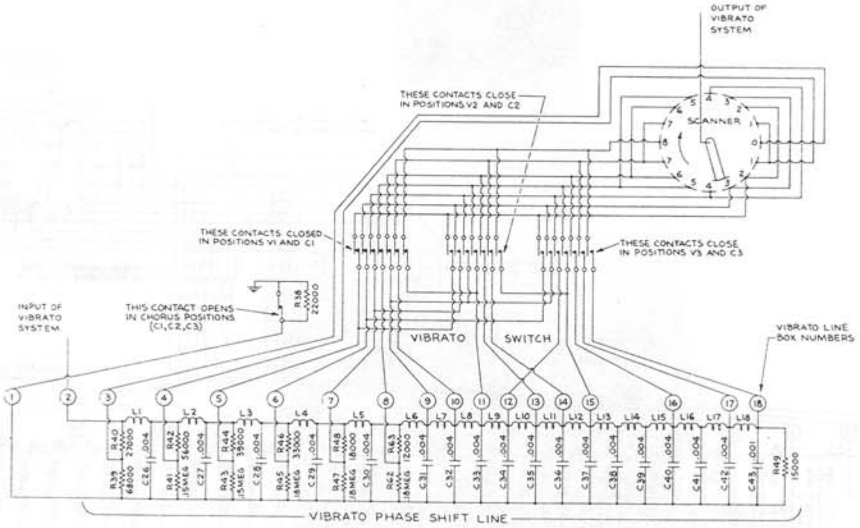


FIGURE 9 - VIBRATO SYSTEM

MODEL B-2 CONSOLES SERIAL NUMBER 45901 TO 46100, AND 46155 AND ABOVE
MODEL C-2 CONSOLES SERIAL NUMBER 46962 AND ABOVE
MODEL RT-2 CONSOLES SERIAL NUMBER 2734 AND ABOVE
MODEL B-3 AND C-3 CONSOLES SERIAL NUMBER 56000 AND ABOVE
MODEL RT-3 CONSOLES SERIAL NUMBER 4000 AND ABOVE

THE HAMMOND ORGAN WITH PERCUSSION.

Percussion tones are available only on the upper manual (with the B adjust key depressed) of all consoles with the suffix "3" in their model designation. These consoles, except for the four percussion control tablets in the upper right hand corner, look and function similar to consoles with the suffix "2" in their model designation, when the percussion effect is not in use.

1. THEORY OF OPERATION

The percussion tones are produced by borrowing the 2nd or 3rd harmonic signal from the corresponding drawbar (of the upper manual "B adjust key" drawbar group), amplifying it, returning part of it to same drawbar, and conducting the balance through push-pull control tubes, which when keyed cause the signal to fade away at a pre-determined rate.

2. GENERAL CIRCUIT OPERATION (All Reference Is To Figure 24 Section 2)

With percussion tablet "on", upper manual "B adjust key" and an upper manual playing key pressed, the 2nd or 3rd harmonic signal appearing on an upper manual busbar is conducted through "B adjust key" drawbar wire to input of percussion amplifier (terminal H) and amplified by T4 and V5. Besides providing push-pull signal for the control tube V7, the percussion input transformer T5 has a third winding which feeds the signal back to the 2nd or 3rd harmonic drawbar through equivalent key circuit resistor R50 and terminal J. Thus the signal that was borrowed from the 2nd or 3rd harmonic drawbar for the percussion amplifier is replaced.

When a key is depressed the signal first sounds loudly through the control tube, transformer T6, a high pass filter, and terminal D to the grid of V4. Immediately condenser C31 in the control tube grid circuit begins to discharge, causing the signal to fade away. Terminal K (approximately +25 volts) is connected to the 8th harmonic "B adjust key" drawbar wire which is connected to manual busbar. When an upper manual key is pressed, terminal K is grounded through the tone generator filters. This virtually grounds the plate of V6 (connected as a diode), stops conduction, and isolates cathode and control tube grid circuit. The grid then drifts from approximately +25 volts to about +15 volts, at a rate determined by the time required for C31 to discharge through R57 and R58. At the completion of this sequence the percussion signal is blocked. No further percussion effects occur until all keys of the upper manual are released and control grids can again rise to +25 volts. The rate of this rise is fixed by the time required to charge C31 to +25 volts through R55 and R56.

3. FOUR PERCUSSION CONTROL TABLETS, CUTOFF CONTROL, AND THEIR FUNCTIONS.

The Percussion On-Off Tablet when turned "on" does five things to the signals of the upper manual "B adjust key" drawbars.

(a) It disconnects the 2nd harmonic drawbar from its signal wire.
(b) It disconnects the 3rd harmonic drawbar from its signal wire.
(c) It connects the 2nd or 3rd harmonic drawbar signal wire (depending on position of Harmonic Selector Tablet) to input of percussion amplifier.
(d) It disconnects the 8th harmonic drawbar from its signal wire. This wire (connected through generator filters to ground when any key is pressed) is connected to terminal K. The 8th harmonic signal is not available on the upper

manual as long as percussion tablet is "on".

(e) It inserts resistor R1 in series with upper manual matching transformer (T2) secondary to reduce upper manual organ signal so that lower manual will musically balance with the combined upper manual organ and percussion signals.

The Preset Percussion Switch is not part of the control tablet assembly or percussion on-off tablet, but functions as an interlock with it. It is located under the upper manual "B adjust key". This switch insures that the full upper manual signal is restored by shorting out series resistor R1 introduced by the percussion "on" tablet when any other upper manual preset or adjust key is pressed.

The Volume Tablet in "soft" position shunts resistor R46 across the percussion output transformer, reducing percussion signal, and also shorts out upper manual matching transformer compensating resistor R1 thus restoring upper manual signal strength to provide proper balance between the manuals.

The Decay Tablet in "fast" position shunts resistor R57 across the slow decay resistor (R58) reducing time for decay capacitor C31 to discharge and for V7 control grids to reach cut-off. Also to preserve the same effective loudness in "fast decay" position as in "slow decay" the control tube bias is reduced by disconnecting R59 and allowing control tube grids to become more positive which increases output signal about 50%.

The Harmonic Selector Tablet does three things to the signals of the upper manual "B adjust key" drawbar group:

In "Second" Position:

(a) It connects the 2nd harmonic signal wire to percussion amplifier input.
(b) It connects the 3rd harmonic signal wire to the 3rd harmonic drawbar.
(c) It connects the signal from terminal J to 2nd harmonic drawbar.

In "Third" Position:

(a) It connects the 3rd harmonic signal wire to the percussion amplifier input.
(b) It connects the 2nd harmonic signal to the 2nd harmonic drawbar.
(c) It connects the signal from terminal J to 3rd harmonic drawbar.

The Percussion Cut-off Control which is located on the amplifier should be readjusted as follows whenever control tube V7 is replaced:

Set expression pedal wide open, both volume tablets "normal", percussion "on", percussion decay "fast", and harmonic selector in either position. Depress any key in upper half of upper manual and then adjust cut-off control exactly to the point where signal becomes inaudible.

PEDAL SOLO UNIT

Used in

Concert Models RT, RT-2, and RT-3 Consoles

HAMMOND ORGAN COMPANY
4200 West Diversey Avenue
Chicago 39, Illinois

4-58

CONCERT MODEL CONSOLES

The Model RT Hammond Organ console is similar electrically to the Model CV console, but differs in the following respects:

1. The console woodwork is larger and somewhat different in design.
2. The pedal keyboard is concave, with 32 pedal keys.
3. The pedal solo unit is added to provide deep and rich pedal tones desired by the concert organist.

The Model RT-2 console includes the above features and also has the selective vibrato system as used in Model C-2.

The Model RT-3 Console is similar to Model RT-2 with the addition of the percussion feature.

PEDAL SOLO UNIT

The pedal solo unit incorporated in these consoles provides a series of bright pedal solo tones in addition to the usual pedal accompaniment tones available on other models. The pedal solo tones, generated by a vacuum tube oscillator circuit, are controlled by a volume control knob and eight tilting stop tablets, of which one turns all the pedal solo tones on or off and the others provide various pitch registers and tone colors. The pedal solo unit is independent of the electromagnetic tone wheel generator and can be turned off without affecting the remainer of the organ.

Only one pedal solo note will play at a time (if two pedals are depressed at a time, only the higher one plays) but this does not affect the foundation or accompaniment tone controlled by the two pedal drawbars. It is possible, therefore, for the left foot to play a bass accompaniment note set up on the pedal drawbars, while at the same time the right foot plays a pedal solo note (the accompaniment tone on this higher note being masked by the high solo quality).

The pedal solo unit is designed as a part of these consoles, and because of mechanical limitations it is not adaptable to any other model.

NOTE: Pedal solo generators of all types have slightly different electrical circuits but are interchangeable in all RT series consoles. Type RTA was used in all Model RT and some Model RT-2 consoles. Types RTB and RTC were originally used only in Model RT-2. Types RTD and RTE have improved components - but no change in circuits.

HOW THE PEDAL SOLO UNIT WORKS

All notes of the pedal solo unit are controlled by a two-triode vacuum tube master oscillator circuit operating at audio frequencies from 523 to 3136 cycles per second, corresponding to 1 foot pitch. Thus the master oscillator operates over the full pedal keyboard range of 32 notes. Each time a pedal is depressed, its tuning contact tunes the oscillator to the pitch associated with the corresponding key in this 32 note range.

The output of the oscillator is fed into a series of five cascaded frequency dividers, each of which divides its input frequency by two and thus produces a note an octave lower than its input frequency. The five dividers thereby provide pitches of one, two, three, four, and five octaves below the pitch of the oscillator. In this way, when the oscillator is tuned to some given note, each divider produces a note in exact octave relation to the oscillator, thus forming a series of six notes having exact octave relationships. The particular frequency divider or dividers selected for sounding through the amplifier and speaker system of the organ will depend upon which of the stop tablets are used.

A control contact under each pedal causes the control tube to transmit the signal to the amplification system with a controlled rate of attack.

COMPONENTS OF THE PEDAL SOLO UNIT

Electrically the pedal solo unit is very similar in principle to the Hammond Solovox, Model L, although there are, of course, many differences. It employes tuning coils, tuning adjustment knobs, a master oscillator, and frequency dividers similar to those in the Solovox, and the stop tablets are similar in function to the register controls of the Solovox.

The pedal solo generator is a chassis which looks like an amplifier and contains the master oscillator, five frequency dividers, an amplifier, a control tube, and a power supply. It is located directly above the pedal switch assembly, near the left side of the console as viewed at the rear.

The tuning coil assembly contains 32 adjustable inductance coils, which tune the master oscillator to the frequencies of the 32 pedal notes. It is mounted above the pedal switch assembly, near the right side of the console as viewed at the rear.

The control panel, with eight stop tablets and a volume control knob, is mounted at the right end of the lower manual.

The pedal switch has nine contacts under each pedal key. One is used for tuning the pedal solo unit, the second serves to key the amplifier and make the pedal solo note sound, and the other seven carry harmonics from the main (tone wheel) generator to the pedal drawbars as in the B and C series consoles.

WIRING DIAGRAMS

In studying the operation of the pedal solo unit, refer first to the block diagram (figure 1) and second to the more detailed schematic circuit (figure 2, 2B or 2C). The schematic diagram of the console, apart from the pedal solo unit, is the same as for the Model CV, C-2, or C-3 console, shown in section 2. Actual connections between the pedal solo unit and other parts of the console are shown in the wiring diagram in section 2.

The Oscillator

The 32 coils which tune the audio frequency oscillator are shown in figure 2. When the lowest "C" note is played (this pedal has no tuning contact), all 32 coils are connected in series to form the tuning inductance of the oscillator. When any other pedal is depressed, its tuning contact shorts out some of these coils (making less total inductance) and thus tunes the oscillator to the higher pitch associated with that note. If two pedals are depressed at the same time only the higher pitched of the two will sound.

Frequency Dividers

Each divider includes three triodes. One acts as a driver and pulse rectifier, supplying sharp and narrow negative pulses to actuate a symmetrical feed-back tripping circuit comprising two triodes. Either one (but only one) of these two triodes can be conducting at a time, for by drawing plate current it holds the other in a cut-off condition.

Suppose, for example, that the first triode is conducting and the second is cut off. Now a negative input pulse impressed on the grids of both triodes will not affect the second one, which is already cut off, but will cut off the first. This produces a positive pulse at the plate of the first triode, which is applied to the grid of the second

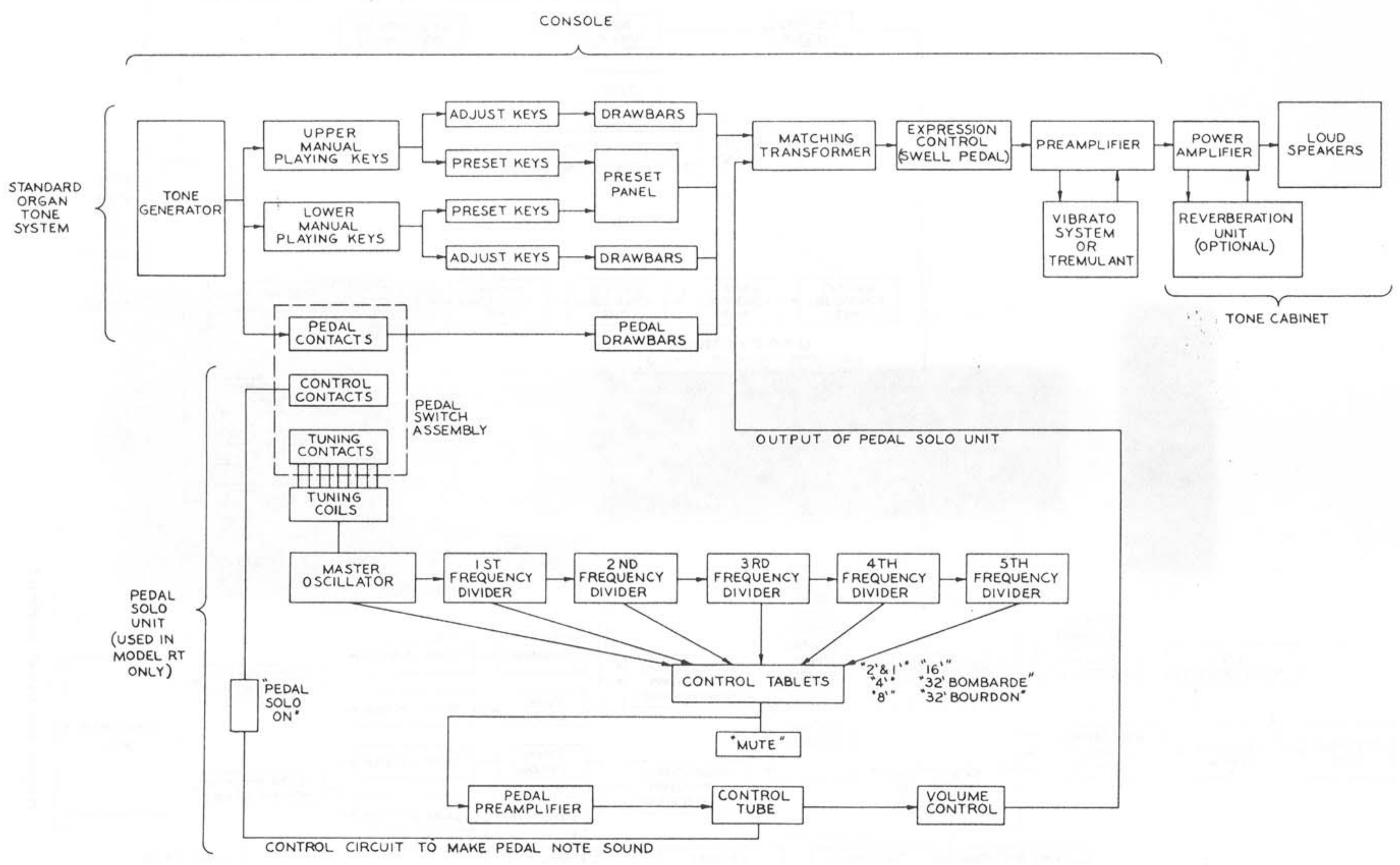


FIG. 1 – BLOCK DIAGRAM OF HAMMOND ORGAN
MODEL A, B, BC, BCV, BV, C, CV, D, DV, G, RT

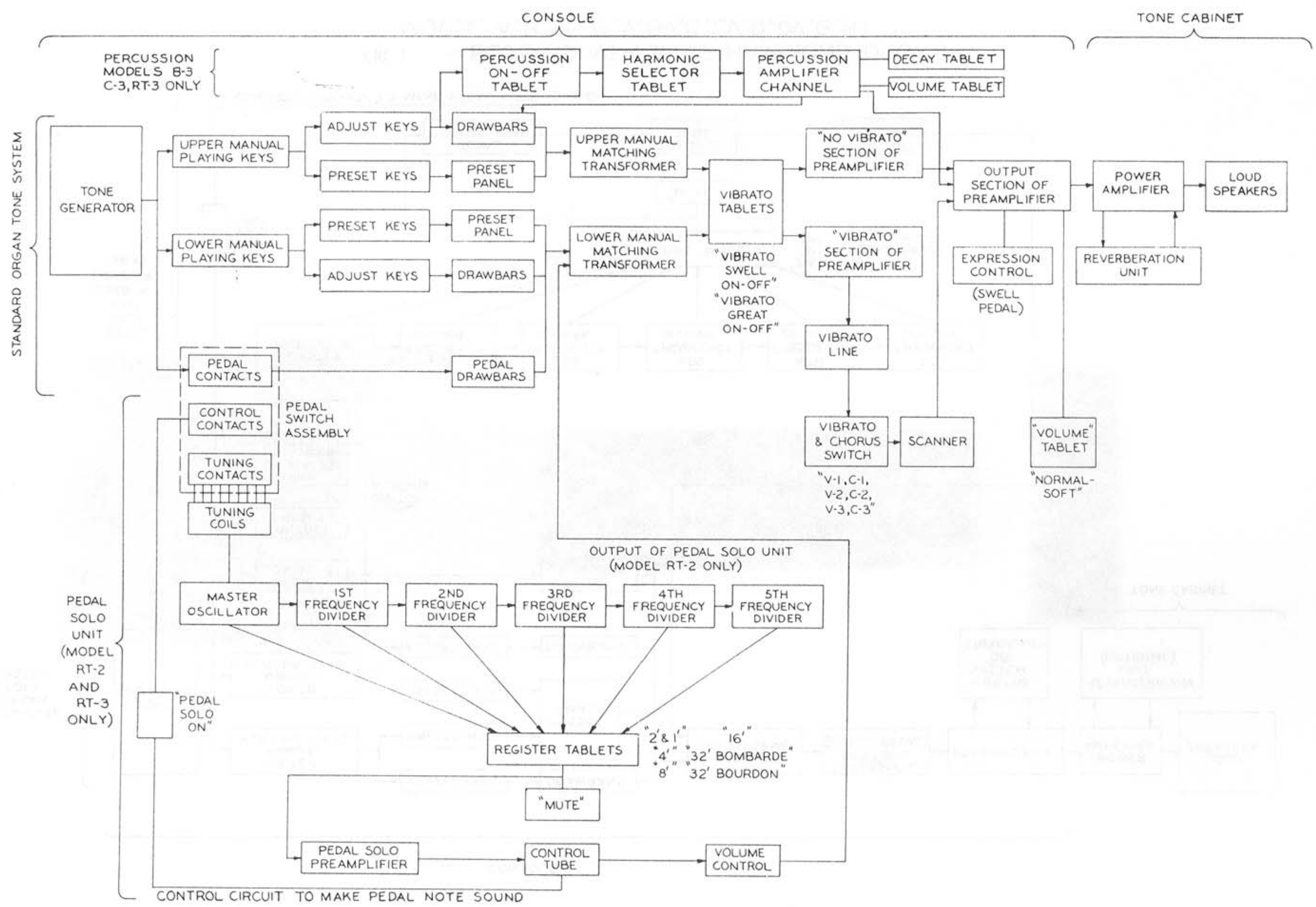


FIGURE 1B - BLOCK DIAGRAM OF ORGAN MODEL B-2, B-3, C-2, C-3, RT-2, OR RT-3 WITH SELECTIVE VIBRATO SYSTEM

(B AND C MODELS DO NOT HAVE PEDAL SOLO UNIT) triode through its feedback connection. The second triode then suddenly conducts current, producing a negative pulse at its plate. This negative pulse, applied to the first triode grid through its feed-back connection, insures that the first triode remains cut off. The situation is now exactly reversed, with the first triode cut off and the second conducting.

