

SERVICE INFORMATION  
ON THE  
HAMMOND CHORD ORGAN  
(Models S, S-1, and S-4)

**HAMMOND ORGAN**

*"music's most glorious voice"*

**HAMMOND ORGAN COMPANY**

4200 WEST DIVERSEY AVENUE • CHICAGO 39 ILLINOIS

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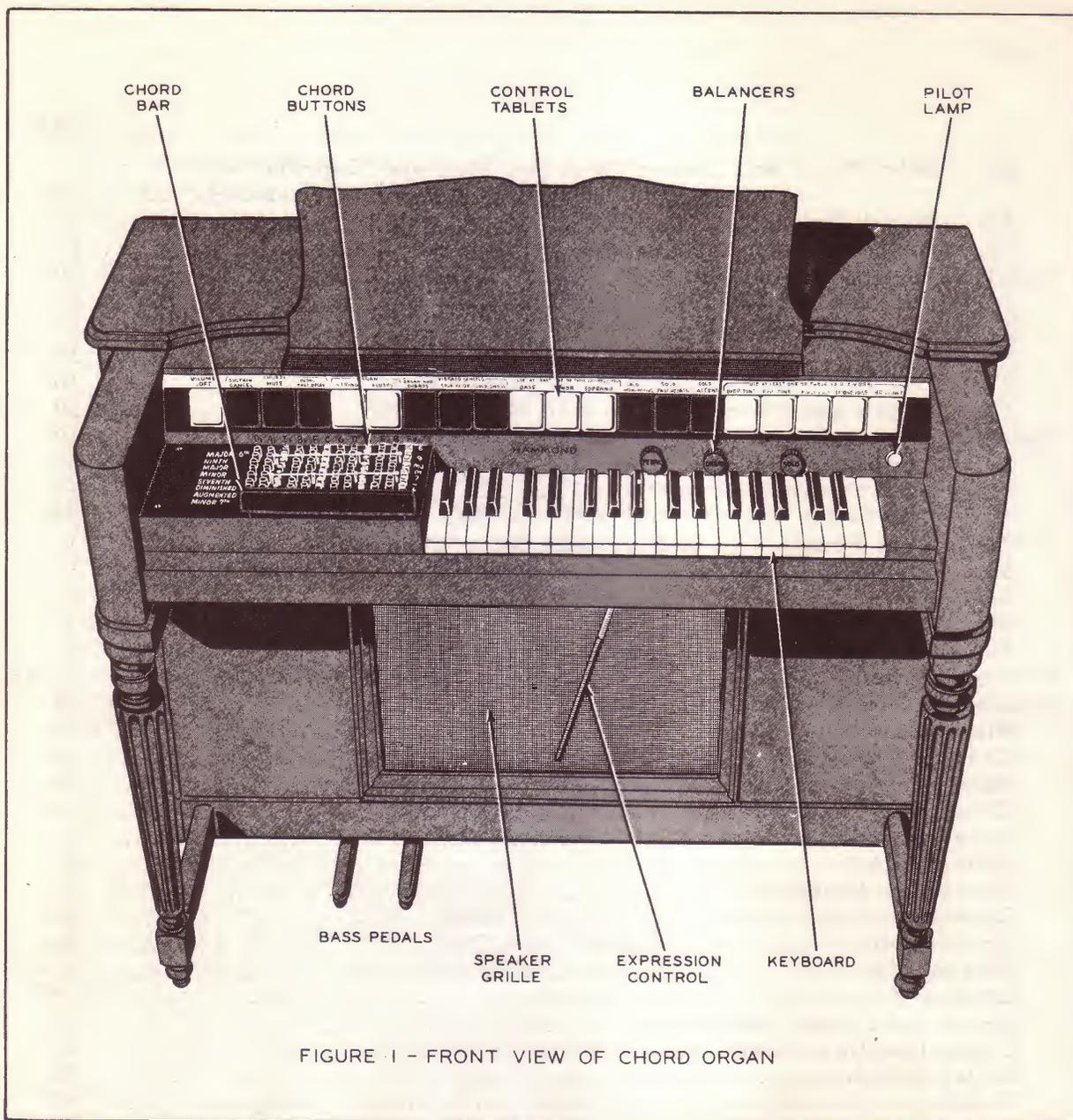


FIGURE 1 - FRONT VIEW OF CHORD ORGAN

Models S, S-1, and S-4 are almost exactly alike in appearance and musical operation.

Model S uses octal tubes and one 12 inch speaker. The first units used type 6SC7 frequency divider tubes which were later replaced with type 6SN7 tubes.

Model S-1 has miniature tubes and one 12 inch speaker, and has some component values different from Model S.

Model S-4 has miniature tubes and two 10 inch speakers. It differs in a number of circuit details from Models S and S-1, and has slightly different woodwork.

Information in this book applies to all models unless otherwise stated. Where necessary, several circuit diagrams or other figures are supplied; for instance, figures 6, 6A, 6B, and 6C are schematic diagrams for various models. Where figure 6 is mentioned in the text, it will be understood that it refers to all of these figures.

Note that figures 1, 9, 10, and 11 are views of a typical Model S instrument, and other models differ in various details.

## GENERAL DESCRIPTION

The Hammond Chord Organ is completely self-contained (see figure 1). It has a 37-note keyboard played with the right hand; a set of 96 chord buttons played with the left hand; a chord bar operated by the palm or thumb of the left hand to accent chord rhythms; two bass pedals played with the left foot; twenty stop tablets for controlling the character of tones produced; three balancers for adjusting the volume of the various divisions; and a knee-operated expression control to regulate the volume of the entire instrument.

## INSTALLATION AND MAINTENANCE

To install the Chord Organ it is necessary only to attach the music rack, which is packed with the console, and to plug the line cord into a wall outlet. The power source must be alternating current of the approximate voltage and frequency indicated on the name plate. The frequency need not be constant, but must remain within the indicated range. Oiling is not required.

## SPECIAL EQUIPMENT

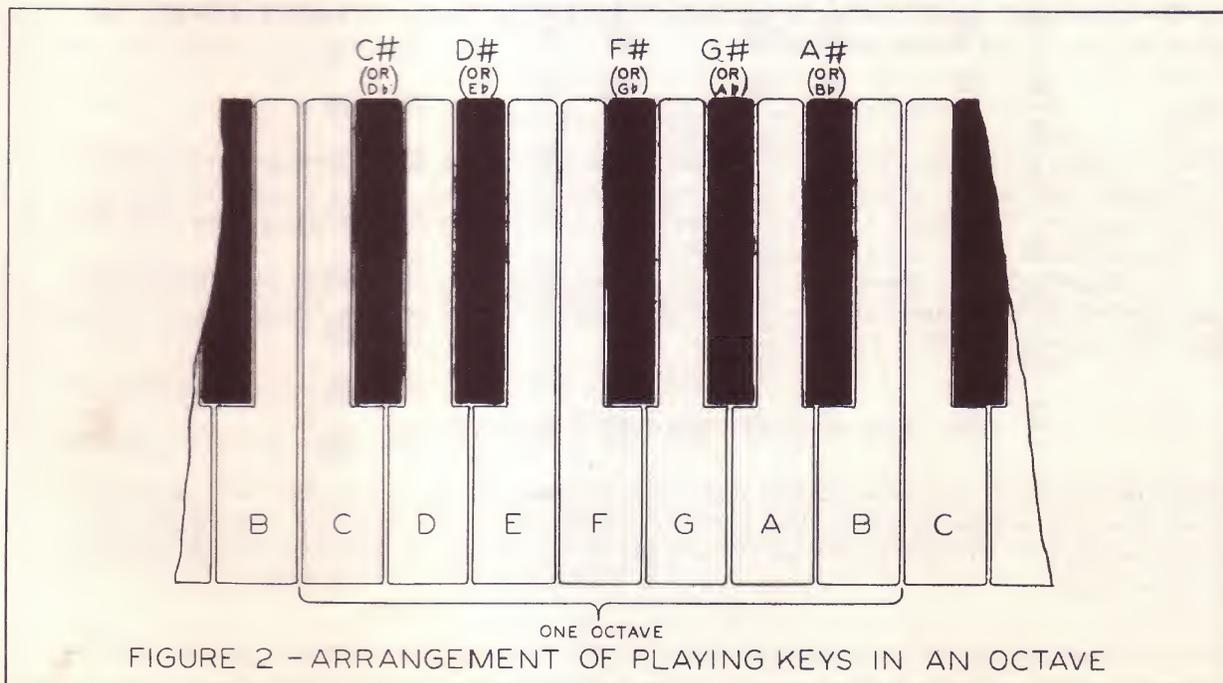
The "Owner's Service Suggestions" booklet gives full instructions for connecting a radio, phonograph, microphone, extension speaker, or ear phones to the Chord Organ.

## MUSICAL TERMS

The service man who has had no musical training will find the following information helpful in studying the operation of the instrument.

### Notes and Octaves

Keyboard instruments are divided into "octaves" of 12 keys or notes, each with 7 "naturals" (white keys) and 5 "sharps" or "flats" (black keys) in a definite sequence. The pitch or frequency increases smoothly from left to right on the keyboard, and each note has a frequency twice that of the corresponding note in the next lower octave. Figure 2 shows the appearance of a typical octave of keys. The octave shown starts with C, but an octave may start with any key.



Black keys occur in groups of two and three in each octave and offer a convenient way to identify the notes of the octave. Technically there is no difference between a black key and a white one, since each key has a frequency 6 percent greater than the frequency of the next one below it. The musical interval between any two adjacent keys is called a semitone. Each white key is called by a letter from A to G. A black key may be called a "sharp" of the note below it or a "flat" of the note above it; for instance, the black key between C and D may be called C# (C sharp) or Db (D flat).

### Tone Qualities

Any musical note has a definite fundamental pitch or frequency and also a certain "tone quality" or "timbre" depending on its wave shape. A simple flute-like tone contains only a single frequency. A complex tone includes not only the fundamental frequency but also one or more "harmonics" or "overtones", which are multiples of the fundamental frequency. The ear does not distinguish the harmonics independently, but instead identifies the note as a complex tone having the pitch of the fundamental.

In the Chord Organ the tone qualities of the various divisions may be changed by such controls as "Mute", "Strings", "Flutes", "Solo Woodwinds", and the five "Solo Timbre" tablets.

### Melody and Accompaniment

Music requires not only a melody (one note played at a time) but also an accompaniment consisting of additional notes which are in harmony with the melody. A group of notes which blend harmoniously when played together is called a chord.

### Attack, Decay, Sustain, and Accent

"Attack" describes the promptness with which a note sounds after a key is pressed, and "decay" describes the rate at which it fades away. "Sustain" refers to the effect of a chord sounding softly while the chord bar is not held down. An "accent" is the effect by which a solo note is made to stand out from the accompaniment; for instance, a note may be accented by giving it a percussive attack, like that of a banjo string being plucked.

### Vibrato

The vibrato effect is created by a periodic raising and lowering of pitch at a rate of about six times a second. It is comparable to the effect produced when a violinist "wiggles" his finger back and forth on a string while playing, varying the pitch but maintaining constant loudness.

In the Chord Organ the vibrato effect is available on all tonal divisions. On the solo division the extent of vibrato is adjustable. The terms "small" and "wide" refer to the extent of pitch variation.

## HOW THE CHORD ORGAN IS PLAYED

This instrument is remarkably easy for anyone to play, and the service man will find it worth while to study the playing controls. A knowledge of how the instrument is played will be found very helpful in locating the source of any trouble that may occur.

## Turning On and Off

To turn on, swing the expression control lever (see figure 1) downward and to the right. A pilot light above the keyboard indicates when the instrument is on. The volume increases as the lever is pushed farther to the right. To turn off, swing the lever to the left and upward until the switch clicks.

## Musical Divisions

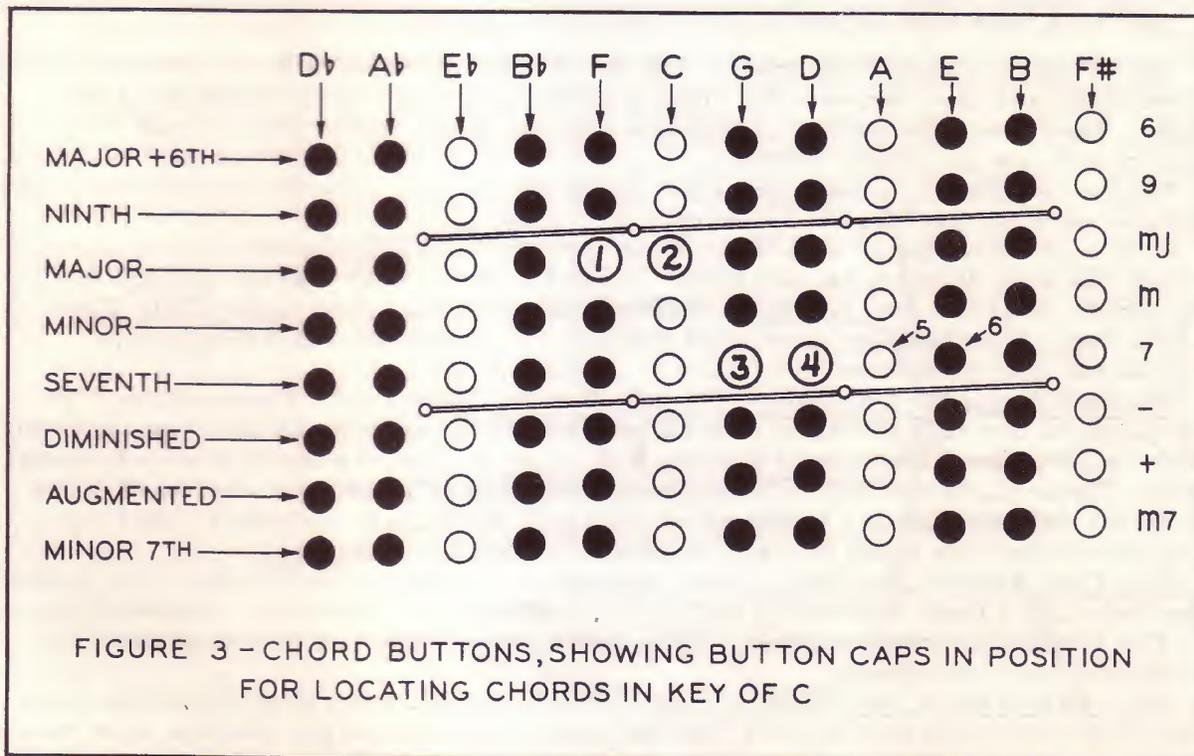
The "Solo" Division is played by the keyboard and is used for playing a melody with the right hand. It is used practically all of the time as it has the greatest variety of tonalities in all pitch registers. As its name implies, this division plays only one note at a time. If several keys are held down at once, the solo note of only the highest one will play.

The "Organ" Division is independent of the solo division but is played by the same keys. Its tones augment those of the solo division and also make it possible to play full chords with the right hand.

It is often desirable to use both the solo and organ divisions at the same time. As the melody note is usually the highest one played, it will be the one played by the solo division and can be emphasized by using a contrasting tone quality and greater volume on the solo division.

The Chord Division has 96 Chord Buttons, played with the left hand, which furnish accompaniment to harmonize with the melody (see figure 3). As each button selects a full chord (along with the accompanying bass note), only one button is played at a time. The chord division also includes the Chord Bar, which is played with the palm or thumb of the left hand to sound the chord selected by the chord buttons. (If the "Sustain Cancel" tablet is off, the chord sounds softly but is made louder by pressing the chord bar.)

The Pedal Division has two bass pedals which are played with the left foot to sound the deep bass notes selected by the chord buttons. The two pedals play two different notes for each chord in order to give tonal variety.



## Expression Control and Balancers

The Expression Control is the lever which extends from underneath the keyboard. It is operated by the right knee, and serves to regulate the volume of the entire instrument as well as to turn it on and off.

The three Balancers are used to adjust the volume of tone produced by the "pedal", "organ", and "solo" divisions. The best balance is generally obtained when the wording on all the knobs is horizontal.

## Control Tablets

The twenty control tablets or "stop" tablets control the pitch range, tone quality, attack, decay, and vibrato of the various divisions, as well as the overall volume and the effect of the chord bar. They are turned "on" to give the indicated effect by pushing them in at the bottom so that the dot is visible.

"Volume Soft". This tablet supplements the action of the expression control by reducing the volume of the entire instrument, and may be used to obtain soft music of great beauty. It may also be used to advantage when playing in a small room or when practicing, as it reduces the volume while maintaining the full range of the expression control.

The Accompaniment Controls - "Sustain Cancel", "Mute", "Pedal Fast Decay". "Sustain Cancel" removes the relatively soft tonal background which is produced when only a chord button is pressed. It is arranged to cancel the sustained background rather than to add it because the background is usually desired. Regardless of the position of this control, pressing the chord bar causes the chord to sound at its full volume.

"Mute" makes the chord button tones more mellow.

"Pedal Fast Decay" is used to obtain a more percussive pedal tone. When it is used, the bass tone fades away very rapidly whenever a pedal is released.

The "Organ" Tone Quality Selectors - "Strings" and "Flutes". These two tablets control the tone quality of the "organ" division, which is played from the keyboard. When neither is used, the "organ" division will be silent. The "Strings" tablet produces a very brilliant tone, the "Flutes" tablet supplies a very mellow and pure tone, and both together give a full rich quality.

The "Vibrato Cancel" Controls. The word "cancel" is used in the name of these controls because they remove the vibrato effect when they are pushed in at the bottom. They are arranged to cancel the vibrato effect rather than to add it because the vibrato is usually desired.

"Organ and Chords", when pressed in at the bottom, cancels the vibrato of the chords as well as the "organ" division.

With both "Solo Small" and "Solo Wide" pressed in at the bottom, the vibrato effect in the solo division is cancelled. To get a small solo vibrato, press only "Solo Small" in at the top, and for a medium solo vibrato, press only "Solo Wide" in at the top. With both pressed in at the top, the maximum vibrato effect is heard on the solo division.

The Solo Register Controls - "Bass", "Tenor", "Soprano". These control the pitch range of the solo division. "Bass" places all the solo tones in a low register; "Tenor" moves them one octave higher; and "Soprano" moves them up an additional octave. These controls may be used in combination to produce a chorus of tones in octave relations similar to the effect obtained with organ couplers. At least one of these controls must be used in order to obtain a solo tone.

The Tone Family Selector - "Solo Woodwinds". This tablet changes the quality of the solo tones from the string or brass family to the clarinet or woodwind family. The particular tone qualities within these two groups are determined by the solo timbre controls used.

"Solo Fast Attack" and "Solo Accent". When neither control is used, the tonal attack of the solo division is very smooth and is well-suited for playing slow moving melodies such as ballads. When "Solo Fast Attack" is used, the attack becomes very prompt and is useful for fast moving melodies. When "Solo Accent" is used

the attack is so rapid as to appear percussive, and accents may be produced by releasing one note before playing the next one.