The next input pulse will act on the second triode, cutting it off again and making the first conductive; and thus two input cycles are required to produce one out-put cycle. Each frequency divider circuit therefore divides its input frequency in half, producing an output signal one octave lower than the preceding divider. One triode plate of each divider stage furnishes a signal of rectangular wave shape to the following driver tube, and output signals are taken from the driver and divider plates as indicated in figures 2, 2-B and 2C.

This divider circuit is capable of operating satisfactorily with wide variations in voltage, input frequency, and values of components, and therefore is remarkably stable and requires no adjustments.

Stop Tablets

From the preceding, we see that whenever any one of the three G pedals, for instance, is depressed, the frequency dividers, together with the oscillator, provide a series of six G notes in exact octave relations. The particular divider whose output is to sound is selected by the stop tablets: 2' & 1', 4', 8', 16', 32' BOMBARDE and 32' BOURDON. Thus the stop tablets act as register controls to shift the pitch range of the pedal solo unit to five different positions. If two or more of these controls are turned on simultaneously, a composite tone will be heard, consisting of the output of several dividers simultaneously sounding in their octave relations. (A tablet is "on" when the white dot is visible.)

Note With Regard To The 32-foot Stops

In playing, care must be exercised by the organist in using the 32' BOURDON and 32' BOMBARDE pedal stops. They are useful in permitting the player to obtain deep bass notes in the second octave of pedals. As the player descends into the first octave of pedals, he will find that the B, A#, A, and G# pedals have a definite pitch like the higher pedals. However, below the G# pedal, it becomes difficult to ascribe a definite pitch to these 32-foot tones. When a 32-foot stop is registered in concert organ music, it will be found that the pedals required will rarely be lower than the G pedal in the first octave. Therefore, do not use the 32-foot pedal stops indiscriminately for ordinary bass purposes where the 16-foot tone is desired. The 32' BOURDON stop produces an effect which is mostly "felt" as a very low bass undulation when playing low in the first octave of pedals. The 32' BOMBARDE is always used in conjunction with other higher pitched stops. When played by itself in the lower half of the lowest octave of pedals, the effect is of such low pitch as to be of little use musically.

"MUTE"

Pressing the mute tablet shunts a small condenser across the signal circuit to reduce the intensity of the higher frequencies. This is effective on all the pedal solo stops to make the tones more mellow.

"PEDAL SOLO ON"

This tablet, connected in series with the keying contacts in the pedal switch, turns on and off any solo combination set up on the other tablets. It may thus be used as a preset control for the pedal solo unit.

Volume Control

The volume knob on the control panel is used to balance the pedal solo tones with the rest of the organ. The over-all volume of the entire organ, including the pedal solo unit, is controlled by the expression pedal.

Control Tube

The push-pull control tube, a double triode, is normally cut off by a large negative bias applied to its grid circuit. When any pedal is pressed its control contact grounds this bias circuit (if the "PEDAL SOLO ON" tablet is "on"), thereby removing the bias and causing the note to sound. A condenser and resistor, C81 and R112, make the tonal attack smooth. The control tube is connected to an output transformer whose secondary feeds the pedal solo signal through the volume control to the organ preset panel, where it is combined with the other tones of the organ.

Tuning

All notes of the pedal solo unit are simultaneously tuned by adjusting two tuning knobs located on the pedal solo generator. These change the frequency of the master oscillator by shunting small additional capacitors across the main tuning condenser.

To tune the pedal solo unit to the organ, proceed as follows:

(a) Press only the "4'", "MUTE", and "PEDAL SOLO ON" tablets and hold down the middle D# pedal. The pedal drawbars must be pushed in, and the vibrato should be off.

(b) Pull out only the first white drawbar for either manual and press the corresponding preset key. Hold down the D# key above the middle C, with the drawbar and the volume control knob set to give approximately equal volume.

(c) Set the "fine tuning" knob on the pedal solo generator to its center position and adjust the "rough tuning" knob to the point which brings the two notes most nearly in tune (slowest beat between them). Then adjust the "fine tuning" knob to make the beat as slow as possible. While it is generally not possible to tune exactly to zero beat, the accuracy of tuning provided will be found to be sufficient.

(d) The organist may prefer to have the pedal solo generator tuned slightly sharp to increase the "chorus effect" between it and the main tone generator. To tune it sharp, turn the "fine tuning" switch counterclockwise one step.

Note: Never tune on the lower pitch registers (especially the 32-foot range) where the pitch acuity of the ear is insufficient for accurate tuning. If the 4-foot stop is tuned as directed above, all other registers will be in tune because they are locked by the frequency dividers to exact octave intervals.

Wiring of Pedal Switch

The nine contacts of each pedal key make contact with nine busbars extending the length of the pedal switch assembly. One set of contacts and the corresponding busbar, used for tuning the pedal solo unit, are wired to a terminal panel on top of the pedal switch, where the tuning coil cable connects. The other eight sets of contacts are wired to the main tone generator as indicated in the pedal wiring chart in the section on manuals and pedals, although only seven sets are actually used to carry tones from the main generator to the pedal drawbars.

The contacts of one set (the one marked "12th harmonic" in the wiring chart) are used as control contacts for keying the pedal solo unit. The fact that they are connected to ground through the pedal switch wiring and the tone generator wiring does not affect their use for this purpose, since the keying circuit impedance is high by comparison. The busbar for these contacts is wired to a terminal on top of the pedal switch to which the white keying wire from the pedal solo control panel connects. These contacts are wired to the main tone generator in the usual way in order that they may supply the 12th harmonic in case special circumstances make it desirable to omit the pedal solo unit. In this case a green wire from the pedal resistor panel on the manual assembly (it will be found wrapped around the pedal switch cable) is connected to the busbar terminal on top of the pedal switch (see wiring diagram in section 2). The pedal tones will then be identical to those on the B and C series organs.

TUBE SOCKET VOLTAGES
For Pedal Generator Stamped "Type RTA"

For voltages of other models see corresponding schematic diagrams.

These readings are taken with a 1000-ohms-per-volt meter having three scales of 50, 250 and 1000 volts. All voltages are taken with 117 volt line, and deviations of as much as 20 per cent may be caused by line voltage variations. The "PEDAL SOLO ON" tablet must be "on", and other tablets may be either on or off. No pedal should be depressed unless specified. The negative lead of the voltmeter is connected to ground except as noted. See figure 5 for terminal locations.

Connect Positive Voltmeter lead to:	Meter should read (volts)	Meter Scale	This shows voltage of:
"+290"	290	1000	1st Filter Capacitor
"+270"	270	1000	2nd Filter Capacitor
"+120"	120	250	3rd Filter Capacitor
"+ 20"	20	50	Divider Bias
Ground (neg. to "-37")	37	50	Control Tube Bias Supply
Tube VI (term. #3)	190	1000	Master Oscillator Plate (1st section)
Tube VI (term. #8)	8.5	50	Master Oscillator Cathode (1st section)
Tube V2 (term. #2)	230	1000	Master Oscillator Plate (2nd section)
Tube V2 (term. #3)	3.5	50	Master Oscillator Cathode (2nd section)
Tube V2 (term. #5)	180	1000	Oscillator Rectifier Plate
Tube V2 (term. #6)	2	50	Oscillator Rectifier Cathode
Tube V3 (term. #2)	75	250	Driver Plate
Tube V3 (term. #5), V6 (term. #3), V8 (term. #2 & #5)	95	250	Driver Plates
Tube V4, V5, V7, V9, V10 (term. #2 and #5)	55 to 75	250	Divider Plates
Tube V12 (term. #3)	120	250	Preamplifier Plate
Tube V12 (term. #8)	4	50	Preamplifier Cathode
Tube V13 (term. #2 and #5)	120	250	Control Tube Plates

Connect Positive voltmeter Lead to:	Meter Should Read (volts)	Meter Scale	This shows Voltage of:
Same, any pedal pressed	105	250	Control Tube Plates
Tube V13 (term. #3)	0	50	Control Tube Cathode
Same, any pedal pressed	3	50	Control Tube Cathode
Tube V11 (term. #8)	290	1000	Rectifier Cathode

AC VOLTAGES

Heater voltage to all tubes except V11		6 V. RMS
Rectifier tube V11 heater voltage		5 V. RMS
V11 term. #4 or #6 to "-37"		280 V. RMS
AC ripple across 1200 ohm resistors R99, R100, R101 (connect a 1/4 mfd. condenser in series with meter)	Less than	2 V. RMS
AC ripple across 5000 ohm resistor R105 (connect a 1/4 mfd. condenser in series with meter)	Less than	1 V. RMS

PRACTICAL SERVICE SUGGESTIONS

The following suggestions cover possible troubles in the pedal solo unit only. Suggestions for the standard organ system will be found elsewhere in the service manual.

Any trouble in the organ ahead of the matching transformer will not affect the pedal solo unit, but trouble following the transformer will affect both systems equally.

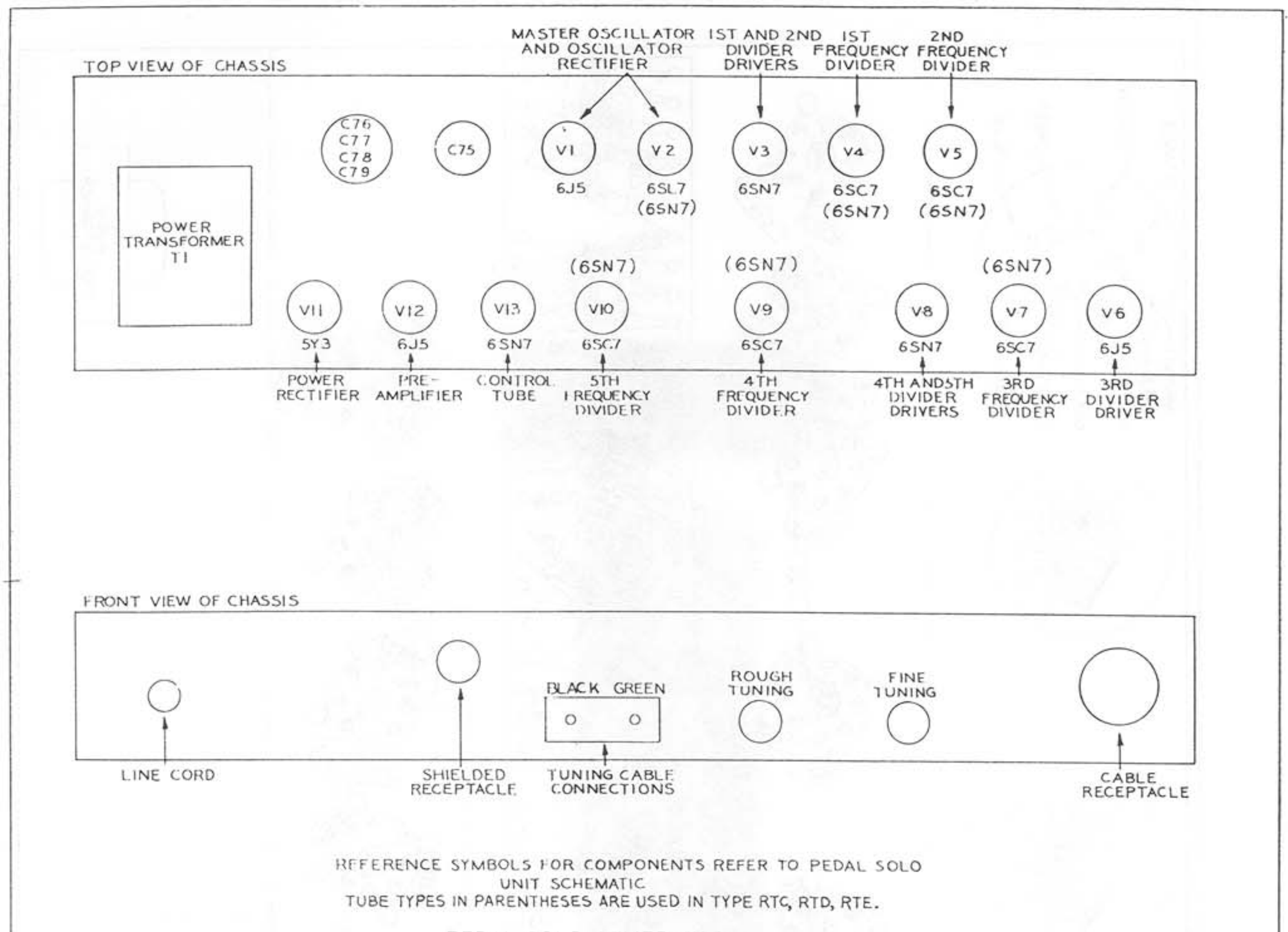
Pedal solo unit does not play. First make sure that the tubes are lighted, all controls are in playing position, and the rest of the organ plays normally. Several possible causes of trouble are listed below in order of probability.

(a) Tubes. The tubes are all standard radio types and can be tested in the usual way. Figure 3 shows their locations in the pedal solo generator.

(b) Loose cable connector. See that the 15 hole plug and the shielded plug are inserted tightly into the pedal solo generator.

(c) Keying circuit. A dirty contact in the "PEDAL SOLO ON" tablet or a defective connection in any part of the keying circuit will prevent removal of the cut-off bias when a key is played. If this is the trouble, grounding pin 15 of the cable plug will make a pedal note sound. The following section, "Procedure for Removing Parts", tells how to reach and clean the tablet contacts.

(d) Amplifier or oscillator circuit. The amplifier circuit is conventional in most respects, and voltage measurements will generally serve to identify any trouble. Failure of the master oscillator will make the pedal solo unit fail to play, and voltage readings will be helpful in this case also. Figures 4, 4A, 4B show the locations of all components, and a chart at the end of this section gives their characteristics.



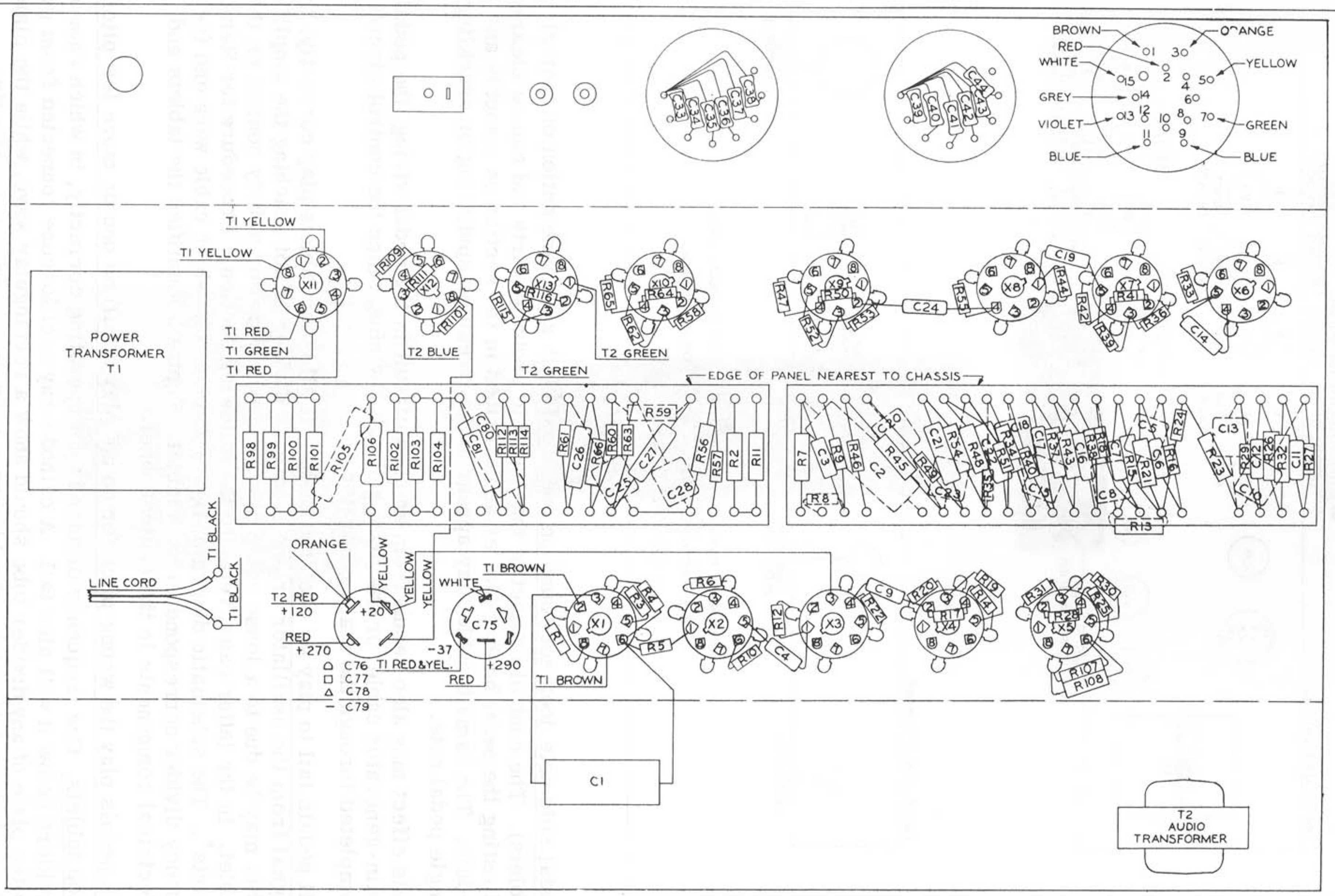
PEDAL SOLO GENERATOR

Pedal solo note does not sound on one pedal (with any combination of control tablets). The control contact of that pedal is probably dirty and can be cleared by adjusting the pedal busbar shifter as described in the section on manuals and pedals. The same trouble may appear as an irregular sputtering or crackling of a single pedal note.

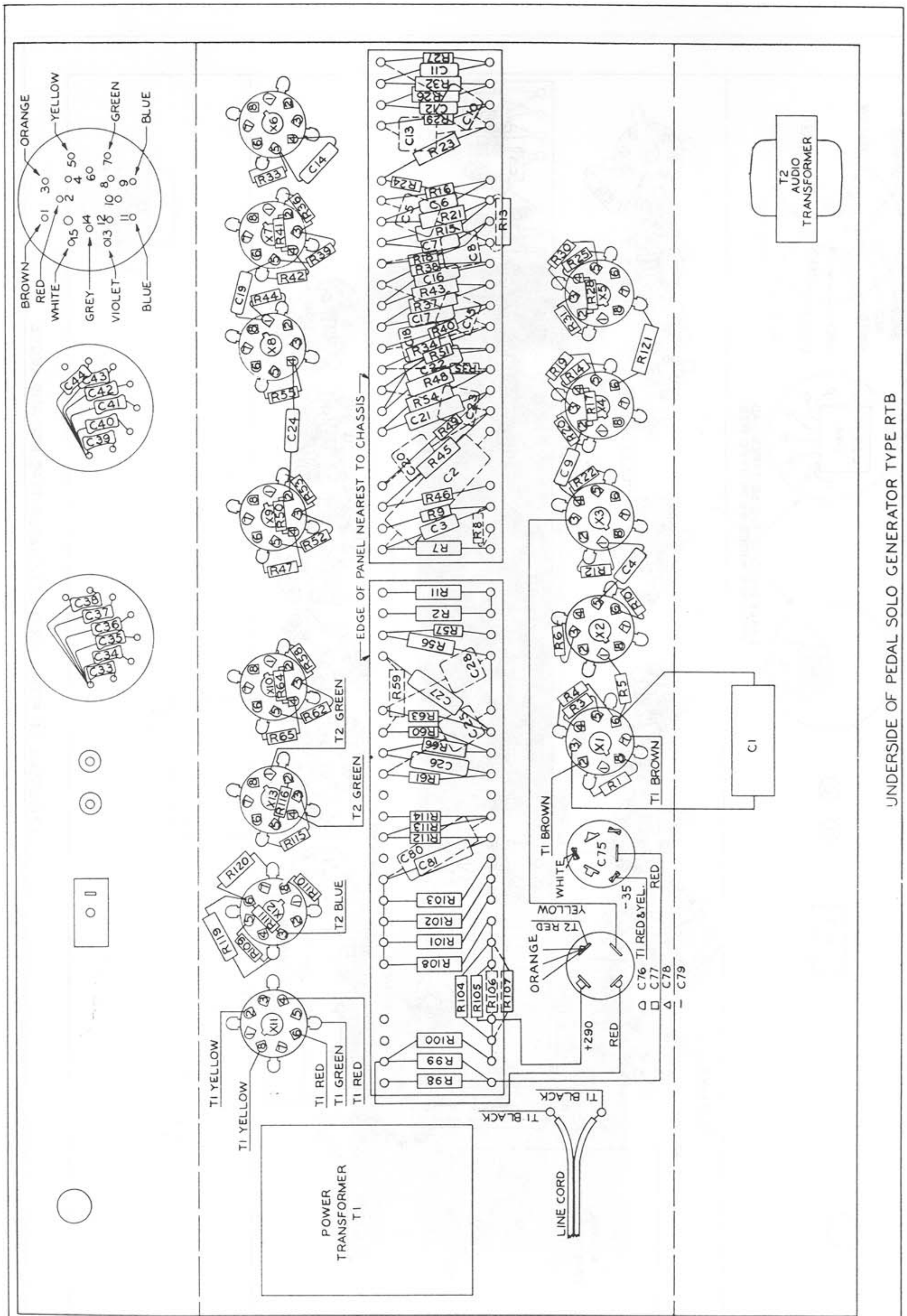
This effect may also result from an open circuit in the pedal wiring, the pedal-to-main-generator cable, or the main generator wiring, since the control circuit is completed through the main generator.