The Solo Timbre Controls - "Deep Tone", "Full Tone", "First Voice", "Second Voice", and "Brilliant". These five tone controls alter the frequency characteristic of the solo division to modify the quality of the tones selected by the Solo Register controls. "Deep Tone" emphasizes the low frequencies to provide a pure mellow type of tone, while "Full Tone" leaves the frequency characteristic essentially flat and gives a generally useful bright quality. "First Voice" puts a resonance in the 750 cycle zone and "Second Voice" puts a resonance near 1000 cycles, producing beautiful solo voices of the horn type. "Brilliant" emphasizes the higher frequencies and gives a piercing quality. These controls can be used singly or in various combinations to produce a great variety of effects. At least one of the five timbre controls must be used in order to obtain a solo tone.

### HOW THE CHORD ORGAN WORKS

All tones of the instrument are generated by vacuum tube oscillators and are mixed and amplified by additional vacuum tube circuits. Figure 4 is a simplified block diagram of the entire instrument.

As figure 4 indicates, the playing keys control the "solo" and "organ" tone generating systems. Tones from either or both systems may sound, depending on the setting of the corresponding control tablets, and the relative volume levels may be regulated with the balancer knobs.

Accompaniment tones originate in the chord generating system and are selected with the chord buttons. The chords selected are sounded by pressing the chord bar, while the pedals play the correct bass notes to harmonize with the chords. The functions of the chord button system and the pedal system are separately controlled by various control tablets. There is no balancer for the chord system, but the relative pedal volume is regulated by a pedal balancer.

Tones of all the divisions are combined at the amplifier and are regulated in volume by the expression control before being reproduced by the loud speaker.

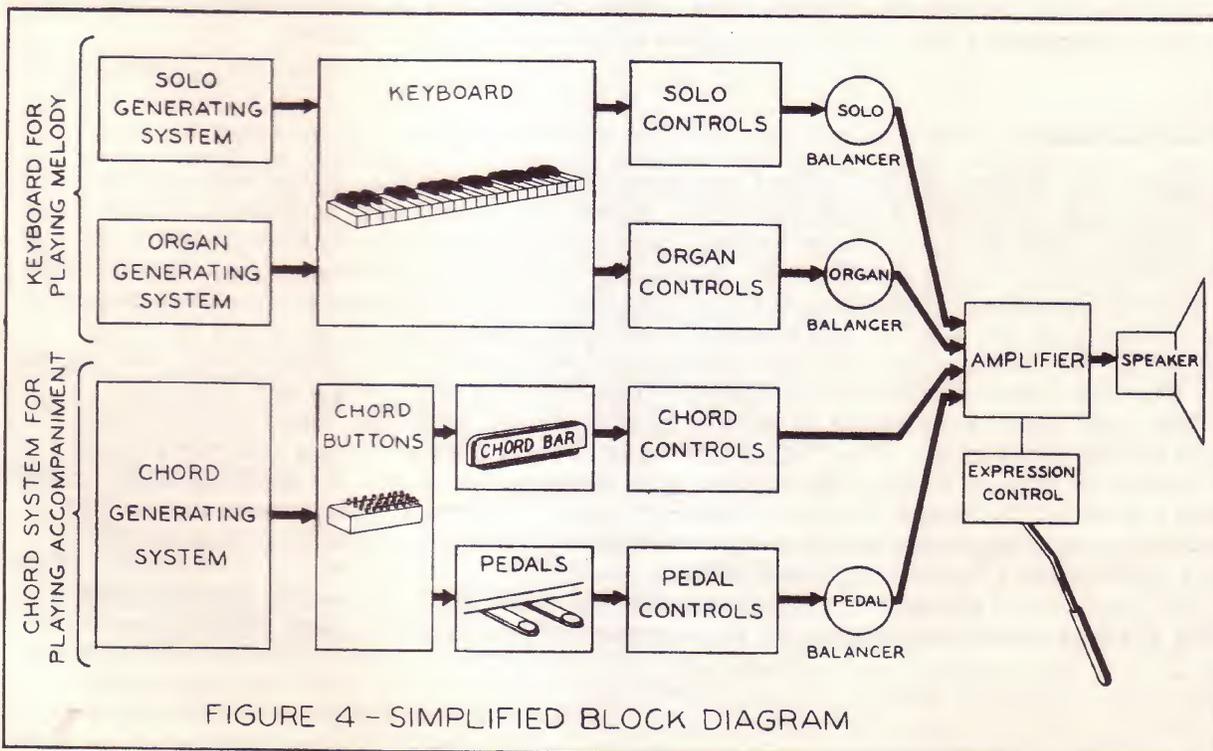


FIGURE 4 - SIMPLIFIED BLOCK DIAGRAM

## DESCRIPTION OF ELECTRICAL CIRCUITS

When studying this section refer to the complete block diagram, figure 5, in which the parts are connected by arrows showing the signal paths. Controlling circuits are indicated by lines without arrows. The schematic circuit diagram, figure 6 (pages 39-41-43-45), shows all circuits in detail. It will be found helpful also to refer to the wiring diagram, figure 7 (pages 47-49-51), which shows cables and other connections between parts of the instrument.

### Keyboard

Four sets of contact springs are operated by the playing keys: tuning contacts and control contacts for the "Solo" division, plus tuning contacts and control contacts for the "organ" division. These four rows of springs make contact with four busbars extending the length of the keyboard. Some keys use four contacts and some use only three, as shown in figure 6. The tuning contact of each division always closes, tuning to the desired note, before the control contact of that division closes and causes the note to sound.

The busbars are movable a short distance endwise, and a slotted stud under the keyboard can be turned to provide a fresh contact surface in case a particle of dust prevents a contact from closing. Refer to the section on "Service Operations" for use of this busbar shifter.

### Vibrato

A single low frequency oscillator provides the vibrato effect for the entire instrument. It is composed of a triode tube in a phase shift circuit (see left end of figure 6), giving a frequency of about 6 cycles per second. The vibrato switch tube has a square wave output and its plate circuit acts as a switch to connect and disconnect small condensers across the solo oscillator tuned circuit. The two solo vibrato switches provide compensating condensers in the "vibrato cancel" position in order to maintain the correct mean frequency with the vibrato on or off.

The organ and chord divisions receive their vibrato from the vibrato switch tube cathode circuit as described later. When the effect is not desired, this cathode is grounded by the "Organ and Chords" vibrato cancel tablet.

### Solo Oscillator

Each solo tuning contact tunes the single solo oscillator to the pitch of the "soprano" note associated with that key. When the lowest key is played (it has no solo tuning contact), all 37 solo tuning coils are connected in series to form the tuning inductance of the oscillator. When any other key is pressed, 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 keys are depressed at the same time, the solo oscillator will sound the pitch of only the higher one. The oscillator frequencies extend from 349 to 2793 cycles per second.

The solo oscillator itself is a two-triode circuit with the tuned circuit connected to the first grid. The "Big Steps" and "Small Steps" tuning switches (upper left corner of figure 6) tune the entire solo division as a unit by placing small condensers across the tuned circuit. Several small trimmer condensers are wired in parallel with the main tuning condenser (left end of figure 6) to bring the total tuning capacitance to the required value.

An "oscillator rectifier" tube following the oscillator serves to furnish waves having a steep wave front suitable for operating the first frequency divider.

## Solo Frequency Dividers

There are two frequency divider stages, each including 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 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 feedback 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 output 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.

## Solo Register Controls and "Solo Woodwinds"

Signals for the "Soprano" register are taken from the master oscillator and the oscillator rectifier; those for the "Tenor" register from the first frequency divider and the driver following it; and those for the "Bass" register from the second frequency divider and a "bass rectifier" following it. The two signals to each register control are of the same frequency but different wave shape; and after passing through suitable tone filter circuits the two sets of signals furnish tones of the woodwinds family if the "Solo Woodwinds" tablet is on, or of the string family if this tablet is off.

## Solo Tone Controls

After preliminary amplification by half of tube V8, the solo signal reaches the five tone controls, which are in series across the signal line. When "Deep Tone" is on (that is, the switch open), the signal develops across a condenser which emphasizes the low frequencies; "Full Tone" has only a resistor, which leaves the frequency response essentially flat; "First Voice" and "Second Voice" are resonant circuits which peak near 750 and 1000 cycles, respectively; and for "Brilliant" the signal appears across an inductance, emphasizing the higher frequencies.

Each of these tone control tablets (with the exception of "Brilliant") has a second contact connected in a volume compensating circuit to avoid excessive increase in volume when two or more controls are used at once.

## Solo Control Tubes

The solo input transformer T1 drives two control (or keying) tubes in push-pull. These are pentodes and are normally cut off because their grid circuit is at ground potential while their cathodes are held at about + 65 volts by a voltage divider composed of R82, R83, and R84. Whenever a key is pressed its solo control contact grounds this voltage divider, removing the cut-off bias and causing the note to sound.

When both the "Solo Fast Attack" and "Solo Accent" tablets are off, condenser C58 makes the attack comparatively slow because a sudden decrease in the positive cathode voltage (caused by pressing a key) causes a negative surge through the condenser,

charges C60 negatively, and moves the grid voltage temporarily in the negative direction. This maintains the cut-off condition for an instant after the key is pressed, until the charge in C60 leaks off through R77.

Operating the "Solo Fast Attack" control eliminates this effect by disconnecting C58.

When the "Solo Accent" control is on, it not only disconnects the slow attack condenser but also connects a large condenser across R80. For a sudden decrease in cathode voltage (caused by pressing a key) this condenser effectively short-circuits the resistor and reduces the bias for an instant, causing the note to be loud at first and give a percussive effect.

The signal from the control tube plates passes through the solo balancer to the preamplifier tube.

### "Organ" Oscillators

Each of these 16 oscillators uses a single triode and a tapped coil. Most of them are used for two adjacent notes each, and some at the high and low ends of the keyboard play three adjacent notes. It happens that adjacent notes are almost never desired to be played together, and this arrangement enables only 16 oscillators to supply the 37 organ notes for the keyboard. The frequencies of these notes range from 175 to 1396 cycles.

In each case the highest note is produced by a tuning condenser connected permanently across the entire tuning coil, and so the highest note of each oscillator requires no tuning contact. The oscillator does not operate, however, unless a key is pressed, for the control contact of each key supplies plate voltage to its oscillator.

For the lower note of each oscillator, the tuning contact connects a second condenser across the lower part of the tuning coil. The coil tap is so located that this condenser may have the same capacity as the one permanently connected across the coil.

In the case of an oscillator serving three notes, the middle tuning contact connects a third condenser in series with the one connected to the tap. This third condenser has a small resistor in series so that all three condensers may be of equal capacity.

Each coil may be tuned by sliding half of the iron core toward or away from the other half, as described under "Tuning".

### "Organ" Controls

Two types of tone are supplied by each oscillator and selected by the "Strings" and "Flutes" tablets. The string signal comes from the lower end of the tuning coils of all the oscillators, with a resistor R185 to ground, while the flute signal comes through a decoupling resistor from the upper end of each tuning coil.

The vibrato effect on the organ oscillators is obtained by applying a varying bias voltage (which comes from the vibrato switch tube cathode) to the grid resistor of each oscillator tube. This varies the frequency of all oscillators by a small amount during each vibrato cycle. To remove the vibrato effect, the "Organ and Chords" vibrato cancel tablet grounds this grid return circuit.

The combined organ signal goes through the organ balancer to the preamplifier tube.

### Chord Oscillators

The six chord oscillators are similar to the organ oscillators, but cover the octave of frequencies from 175 cycles (F) to 330 cycles (E). Each one uses a single triode with a tapped coil, and each can play either of two adjacent notes, using two

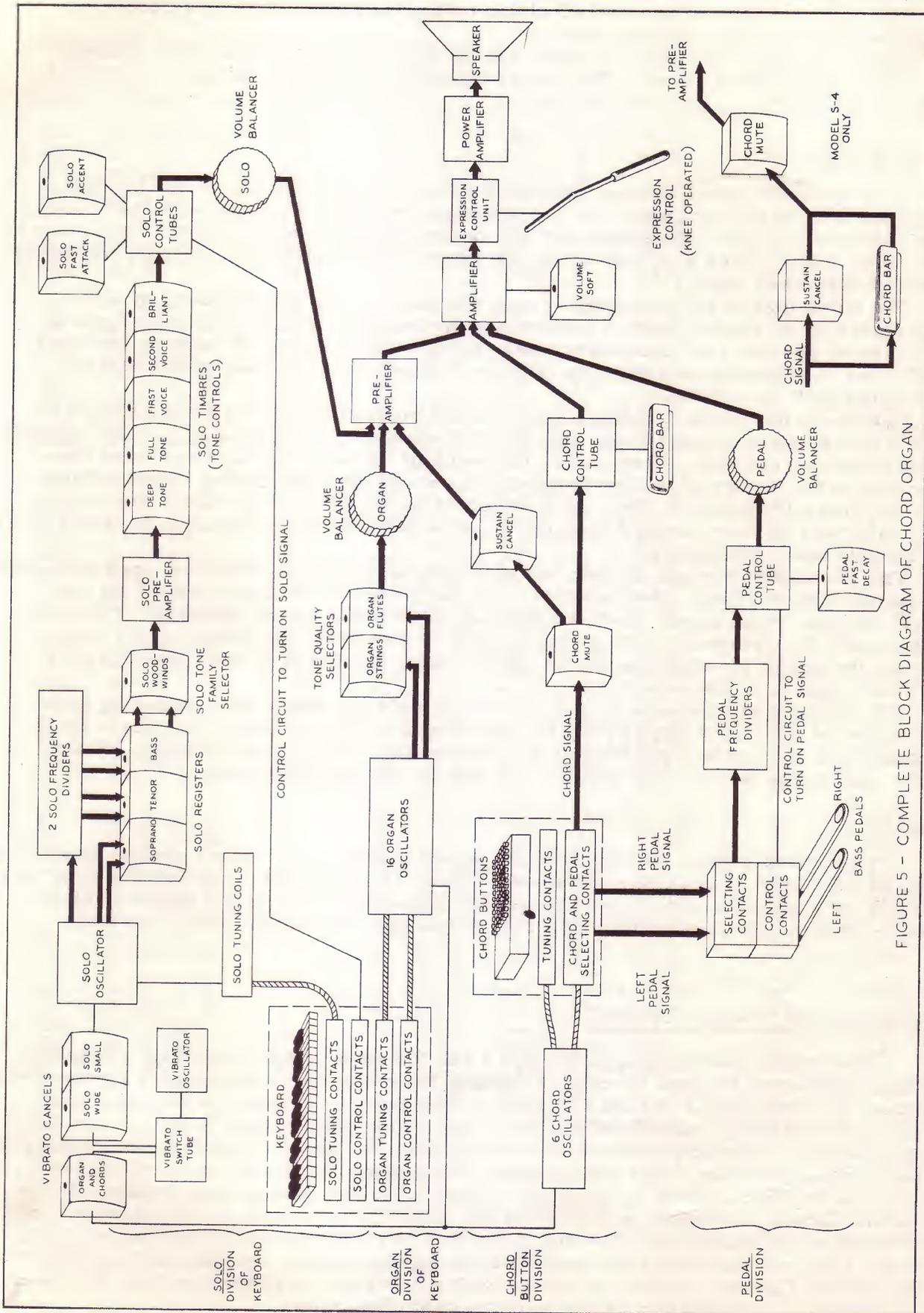


FIGURE 5 - COMPLETE BLOCK DIAGRAM OF CHORD ORGAN

tuning condensers of the same capacity. The vibrato effect is produced in the same way as for the organ oscillators. It is possible to make the 12 chord notes available with only six oscillators, because no chord button uses more than five oscillators and no button requires two adjacent notes.

Unlike the organ oscillators, these oscillators operate continuously, whether notes are being played or not. The signal output is taken from the plate circuit of each oscillator.

### Chord Buttons

Each of the 96 chord buttons selects the correct three or four notes for that chord, as well as correct notes for the right and left pedals to play with that chord. (The notes selected for the pedals are the correct musical notes but are two octaves too high in pitch. They are lowered to the correct pedal pitch by the pedal frequency dividers described later.)

The notes played by the buttons are predetermined by the positions of small projections on 96 pivoted levers underneath the buttons. These projections press actuators to operate the required contact springs. Each of the 96 buttons operates a different combination of contacts. Figure 8 shows the chord and pedal notes associated with each button.

For each chord note a chord signal contact must close (carrying the oscillator signal) and a tuning contact must tune the corresponding oscillator if it is not already playing the correct note. (Remember that each of these oscillators operates continuously at the higher of its two frequencies except when the tuning contact shifts it to the lower frequency.) Thus each button closes three or four chord signal contacts, as many as four tuning contacts, and also two additional contacts to select notes for the left and right pedals.

The 24 contact springs include six chord signal contacts (one from each oscillator), six tuning contacts (each of which tunes one oscillator to the lower one of its two notes), six left pedal signal contacts, and six right pedal signal contacts. They make contact with four busbars. The tuning busbar is grounded; the chord signal busbar carries the chord signal to the chord control tube; and the last two busbars carry the pedal signals to the pedals.

The busbars are movable a short distance endwise, and a stud extending from the bottom of the chord switch may be moved to the right or left to provide a fresh contact surface in case a particle of dust prevents a contact from closing. Refer to the section on "Service Operations" for use of this busbar shifter.

### "Mute"

The chord signal, collected by the signal busbar of the chord switch, goes to the grid of the chord control tube. When the "Mute" control is on, it makes the tone more mellow by shunting a condenser across this signal line. In the off position (Models S and S-1 only) it short-circuits a resistor to maintain the signal level constant.

### Chord Bar and "Sustain Cancel"

The chord control tube in Models S and S-1 is normally cut off by a negative voltage applied to its grid circuit. Pressing the chord bar substantially removes this voltage by connecting a resistor to ground, and the chord signal is then allowed to pass to the amplifier tube (half of V20). Part of the chord signal ahead of the chord control tube is normally routed through the "Sustain Cancel" control to the preamplifier tube. This makes the chord tones sound faintly when the chord bar is not pressed, and the chord bar then serves to accent the chord tones by making them louder. If the "Sustain Cancel" control is pushed in at the bottom this circuit is not connected, and the chord tones sound only when the chord bar is pressed. Model S-4 has no chord control tube, and the chord bar switches the signal directly into the preamplifier tube. The "Sustain Cancel" control, in series with a resistor, is shunted across the chord bar contacts. Its operation is the same as described above.

Button	Notes in Chord	Left Pedal Note	Right Pedal Note	Button	Notes in Chord	Left Pedal Note	Right Pedal Note
Db6	F G# A# C#	C#	G#	G6	G B D E	G	D
Db9	F G# B D#	C#	G#	G9	F A B D	G	D
Dbmj	F G# C#	C#	G#	Gmj	G B D	G	D
Dbm	G# C# E	C#	G#	Gm	G A# D	G	D
Db7	F G# B C#	C#	G#	G7	F G B D	G	D
Db-	G A# C# E	C#	G	G-	G A# C# E	G	C#
Db+	F A C#	C#	A	G+	G B D#	G	D#
Dbm7	G# B C# E	C#	G#	Gm7	F G A# D	G	D
Ab6	F G# C D#	G#	D#	D6	F# A B D	D	A
Ab9	F# A# C D#	G#	D#	D9	F# A C E	D	A
Abmj	G# C D#	G#	D#	Dmj	F# A D	D	A
Abm	G# B D#	G#	D#	Dm	F A D	D	A
Ab7	F# G# C D#	G#	D#	D7	F# A C D	D	A
Ab-	F G# B D	G#	D	D-	F G# B D	D	G#
Ab+	G# C E	G#	E	D+	F# A# D	D	A#
Abm7	F# G# B D#	G#	D#	Dm7	F A C D	D	A
Eb6	G A# C D#	D#	A#	A6	F# A C# E	A	E
Eb9	F G A# C#	D#	A#	A9	G B C# E	A	E
Ebmj	G A# D#	D#	A#	Amj	A C# E	A	E
Ebm	F# A# D#	D#	A#	Am	A C E	A	E
Eb7	G A# C# D#	D#	A#	A7	G A C# E	A	E
Eb-	F# A C D#	D#	A	A-	F# A C D#	A	D#
Eb+	G B D#	D#	B	A+	F A C#	A	F
Ebm7	F# A# C# D#	D#	A#	Am7	G A C E	A	E
Bb6	F G A# D	A#	F	E6	G# B C# E	E	B
Bb9	F G# C D	A#	F	E9	F# G# B D	E	B
Bbmj	F A# D	A#	F	Emj	G# B E	E	B
Bbm	F A# C#	A#	F	Em	G B E	E	B
Bb7	F G# A# D	A#	F	E7	G# B D E	E	B
Bb-	G A# C# E	A#	E	E-	G A# C# E	E	A#
Bb+	F# A# D	A#	F#	E+	G# C E	E	C
Bbm7	F G# A# C#	A#	F	Em7	G B D E	E	B
F6	F A C D	F	C	B6	F# G# B D#	B	F#
F9	G A C D#	F	C	B9	F# A C# D#	B	F#
Fmj	F A C	F	C	Bmj	F# B D#	B	F#
Fm	F G# C	F	C	Bm	F# B D	B	F#
F7	F A C D#	F	C	B7	F# A B D#	B	F#
F-	F G# B D	F	B	B-	F G# B D	B	F
F+	F A C#	F	C#	B+	G B D#	B	G
Fm7	F G# C D#	F	C	Bm7	F# A B D	B	F#
C6	G A C E	C	G	F#6	F# A# C# D#	F#	C#
C9	G A# D E	C	G	F#9	G# A# C# E	F#	C#
Cmj	G C E	C	G	F#mj	F# A# C#	F#	C#
Cm	G C D#	C	G	F#m	F# A C#	F#	C#
C7	G A# C E	C	G	F#7	F# A# C# E	F#	C#
C-	F# A C D#	C	F#	F#-	F# A C D#	F#	C
C+	G# C E	C	G#	F#+	F# A# D	F#	D
Cm7	G A# C D#	C	G	F#m7	F# A C# E	F#	C#

Figure 8 -- Chord Button Chart

## Bass Pedals

As pointed out above, each chord button selects the two proper musical notes for the two bass pedals. The note selected for the left pedal is always the "root" (or key note) of the chord, while the one for the right pedal is a musical "fifth". In the case of the C major chord, for example, having notes C-E-G, the "root" note is C and the "fifth" note is G (see chord button chart, figure 8).

The pedal notes selected by the chord buttons cannot sound until one or the other of the bass pedals is played. As a pedal is pressed its signal contact closes first, carrying the corresponding note from the chord switch busbar to the pedal frequency dividers. The pedal note is not heard, however, until the pedal control contact closes, energizing the pedal control tube. This tube follows the pedal frequency dividers and will be discussed later.

The signal contacts of the two pedals are mechanically interlocked so that the last-played contact always remains closed until the other pedal is pressed. This insures that the correct pedal note will continue to be available for the duration of the pedal decay time.

## Pedal Frequency Dividers

The pedal notes selected by the chord buttons and pedals are the correct notes of the scale but are still in the pitch range of the chord tones. To bring them to the right pitch for the pedals they are fed into two frequency dividers, substantially identical to the solo frequency dividers. Each one divides its input frequency in half, which means that its output is the same note of the scale but an octave lower. Thus the two dividers in cascade lower the signal two octaves below the chord notes, producing pedal notes in the frequency range of 44 to 82 cycles.

A limiter tube preceding the pedal first divider establishes waves of suitable shape to trip the divider properly. Signals from the limiter, the first divider, and the second divider are mixed to give the desired pedal tone. The combined pedal signal is then fed through a tone filter network into the pedal control tube.

## Pedal Control Tube

In Models S and S-1 this tube is normally cut off by a negative voltage applied to its grid circuit. When the pedal keying wire is grounded by pressing a pedal, it removes the bias and allows the note to sound with a controlled rate of attack determined by R259 and C220. When the pedal is released, the tube is cut off again as the current through R260 and R261 charges C220. If the "Pedal Fast Decay" switch is closed, the tube cuts off much more rapidly because the resistance in this leak path is greatly reduced, allowing the condenser to charge sooner.

In Model S-4 this circuit is essentially the same except that the pedal control tube is normally cut off by a positive voltage applied to its cathode circuit. The note sounds when the pedal keying contact connects the grid circuit to the same positive potential.

The signal from the plate of the pedal control tube goes through the pedal balancer to the amplifier tube V20, where it joins the combined solo, organ, and chord signals.

## "Volume Soft"

This control shunts a resistor across the signal line to reduce the volume of the solo, organ, and chord tones equally. It is arranged to reduce the volume of the pedal tones by a smaller amount in order to compensate for the frequency response characteristic of the human ear.

## Expression Control Unit

After passing through a stage of amplification, the signal reaches the expression control unit, a special variable air condenser with two sets of fixed plates and a set of movable plates coupled to the knee-operated expression control lever. With the lever in "loud" position the plate signal of V20 goes directly to V27, while in the "soft" position it goes through a tone-compensated attenuating network.

## Power Output Stage

Tube V27 is a common-cathode-impedance phase inverter, which drives the two output tubes. An adjustable feed-back condenser C237 serves as a factory volume adjustment.

## Power Supply

The power supply circuit is conventional in design, using resistance-capacity filters.

## DESCRIPTION OF COMPONENTS

Most of the assemblies comprising the instrument are visible in figures 9, 10, and 11.

## Generator Assembly

The generator contains the solo oscillator, frequency dividers and tuning switches; the vibrato oscillator and vibrato switch tube; the six chord oscillators; the pedal frequency dividers; the expression control unit; all the control tubes and amplifier tubes; and portions of the power supply.

This chassis is pivoted between the keyboard chassis blocks (figure 9). By removing two screws (see figure 9) it can be unfastened so that it will swing down (as shown in figure 10) to expose the components inside the chassis. The instrument can be operated (but the expression control will not work) with the generator in this position.

Figure 12, showing the outside of the chassis, identifies all external components, and figure 13 (pages 53-55-57) is a view of the inside, with all components identified by the schematic diagram reference symbols.

## Organ Oscillator Assembly

This chassis contains circuits of the 16 "organ" oscillators. Figure 15 identifies the external components and figure 16 shows the inside.

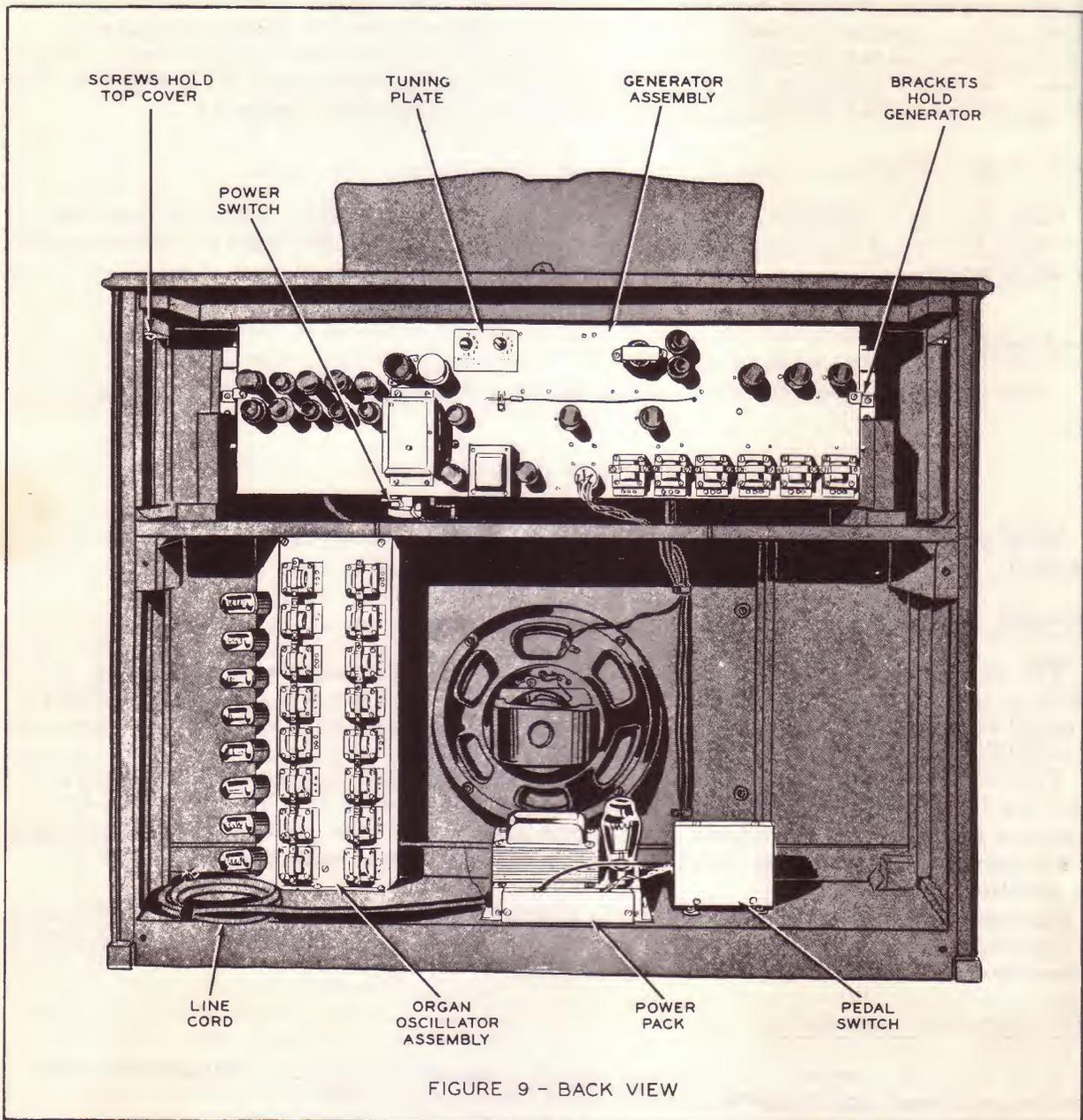
If it is necessary to work on the inside of this chassis, it will be found convenient to place it on a chair directly behind the instrument. The cables are long enough to reach to this position.

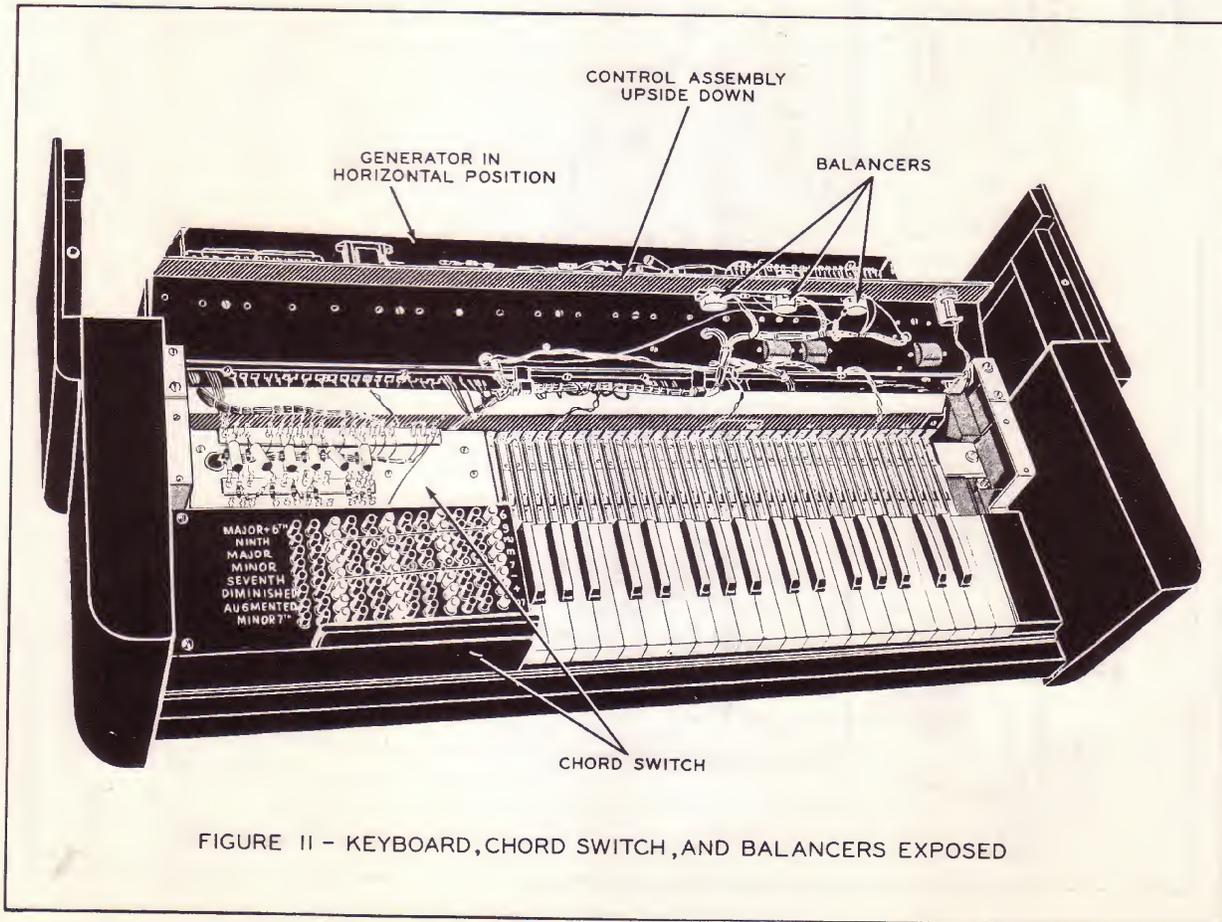
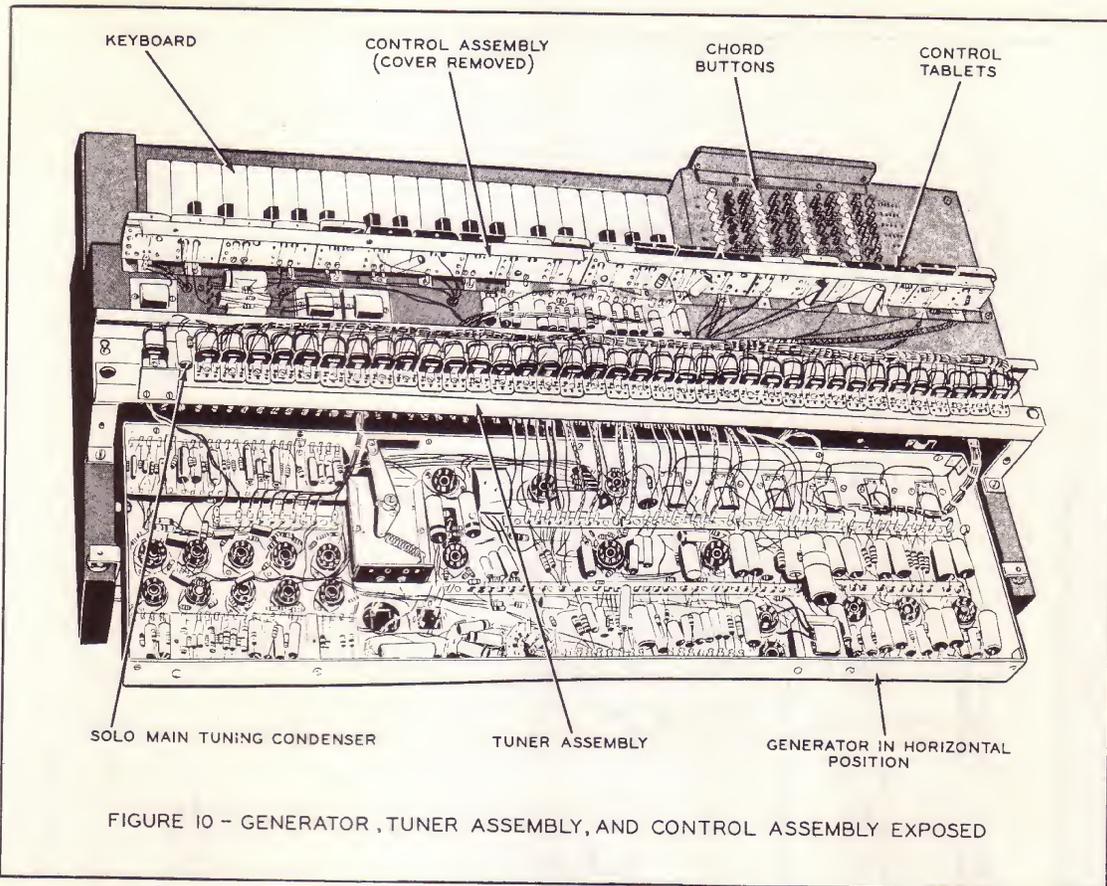
## Keyboard Chassis

This unit includes the two keyboard chassis blocks and the units mounted on them; the keyboard, chord switch, control assembly, tuner assembly, and generator.

## Keyboard

The keyboard itself includes 37 molded plastic keys and a contact mechanism sealed against dust. Figure 17 shows the locations of busbar shifters for the keyboard and the chord switch.