All pedals fail to play on one stop tablet. If all other tablets play correctly, the signal from the oscillator or one frequency divider is not reaching the amplifier. This may be due to a loose cable plug, a broken wire, or a dirty contact on the tablet. In the latter case, refer to the following section, "Procedure for Removing Parts". The schematic diagram, figure 2, indicates which cable wire and frequency divider correspond to each tablet. Figure 5 identifies the tablets and electrical components in the control panel.

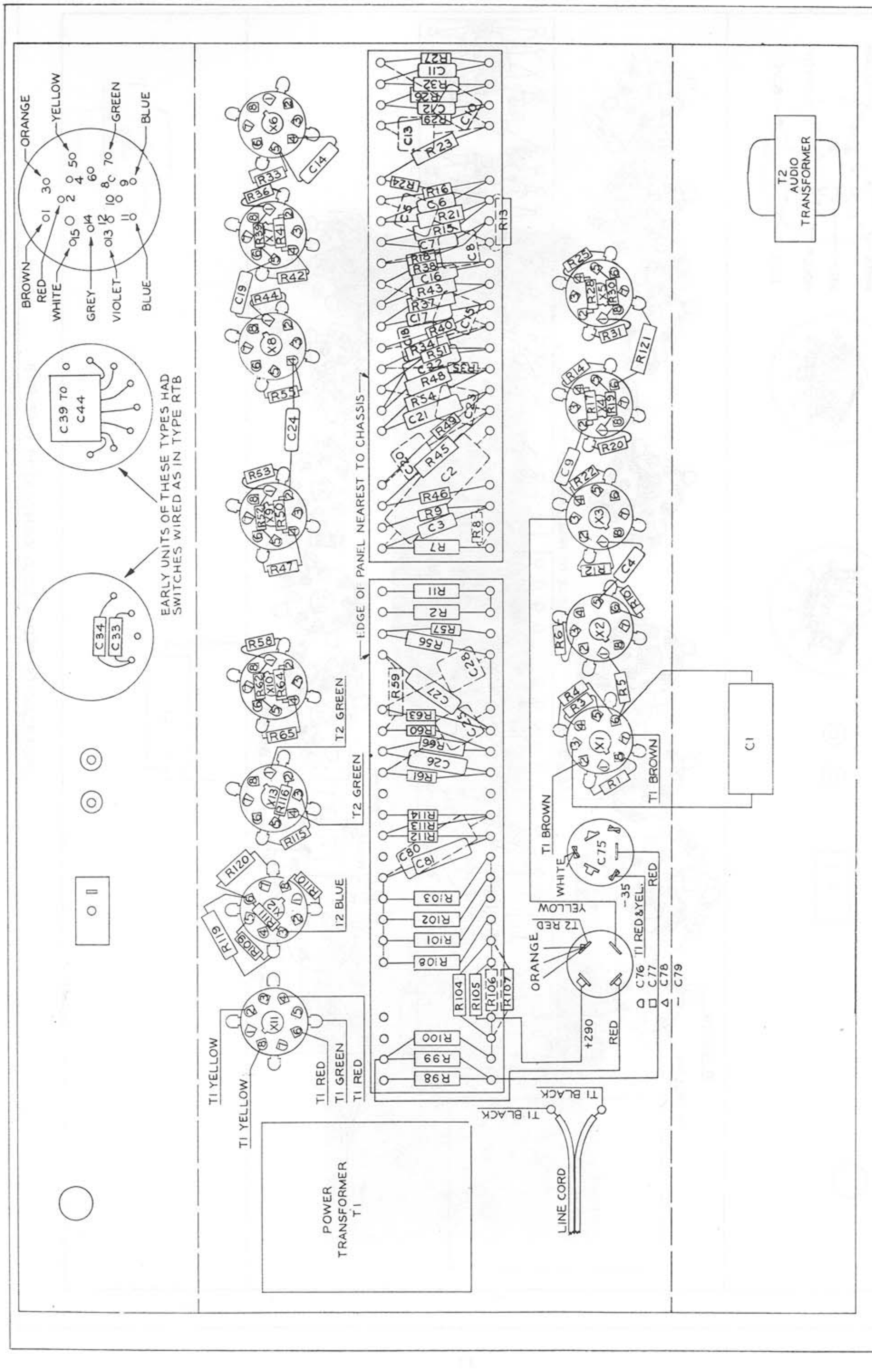
All pedals play the wrong pitch (or do not play at all) on one or more low pitched stop tablets. One frequency divider is not operating correctly, in which case all dividers below it will also fail. A cathode-ray oscilloscope connected from ground to the plate of any divider tube should show a rectangular wave, while the plate of any divider driver tube should show a very sharp and narrow negative



UNDERSIDE OF PEDAL SOLO GENERATOR TYPE RTA



UNDERSIDE OF PEDAL SOLO GENERATOR TYPE RTB



UNDERSIDE OF PEDAL SOLO GENERATOR TYPE RTC AND ABOVE pulse. If electrolytic capacitor C78 is open or very low in capacity, all the dividers may fail to operate.

Key thumps or clicks. If capacitor C 81 is open, there will be a loud thump each time a pedal is played.

Hum. An excessive 120 cycle hum in the output will result from failure of one of the filter capacitors C75, C76, C77 and C78

Tuning of individual notes. The individual note tuning system consists of 32 small inductance coils, each of which is adjustable by moving the coil on its iron core. This tuning system is very stable because it has practically no aging effect and is very insensitive to ordinary humidity and temperature changes. However, after long use under adverse climatic conditions it is possible that some pedal solo notes may not be exactly in tune with each other.

Always tune first with the tuning knobs as indicated above. Keep in mind the fact that it is generally desirable to have the pedal solo unit slightly out-of-tune with the organ. If you are sure some notes actually require tuning, proceed as follows:

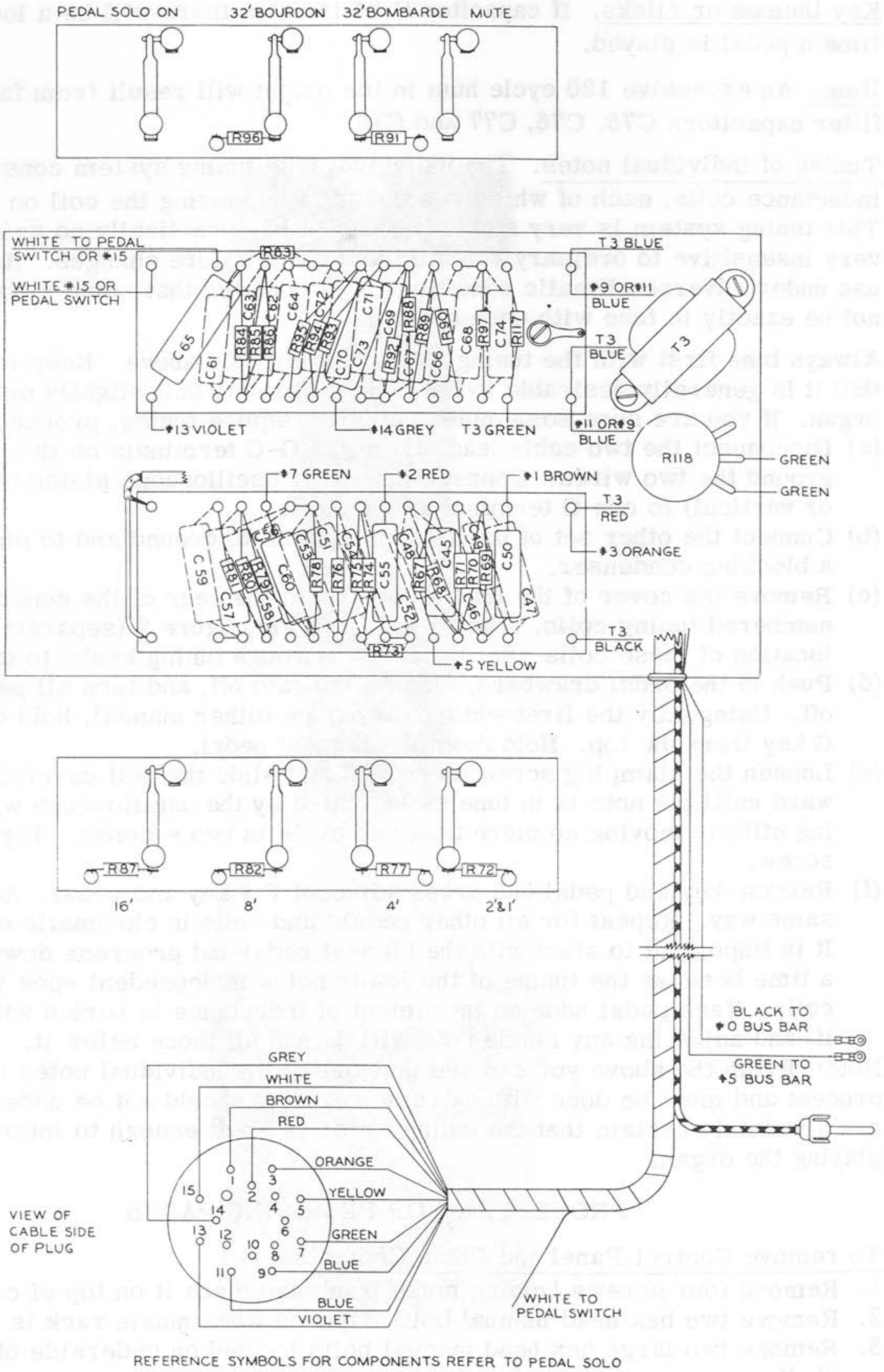
(a) Disconnect the two cable leads from the G-G terminals on the preamplifier and ground the two wires. Connect one set of oscilloscope plates (either horizontal or vertical) to one G terminal and ground.
(b) Connect the other set of oscilloscope plates to ground and to pin 3 of V6 through a blocking condenser.
(c) Remove the cover of the tuning coil box at the rear of the console, exposing the numbered tuning coils. The wiring diagram, figure 3 (separate sheet), shows the location of these coils. Set the fine and rough tuning knobs to their center positions.
(d) Push in the pedal drawbars, turn the vibrato off, and turn all pedal solo tablets off. Using only the first white drawbar on either manual, hold down the second key G key from the top. Hold down the highest pedal.
(e) Loosen the clamping screw on coil 32 and slide the coil carefully forward or backward until the note is in tune as indicated by the oscilloscope wave pattern standing still or moving no more than one cycle in two seconds. Tighten the clamping screw.
(f) Release key and pedal and press adjacent F # key and pedal. Adjust coil 31 in same way. Repeat for all other pedals and coils in chromatic order downward. It is important to start with the highest pedal and progress downward one pedal at a time because the tuning of the lower notes is dependent upon all of the higher coils. Each pedal adds an increment of inductance in series with all coils above it, and adjusting any single note will detune all those below it.

Note: From the above you can see that tuning the individual notes is a long and tedious process and must be done with extreme care. It should not be undertaken unless you are absolutely certain that the tuning error is great enough to interfere seriously with playing the organ.

PROCEDURE FOR REMOVING PARTS

To remove Control Panel and Clean Contacts

1. Remove four screws holding music rack and place it on top of console.
2. Remove two hex head manual bolts exposed when music rack is removed.
3. Remove two large hex head manual bolts located on underside of generator shelf near rear.
4. Remove two screws passing up through right-hand chassis block of lower manual into control panel.



REFERENCE SYMBOLS FOR COMPONENTS REFER TO PEDAL SOLO UNIT SCHEMATIC, FIGURE 2

FIGURE 5 - UNDERSIDE OF PEDAL SOLO CONTROL PANEL

5. Remove one screw holding angle bracket to bottom cover of control panel.
6. Tilt upper manual upward and slide control panel assembly through opening toward back of console.
7. Remove bottom cover of control panel.
8. Remove four wood screws holding wood frame work to chassis of control panel.
9. Remove knob and loosen nut which holds volume control.
10. Tip wood frame up and slide back until rear wooden strip clears tablet identification strip.
11. Slide pivot rod out of tablet assembly and remove tablets.
12. Remove four #3 screws holding tablet assembly to chassis of control panel, and tilt assembly up. Contacts are now visible and can be cleaned by wiping gently with a cloth.

ELECTRICAL PARTS LIST FOR PEDAL SOLO GENERATOR

CONDENSERS

REFERENCE SYMBOL	CAPACITY	VOLTAGE	TYPE	PART NUMBER
C75	20 mfd.	400	Electrolytic	AO-21325-0
C76	20 mfd.	300	Electrolytic Used in Generator "Type RTA" only	AO-21326-0
C77	80 mfd.	150		
C78	30 mfd.	50		
C79	30 mfd.	15		
C76	40 mfd.	400	Electrolytic Not Used in Generator "Type RTA"	AO-19131-1
C77	20 mfd.	350		
C78	20 mfd.	350		
C79	6 mfd.	200		

WIRE WOUND RESISTORS

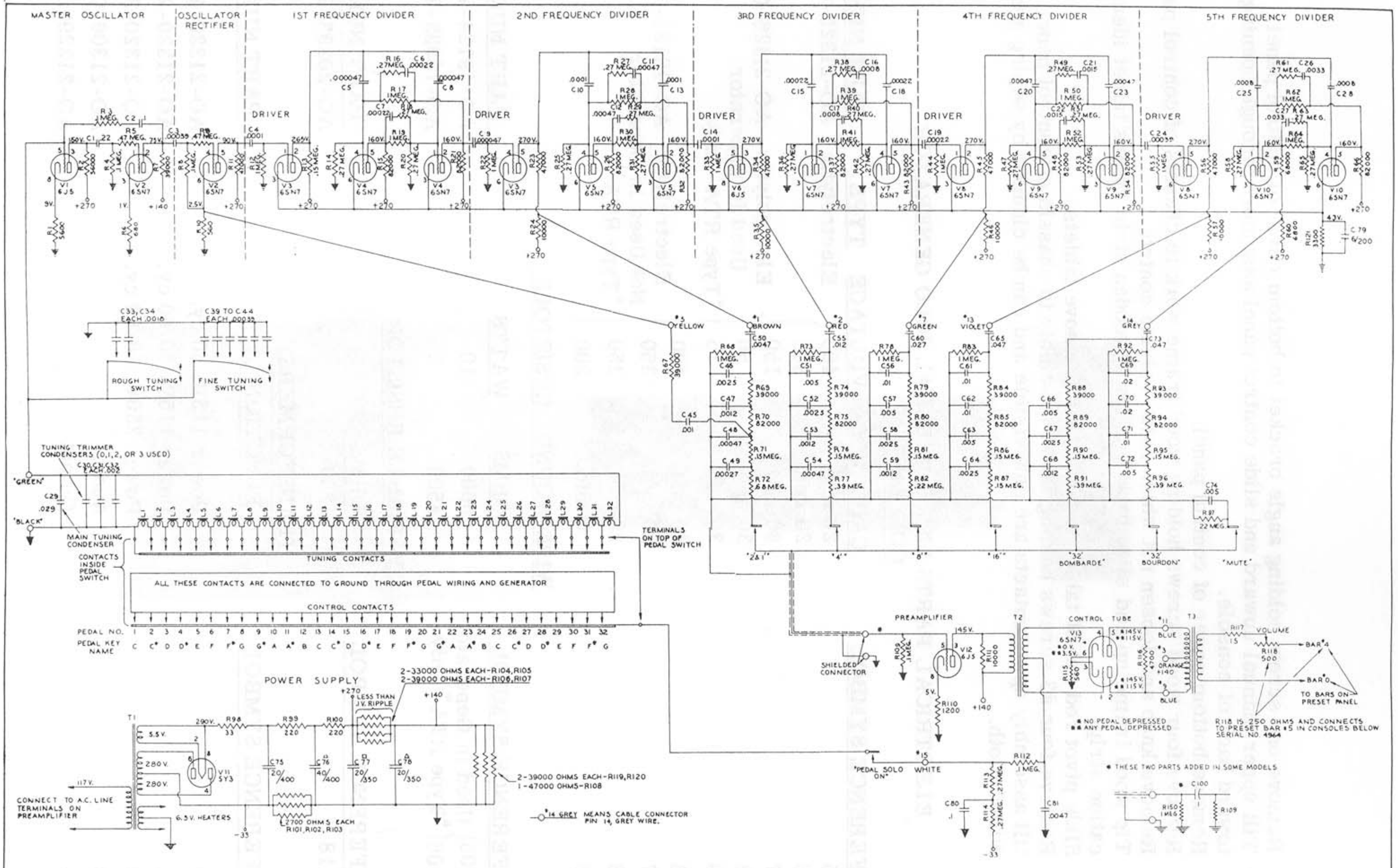
REFERENCE SYMBOL	OHMS	WATTS	PART NUMBER
R 105 Used in Generator "Type RTA" only	5000	10	AO-19124-72
R 106	4500	5	AO-18933-74

VARIABLE RESISTOR

REFERENCE SYMBOL	OHMS	PART NUMBER
R 118	250	AO-20293-20

TRANSFORMERS

REFERENCE SYMBOL	FUNCTION	PART NUMBER
T 1	Power 115V. 60 cy.	AO-21320-1
T 1	Power 115V. 50/60 cy.	AO-21320-2
T 1	Power 230V. 50/60 cy.	AO-21320-3
T 2	Audio	AO-21306-0
T 3	Output	AO-21229-0



FORMER 6SC7 & 6SL7 TUBES CHANGED TO 6SN7 (SERIAL NO. 2336 AND ABOVE.)

SCHEMATIC - PEDAL SOLO UNIT - TYPES RTC, RTD, RTE
MODEL RT-2 AND RT-3 CONSOLES

THE HAMMOND ORGAN

Reverberation Control

HAMMOND ORGAN COMPANY
4200 West Diversey Avenue
Chicago 39, Illinois

10/56

REVERBERATION CONTROL

Reverberation control is an important feature of any Hammond Organ installation. This device is enjoying wide acceptance because it produces reverberation in variable degrees so the Hammond Organ, when installed in an acoustically "dead" enclosure, sounds very much like an organ played in a large acoustically "live" church or auditorium where organ music, enhanced by considerable reverberation, sounds at its best.

Reverberation is the prolongation of sound by repeated reflections or echoes, and is measured by the time required for a sound to become inaudible after the source of sound has been stopped. It is present in some degrees in all enclosures, and music is more pleasing to the ear when accompanied by some amount of reverberation. This is particularly true of organ music.

Reverberation results from the fact that the longer path traveled by reflected sound causes a delay in hearing the reflected sound waves. This is easily realized in the case of sharp staccato sounds and a fairly distant reflecting surface, as the delayed sound is then heard separately from the direct sound and is recognized as an echo. When music is played in a large room, however, the sound echoes and re-echoes repeatedly until absorbed by the surroundings.

The Hammond reverberation control is an electro-mechanical device which introduces multiple echoes by means of reflections within a network of coil springs and thereby provides adequate reverberation in locations where the natural reverberation is not sufficient.

The reverberation unit (see figure 1), about 4 x 5 inches in cross section and about 4 feet high, is connected to a reverberation preamplifier built into the power amplifier. (In some models of tone cabinets the reverberation preamplifier is a separate unit connected to the power amplifier by cables.) The entire equipment is attached to the organ tone cabinet.

Reverberation is applied to the organ music after it leaves the console. Part of the console signal goes directly to the power amplifier and part goes into the reverberation channel, after suitable amplification.

The electrical signal fed into the reverberation unit is converted into mechanical energy by a moving coil driver unit, similar to a dynamic speaker without a cone. The mechanical waves are transmitted through coil springs, which have the property of conducting sound vibrations much more slowly than the speed of sound waves in air. In this way a spring of convenient length can introduce a delay equivalent to that obtained in a large hall.