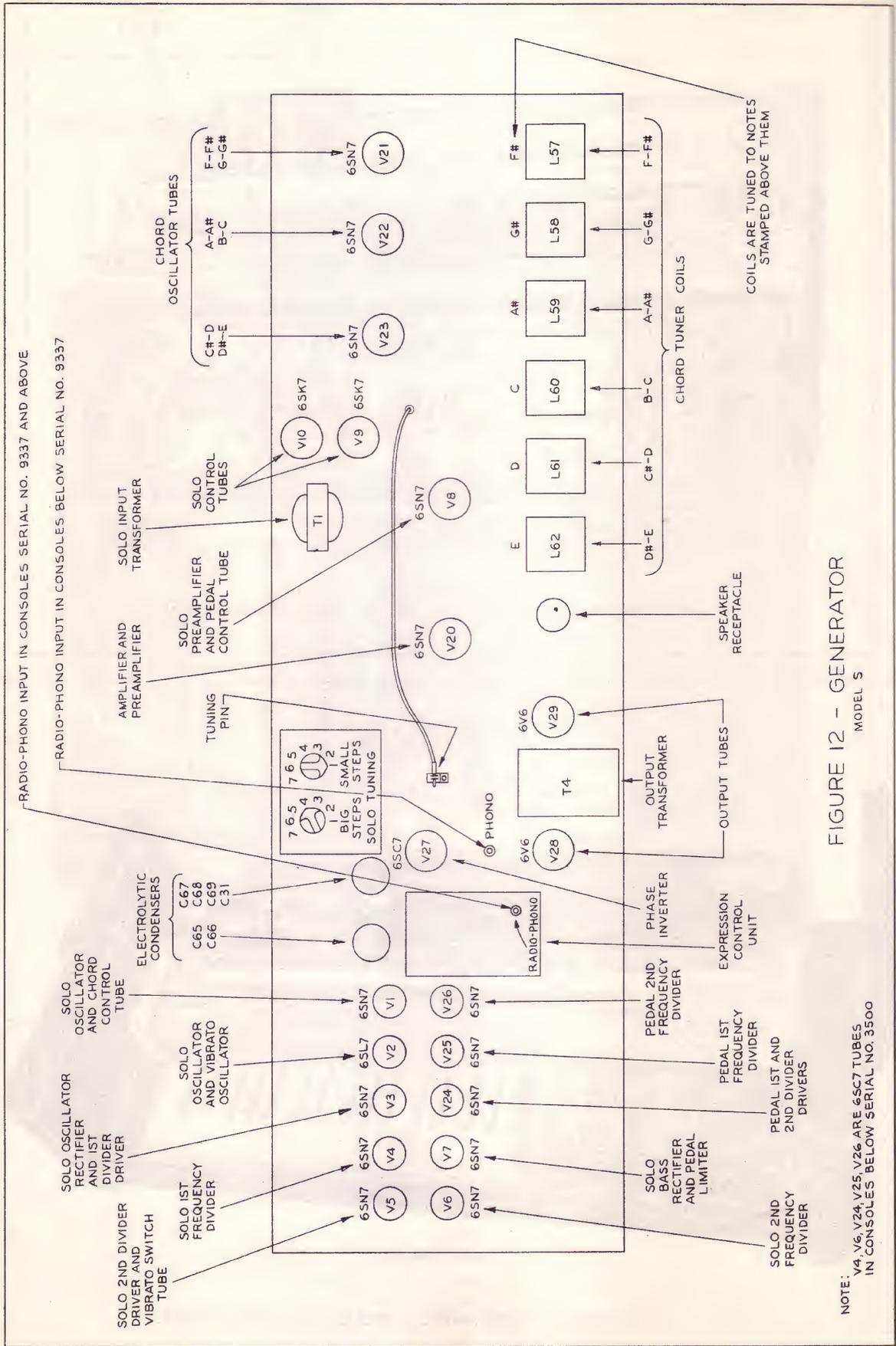
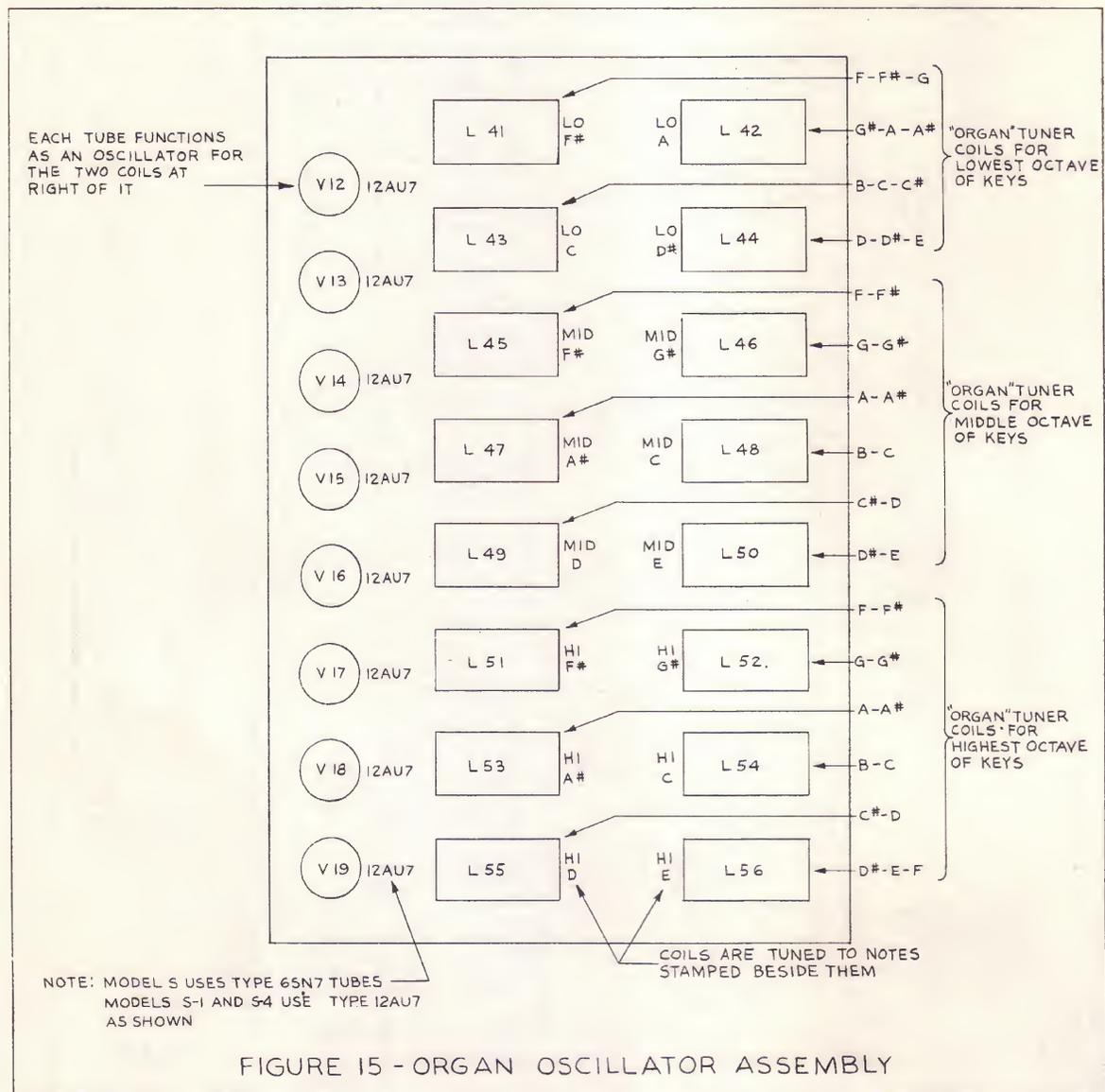
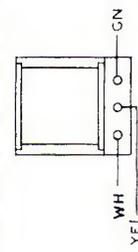
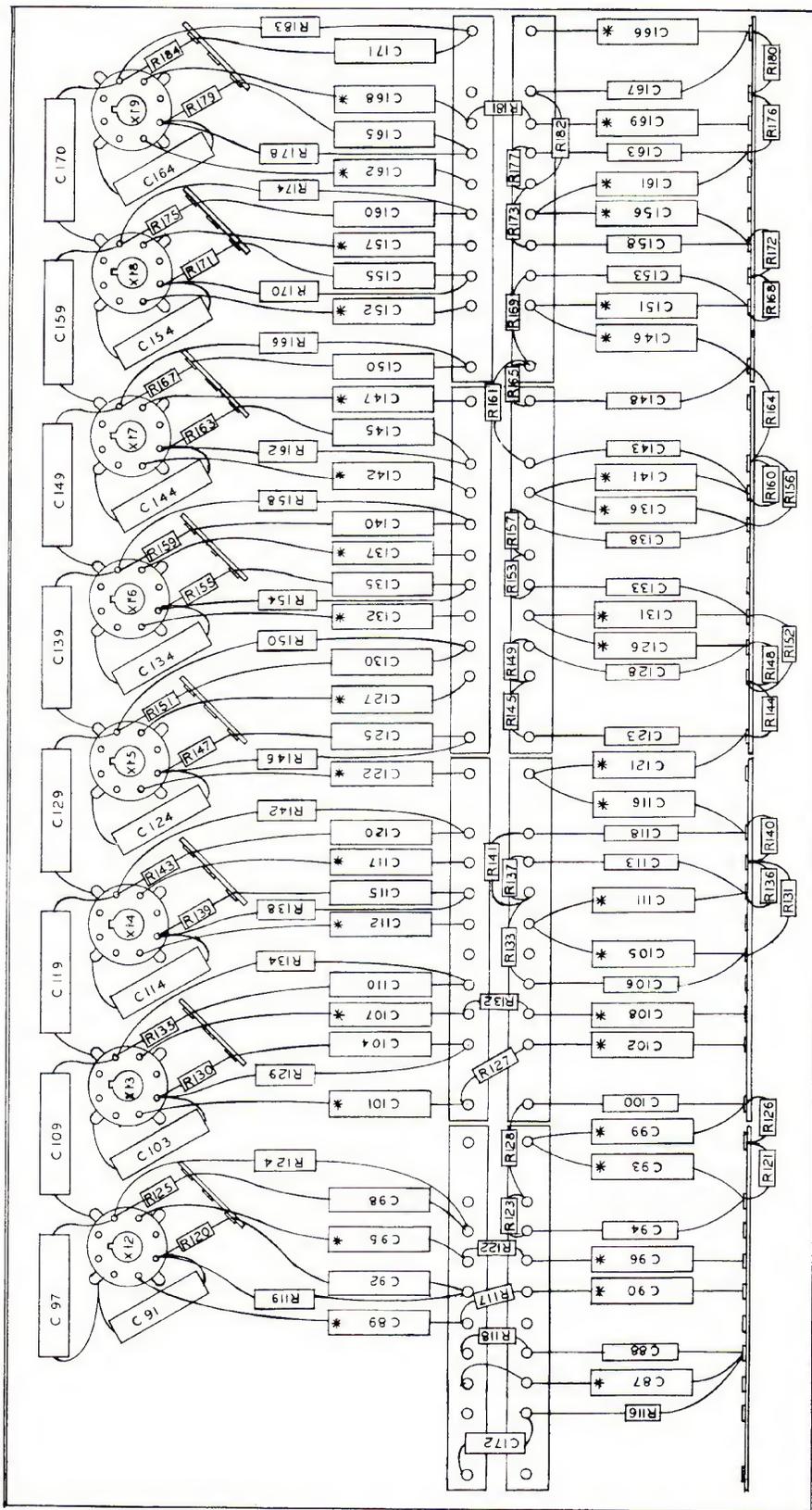


FIGURE 12 - GENERATOR  
MODEL 5

NOTE: V4, V6, V24, V25, V26 ARE 6SC7 TUBES IN CONSOLES BELOW SERIAL NO. 3500







WIRING CONNECTIONS  
TO TYPICAL COIL (INSIDE VIEW)

FIGURE 16 - INSIDE OF ORGAN OSCILLATOR ASSEMBLY  
MODEL S

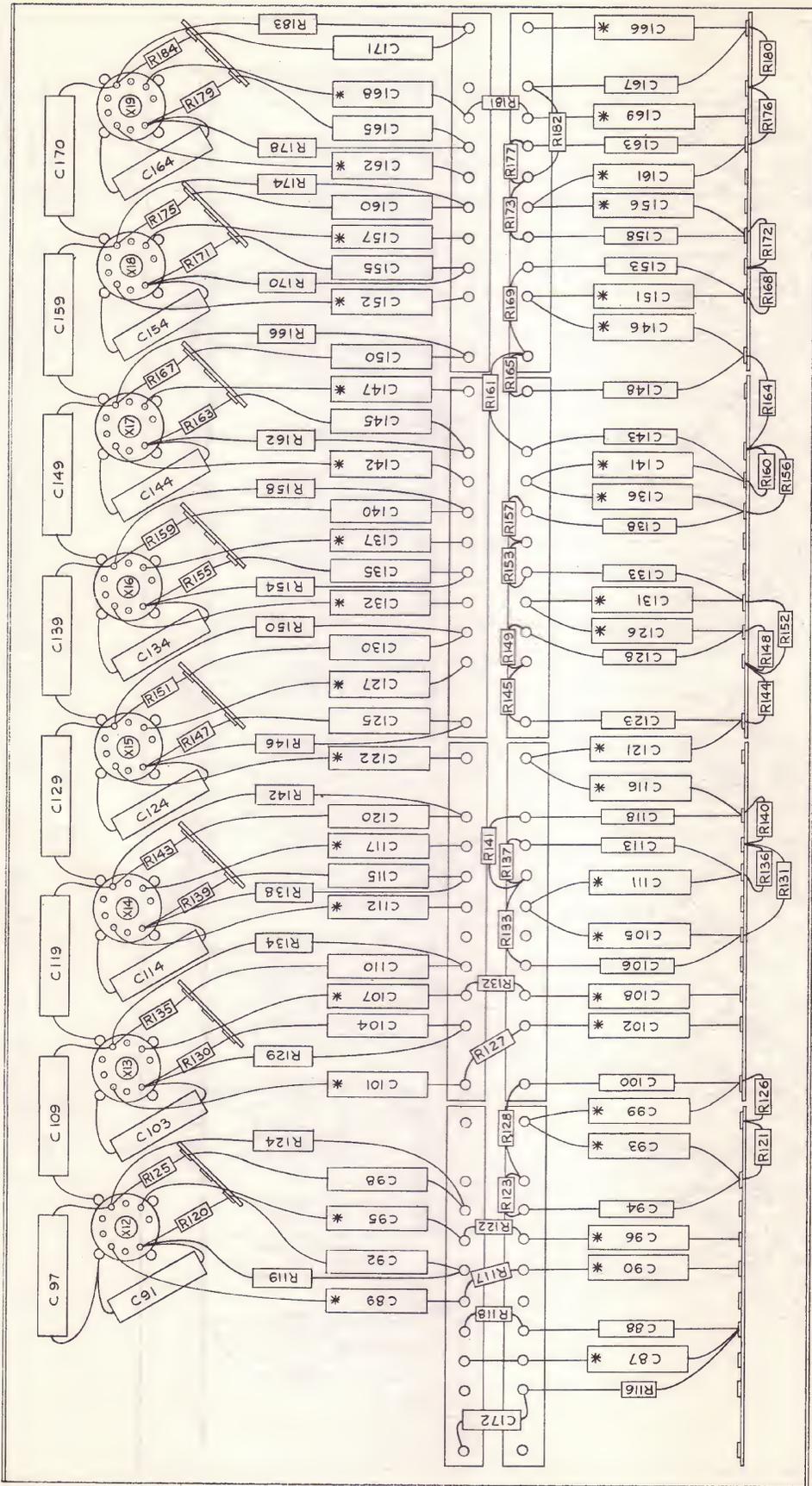
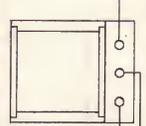
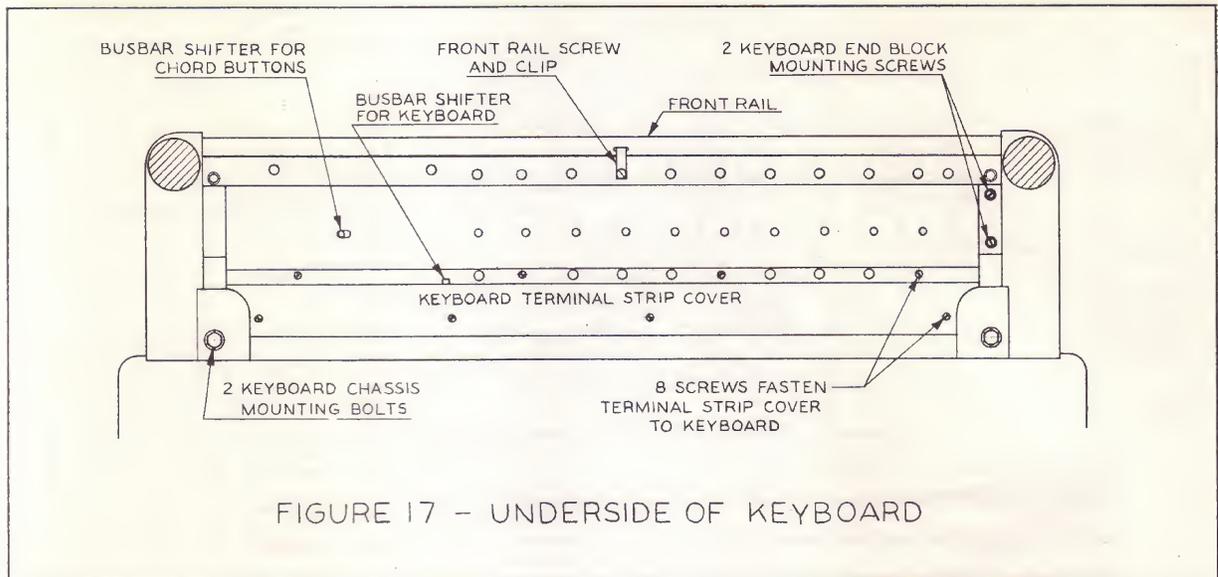


FIGURE 16B - INSIDE OF ORGAN OSCILLATOR ASSEMBLY  
 MODELS S-1 AND S-4

WIRING CONNECTIONS  
 TO TYPICAL COIL (INSIDE VIEW)





### Chord Switch

The chord switch assembly includes the chord buttons, the mechanism under them, the chord contacts and busbars, and some electrical components associated with them. Figure 18 shows the locations of components, the positions of contacts, and some details of the mechanical construction.

### Control Assembly

This unit includes all the control tablets and their contacts, the tone control networks, the register control circuits, the balancers, and the pilot light. Figure 14 (page 59) shows the position of components in this assembly.

### Tuner Assembly

This is a long channel in which all the solo tuning coils are mounted. It also includes the main solo tuning condenser and the solo tuning trimmer condensers.

### Expression Control and Power Switch

The knee-operated expression control lever is attached to the wood case of the instrument, and the power switch is attached to it. The back end of the lever pushes the expression control unit (mounted on the generator) when the generator is in its normal position.

### Pedals and Pedal Switch

The two bass pedals are attached to the underside of the wood case, and bakelite strips extending through the case bottom operate contact springs in the pedal switch. Figure 19 shows details of the pedal switch.

### Power Pack

The power pack includes only the power transformer, the rectifier tube, and one resistor. Figure 20 shows its internal connections.