The driver unit, at the top of figure 1, introduces up-and-down vibrations into the stirrup directly under it. The two enclosed springs under the stirrup hold it in position but permit it to move freely up and down, and the spring at the far left balances the pull of the others. These three springs are almost entirely immersed in damping fluid, as they act largely as dampers to stabilize the response of the driver and prevent undesired reflections.

A sound wave from the stirrup travels down the open spring at the far right to the crystal pickup, where an electrical signal is produced and conducted to the power amplifier. This is the "first reflected signal", delayed about 1/15 second from the part of the original signal which went directly to the power amplifier.

The same wave from the stirrup also travels down the second spring from the left, which enters the short damping tube. At the bottom of this spring the wave is reflected back along the spring, reduced in intensity by the damping action of the fluid. At the stirrup the horizontal lever transfers the wave to the right-hand spring, and it goes on to the crystal to produce a "second reflected signal" about 3/15 second after the direct signal.

Very little of the energy of each wave is absorbed by the crystal, and the rest is reflected back along the spring. The "first reflected signal" traverses the right spring, is transferred by the lever, and goes down the spring to the short damping tube.

Here it is reflected in reduced intensity, retraces the same path to the crystal, and produces a "third reflected signal" about 5/15 second after the direct signal. The "second reflected signal" is similarly repeated, and this process continues over and over, giving a series of signals about 2/15 second apart, until the vibration is dissipated by fluid friction in the short tube.

Just above the short damping tube a "reflecting pin" attached to the spring causes partial reflection of high frequencies and helps to make the over-all response more uniform.

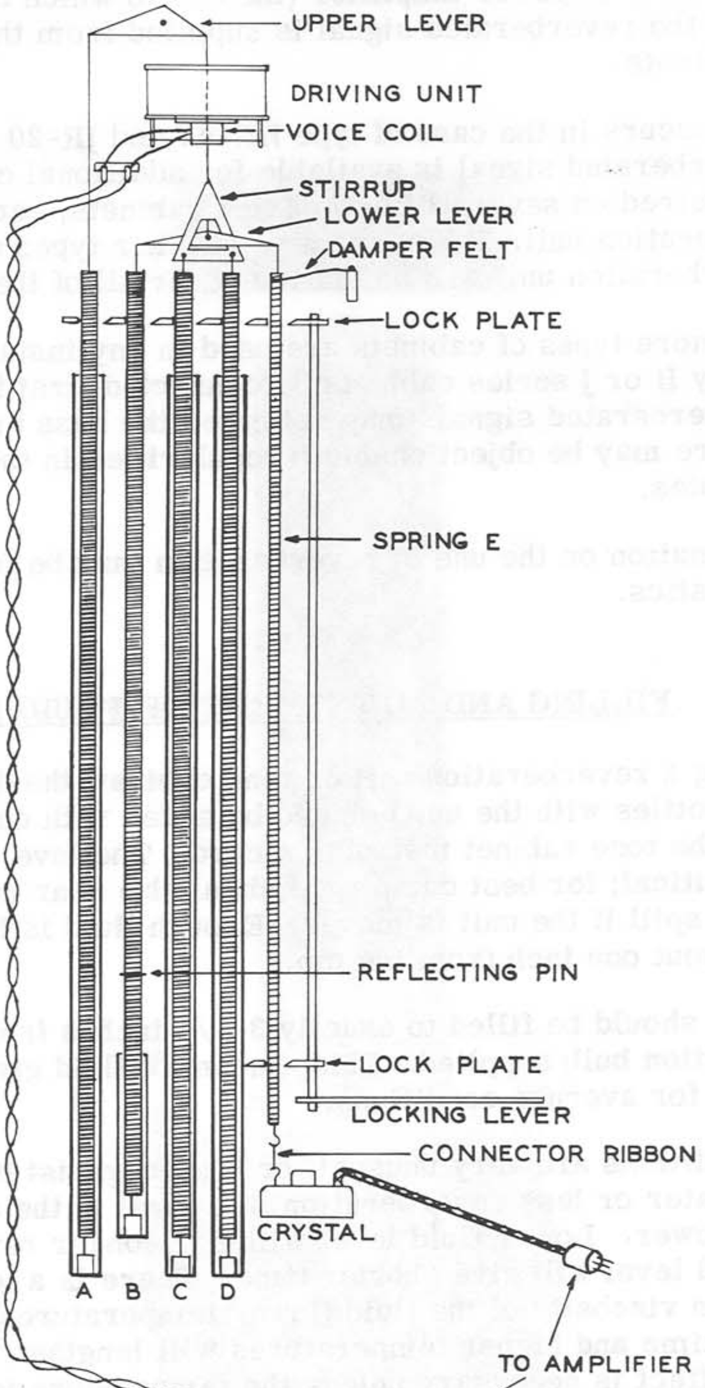
The damper felt avoids undesirable transverse vibration of the springs.

A greater amount of fluid in the short tube will cause increased energy loss at each reflection and thereby reduce the number of audible reflections. Adjusting the level of fluid in this tube, therefore, changes the reverberation time and simulates enclosures of different sizes.

A "reverberation selector switch" in the amplifier circuit following the crystal can be adjusted to pass more or less of the reflected signal in proportion to the direct signal. While this does not actually change the reverberation time, it is a convenient way to change the amount of reverberation instantly. Generally, therefore, the fluid level in the short tube is left constant, at the position recommended on the tone cabinet instruction card, and the switch is used to select the best amount of reverberation for each installation.

The photograph of the reverberation unit (back of title page) shows a reverberation preamplifier of the type used-in kits for installation in some non-reverberation tone cabinets. In late reverberation type tone cabinets the power amplifier is wired so that this preamplifier is unnecessary.

Amplifier circuits associated with the reverberation unit are shown in the section containing amplifier diagrams.



REVERBERATION UNIT
FIG. 1

INSTALLATION

Generally only a single reverberation unit is necessary for any installation, regardless of the number of tone cabinets used. The reverberation unit is connected to the first power amplifier (the one to which the console cable connects) and the reverberated signal is supplied from that amplifier to additional cabinets.

An exception occurs in the case of type HR-40 and JR-20 tone cabinets, in which no reverberated signal is available for additional cabinets. If reverberation is desired on several H or J series cabinets, each must be equipped with a reverberation unit. If any cabinets of other types are used in addition, a single reverberation unit will be sufficient for all of them.

When two or more types of cabinets are used in any installation, it is preferable that any H or J series cabinets be connected first to the console in order that reverberated signals may not enter the bass amplifier channel. Otherwise there may be objectionable irregularities in the response of the lower pedal notes.

Further information on the use of reverberation may be found in the section covering Acoustics.

FILLING AND ADJUSTMENT OF FLUID LEVEL

When installing a reverberation unit or tone cabinet, the damping fluid (furnished in bottles with the unit) should be added with care, following directions on the tone cabinet instruction card. The level in the three long tubes is not critical; for best damping it should be near the top, but not high enough to spill if the unit is moved. Enough fluid is furnished to fill each tube to about one inch from the top.

The short tube should be filled to exactly 3-1/4 inches from the top, using the special suction bulb supplied. This amount of fluid gives the best reverberation effect for average conditions.

If acoustic conditions are very unusual, or if an organist has a definite preference for greater or less reverberation, the level in the short tube may be set higher or lower. Lower fluid level will give longer reverberation time and higher fluid level will give shorter time. There is a temperature effect due to change in viscosity of the fluid (lower temperatures will shorten the reverberation time and higher temperatures will lengthen it) but no adjustment for this effect is necessary unless the temperature is consistently below 50° F or above 95° F.

The reverberation selector switches are set at "HI" when leaving the factory, and should be readjusted on installation to give the most desirable reverberation effect. If there is any uncertainty as to the proper adjustment, it is generally preferable to allow too much reverberation rather than too little.

OPERATIONAL ADJUSTMENTS

It is a well known acoustical phenomenon that audibility of some frequencies is emphasized over others in any given enclosure. Range of frequencies affected depends upon the size and type of reflecting surfaces such as walls and ceilings. Thus if a musical instrument such as an organ is played in an enclosure of almost any size, some frequencies will sound louder in one portion of the listener area than in another, and conversely some frequencies will sound weak. This can be effectively demonstrated by playing the organ in a small room with a microphone, then listening to the signal picked up by the microphone in another room. Variations in loudness will be startling especially when single frequencies are sounded.

The reverberation unit similarly produces a "response pattern" which tends to emphasize some frequencies over others to a slight degree. This is an operating phenomenon of the equipment and cannot be eliminated. This room pattern effect has not proved seriously objectionable, because as described above it similates an acoustical effect which is present in some degree whenever any musical instrument producing a wide range of frequencies is played in an enclosure.

If some notes on the organ sound excessively loud while others sound weak it may be traceable to the reverberation control system. In investigating this, disconnect the reverberation system by turning the switch on the reverberation preamplifier or amplifier to the "off" position. If notes then sound at equal loudness, turn reverberation system on again and make the following adjustments:

1. The two-pole plug, which is connected to wires carrying signal to the driving unit at the top of the reverberation unit, may be inserted in two positions. Reversing this plug by turning it 90° will reverse the input signal phase, thus changing the response pattern of the reverberation system. Reversing this plug will often improve evenness of overall frequency response for a given installation.

2. Sometimes evenness of frequency response can be improved by cutting down amplitude of the reverberated signal. This is accomplished by changing the position of the reverberation switch. If switch is on "HI" move it to "Med", and if switch is on "Med" move it to "Lo."

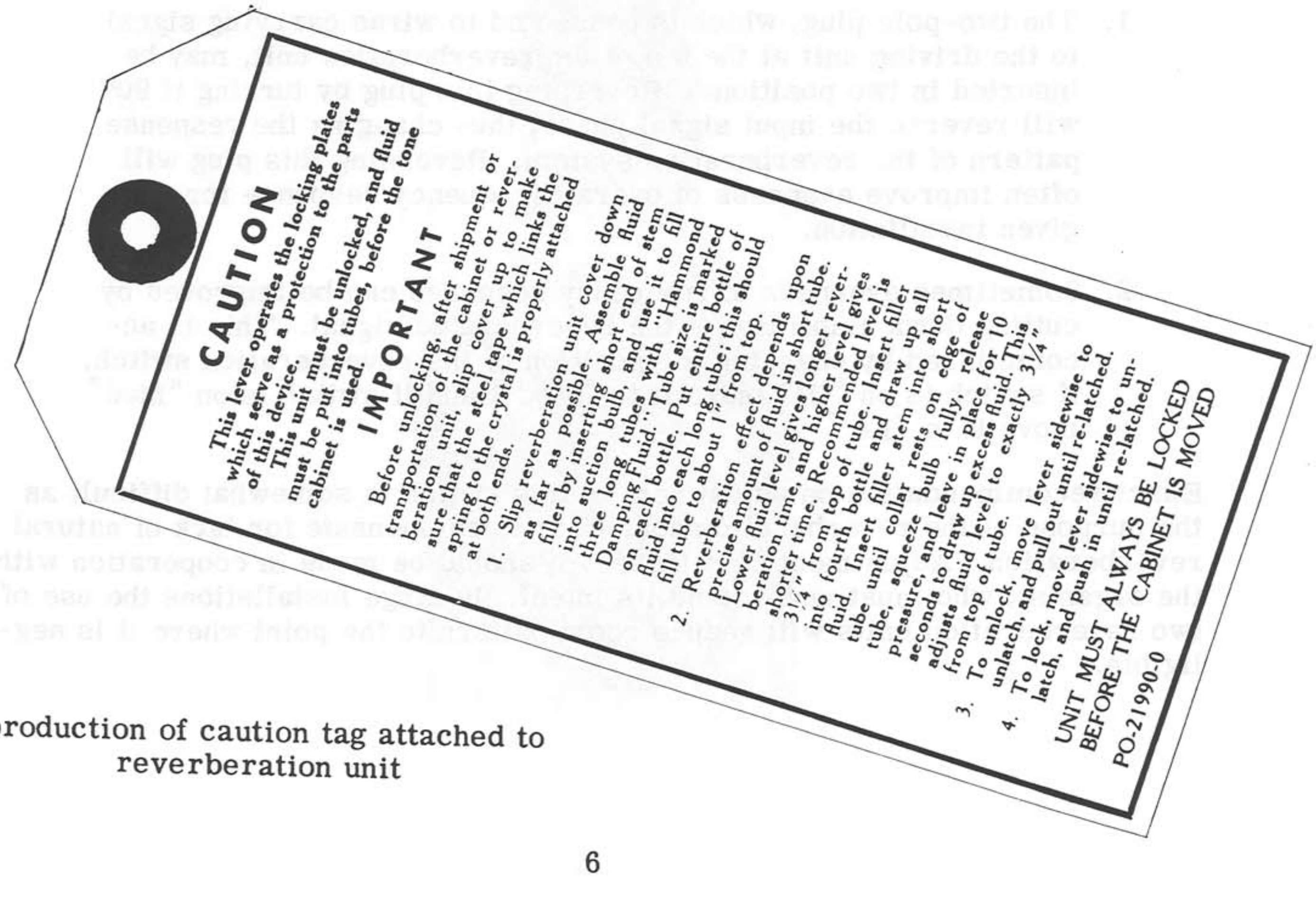
Exact recommendation on adjustment of this switch is somewhat difficult as the purpose of the reverberation control is to compensate for lack of natural reverberation. Adjustment of it therefore should be made in cooperation with the organist, who must understand its intent. In large installations the use of two reverberation units will reduce room pattern to the point where it is negligible.

MOVING THE UNIT

The reverberation unit appears to be a delicate device but when once set up it is very dependable and requires no further attention. When a tone cabinet is moved even a few feet, however, the reverberation unit must be locked to avoid excessive vibration of the springs. If the cabinet is to be tilted, the unit must be removed, to avoid spilling the fluid, and replaced after moving. If the unit itself cannot be kept upright while moving, the fluid must be drained and later replaced. Hammond damping fluid is a grade especially selected for this purpose, and no other kind should be used.

Failure to lock the unit when moving usually necessitates replacement of the complete driver assembly or the upper or lower lever assemblies which are a part of it. When parts are replaced, the springs must be balanced as follows:

> In a complete driver assembly ordered for replacement, the wire passing through the unit from the upper lever to the stirrup is not soldered. It should be left unsoldered until this adjustment is made. Replace the driver assembly and attach all the springs; check and adjust the single damping tube, if necessary, to make the upper lever assembly level. Then solder the wire to the small tube passing through the voice coil. When only the upper or lower lever assembly is replaced, the wire need not be unsoldered, but the upper lever must be made level by adjusting the single tube.



Reproduction of caution tag attached to reverberation unit

THE HAMMOND ORGAN

Cable & Plug Assemblies

and Cable Connection Diagrams

HAMMOND ORGAN COMPANY
4200 West Diversey Avenue
Chicago 39, Illinois

1/54

CABLES

Each console is shipped from the factory with cables sufficient for an ordinary installation having a single tone cabinet. It has a 15 foot 2 conductor line cord for connecting to an AC wall outlet, and a 35 foot console-to-cabinet cable (6 conductor or 5 conductor, depending on the console model) to connect to the first power amplifier. In case the console is located an unusually long distance from the tone cabinet, additional 6 or 5 conductor cable must be ordered. If the console has an echo switch, a 5 conductor cable of the required length must be ordered separately to connect it to the echo tone cabinet. (See "Echo Organ Wiring", on the following page).

For installations having two or more tone cabinets, cable suitable in length must be secured to connect between cabinets. Each power amplifier has a 6 pole input plug and a 5 pole coupling receptacle for connecting additional amplifiers.

TYPES OF CABLES USED

6 Conductor console-to-cabinet cable used only on models A, B, BA, BC, BCV, BV, C, CV, D, DV, E, G, RT. This is used only between these models of consoles and the first power amplifier, and has a 6 pole plug at one end and a 6 pole receptacle at the other. It consists of two AC wires, two grid (signal) wires, a B plus wire to carry plate current from the first power amplifier to the console preamplifier, and a ground (signal return) conductor, which is actually a shield over the B plus wire. This cable is especially designed for use with the Hammond Organ and is approved by the Underwriters' Laboratories for that purpose.

5 Conductor console-to-cabinet or cabinet-to-cabinet cable. This is identical to the 6 conductor cable except that it has no shield and one end has a 5 pole plug instead of a 6 pole plug. It has no B plus conductor, the fifth wire being used for ground. It is used for carrying power and signal between amplifiers, since a B plus connection is never needed beyond the first power amplifier; to connect an echo cabinet, since in this case also no B plus connection is required; and as a console-to-cabinet cable for models where the console preamplifier has its own power supply. In case 5 conductor bulk cable is not available, a 5 conductor cable assembly may be made from 6 conductor bulk cable, using the shielded wire for ground and leaving the shield disconnected. NOTE: 5 conductor console-to-cabinet cable is used with Models B-2, C-2, and RT-2.

3 Conductor cabinet-to-cabinet cable. This is used for carrying only the signal between amplifiers, and is used for connecting cabinets when external AC power circuits are employed. It is standard 3 conductor indoor telephone cord and has 5 pole plugs on both ends. A cable may be made up with a number of plugs along its length in order to connect several cabinets together. This wire can be secured from your local electrical jobber.

2 Conductor line cord. This supplies AC power to the console and has a standard attachment plug on one end and a standard attachment receptacle on the other.

2 Conductor cabinet power cord. This is used to furnish AC power to additional power amplifiers, when the signal is supplied through a 3 conductor signal cable. It has a standard attachment plug at one end and a 6 pole receptacle at the other.

All cables with the exception of the 3 conductor may be ordered in lengths as shown on current price list, with or without connectors attached. Figure 10 shows how all connectors are wired.

For permanent installations, when the cables are to be installed in conduit, special "Jones" fittings manufactured by the Cinch Manufacturing Company are obtainable through your electrical supplier Those recommended for console location are:

1-S406-CCE 6 prong socket
1-P406-WP 6 prong plug with wall plate

For each tone cabinet location:

1-P406-CCE 6 prong plug
1-S406-WP 6 prong socket with wall plate

BLOCK DIAGRAMS

Figure 1 is a simplified diagram showing how the console is connected to a single tone cabinet or group of cabinets drawing not over 620 watts input. This is the maximum AC power which can be supplied through the console without damaging the console switch or wiring. The name plate on each cabinet shows its wattage rating.

If the tone cabinet power requirements exceed 620 watts, some of the cabinets must be supplied from a separate AC source as indicated in figures 2 and 3. Figure 2 is the preferred method, employing a relay to turn on the additional cabinets. The relay must have a coil of the same voltage and frequency rating as the organ, and must have contacts suitable for carrying the amount of power drawn by the additional cabinets. Allen-Bradley Bulletin 700 relays are suitable for this purpose and may be obtained from your electrical supplier.

When the AC power is supplied separately to additional cabinets, as in figures 2 and 3, a 3 conductor cable is sufficient to carry the signal between cabinets.

DETAILED WIRING DIAGRAMS

Figures 4,5, and 6 are detailed versions of figure 1. In figure 4 the console is connected to one tone cabinet having a single amplifier, and figure 5 shows connections to a cabinet with two power amplifiers, connected together by a 5 conductor coupling cable. Additional amplifiers, up to a maximum of 620 watts AC input, may be connected as shown in figure 6.

Figure 7 is a detailed diagram of the arrangement in figure 2. The 3 conductor cable carries signal to all cabinets, while each cabinet has its own AC power cord. In this case the 6 pole input plug in each additional cabinet is used for power input only, and the signal is fed into the 5 pole coupling receptacle.
A switch may be connected in place of the relay contacts to convert this circuit to the arrangement of figure 3.

ECHO ORGAN WIRING

Some desirable musical effects may be secured by an "echo" tone cabinet installed at a location some distance from the main cabinet or cabinets. As indicated in the block diagram, figure 8, an echo switch on the console controls only the tone cabinet signal circuits, and all cabinets remain energized so that they will sound instantly when desired. Figure 9 shows the cable connections required.

REVERBERATION EQUIPMENT

Some types of tone cabinets have reverberation units and reverberation preamplifiers built into them. In this case, see the instruction card attached to the cabinet for correct cable connections. While there are several different styles of wiring, it will be found that every cabinet has a 6 pole input plug and a 5 pole output receptacle for connecting additional amplifiers. Some reverberation preamplifiers employ a special detachable coupling cable, wired as shown at the bottom of figure 10.

In reverberation-equipped tone cabinets type CR-20, DR-20, ER-20, FR-40, and G-40, reverberation is applied to all organ frequencies. In this case only one reverberation unit is required for any installation, no matter how many tone cabinets are used. The reverberation unit should be in the cabinet which is connected directly to the console, in order that reverberated signal may be supplied by it to all other cabinets.

In double-channel tone cabinets type HR-40 and JR-20 a reverberated signal is not available to drive succeeding cabinets. For this reason an installation using several such cabinets must have a reverberation unit in each cabinet if it is desired that reverberation be present in all cabinets.

It is not recommended that double-channel cabinets be driven by a reverberated signal from a preceding cabinet because irregularities in the bass response of the reverberation system may be emphasized by the bass amplifier channel. In case one of these cabinets is to be used with one or more reverberation cabinets of other types, it should be connected directly to the console, with the other cabinets following it in the usual way.

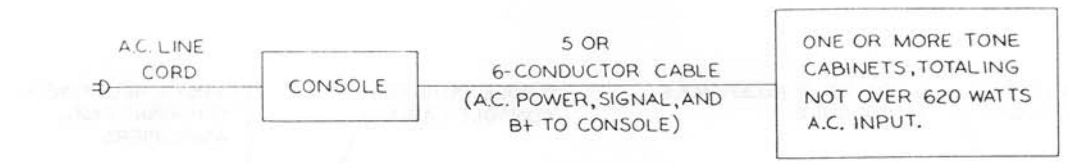


FIGURE 1. BLOCK DIAGRAM OF BASIC TYPE OF INSTALLATION

(FOR DETAILED CONNECTIONS, SEE FIGURES 4, 5, AND 6)

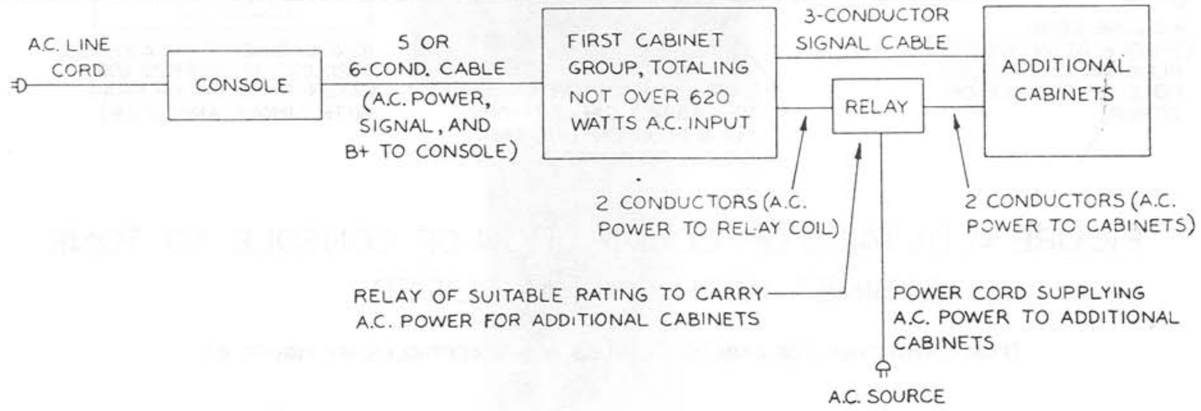


FIGURE 2. BLOCK DIAGRAM OF LARGE INSTALLATION (WITH TONE CABINETS TOTALING MORE THAN 620 WATTS A.C. INPUT), USING POWER RELAY

(FOR DETAILED CONNECTIONS, SEE FIGURE 7)

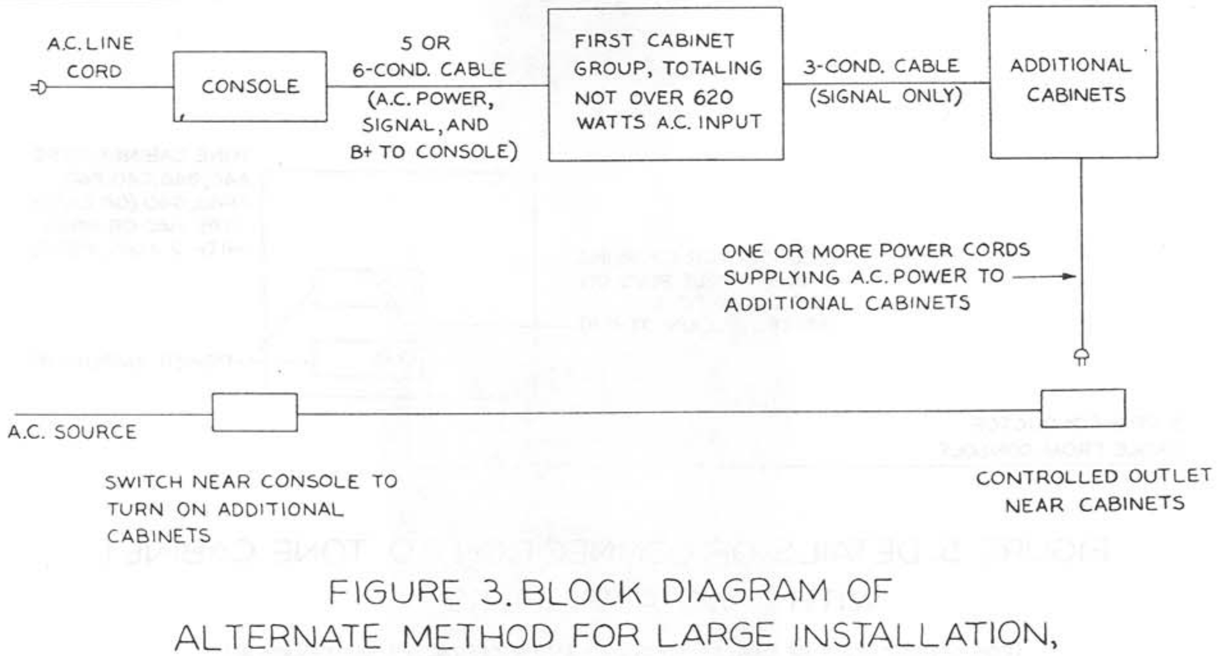


FIGURE 3. BLOCK DIAGRAM OF ALTERNATE METHOD FOR LARGE INSTALLATION, NOT USING RELAY

(FOR DETAILED CONNECTIONS, SEE FIGURE 7)

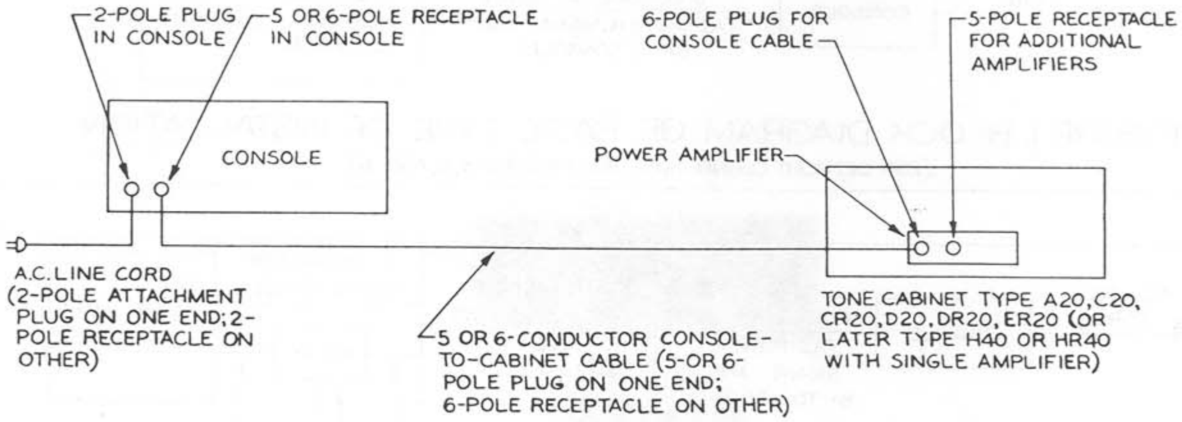


FIGURE 4. DETAILS OF CONNECTION OF CONSOLE TO TONE CABINET WITH ONE AMPLIFIER

(FOR CONNECTIONS OF CABLES TO PLUGS AND RECEPTACLES, SEE FIGURE 10)

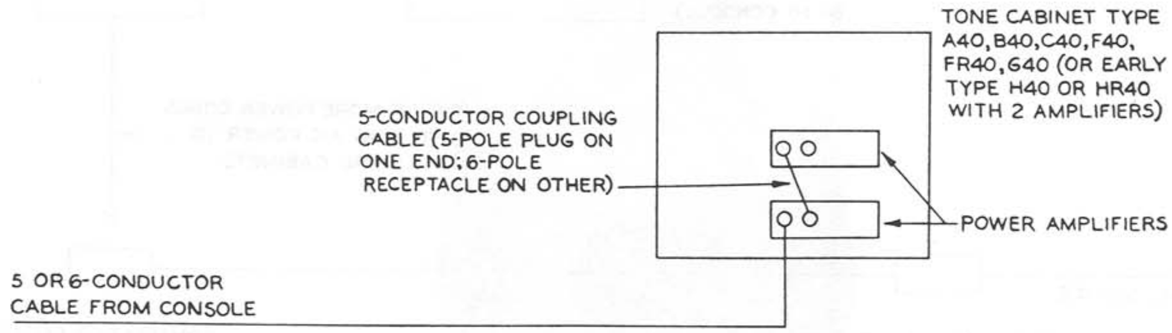


FIGURE 5. DETAILS OF CONNECTION TO TONE CABINET WITH TWO AMPLIFIERS

(FOR CONNECTIONS OF CABLES TO PLUGS AND RECEPTACLES, SEE FIGURE 10)

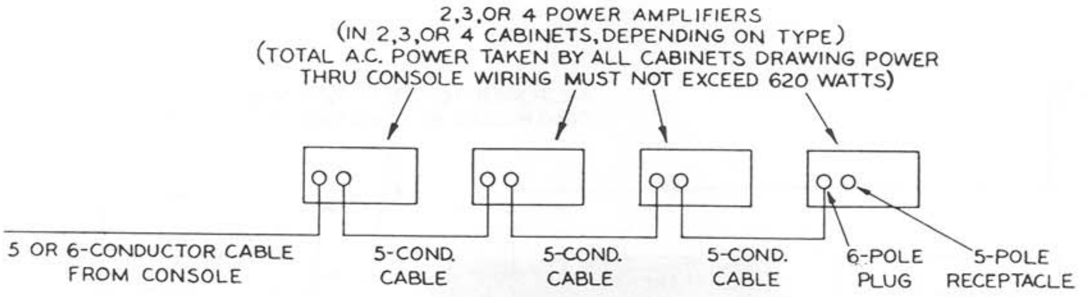


FIGURE 6. DETAILS OF CONNECTION TO TWO OR MORE TONE CABINETS WITH TOTAL OF NOT OVER 620 WATTS A.C. INPUT

(FOR CONNECTIONS OF CABLES TO PLUGS AND RECEPTACLES, SEE FIG. 10)

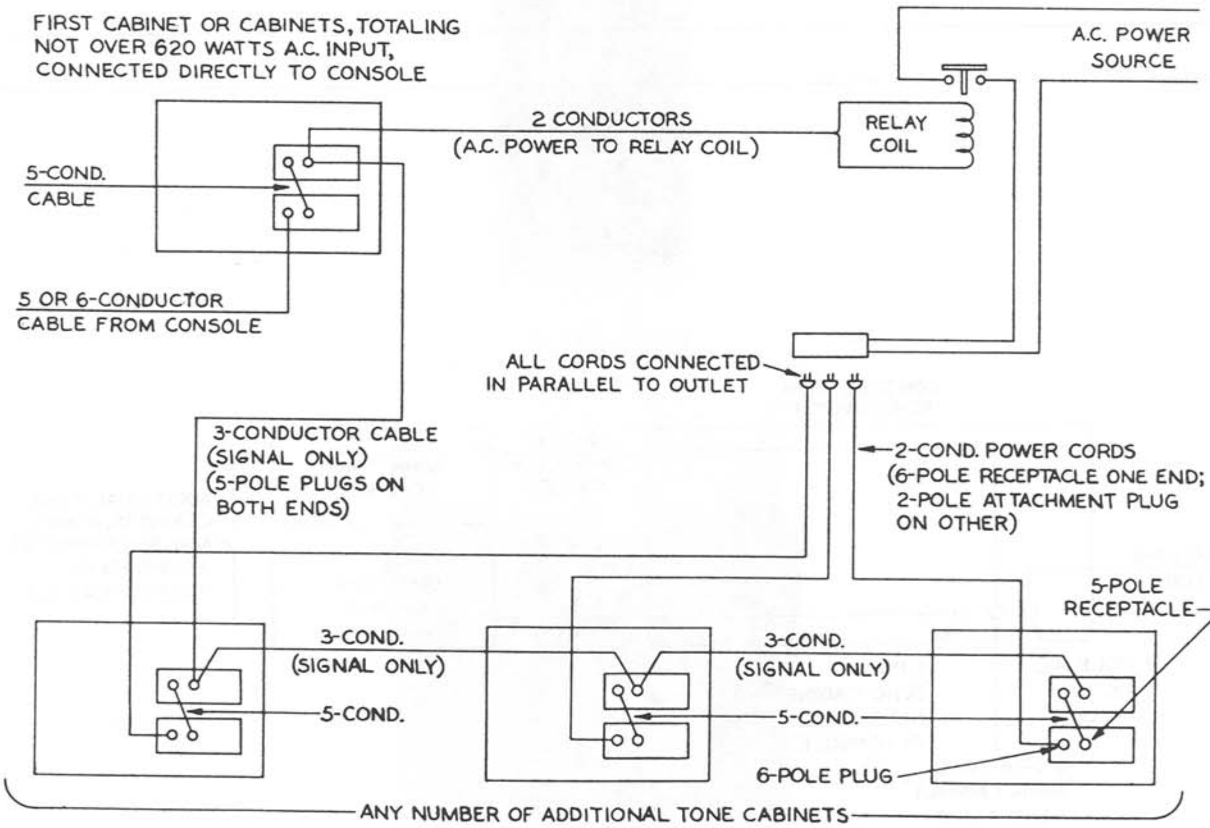


FIGURE 7. DETAILS OF TYPICAL INSTALLATION OF TONE CABINETS WITH A.C. INPUT TOTALING MORE THAN 620 WATTS

(FOR CONNECTIONS OF CABLES TO PLUGS AND RECEPTACLES, SEE FIGURE 10)

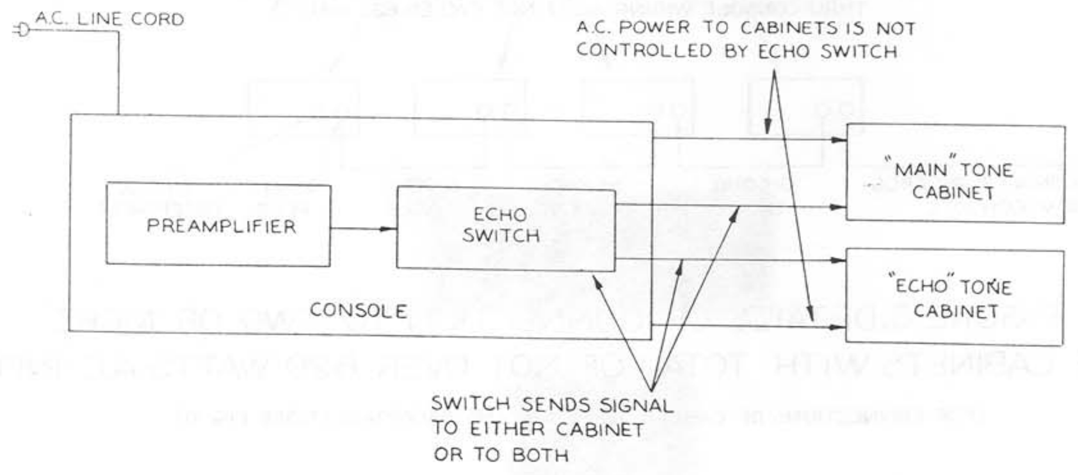


FIGURE 8. BLOCK DIAGRAM OF "ECHO" ORGAN

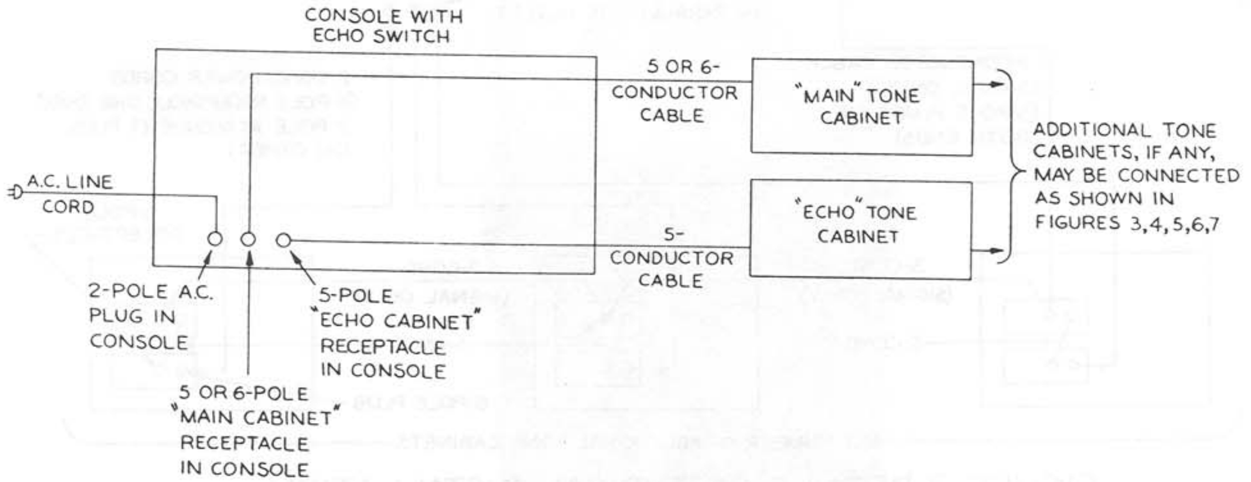
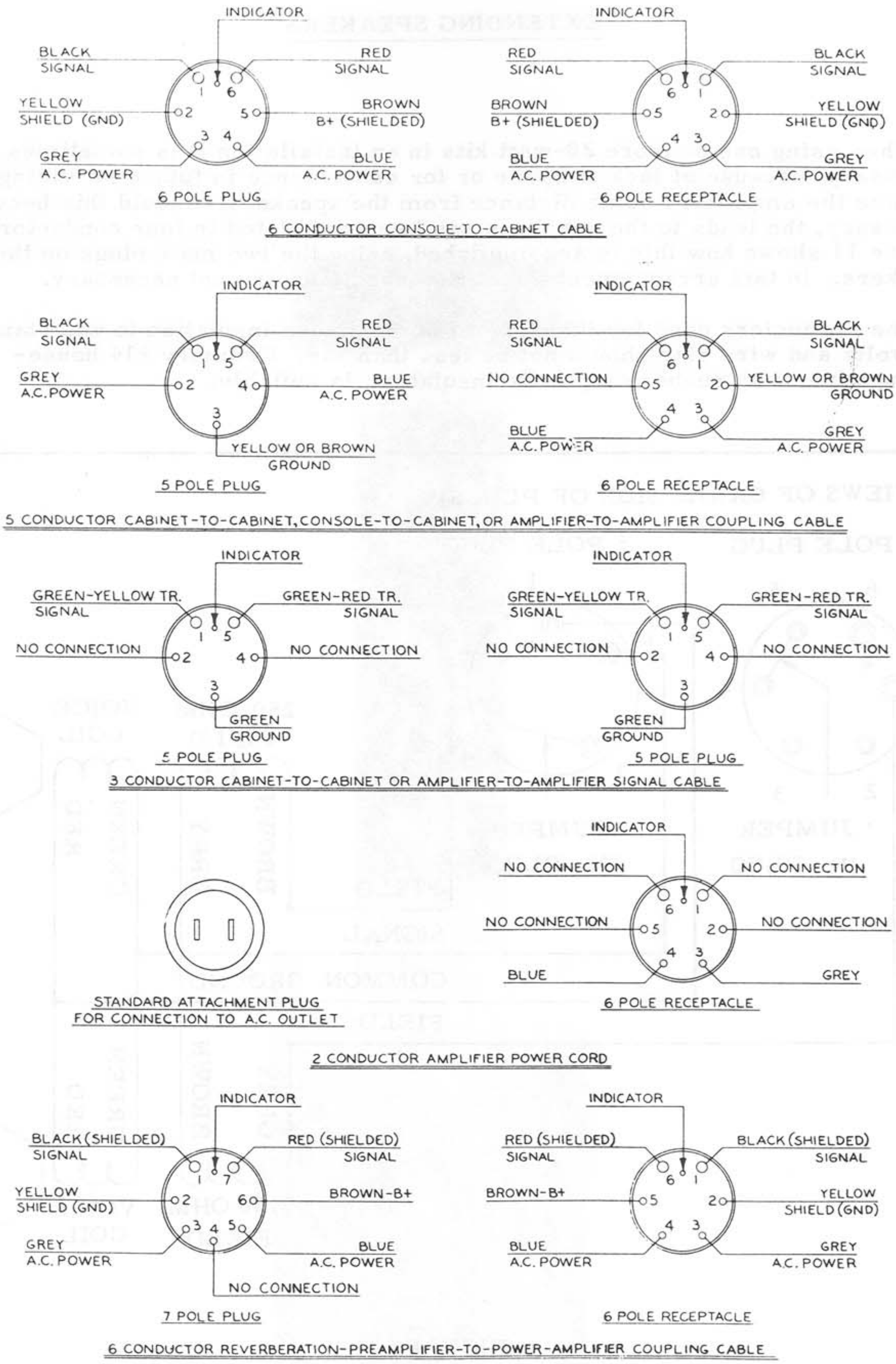


FIGURE 9. CONNECTIONS OF CONSOLE TO MAIN AND ECHO TONE CABINETS



CABLE CONNECTOR WIRING
FIGURE 10
ALL VIEWS SHOW BACK OR CABLE SIDE OF CONNECTOR

EXTENDING SPEAKERS

When using one or more 20-watt kits in an installation it is sometimes necessary, because of lack of space or for convenience in future servicing, to place the amplifiers some distance from the speakers. Should this become necessary, the leads to the speakers can be consolidated in four conductors. Figure 11 shows how this is accomplished, using the two male plugs on the speakers. In this arrangement the stud connections are not necessary.