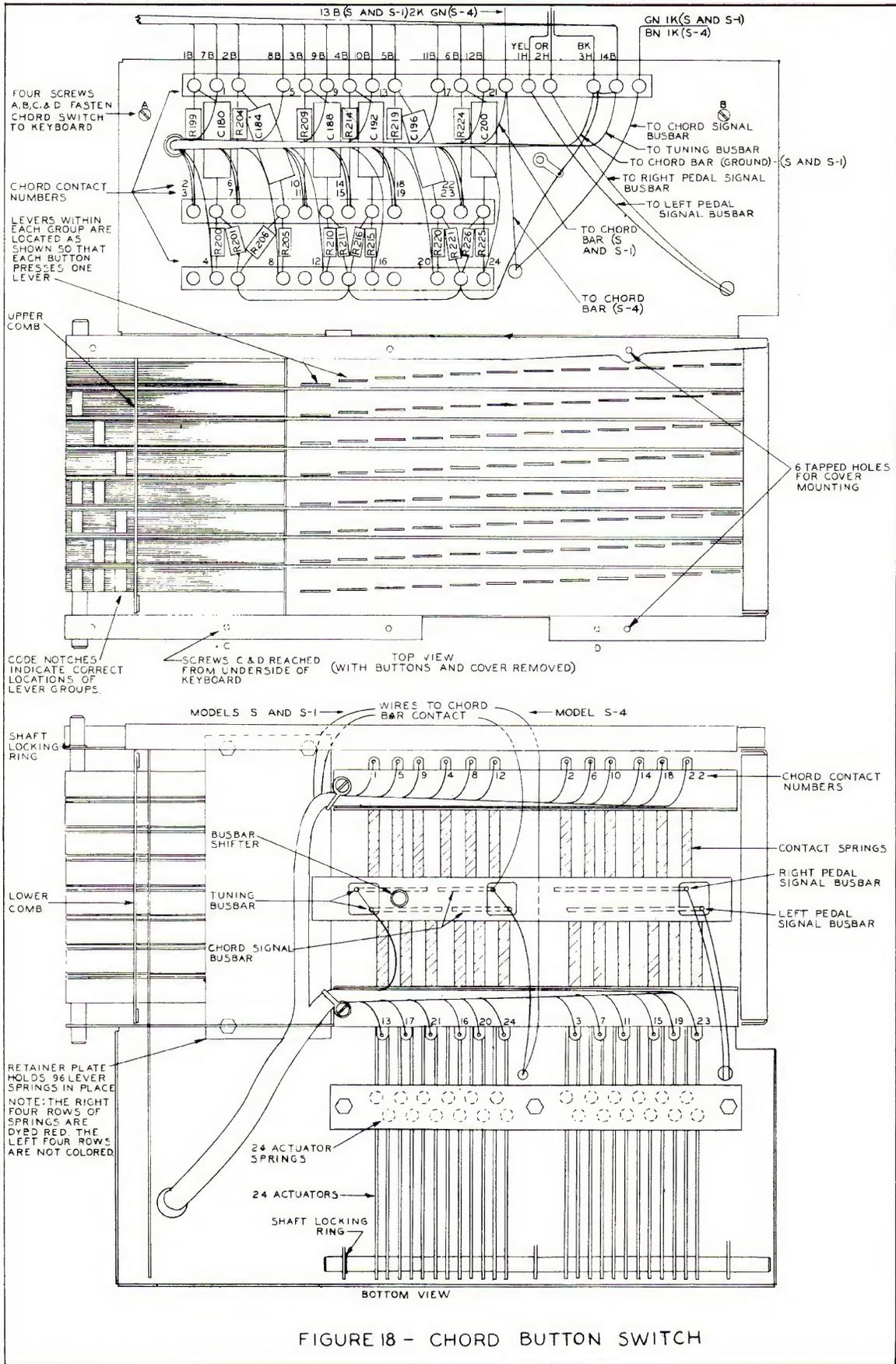


FIGURE 18 - CHORD BUTTON SWITCH

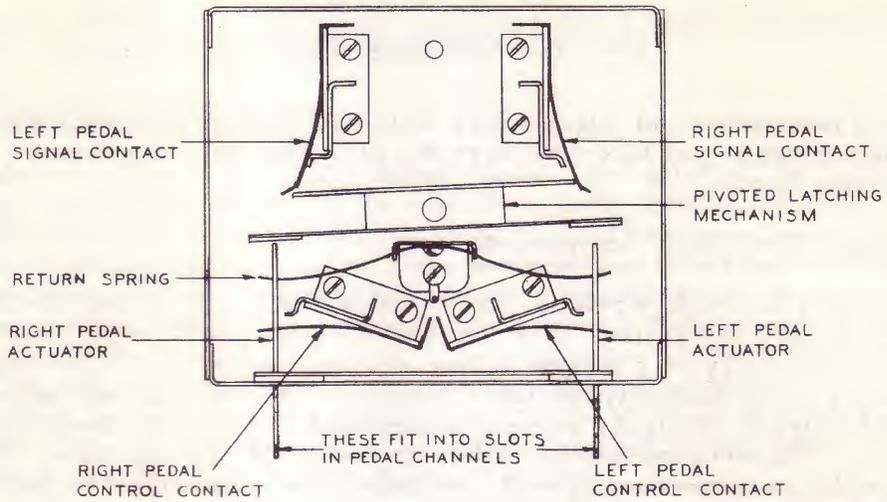


FIGURE 19 - PEDAL SWITCH

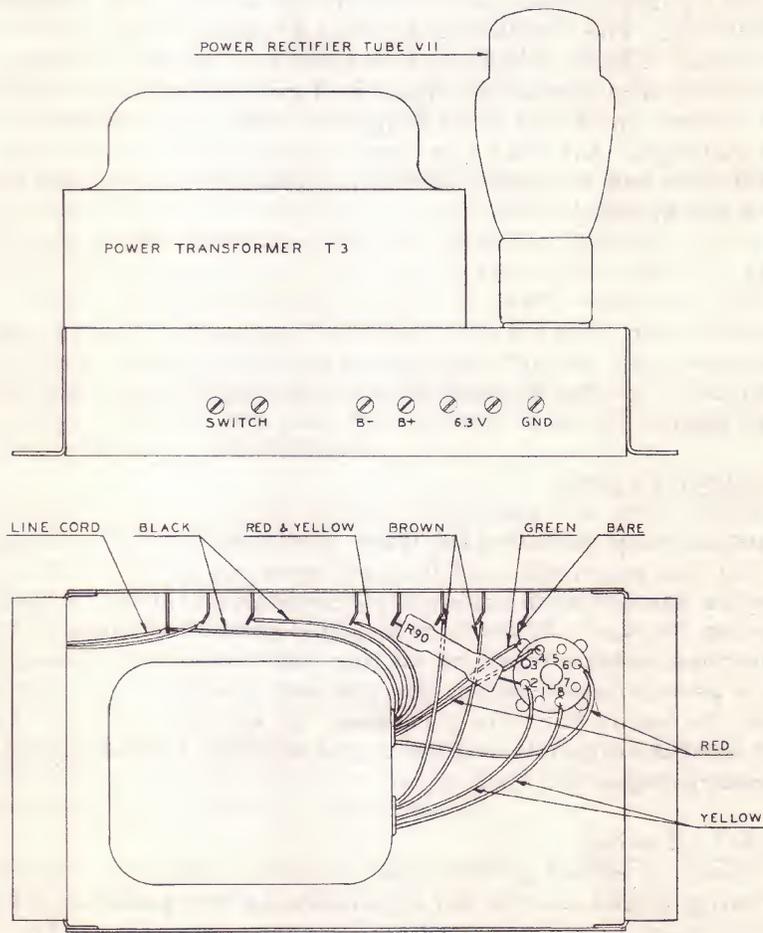


FIGURE 20 - POWER PACK

## SERVICE OPERATIONS

The first few numbered suggestions deal with general service problems that may be encountered, and later paragraphs give specific suggestions for certain troubles which may occur.

### 1. Tubes and Other Electrical Components

As in other electronic devices, the vacuum tubes are among the most likely cause of unsatisfactory operation. The tubes are all standard radio types and can be tested in the customary way to see if they are dead or weak. However, such tubes occasionally show intermittent leaks which fail to show up on conventional tube testers, and therefore it is highly recommended that the service man rely on interchanging tubes wherever possible, rather than simply testing them. A suspected tube may generally be interchanged with another of the same type to see if the trouble appears in its new location.

Most of the symptoms of tube failure are indicated in following paragraphs. Note that many of the tubes are double triodes and in some cases a defective tube may cause trouble in more than one section of the instrument.

Refer to the "Owner's Service Suggestions" booklet for a simplified non-technical procedure for checking the vacuum tubes.

Other circuit components, particularly resistors and condensers, may occasionally give trouble. The resistors are all standard sizes and can be secured through local sources. Their resistance values are shown on the circuit diagram. Most of the condensers are standard types and can be secured locally. Their capacity values are shown on the circuit diagram, and replacements must have equal or higher voltage ratings. All that are special are listed at the end of this section so that they can be ordered from the factory. Transformers and coils are also listed, as they are all special.

### 2. Busbar shifters

If a key contact or chord switch contact appears to be failing (see following paragraphs for symptoms), adjust the corresponding busbar shifter as instructed under "Contact Shifters" in the "Owner's Service Suggestions" booklet. The two shifters are visible in figure 17.

### 3. Contacts on Control Tablets

The control or stop tablets also have precious metal contacts, which are similarly subject to the possibility of failure because of dirt. If a contact appears to be failing, remove the control assembly cover as directed in the section on "Procedure for Removing Parts." After locating the offending contact spring and the fixed contact it touches, clean them by wiping the contact surfaces gently, taking care not to place a permanent bend in the contact spring. The corner of a small piece of stiff paper is handy for this purpose. In severe cases it may be necessary to rub the contact surfaces gently with a piece of very fine sandpaper. (Never use emery cloth or emery paper.)

### 4. Adjustment of Solo Tuning

The two tuning knobs on the back surface of the generator (figure 12) tune all solo notes up or down simultaneously. The procedure for adjusting them is described under "Simple Tuning" in the "Owner's Service Suggestions" booklet.

## 5. Tuning of Individual Organ and Chord Notes

Complete instructions for such tuning are given under "Screwdriver Tuning" in the "Owner's Service Suggestions" booklet.

## 6. Tuning of Individual Solo Notes

The Chord Organ is carefully tuned to standard pitch at the factory and can be expected to remain satisfactorily in tune for a long time. The solo tuning system is particularly stable in regard to the musical interval between notes, and so the "Owner's Service Suggestions" booklet does not mention this type of tuning. However, after long use under extremely adverse humidity conditions, it is possible that some solo notes may not be exactly in tune with each other. Before concluding that re-tuning is necessary, be absolutely certain that the notes are actually far enough out of tune to make them unsatisfactory. Remember that small differences in tuning are actually desirable in many cases because they add a "chorus" effect which gives added richness to the tone. A note generally requires retuning if the "Small Steps" knob must be turned more than one step to bring it in tune.

If it is decided that tuning is required, the following procedure is recommended. A Hammond Organ is preferred as a pitch standard because its pitch is positively established by the frequency of the electric current supply. Never use any other instrument as a pitch standard unless it is known to be precisely tuned to standard pitch.

Note: While any single chord or organ note of the Chord Organ can be tuned individually, no solo note can be adjusted without affecting the ones below it. If any solo note has to be retuned, it will be necessary to follow this entire procedure in order.

- (a) Connect the voice coil terminals of the Chord Organ to one set of plates (either horizontal or vertical) of an oscilloscope, and connect the voice coil terminals of a Hammond Organ to the other set of oscilloscope plates. Pull out only the first white drawbar (fundamental) of the organ and press the corresponding pre-set key. If the organ is equipped with vibrato, tremulant, or chorus, they should be turned off.
- (b) Leave the Chord Organ on for at least 15 minutes before starting to tune. Press all 20 control tablets in at the top and then press "Tenor", "Full Tone", and the three "Vibrato Cancels" in at the bottom.
- (c) Remove the top cover of the Chord Organ, exposing the solo tuning coils. The generator and control assembly cover must be in their normal positions.
- (d) Observe the setting of coil 37 (figure 7 shows the locations of all coils). The end of the coil bobbin should be within  $1/32$ " of the end of the iron core. If it is not, loosen the clamping screw, slide the coil carefully forward or backward until the bobbin end is even with the core, and tighten the screw.
- (e) Hold down the highest key (F) of the Chord Organ and the highest F key of the Hammond Organ. Adjust the volume levels so that the oscilloscope has approximately equal horizontal and vertical deflections.
- (f) Adjust the "Big Steps" and "Small Steps" solo tuning knobs to make the oscilloscope wave pattern move as slowly as possible.

- (g) Adjust coil 37, if necessary, to bring it in tune with the Hammond Organ as indicated by the oscilloscope pattern standing still or moving no more than one cycle in two seconds.
- (h) Release the F keys and hold down the next lower keys (E) on the two instruments. Adjust coil 36 in the same way. Repeat for all other keys and coils in chromatic order downward. It is important to start tuning with the highest note and progress down one key at a time, because the tuning of the lower notes is dependent upon all of the higher coils.
- (i) After tuning, recheck all notes to see that all coils are tuned accurately.

### SPECIFIC SERVICE SUGGESTIONS

The Chord Organ appears complicated, but a careful study of the circuit diagram (figure 6) shows that any possible trouble can generally be isolated by observing the operation of the various controls. This technique is illustrated by the following list of possible troubles, arranged according to their symptoms. It is assumed in all cases that the entire instrument plays correctly with the exception of the symptoms mentioned.

Only the most likely causes of each symptom are listed, but similar symptoms may be caused by other components directly associated with the circuits mentioned.

When a trouble has been traced to a certain part of the instrument, the service man will find it helpful to observe voltages and compare them with those shown on the circuit diagram (figure 6). All D-C voltages are taken with a 20,000-ohms-per-volt meter, and some may vary if a meter of different sensitivity is used. All are based on a line voltage of 117 volts.

Wave shapes may be checked with an oscilloscope in some parts of the circuit, particularly the oscillators and frequency dividers, and compared with patterns shown on the circuit diagram (figure 6). It should be noted that some oscilloscopes will show the patterns inverted.

- 7. Entire instrument fails to play. If all the tubes are lighted but no sound can be obtained, the rectifier tube V11 may be defective. In this case all DC voltages will be missing. If voltages are present, probably there is a defect in the amplifier tube (half of V20) or the phase inverter and driver tube V27.
- 8. Vibrato effect completely missing. The vibrato oscillator (half of tube V2) may not be working, or the vibrato switch tube (half of V5) may be defective.
- 9. Radio Frequency oscillation. Check R254, which acts as a radio frequency suppressor. This resistor was not used in early Model S instruments, and should be added if RF oscillation occurs.

### SPECIFIC SERVICE SUGGESTIONS FOR SOLO DIVISION

- 10. All solo notes fail to play or are weak. One of the solo oscillator tubes (half or all of V1 and half of V2) or the solo preamplifier tube (half of V8) may be defective.
- 11. Solo and organ divisions fail to play or are weak. The preamplifier tube (half of V20) is probably defective. In Model S or S-1 with defective preamplifier, chords play when chord bar is pressed, but do not sustain or are weak when "Sustain Cancel" is off; in Model S-4, all solo, organ, and chord tones are absent or weak, whether "Sustain Cancel" is on or off.

12. One key will not play a solo note on any register control. A dirty solo control contact on one key may make the note play irregularly or fail entirely. Adjust the keyboard busbar shifter (paragraph 2).
13. One key plays lowest "F" solo note instead of its correct pitch (with adjacent keys playing correctly). In this case the solo tuning contact is dirty. This may also make the note noisy or irregular. Adjust the keyboard busbar shifter (paragraph 2).
14. One solo timbre control will not turn off. The tablet has a dirty contact. Clean as directed in paragraph 3.
15. All solo notes fail to play for one position of the "Solo Woodwinds" tablet. One of the contacts on the tablet is dirty. Clean as instructed in paragraph 3.
16. Solo key thumps or clicks. An annoying thump each time a key is released indicates that the two solo control tubes V9 and V10 are not properly matched. In this case install two new tubes of the same make.
17. One solo register control does not play for one position of the "Solo Woodwinds" tablet. In this case one contact of the register control tablet is probably dirty. Clean as instructed in paragraph 3. If the "Bass" tablet fails with "Solo Woodwinds" off, the bass rectifier tube (half of V7) may be defective.
18. Solo "Bass" does not play at all (with "Solo Woodwinds" either on or off). Divider tube V6 may be at fault. This may also make the tones irregularly noisy or an octave too high in pitch.
19. Solo "Bass" does not play at all and "Tenor" does not play with "Solo Woodwinds" tablet off. The second divider driver tube (half of V5) may be defective. This may also make the tones irregularly noisy or an octave too high in pitch.
20. Solo "Bass" and "Tenor" will not play at all (with "Solo Woodwinds" tablet in either position). Divider tube V4 or its driver tube (half of V3) may be defective. This may also make the tones irregularly noisy or an octave too high in pitch.
21. Solo "Bass" and "Tenor" will not play at all and "Soprano" will not play with "Solo Woodwinds" tablet off. The oscillator rectifier tube (half of V3) may be defective.

Note: There is a common bias resistor R37 for all solo and pedal dividers, bypassed by C31, and a fault in one of these parts may cause all solo and pedal dividers to fail. It is possible also that a fault in one divider may upset this common bias and make all dividers fail. A helpful procedure in this case is to shunt a resistor across R37 of whatever size is necessary to restore the bias to its normal value. All dividers should then work with the exception of the faulty one.

22. Solo small vibrato or solo wide vibrato does not come on when corresponding "Vibrato Cancel" tablet is pushed in at top. The tablet may have a dirty contact. Clean as instructed in paragraph 3.
23. Average pitch of solo note changes when "Solo Small" or "Solo Wide" is turned on and off. This means that the compensating contact on the tablet is dirty. Clean as instructed in paragraph 3.

## SPECIFIC SERVICE SUGGESTIONS FOR ORGAN DIVISION

24. One key will not play an organ note. A dirty organ control contact on one key may make the note play irregularly or fail entirely. Adjust the keyboard busbar shifter (paragraph 2).
25. Two, three, four, five, or six adjacent keys will not play organ notes. Each organ oscillator tube is a double triode, and each half of each tube plays two or three adjacent notes. If one triode fails, two or three notes will fail to sound, and if the whole tube fails it will make four, five, or six notes inoperative.

Missing Notes	Tube which may be faulty
low F, F#, & G; or low G#, A, & A#; or all 6	V12
low B, C, & C#; or low D, D# & E; or all 6	V13
middle F & F#; or middle G & G#; or all 4	V14
middle A & A#; or middle B & C; or all 4	V15
middle C# & D; or middle D# & E; or all 4	V16
high F & F#; or high G & G#; or all 4	V17
high A & A#; or high B & C; or all 4	V18
high C# & D; or high D#, E, & F; or all 5	V19

26. "Organ Strings" or "Organ Flutes" will not play for any key. The defective tablet probably has a dirty contact. Clean as instructed in paragraph 3.
27. One key plays organ note having pitch of next higher note or second note higher. In this case the organ tuning contact is probably dirty. This may also make the note noisy or irregular. Adjust the keyboard busbar shifter (paragraph 2).
28. Organ and chord vibrato effect will not turn off. The "Organ and Chords" vibrato cancel tablet has a dirty contact. Clean as instructed in paragraph 3.

## SPECIFIC SERVICE SUGGESTIONS FOR CHORD BUTTON AND PEDAL DIVISIONS

Trouble in the chord section of the instrument, which includes the chord button and pedal divisions, is likely to affect both of these divisions. It is most likely to be observed in the pedals, however, because any single note in a chord tends to be masked by the other notes.

29. One pedal fails to play with any chords. If the other pedal plays correctly, the oscillators, pedal control tube, and frequency dividers must be working. The signal contact or control contact in the pedal switch is probably dirty and can be cleaned in the same manner as the control tablet contacts (paragraph 3). See figure 19 for positions of contacts.
30. Both pedals fail to play with any chords. The pedal control tube (half of V8) may be defective, or the trouble may lie in the pedal frequency divider system (half of V7 plus V24, V25, and V26). Failure of the divider system may also make the pedals irregularly noisy or may make them an octave or two octaves too high in pitch. See note after paragraph 21.
31. One pedal fails to play with certain chords. If the other pedal plays correctly with all chords, all the oscillators must be working. This means that one pedal signal contact in the chord switch is failing. Adjust the chord switch busbar shifter (paragraph 2).

32. One pedal fails to play with some chords and the other pedal fails to play with some other chords. Probably one or more oscillators are inoperative. As the left pedal plays the "root" note of the chord, the buttons with which the left pedal fails to play will indicate which oscillator is defective. If half a tube is faulty, both notes associated with that half will be missing. If the entire tube is defective, four notes will be absent.