The conductors used for this extension must have insulation to withstand 300 volts and wire size should not be less than #14. Ordinary #14 house-wiring wire, with rubber or plastic insulation, is suitable.

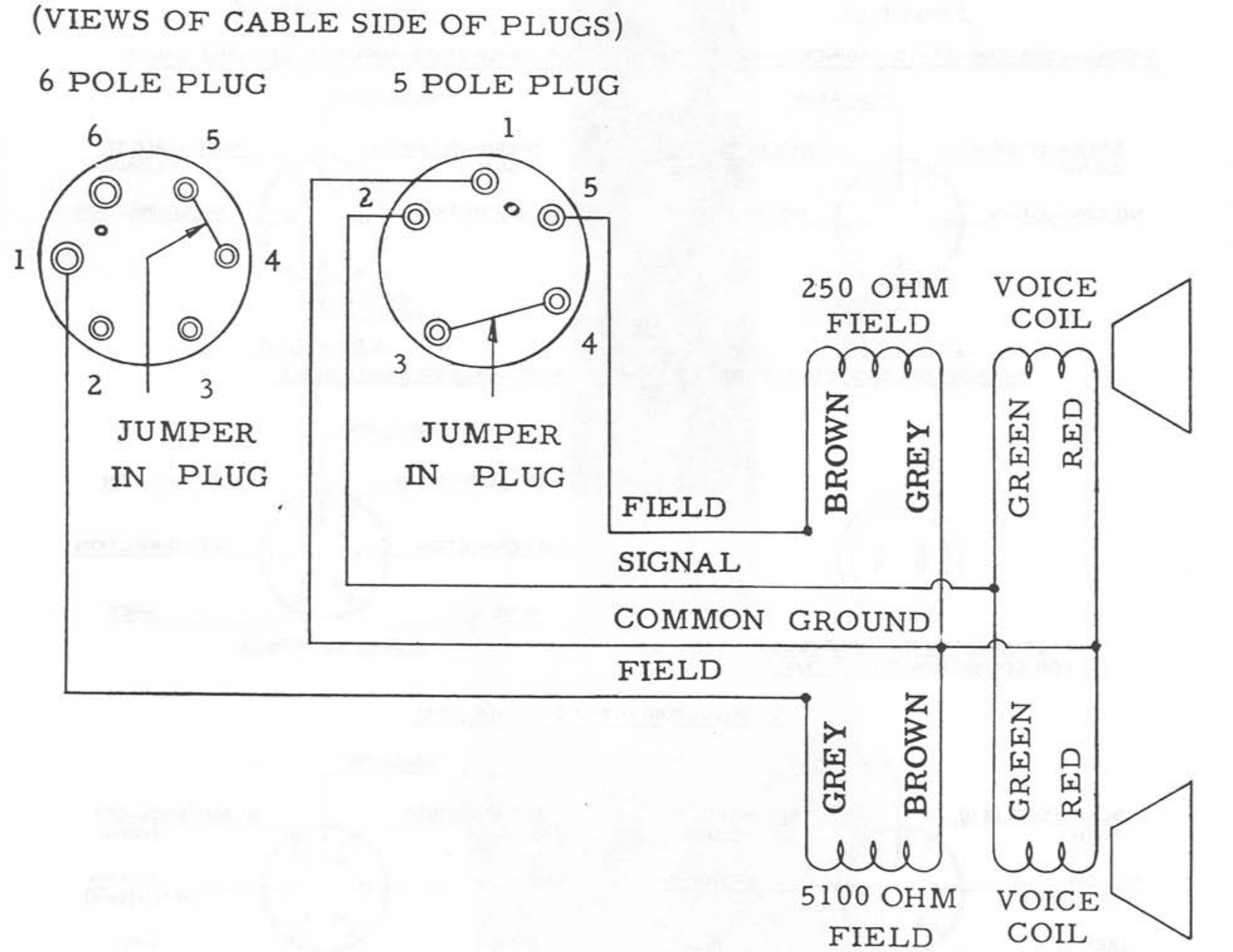


FIGURE 11

THE HAMMOND ORGAN

Console Power Wiring

HAMMOND ORGAN COMPANY
4200 West Diversey Avenue
Chicago 39, Illinois

8/57

CONSOLE POWER WIRING
(Main and Chorus Generators)

Starting and Synchronous Motors

A shaded pole induction motor is used for starting the generator and is located at the right end of the generator as viewed from the back. The rotor of this motor will slide endwise when current is supplied and engage a pinion on its shaft with a gear on the generator driving shaft, bringing the tone generator up to slightly greater than synchronous speed.

When the organ is started, the starting switch is turned on and held for about 8 seconds while the starting motor brings the system up to speed. The "run" switch is then turned on. This switch simultaneously connects the synchronous motor and introduces a resistor in series with the starting motor (Figure 1), thus reducing its driving power. With a braking action of the synchronous motor and a loss of power of the starting motor, the system slows to synchronous speed and the synchronous motor begins to carry the load. A period of about 8 seconds should be allowed for this to take place, after which the starting switch may be released. The starting switch springs back to the "off" position, and turns off the starting motor, which is disengaged from the rotating shaft by a spring.

It should be noted that the synchronous motor can supply power only at synchronous speed. Therefore, if for any reason the system fails to reach synchronous speed it will not continue to run after the starting switch is released. Failure to start properly is usually due to increased oil viscosity and may be overcome by an increase in starting time.

As the schematic diagram (Figure 1) indicates, the "run" switch in its "off" position shorts out the wirewound resistor attached to the line panel. If the "run" switch is defective in its "off" position, the generator will not start because this resistor will be permanently in series with the starting motor. Before assuming that there is anything amiss with the motors, short out this resistor and start the generator in the normal manner. If the generator operates satisfactorily, replace the "run" switch.

The "run" switch on all consoles is a two-circuit switch, but types of switches having two different terminal arrangements have been used, as shown in Figure 2. When replacing a switch, observe the wiring of the old switch and check the connections of the new switch with an ohmmeter. Note that black and blue are connected in the "on" position, and yellow and brown are connected in the "off" position, no matter which type of switch is used.

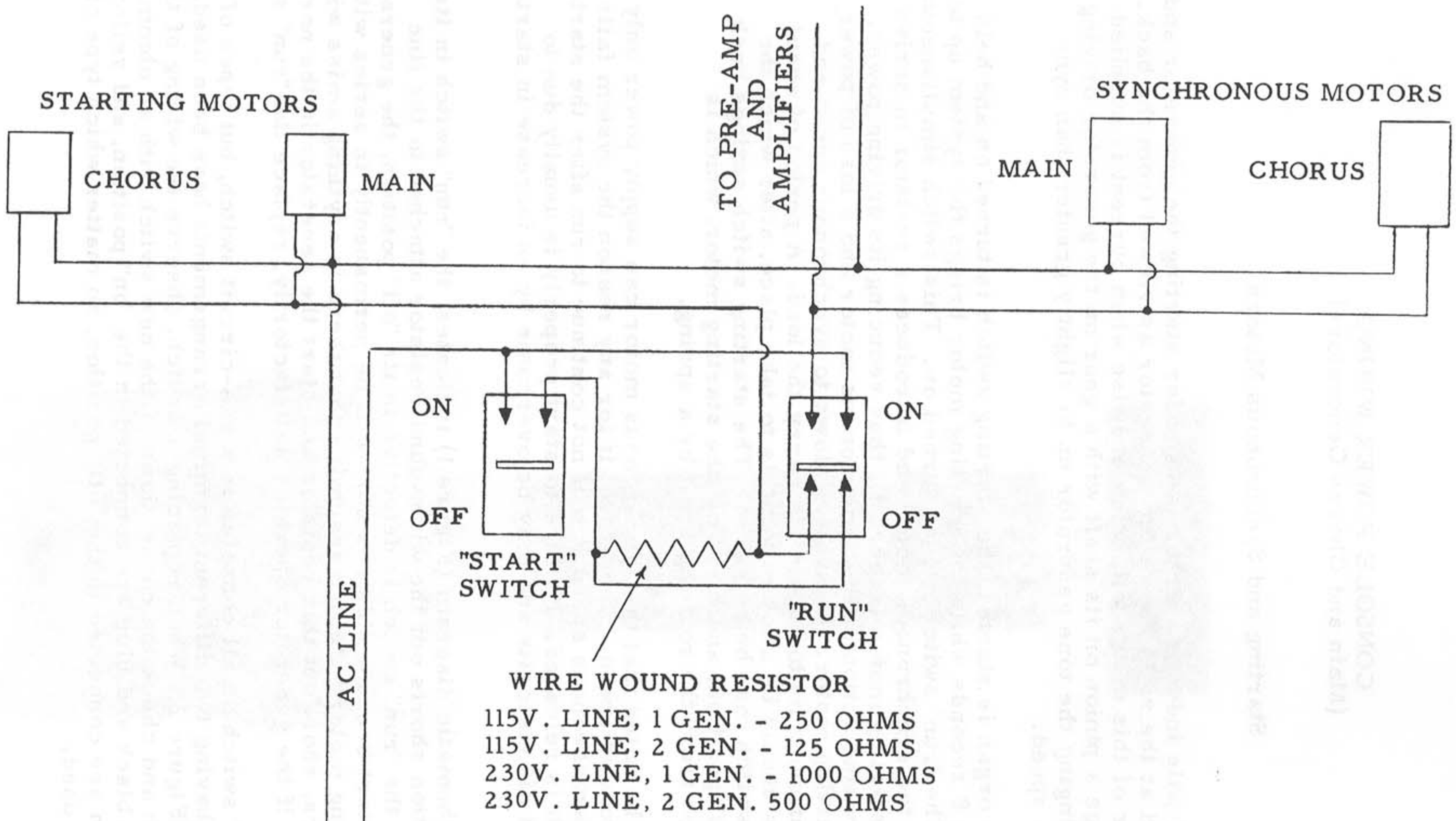


FIGURE 1
SWITCH AND MOTOR CIRCUITS

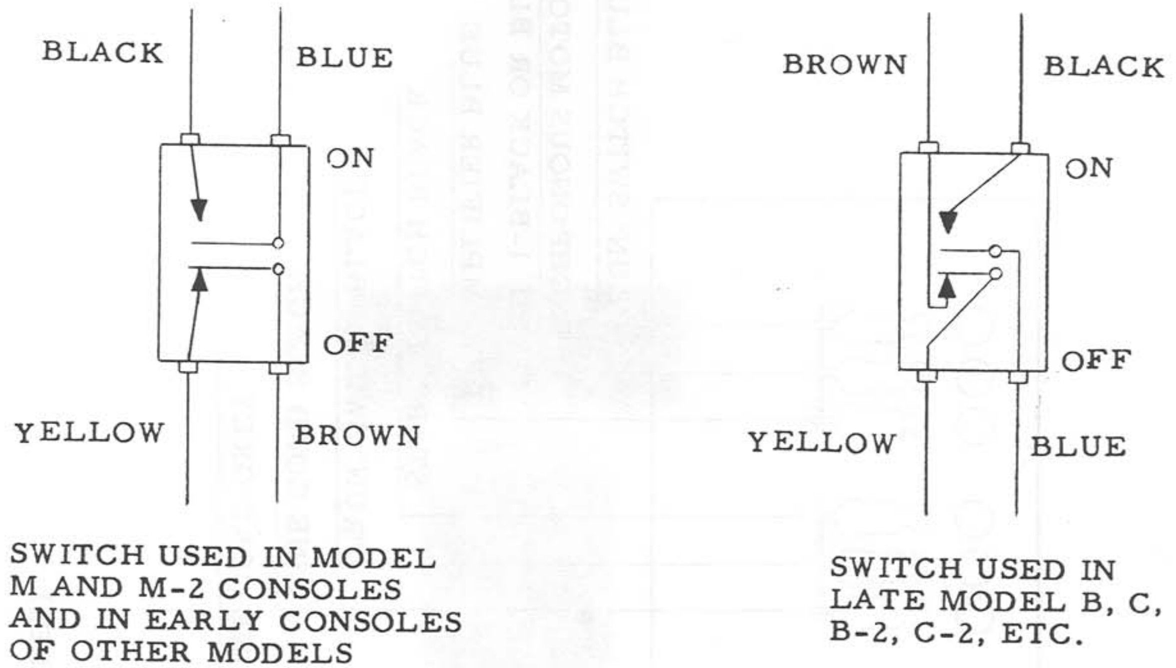


FIG 2
TWO TYPES OF "RUN" SWITCHES

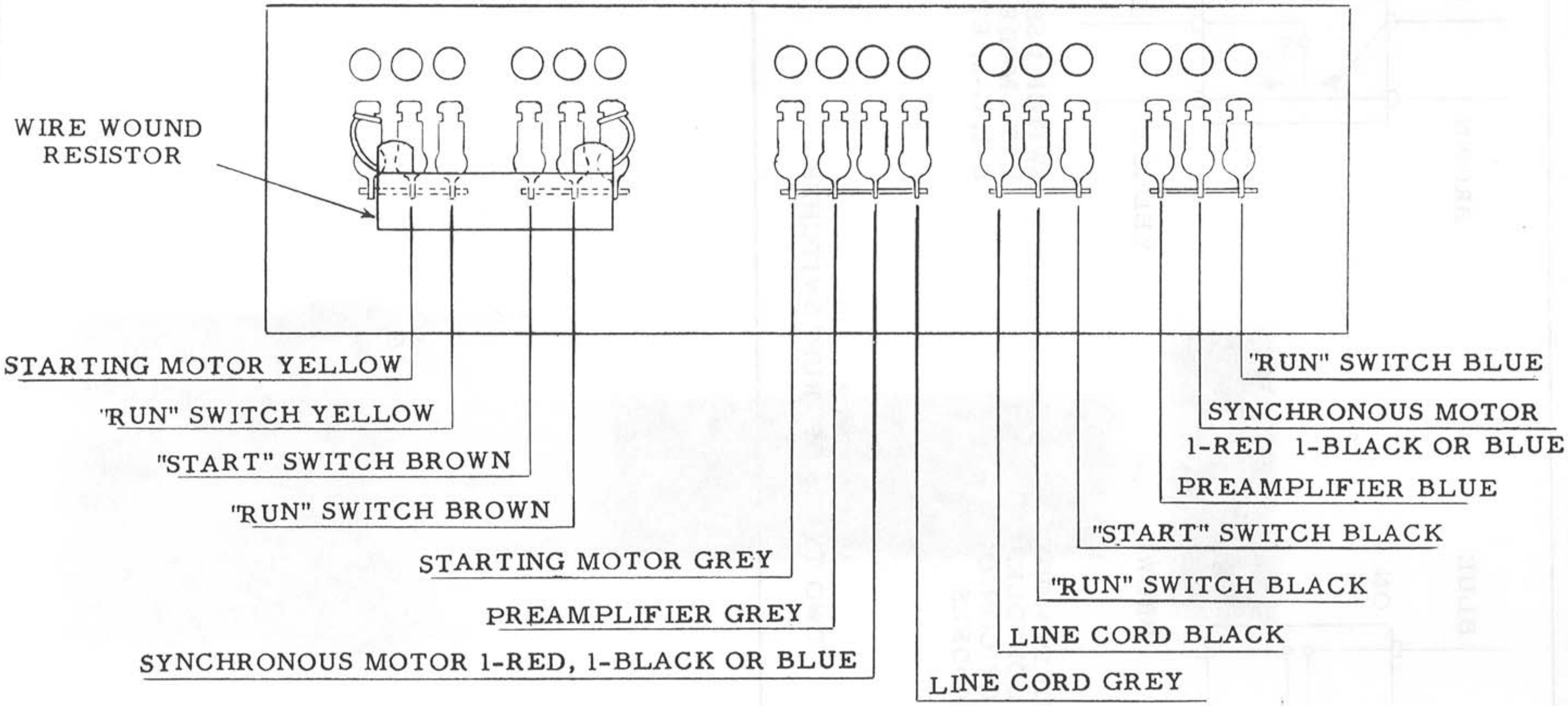


FIG. 3

LINE PANEL (EARLY CONSOLES)

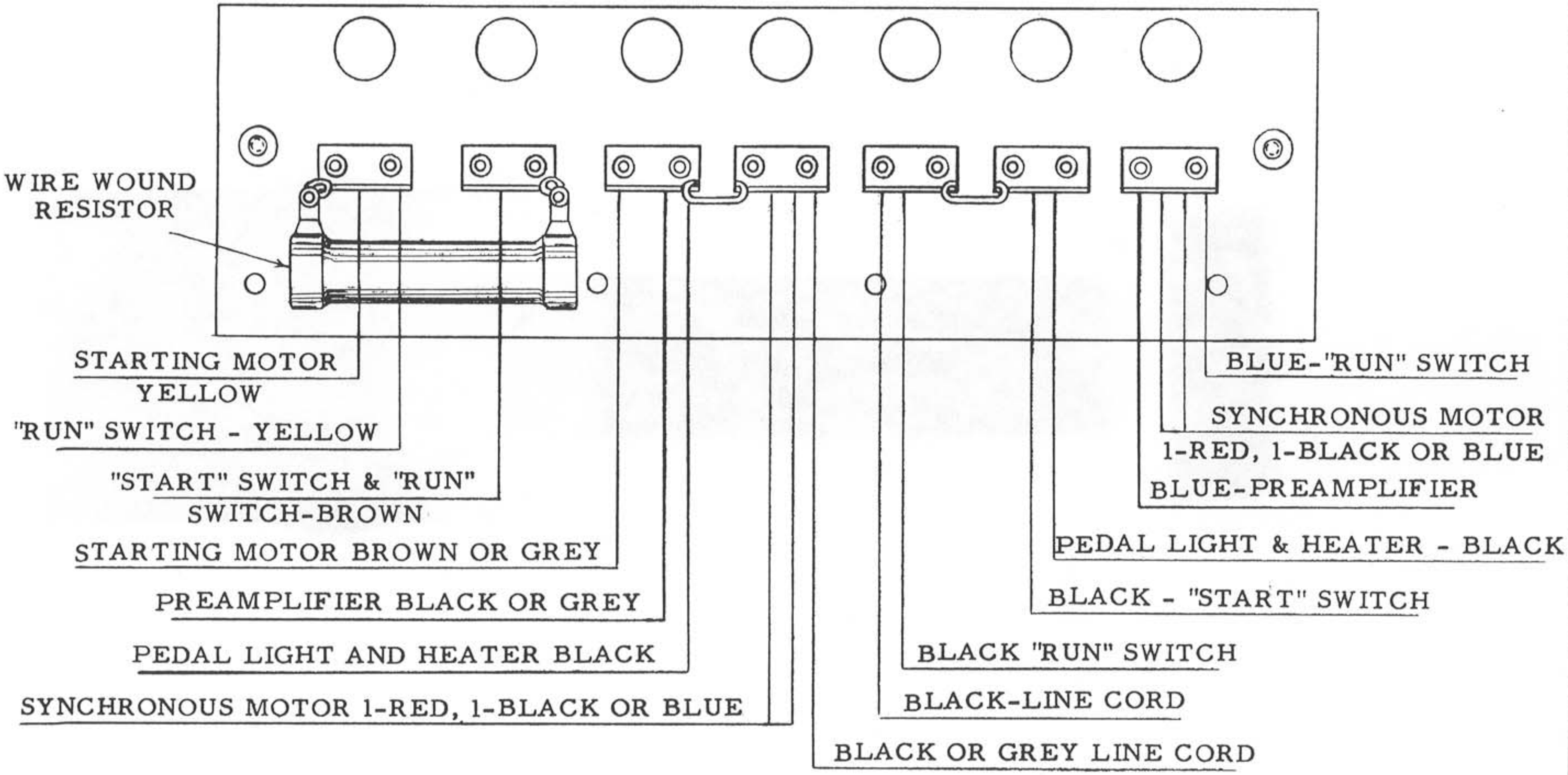


FIG. 4

LINE PANEL (LATER CONSOLES)

THE HAMMOND ORGAN

Tremulant Switch and Control
Models A-BA-BC-C-D-G

Rheostat Box Connections
Models Without Selective Vibrato

HAMMOND ORGAN COMPANY
4200 West Diversey Avenue
Chicago 39, Illinois

8/53

TREMULANT SWITCH AND CONTROL
MODELS A-BA-BC-C D-G

The tremulant sometimes called tremolo, is a periodic loudness variation, or change in intensity, which occurs at a constant frequency. It is fundamentally different from the vibrato effect, which is created by a periodic raising and lowering of pitch.

In the Hammond Organ the tremulant effect is produced and controled principally by two components: the tremulant switch and the tremulant control.

The tremulant switch, mounted on the synchronous motor at the extreme left end of the tone generator, is in effect a variable resistor with no sliding or rubbing contacts. It consists of an eccentric, geared to the motor shaft, which advances a laminated bakelite strip so as to alternately make and break 6 contacts in order. Five resistors are connected to these contacts, ranging in value from 15,000 to 450,000 ohms, together with a length of copper wire of very little resistance. At one extreme position of the eccentric all contacts are broken and the circuit is open. At the other extreme all contacts are closed and there is practically no resistance in the circuit.

The tremulant control, a 130,000 ohm variable resistor mounted on the manual chassis assembly, is in parallel with the tremulant switch. When this control is turned to a position of no resistance, the tremulant switch is shorted out. Conversely, when the control is turned to its maximum resistance, the movement of the eccentric varies the resistance of the circuit periodically from 0 to 130,000 ohms. This parallel circuit is in series with the signal from the console, ahead of the pre-amplifier. Therefore, the signal is varied during each revolution of the eccentric by an amount depending upon the adjustment of the tremulant control.

The tremulant system is not used in console models having vibrato.

Model E

The tremulant system for Model E organ is the same as that on other models except that two switches are used. Each switch is mounted on one of the two synchronous motors that are a part of the main generator and chorus generator respectively, and each one is connected to one manual. The switch mounted on the main generator operates at 400 R.P.M. and is connected to the Great manual. The other switch operates at 348 R.P.M. and is connected to the Swell manual.

Two types of tremulant switches have been supplied, namely, the cage type and the enclosed type. These are mechanically interchangeable, but replacing the cage type with the enclosed type does require a slight change in the circuit. In the enclosed type, the condenser shown as C5 in Figure 4 is incorporated within the metal housing. Therefore, the C5 located in the rheostat box is not required and the tremulant switch red wire may be attached to terminal 6,7, or 8.

RHEOSTAT BOX

The rheostat box contains the expression control rheostat and other components, including some terminals associated with the tremulant system. Figures 1 to 8 show various models of rheostat boxes and their circuits. The rheostat box is used only in console models with tremulant and with non-selective vibrato.

The rheostat itself is actually a variable resistor with no sliding contacts. When the expression pedal is advanced a bakelite cam moves down, opening in succession a series of 32 contacts, tipped with precious metal. The contacts are connected to fixed carbon resistors.

Resistor R2 in figures 2 and 4 forms a constant load on the matching transformer, while R4 and C4 serve to attenuate the higher frequencies. R4 and C4 were not used in Model A consoles below serial number 1231. The rheostat, in series with bass compensating condenser C2, is across the signal line, so that when its resistance is least the volume is least. Condenser C5 avoids excessive tremolo on the lower bass frequencies. It was not originally installed in Model A consoles below serial number 2311. C3 is a blocking condenser and R3 is a grid resistor for the first preamplifier tube.

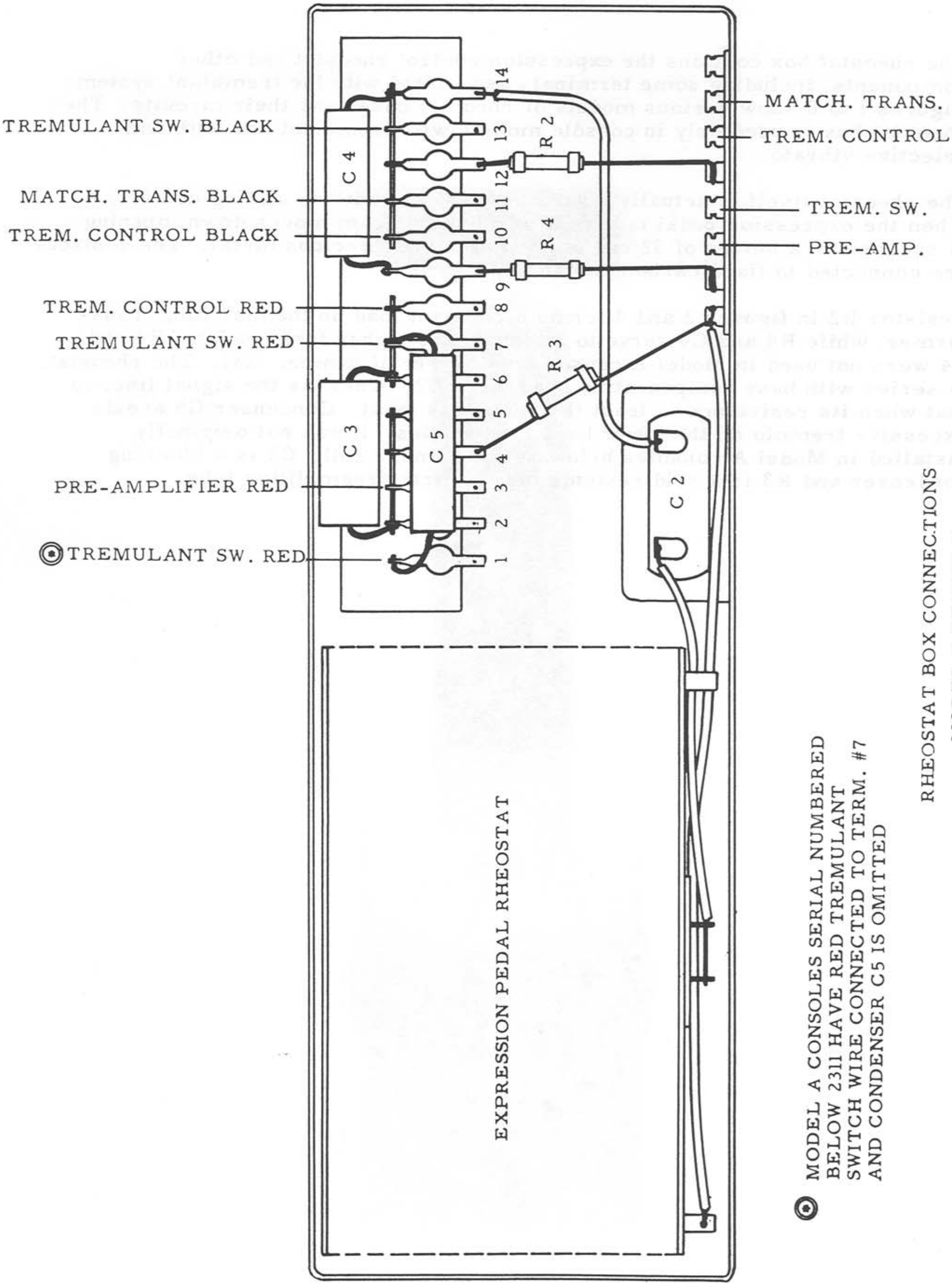
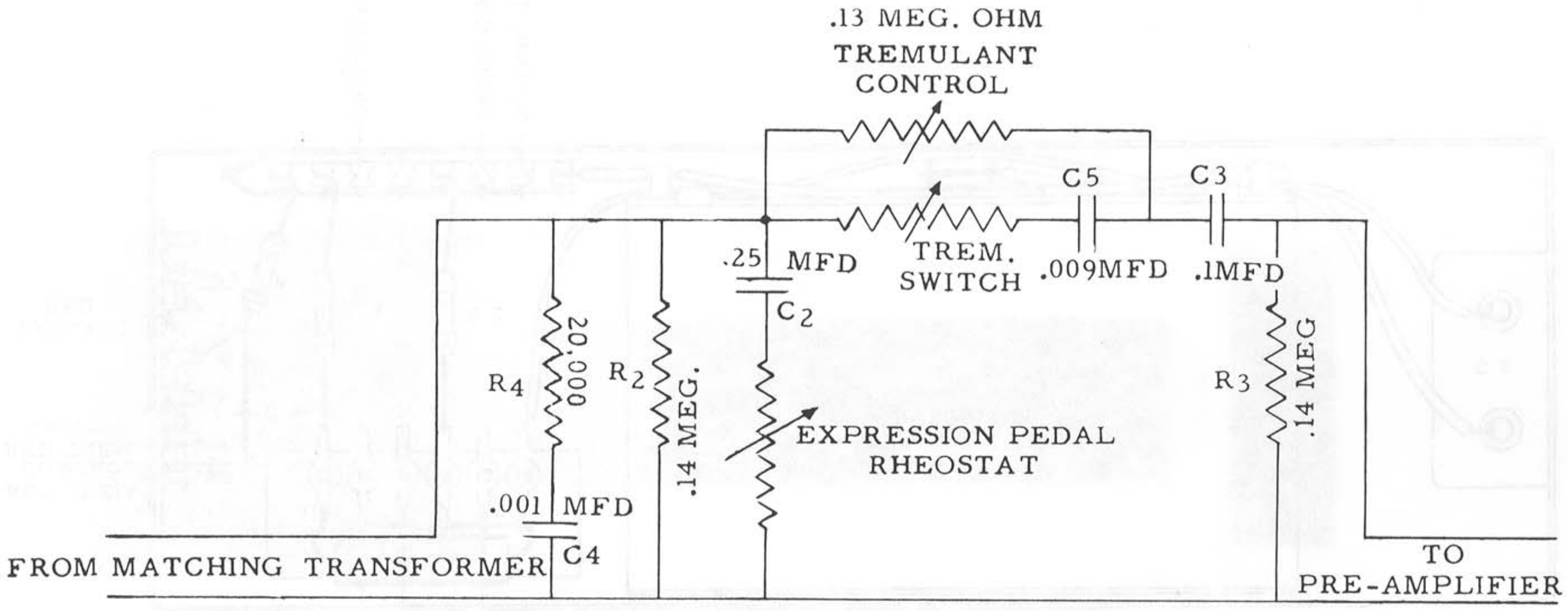


FIGURE 1

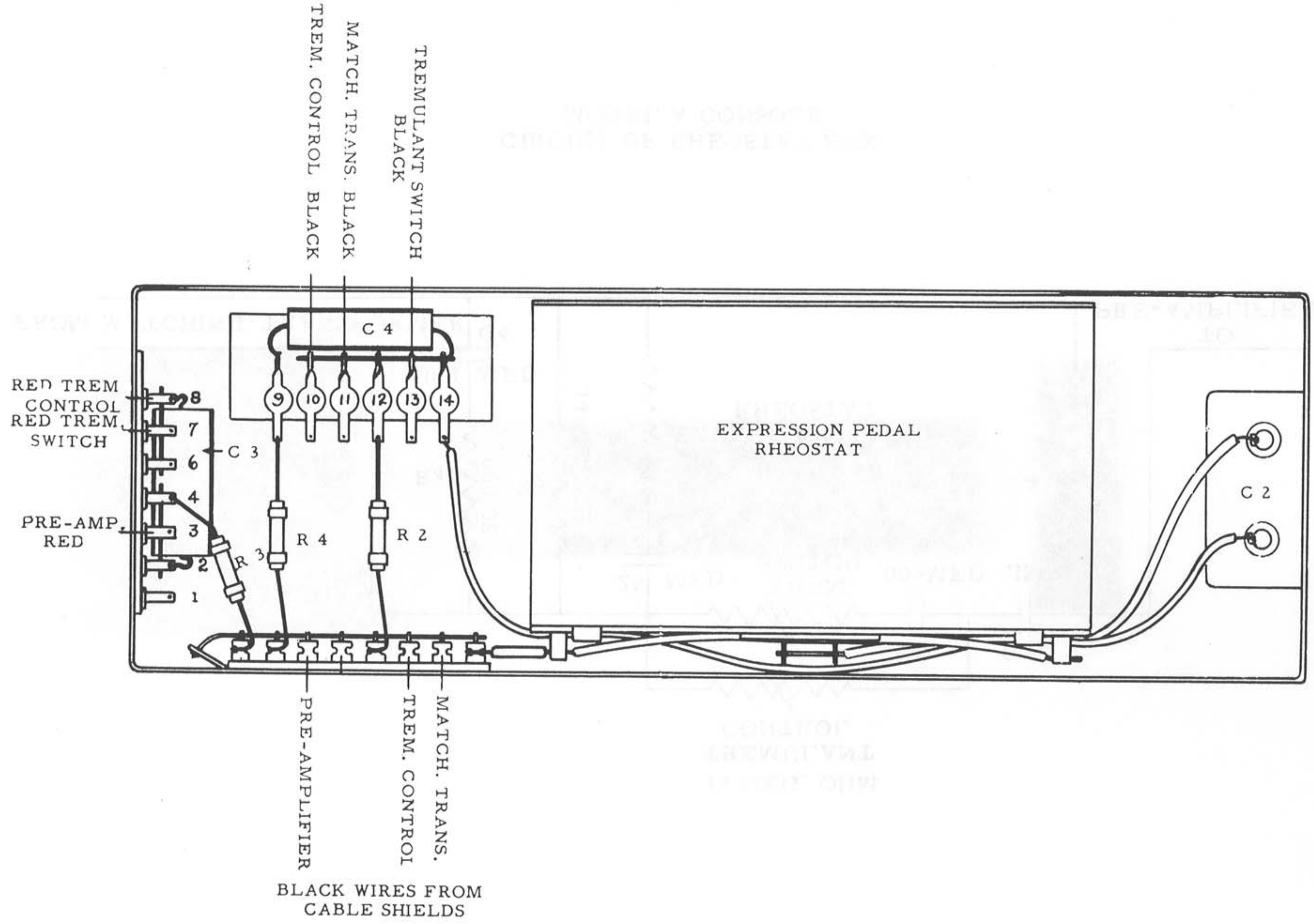
RHEOSTAT BOX CONNECTIONS

MODEL A CONSOLE



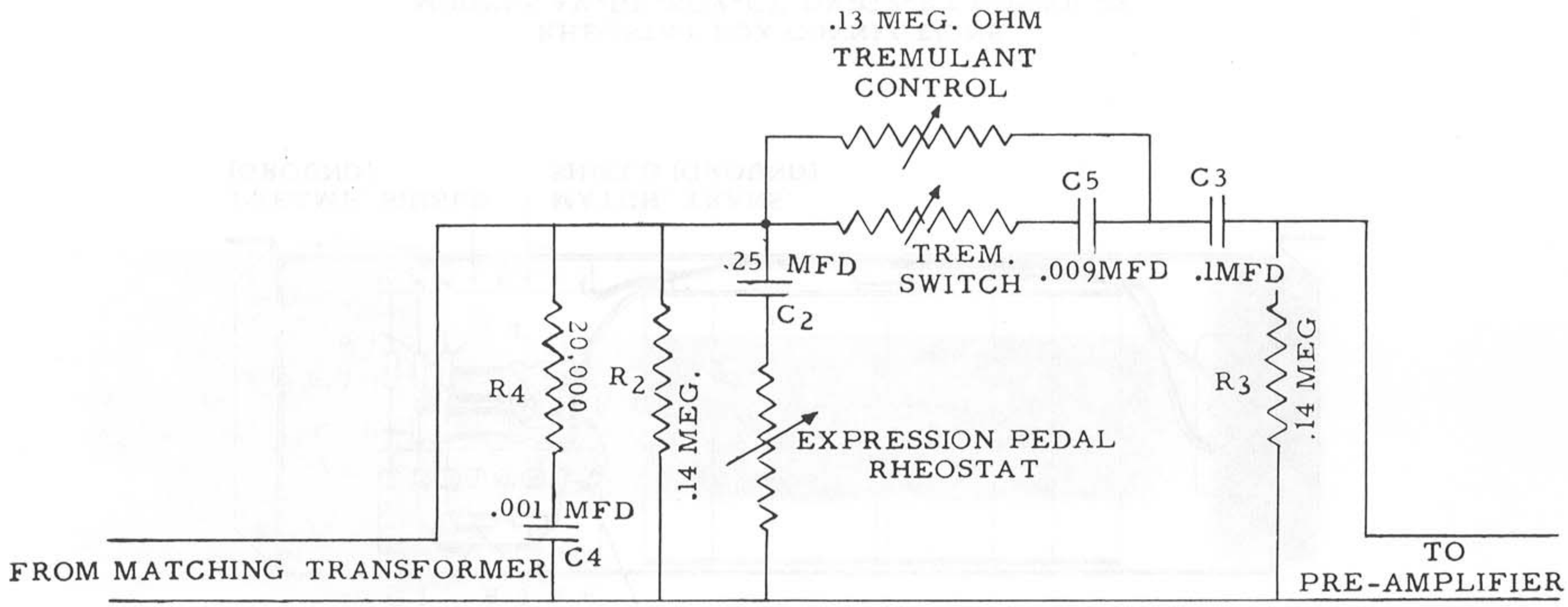
CIRCUIT OF RHEOSTAT BOX
MODEL A CONSOLE

FIGURE 2



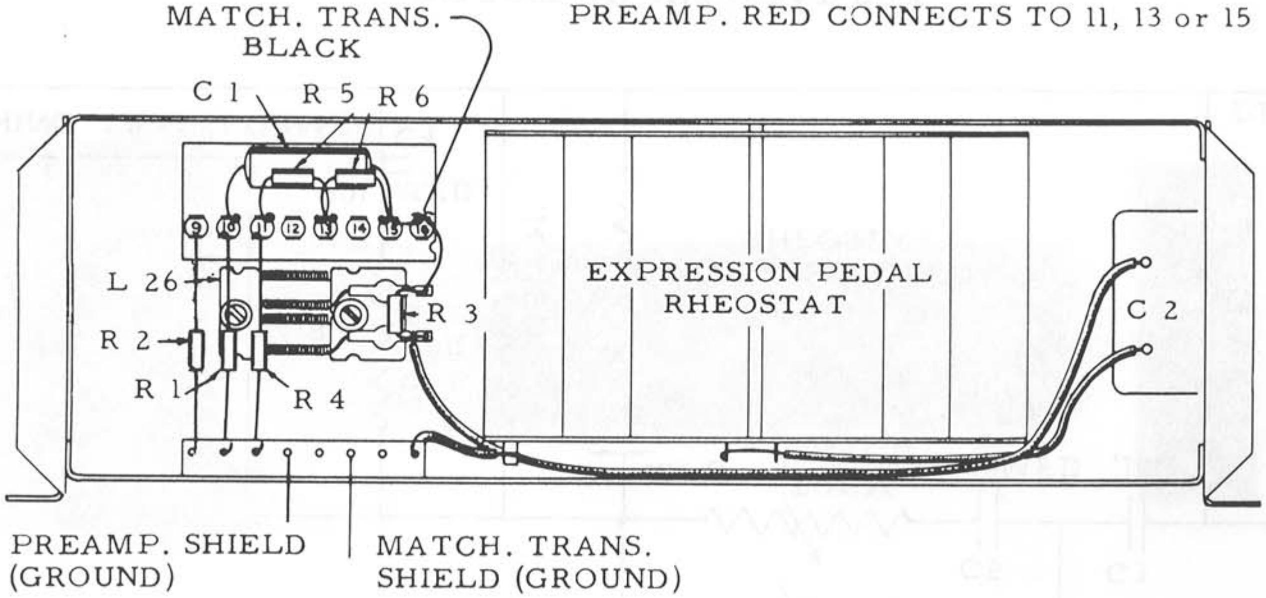
RHEOSTAT BOX CONNECTIONS
MODEL B-BA-BC-C-D-G