Left pedal fails to play with	Faulty oscillator	Tube which may be faulty
all F & F# buttons	F-F#	V21
all G & Ab buttons	G-G#	V21
all A & Bb buttons	A-A#	V22
all B & C buttons	B-C	V22
all Db & D buttons	C#-D	V23
all Eb & E buttons	D#-E	V23

If an oscillator is not operating, its two notes will be missing from the right pedal as well as the left. Refer to the chord button chart (figure 8) for the exact notes each pedal plays with each chord. The same notes will also be missing from the chords, but their absence may not be readily noticeable.

33. Pitch of one pedal is one note too high on some chords. This will happen if a tuning contact in the chord switch fails to close. If failure of a tuning contact makes a note play the wrong pitch, this note will have the wrong pitch wherever it occurs on either pedal or in the chords. (See chord chart, figure 8). Adjust the chord switch busbar shifter (paragraph 2).
34. "Pedal Fast Decay" tablet does not affect the decay rate. Probably the contact is dirty. Clean as instructed in paragraph 3.
35. Chord bar has no effect (but chords will play if "Sustain Cancel" tablet is pressed in at the top). The chord bar may have a dirty contact; if so, the contact may be reached by removing the chord bar (held in place by two screws) and may be cleaned in the same manner as the control tablet contacts (paragraph 3). If the instrument is Model S or S-1, the chord control tube (half of V1) may be defective.
36. One note missing from a chord. It is difficult for anyone who is not a trained musician to identify a missing note by listening to the chord alone. A chord may, however, be checked against the corresponding organ notes.  
To do this, turn off all control tablets (by pushing them in at the top) except "Flutes", "Strings", and "Organ and Chords" vibrato cancel. Refer to the chord button chart (figure 8) to see which notes are supposed to be present in the chord, and play these same notes in the lowest octave of keys on the keyboard. By alternately playing the keys and the chord button, it is easy to tell if the two chords sound alike.

If this test indicates that a note is missing, but the pedals play correctly on all buttons, the most likely cause is a dirty chord signal contact in the chord switch. This will cause the two notes of one oscillator (see chart in paragraph 32) to be missing from all chords where they are used. Adjust the chord switch busbar shifter (paragraph 2).

## ELECTRICAL PARTS LIST

This list includes only the parts which have special or unusual values so that replacements must be ordered from the factory. All other electrical components can generally be secured locally. If it is found necessary to order any parts not listed here, they may be identified by their reference symbols shown on the schematic wiring diagram. To be sure of getting the correct parts always mention the model and serial number of the instrument.

<u>REFERENCE SYMBOL</u>	<u>CAPACITY MFD.</u>	<u>VOLTAGE</u>	<u>TYPE</u>	<u>REPLACEMENT PART NUMBER</u>
C31	4	100	} Electrolytic	AO-26386-0
C67	30	400		
C68	20	400		
C69	20	400		
C65	30	450	} Electrolytic	AO-26385-0
C66	30	450		
C87,C89,C90,C93 C95,C96,C177,C179 C181,C183,C185,C187	.167 *	200	Plastic Film	AO-500-32
C99,C101,C102,C105 C107,C108,C189,C191 C193,C195,C197,C199	.141 *	200	Plastic Film	AO-500-35
C111,C112,C116 C117,C121,C122	.0882 *	200	Plastic Film	AO-500-43
C126,C127,C131 C132,C136,C137	.0556 *	200	Plastic Film	AO-500-51
C141,C142,C146 C147,C151,C152 C156,C157,C161 C162,C166,C168,C169	.035 *	200	Plastic Film	AO-500-59
C237	.000028-.000090		Variable	AO-21468-0

\* Tuning Condensers. Capacity values given are approximate, and exact values are selected at factory. The two or three tuning condensers on any one oscillator must be alike within 2%. If a tuning condenser becomes defective, it is preferable that the tuning coil for that note and the two or three condensers associated with it be replaced with a matched set from the factory.

## RESISTORS

<u>REFERENCE SYMBOL</u>	<u>OHMS</u>	<u>TYPE</u>	<u>REPLACEMENT PART NUMBER</u>
R85	8000	Variable	AO-20293-30
R90	30	10 watt wirewound	AO-19124-3
R100	16,000	10 watt wirewound	AO-19124-108
R188	25, 000	Variable	AO-20293-31
R265	1 meg.	Variable	AO-20293-32

## TRANSFORMERS

<u>REFERENCE SYMBOL</u>	<u>FUNCTION</u>	<u>REPLACEMENT PART NUMBER</u>
T3	Power (117V 60 cycles)	AO-26334-1 (S) AO-26577-1 (S-1) AO-26577-4 (S-4)
T1	Solo input	AO-26361-0
T2	Solo output	AO-26363-0 (S,S-1) AO-26363-1 (S-4)
T4	Output	AO-20936-1 (S,S-1) AO-20936-2 (S-4)

PROCEDURE FOR REMOVING PARTS IN NEED OF REPAIR OR  
REPLACEMENT

To Replace Pilot Lamp

- (a) Unscrew white dome cover and replace bulb with a #44 (bayonet base).

To Remove a Control Tablet

- (a) If console has a back panel, remove by taking out 12 screws.
- (b) Remove outermost screw from bracket fastened to each end of generator and swing generator into horizontal position.
- (c) Remove console top by taking out screw from underside of cleat at each end of console.
- (d) Loosen four screws at ends of tuner assembly (figure 10), slide tuner assembly back, lift off and carefully rest it upside down on generator.
- (e) Remove six screws in top and loosen six screws in back of control assembly cover (figure 10) and lift off. To avoid scratching woodwork, slip a piece of cardboard in at each end of console.
- (f) Remove two screws at each end in base of control assembly and prop up so that ends of tablet assemblies are accessible.
- (g) Ten tablets are pivoted on each of two long rods. Using cutting pliers, pull out rod which holds tablet to be removed, pulling it out only far enough to replace faulty tablet. In case rod does not extend far enough to hold it with pliers, tap other rod (at far end of assembly) gently to drive desired rod out a small amount.
- (h) Carefully hold tablets in alignment when sliding rod back.
- (i) If more than one tablet is removed, be sure to replace all tablets in their original positions.

To Remove a Balancer Potentiometer

- (a) If console has a back panel, remove by taking out 12 screws.
- (b) Remove outermost screw from bracket fastened to each end of generator and swing generator into horizontal position.
- (c) Remove console top by taking out screw from underside of cleat at each end of console.
- (d) Loosen four screws in tuner assembly (figure 10), slide tuner assembly back, lift off and carefully rest it upside down on generator.
- (e) Remove two screws at each end in base of control assembly and carefully lay control assembly on generator. To avoid scratching woodwork, slip a piece of cardboard in at each end of console.
- (f) Pull off all three balancer knobs after turning them to their minimum position (counterclockwise) and marking position of wording to insure replacement in correct positions.

- (g) Detach potentiometer bracket by removing three screws under knobs.
- (h) Unsolder wires from faulty potentiometer and remove it. Refer to wiring diagram (figure 7) when reconnecting wires.
- (i) Turn all potentiometers to their minimum position (counterclockwise) to insure replacement of knobs in correct positions.

#### To Remove Chord Bar

- (a) Take out two screws next to the chord bar, lift the bar, and unsolder two wires from it. When reconnecting, be sure to connect wires to same terminals.

#### To Remove Chord Switch Cover and Buttons.

- (a) Remove chord bar as above.
- (b) Lay strips of scotch tape across all buttons so they will not fall out when cover is removed.
- (c) Take out remaining four screws in cover and lift out cover with buttons.

#### To Remove Chord Switch

- (a) If console has a back panel, remove by taking out 12 screws.
- (b) Remove outermost screw from bracket fastened to each end of generator and swing generator down into horizontal position.
- (c) Remove console top by taking out screw from underside of cleat at each end of console.
- (d) Loosen four screws at ends of tuner assembly (figure 10), slide tuner assembly back, lift off and carefully rest it upside down on generator.
- (e) Remove two screws at each end in base of control assembly and carefully lay control assembly on generator. To avoid scratching woodwork, slip a piece of cardboard in at each end of console.
- (f) Unsolder cable and wires from terminal strip at rear of chord switch. Refer to wiring diagram (figure 7) to reconnect cable and wires.
- (g) Remove four screws fastening chord switch to keyboard (figure 18) and lift out chord switch.
- (h) For access to coil springs, refer to figure 18.

#### To Remove Generator Assembly

- (a) If console has a back panel, remove by taking out 12 screws.
- (b) Pull out speaker plug from generator chassis (Models S and S-1).
- (c) Remove outermost screw from bracket fastened to each end of generator, and swing generator into horizontal position.

- (d) Remove console top by taking out screw from underside of cleat at each end of console
- (e) Unsolder all external wires from generator terminal strip.
- (f) Take out pivot screw at left end of generator, push generator to left to unhook from other pivot, and lift out.

#### To Remove a coil from Generator

- (a) Remove two screws from coil strap.
- (b) Carefully pull coil away from chassis an inch or two to permit unsoldering wires from three lugs on inner side of coil. Refer to figure 13 when reconnecting wires.

#### To Remove On-Off Switch

- (a) If console has a back panel, remove by taking out 12 screws.
- (b) Remove outermost screw from bracket fastened to each end of generator and swing generator down into horizontal position.
- (c) Remove two screws which screw into switch mounting plate from underside of upper shelf.
- (d) Lift out entire switch assembly and expression control arm.
- (e) Remove switch by taking out two screws and unsoldering two wires.

#### To Remove a Playing Key

- (a) If console has a back panel, remove by taking out 12 screws.
- (b) Pull out speaker plug from generator chassis (Models S and S-1).
- (c) Remove outermost screw from bracket fastened to each end of generator and swing generator down into horizontal position.
- (d) Remove console top by taking out screw from underside of cleat at each end of console.
- (e) Take out pivot screw at left end of generator, push generator to left to unhook from other pivot, and lift and block up generator in vertical position as high as possible without damaging connecting cables.
- (f) Remove two screws at each end in base of control assembly. To avoid scratching woodwork, slip a piece of cardboard in at each end of console.
- (g) To remove a black key loosen its key mounting screw at rear of keyboard, lift up control assembly, unhook key from screw and lift out key.
- (h) To remove a white key loosen its key mounting screw at rear of keyboard, and those of adjacent black keys. Lift up control assembly, unhook these keys from screws, push them back, and lift out white key.

### To Remove Keyboard

- (a) If console has a back panel, remove by taking out 12 screws.
- (b) Pull out speaker plug from generator chassis (Models S and S-1).
- (c) Remove outermost screw from bracket fastened to each end of generator and swing generator into horizontal position.
- (d) Remove console top by taking out screw from underside of cleat at each end of console.
- (e) Remove keyboard terminal strip cover by taking out eight screws (figure 17).
- (f) Unsolder all wires from keyboard terminal strip. For S-4 form B only, unsolder solo tuner cable from solo tuner assembly. Refer to wiring diagram (figure 7) when resoldering these wires.
- (g) Tilt generator enough to remove tuner cable clip from rear of keyboard and pull out cable (S, S-1, and S-4 form A). Loosen four screws holding tuner assembly (figure 10), slide tuner assembly back, and lift out.
- (h) Unsolder cable and wires from terminal strip at rear of chord switch. Refer to wiring diagram (figure 7) when reconnecting cable and wires.
- (i) Remove four screws fastening chord switch to keyboard (figure 18) and lift out chord switch.
- (j) Unsolder pedal switch cable wires from generator terminal strip.
- (k) Disconnect cable from power pack.
- (l) Take out pivot screw at left end of generator and push generator assembly to left to unhook from other pivot.
- (m) Remove two screws at each end in base of control assembly, carefully rest control assembly on generator, and lift out both assemblies.
- (n) Remove two brackets (to which control assembly and tuner assembly were attached) from keyboard chassis mounting blocks by taking out four screws.
- (o) Detach keyboard assembly from console by taking out four hexagonal bolts from keyboard chassis mounting blocks (two from underneath keyboard and two from underneath upper shelf).
- (p) Remove front rail screw and clip (figure 17) which fastens front rail to keyboard.
- (q) Lift out keyboard assembly with chassis mounting blocks attached.

### To Remove Organ Oscillator Assembly

- (a) Remove three screws from lower shelf and three screws from bracket mounted on underside of upper shelf. To facilitate servicing, it will be found convenient to place the oscillator chassis on a chair directly behind the instrument. The cables are long enough to reach to this position.

- (b) If necessary to disconnect completely, remove keyboard terminal strip cover by taking out eight screws (figure 17). Unsolder orange wire and organ oscillator cable from keyboard terminal strip. Refer to wiring diagram (figure 7) when resoldering these wires.

#### To Remove a coil from Organ Oscillator Assembly

- (a) Remove two screws from coil strap.
- (b) Carefully pull coil away from chassis an inch or two to permit unsoldering wires from three lugs on inner side of coil. Refer to figure 16 when reconnecting wires.

#### To Remove Pedal Switch

- (a) If console has a back panel, remove by taking out 12 screws.
- (b) Remove back cover of pedal switch by taking out four screws.
- (c) Take out two screws fastening pedal switch to lower shelf and carefully lift out.
- (d) Unsolder wires. See wiring diagram (figure 7) when reconnecting wires. Refer to figure 19 for details of contact assemblies.
- (e) When replacing pedal switch, be sure to seat actuators (figure 19) into pedal slots carefully.

#### To Remove a Pedal

- (a) If console has a back panel, remove by taking out 12 screws.
- (b) Place suitable pad on floor and tip console over on side farthest from pedals.
- (c) From underside of pedal remove screw from center of pedal; also remove nut, washers and two felt spacers from end of pedal fastened to console.
- (d) Lift off pedal carefully to avoid damaging bakelite actuators in pedal switch.

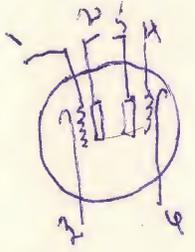
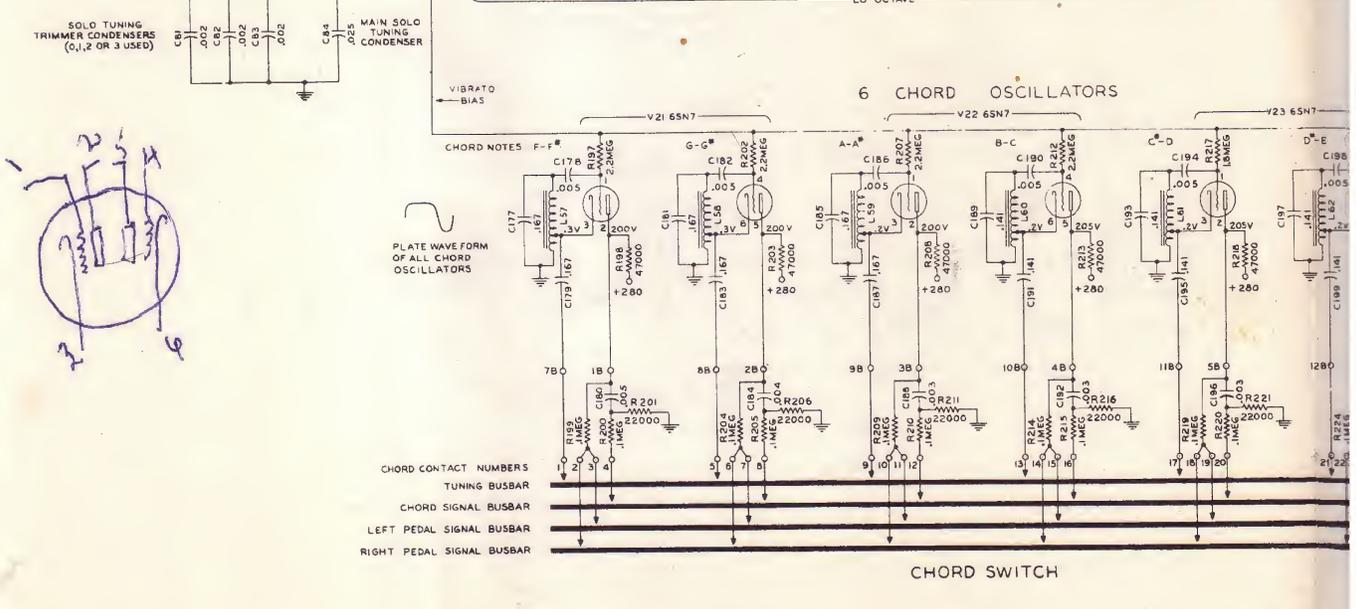
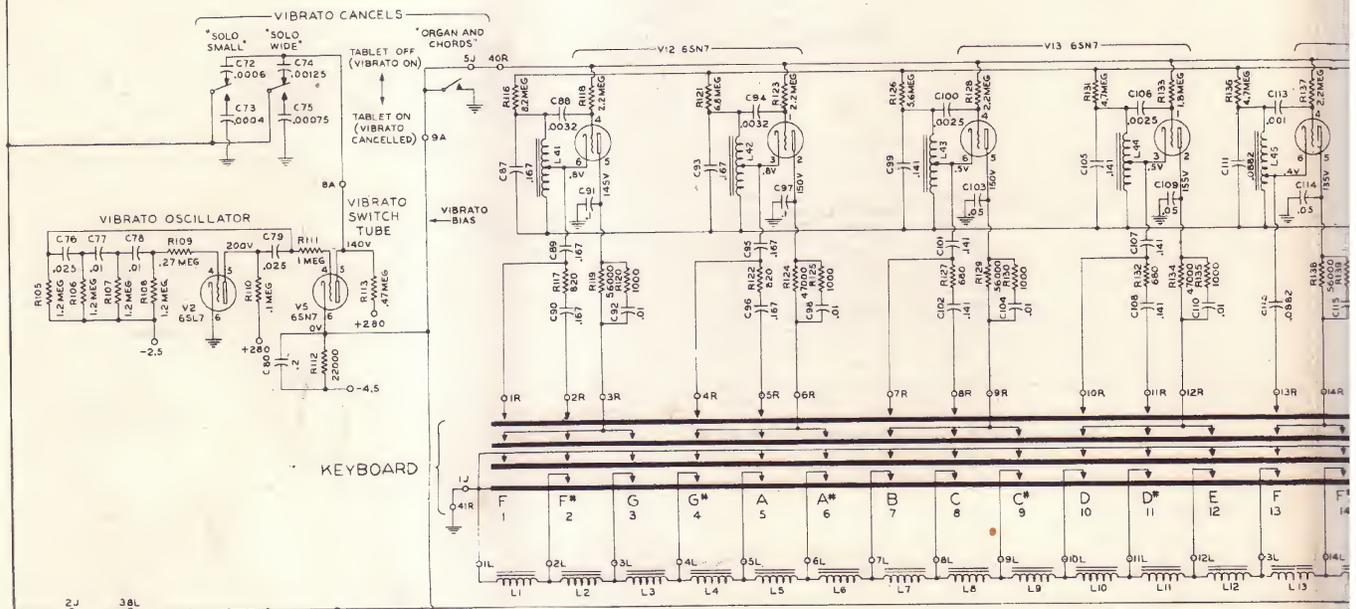
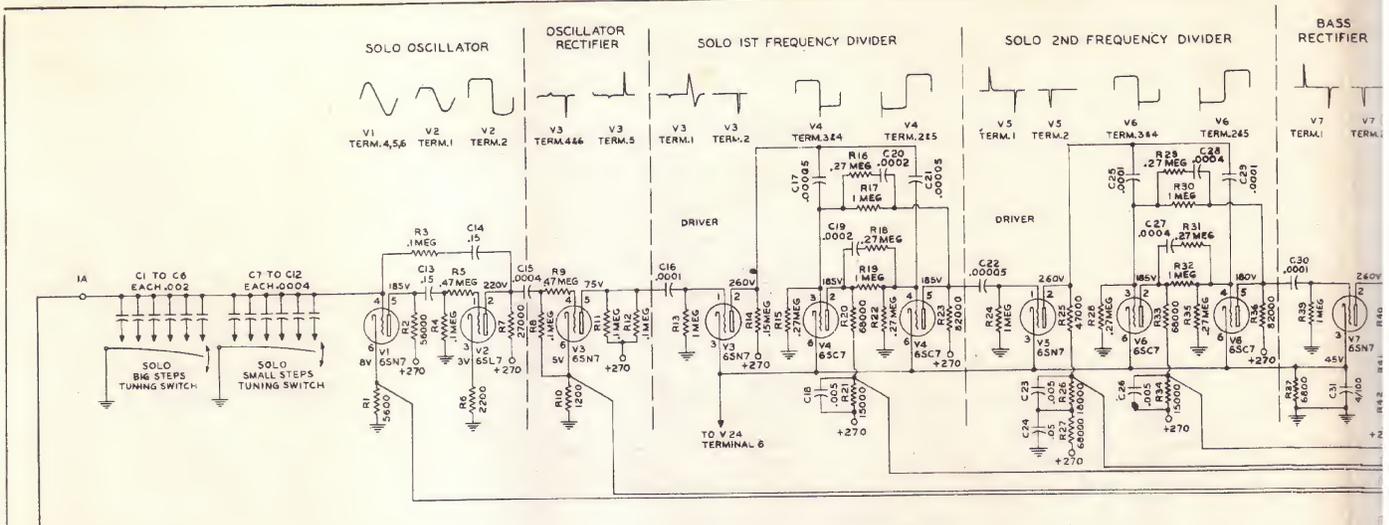


PLATE WAVE FORM OF ALL CHORD OSCILLATORS

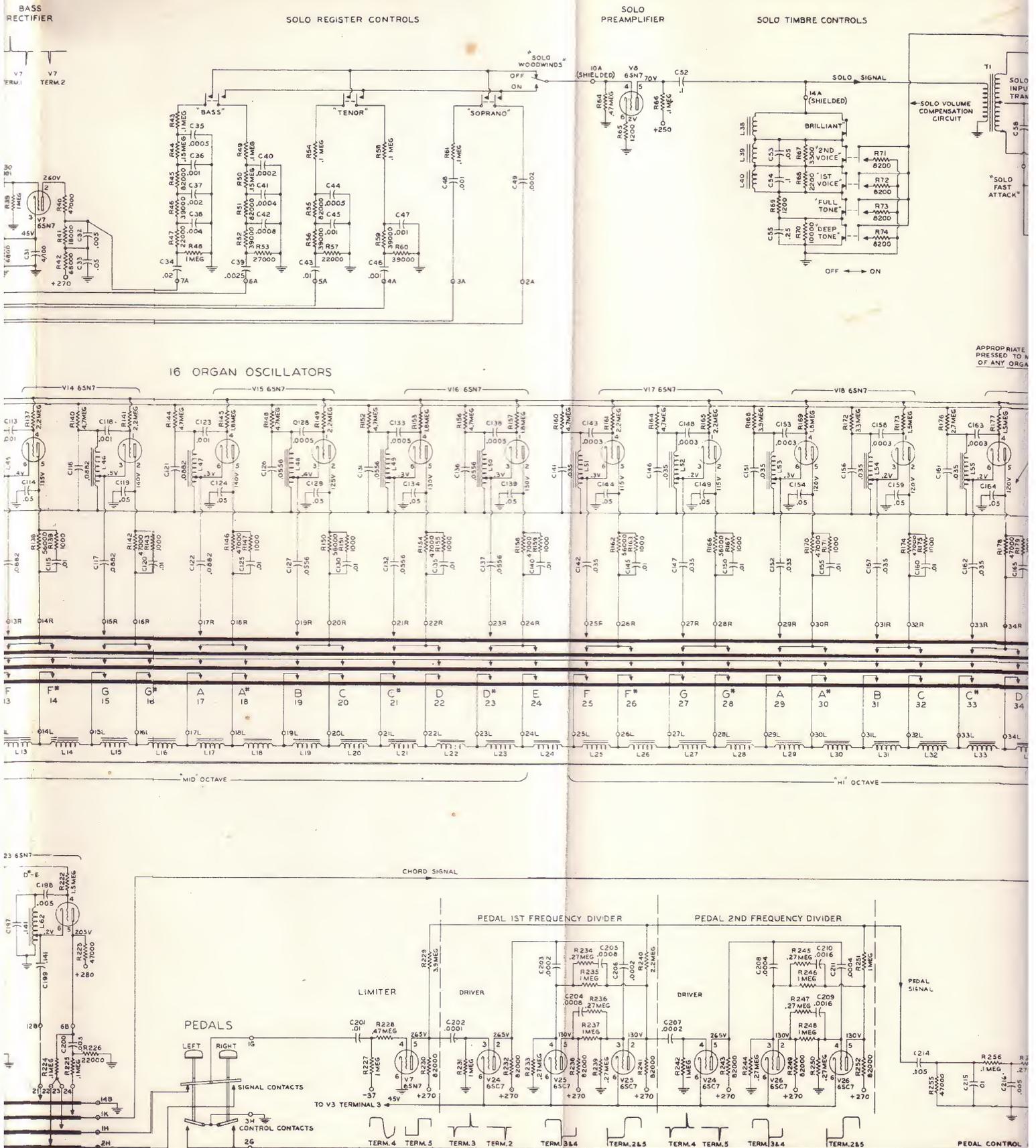
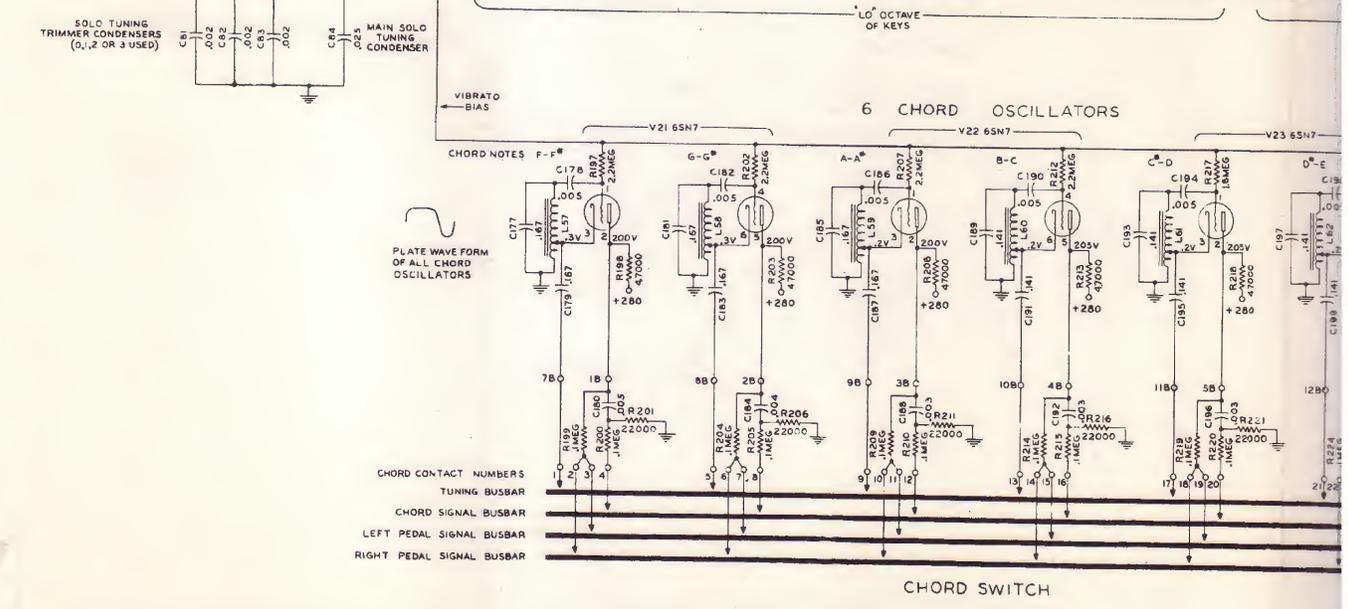
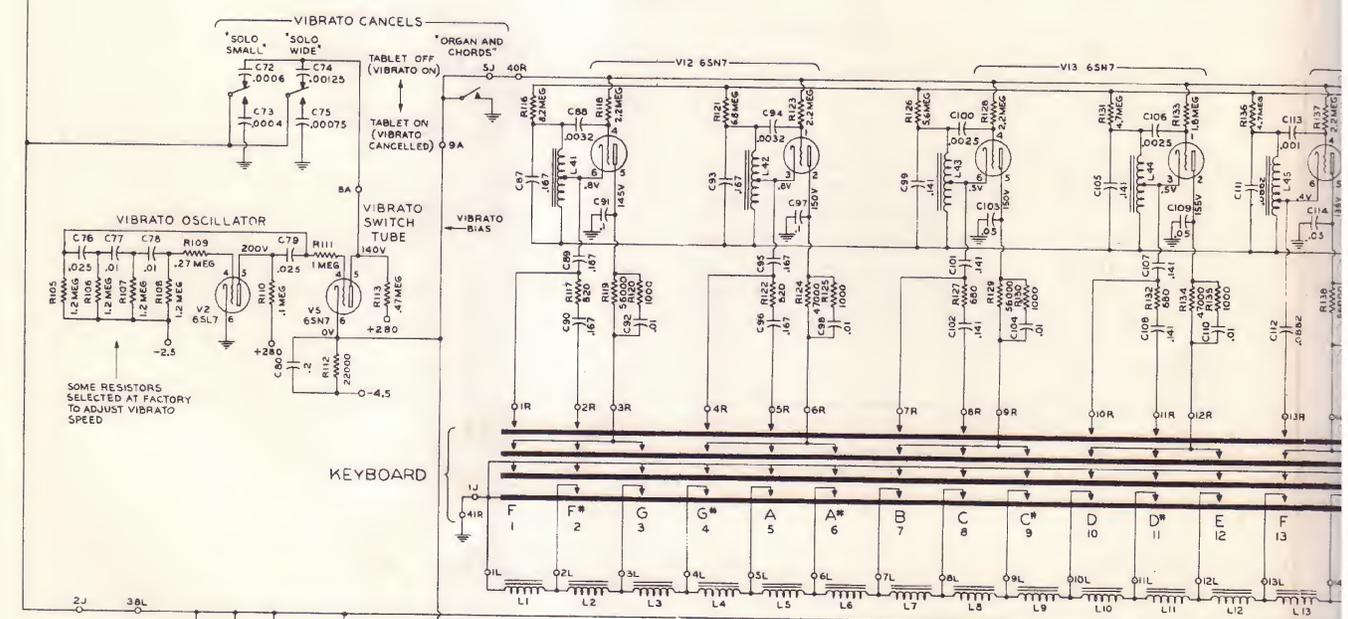
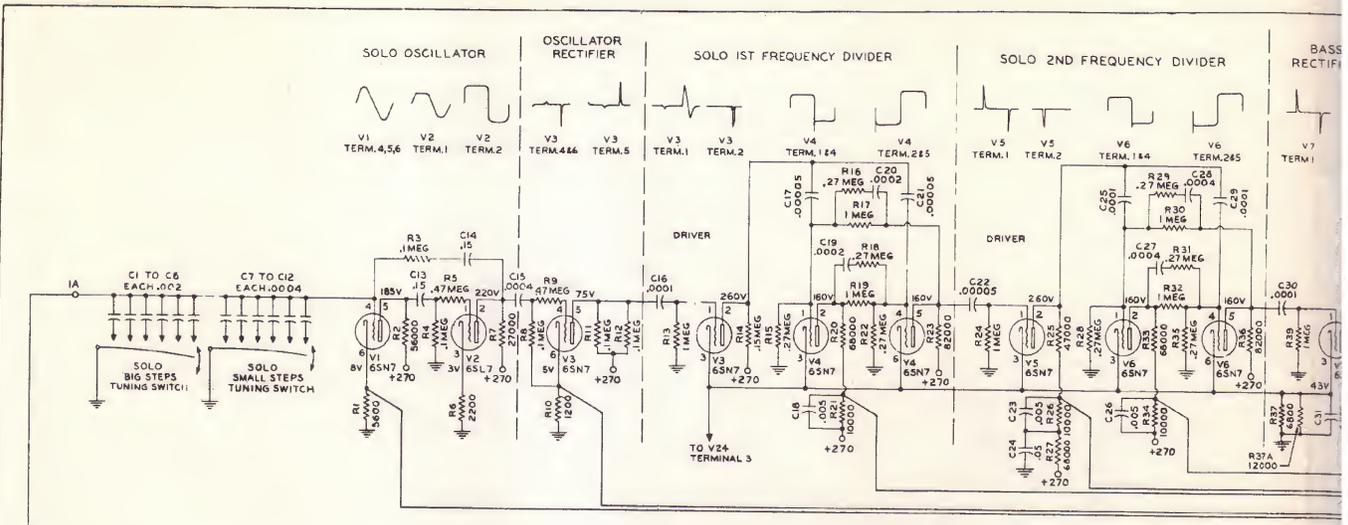


FIGURE 6—SCHEMATIC CIRCUIT DIAGRAM OF CHORD ORGAN MODEL S (BELOW SERIAL NUMBER 3500)