FIGURE 3



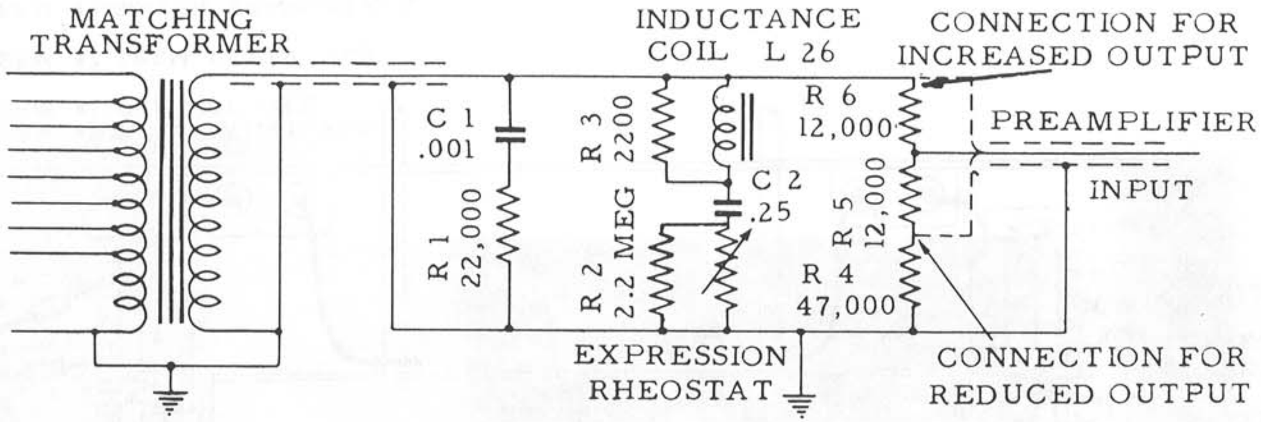
CIRCUIT OF RHEOSTAT BOX
MODEL B-BA-BC-C-D-G

FIGURE 4



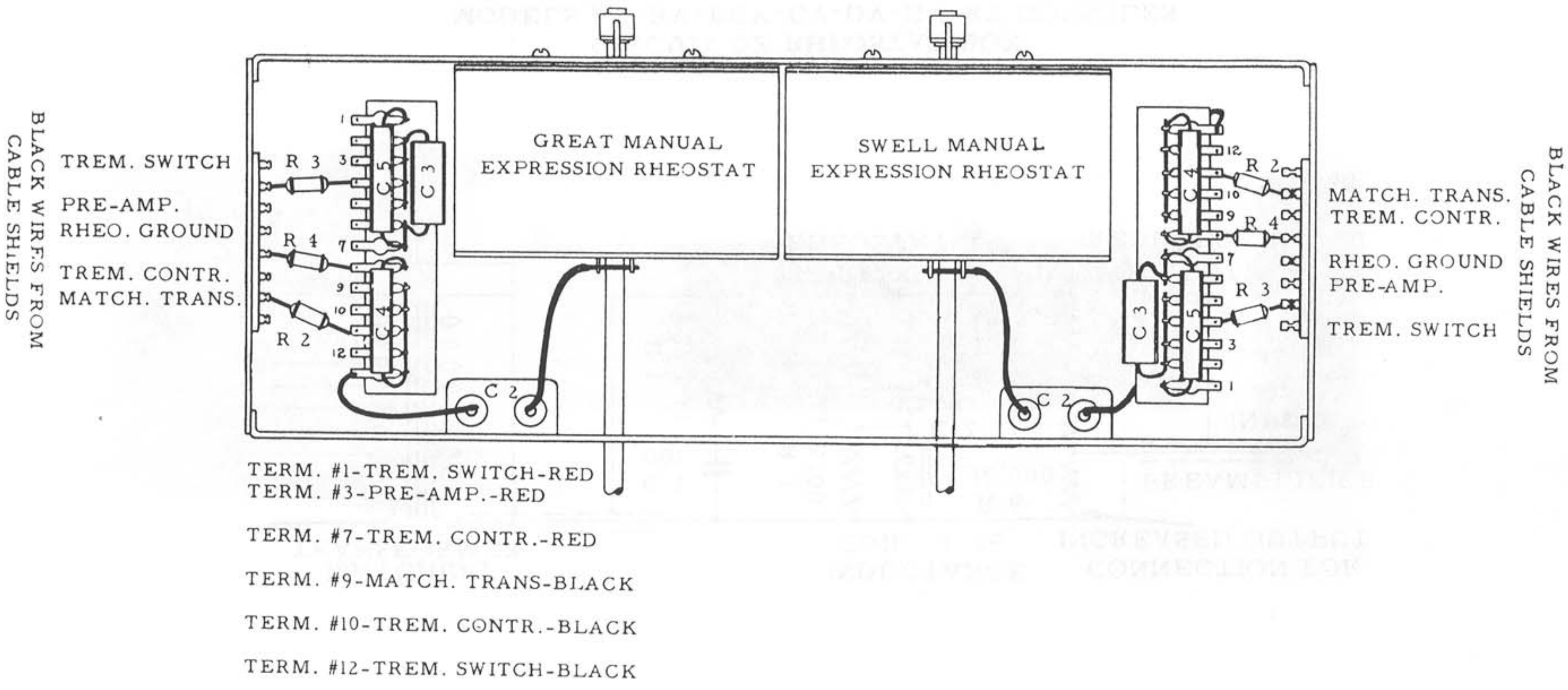
RHEOSTAT BOX CONNECTIONS
MODELS AV-BV-BCV-CV-DV-GV-RT CONSOLES

FIGURE 5



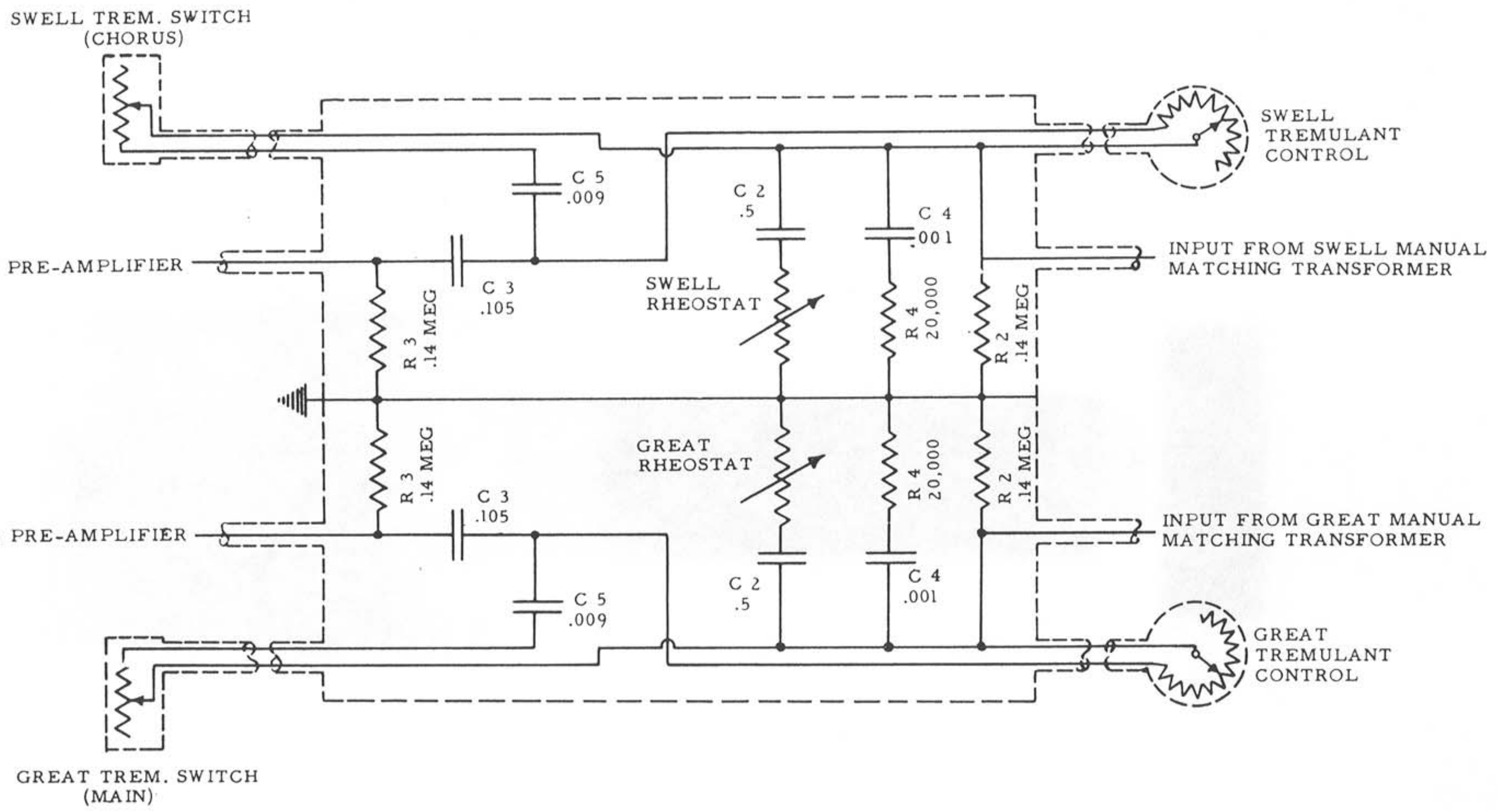
CIRCUIT OF RHEOSTAT BOX
MODELS AV-BV-BCV-CV-DV-GV-RT CONSOLES

FIGURE 6



RHEOSTAT BOX CONNECTIONS
MODEL E CONSOLE

FIGURE 7



CIRCUIT OF RHEOSTAT BOX
MODEL E CONSOLE

FIGURE 8

THE HAMMOND ORGAN

Chorus Generator

HAMMOND ORGAN COMPANY
4200 West Diversey Avenue
Chicago 39, Illinois

11/53

CHORUS GENERATOR

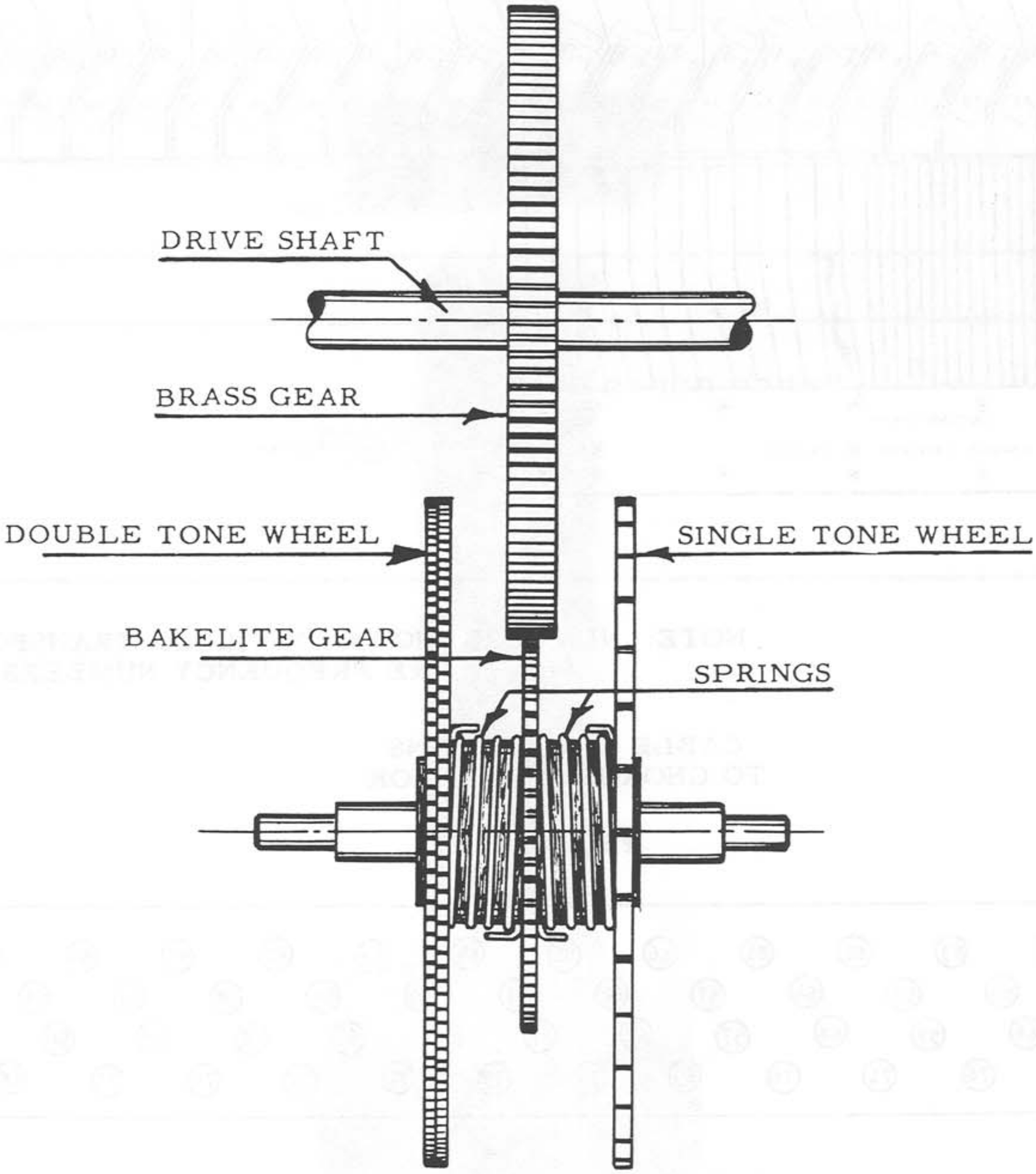
(Used in models BC, D, E, and G)

The purpose of the chorus generator is to add a series of slightly sharp and slightly flat tones to the true tones produced by the main generator. The resulting electrical wave contains a complex series of undulations which enhance the pleasing effect of many tone qualities, notably string and full organ combinations. It should be noted that no chorus effect is produced on frequencies below 56.

The frequencies covered by the chorus generator are numbers 56 to 91 inclusive on the main generator. The difference in frequency between the main generator and either flat or sharp tone is .8% for frequencies 56 to 67 and .4% for frequencies 68 to 91. It is necessary that a lesser percentage of frequency difference be present in the higher register in order to avoid too rapid undulation.

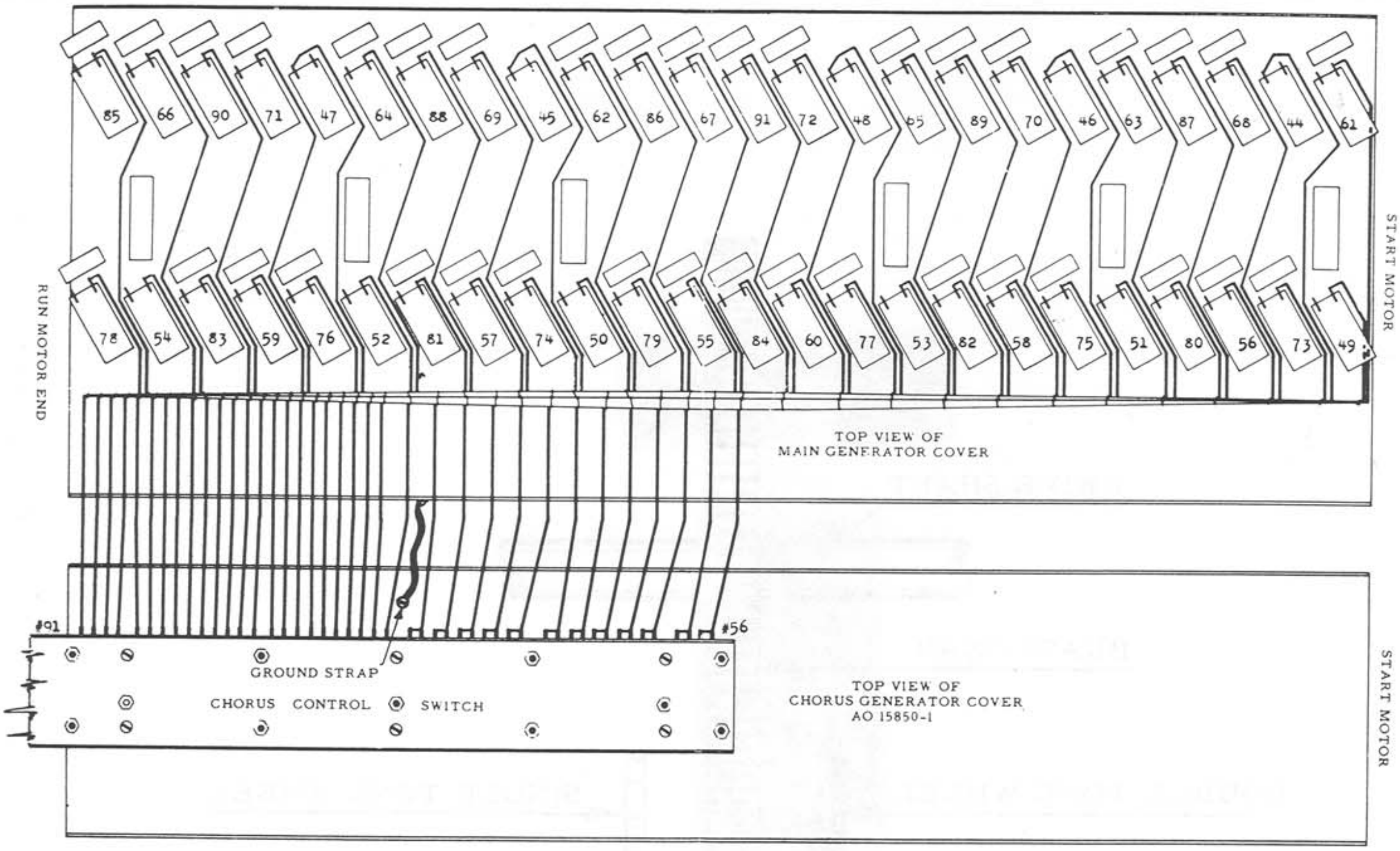
The chorus generator assembly, like the main generator, has a drive shaft with twenty-four brass gears. Each gear drives a single assembly consisting of two tone wheels. The drive gears vary as to the number of teeth, and the tone wheels operate at twenty-four different speeds. This generator has forty-eight tone wheels, each with a separate magnet and pick-up coil. Of these tone wheels, twenty-four are single and twenty-four are double (see Figure 1). The double tone wheels consist of two discs with different numbers of teeth mounted on one brass hub. The single wheels are electrically connected in pairs, each pair being so connected as to have the same effect as one double wheel.

Figure 2 is a complete wiring diagram for connections between main and chorus generators, and Figure 3 is a back view of the chorus generator indicating the frequency number of each magnet.



CHORUS GENERATOR
TONE WHEEL ASSEMBLY

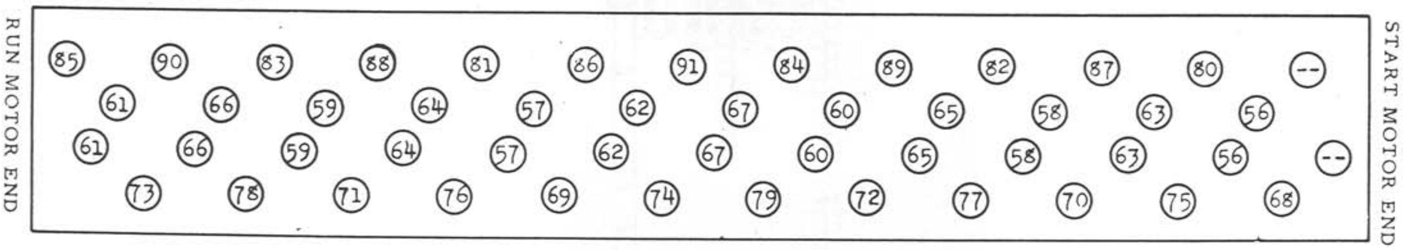
Figure 1.



NOTE: NUMBERS SHOWN ON FILTER TRANSFORMERS ARE FREQUENCY NUMBERS.

CABLE CONNECTIONS
TO CHORUS GENERATOR

Figure 2.



BACK VIEW OF CHORUS GENERATOR

(NUMBERS SHOWN ARE FREQUENCY NUMBERS)

CHORUS GENERATOR MAGNET LOCATIONS

Figure 3