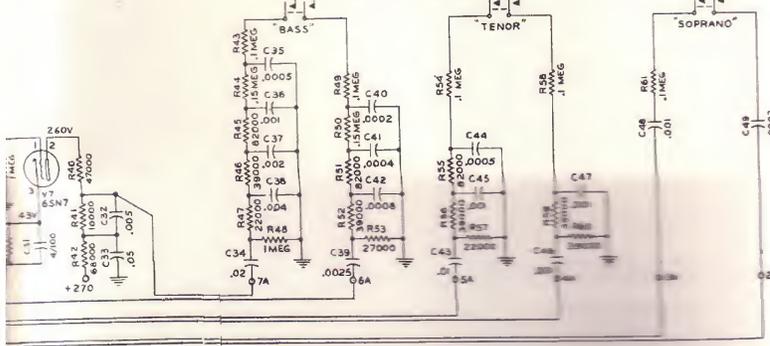






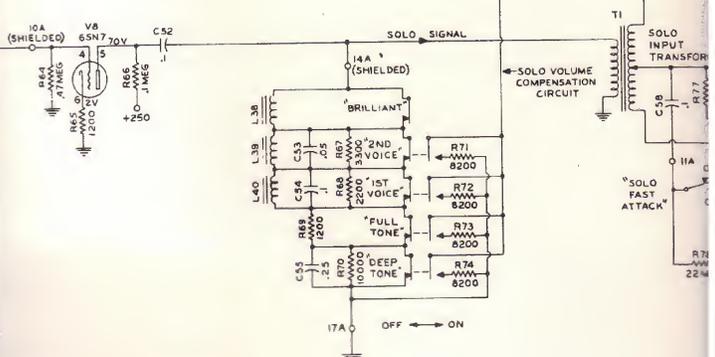
BASS  
CTIFIER

V7  
TERM.2



SOLO  
PREAMPLIFIER

SOLO TIMBRE CONTROLS



APPROPRIATE KEY  
PRESSED TO MEAS  
OF ANY ORGAN OS

16 ORGAN OSCILLATORS

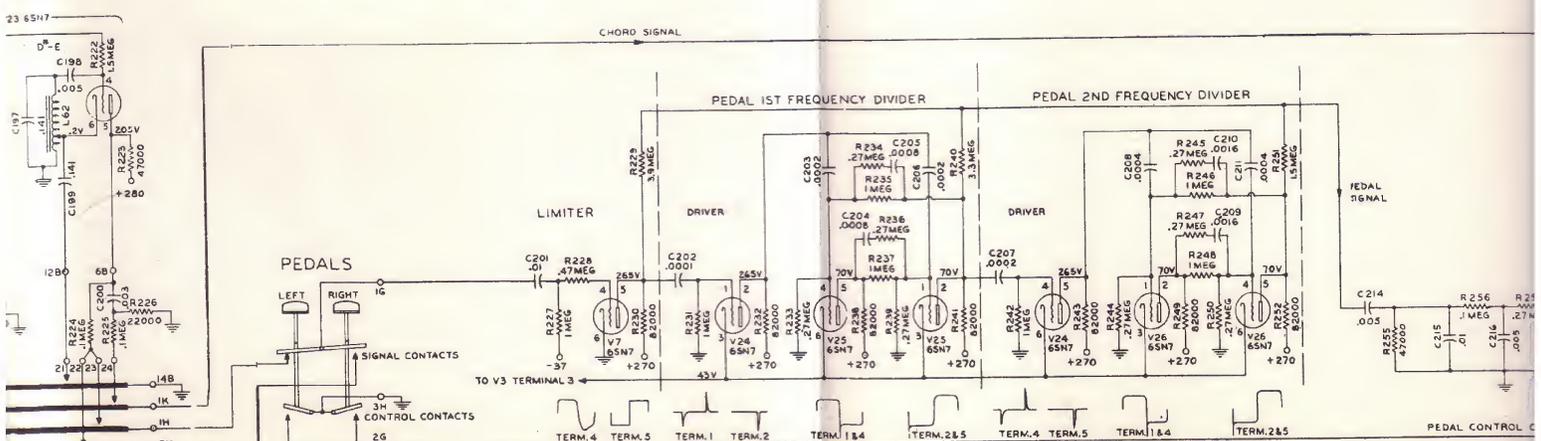
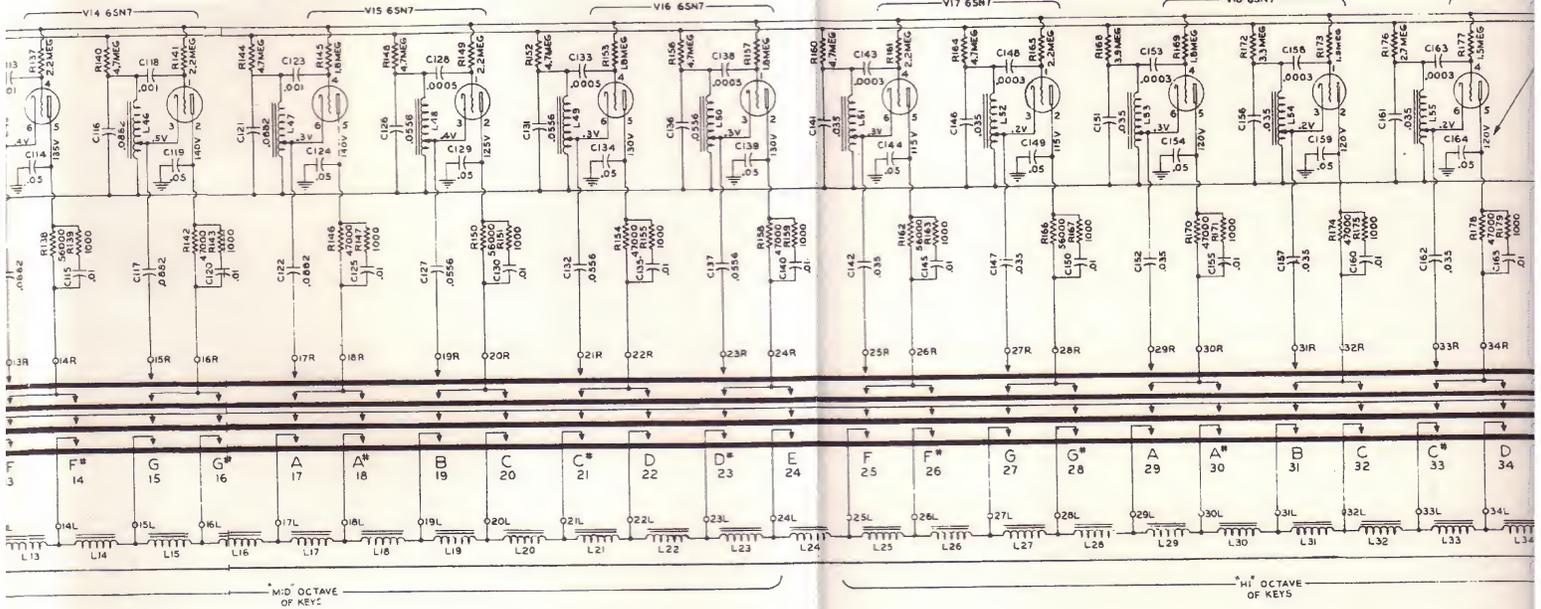
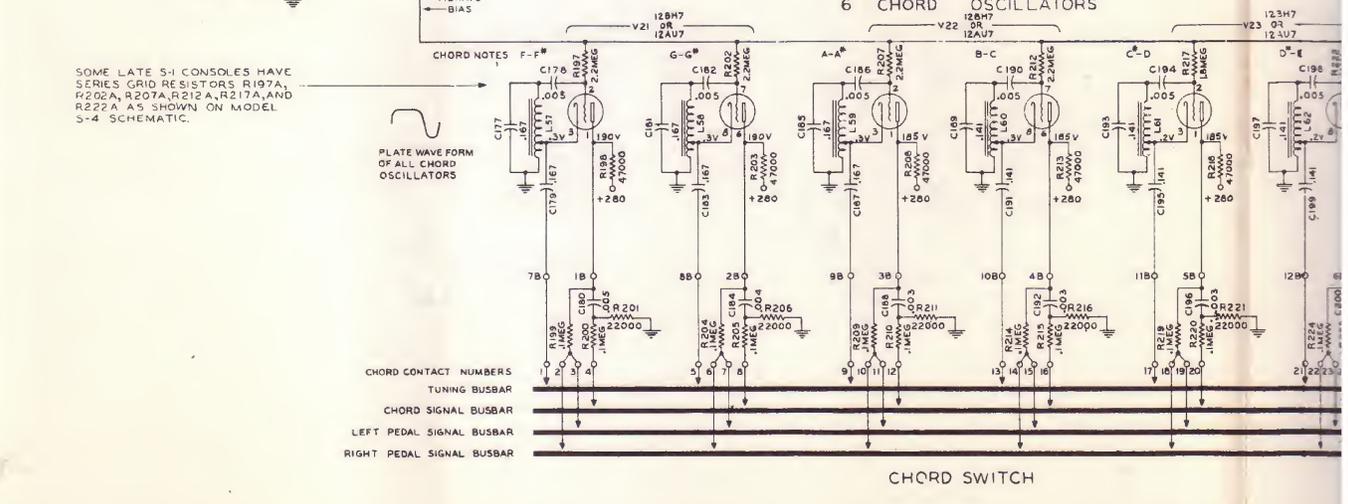
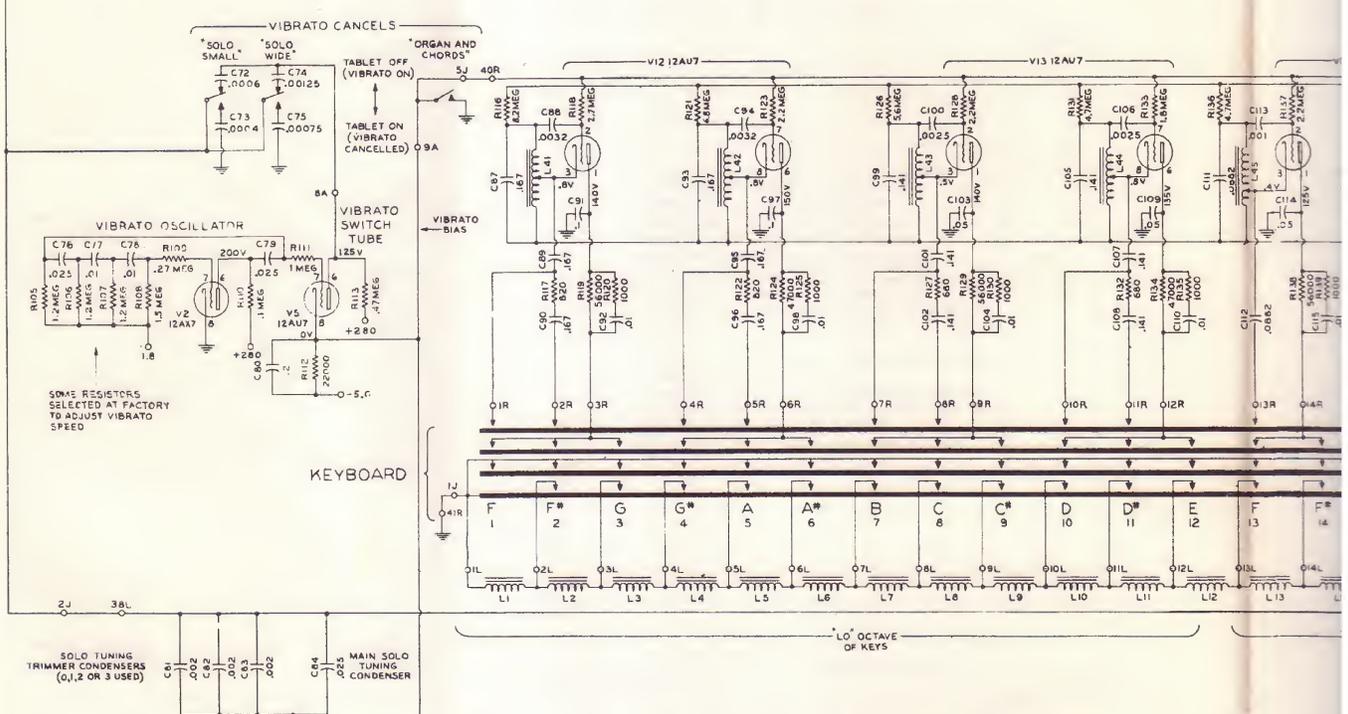
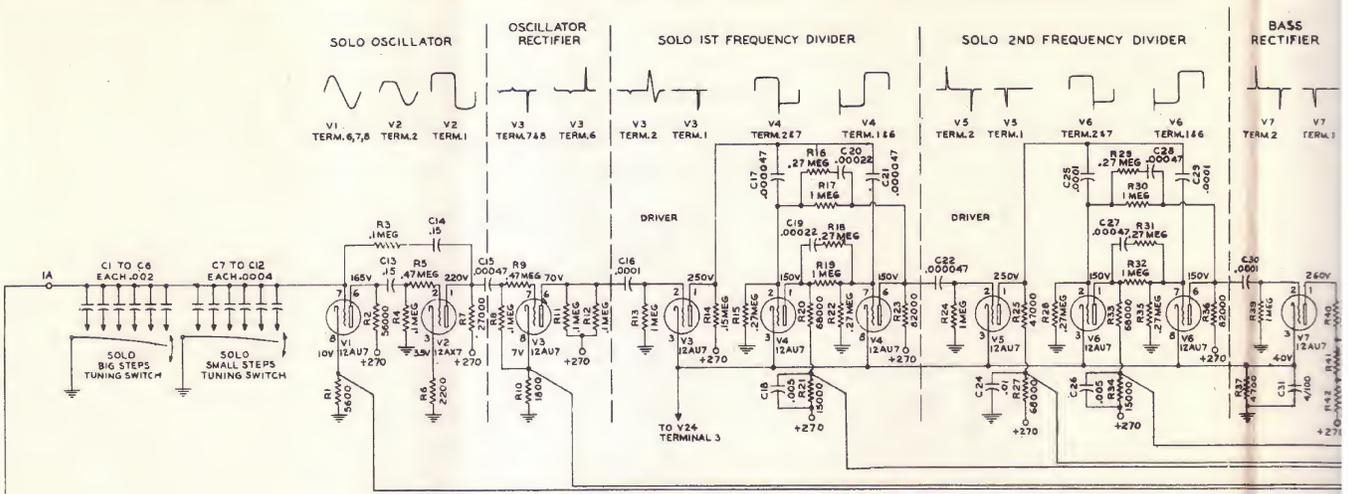


FIGURE 6A-SCHEMATIC CIRCUIT DIAGRAM OF CHORD ORGAN - MODEL S

(REVISED TO OMIT 6SC7 TUBES - SERIAL NO. 3500 AND ABOVE)





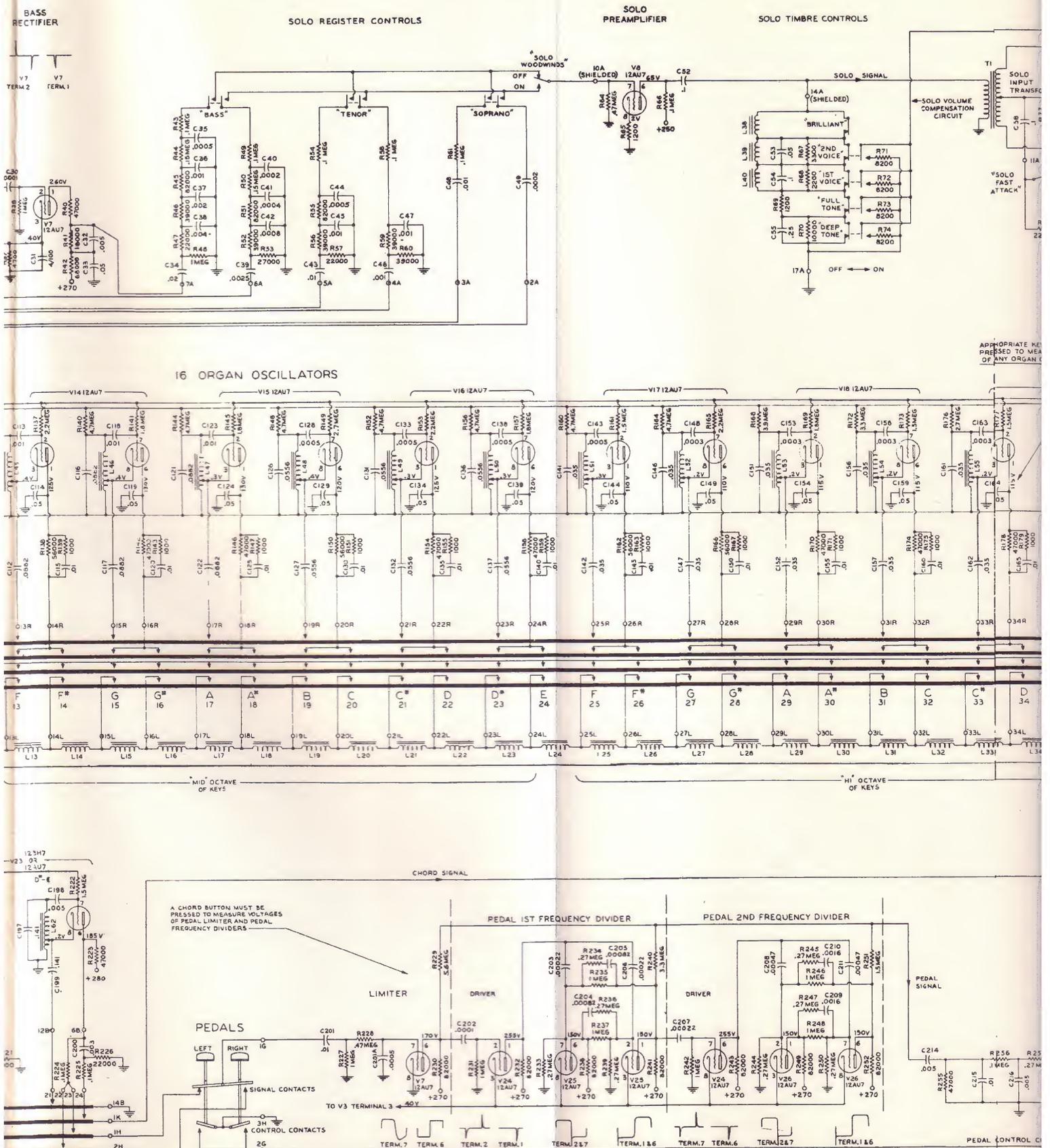
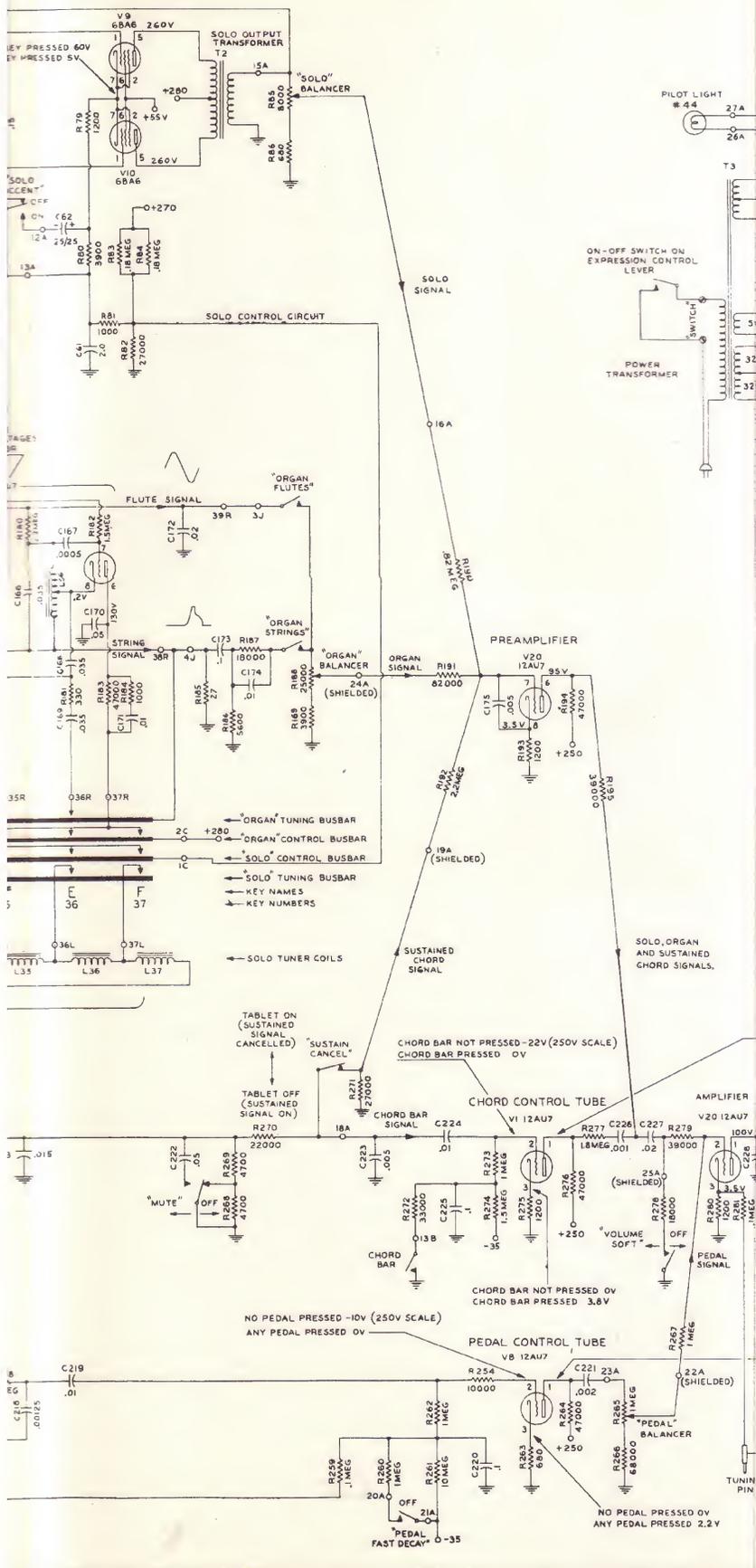
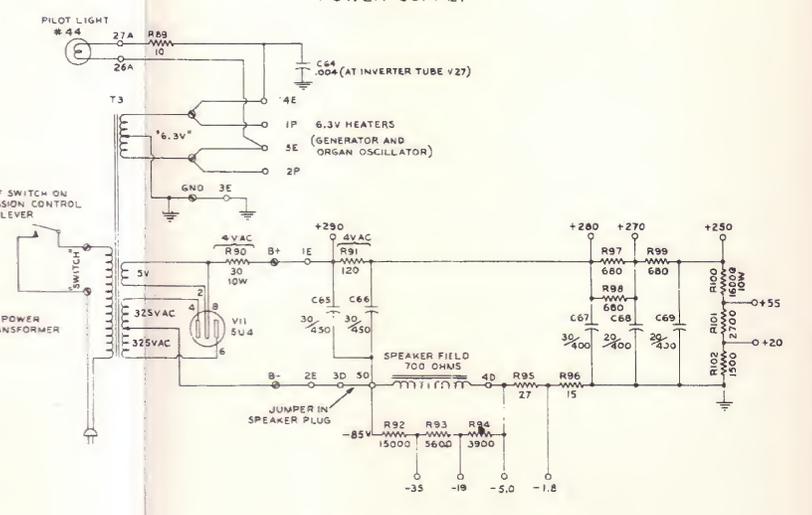


FIGURE 6B—SCHEMATIC CIRCUIT DIAGRAM OF CHORD ORGAN MODEL S-1

SOLO CONTROL TUBES



POWER SUPPLY



16A MEANS WIRE #16 IN GROUP A

WIRE CODE LETTERS

- A WIRES CONNECT GENERATOR TO CONTROL ASSEMBLY
- B WIRES CONNECT GENERATOR TO CHORD SWITCH
- C WIRES CONNECT GENERATOR TO KEYBOARD
- D WIRES CONNECT GENERATOR TO SPEAKER
- E WIRES CONNECT GENERATOR TO POWER PACK
- G WIRES CONNECT GENERATOR TO PEDAL SWITCH
- H WIRES CONNECT CHORD SWITCH TO PEDAL SWITCH
- J WIRES CONNECT KEYBOARD TO CONTROL ASSEMBLY
- K WIRES CONNECT CHORD SWITCH TO CONTROL ASSEMBLY
- L WIRES CONNECT KEYBOARD TO SOLO TUNER ASSEMBLY
- F WIRES CONNECT ORGAN OSCILLATOR ASSEMBLY TO POWER PACK
- R WIRES CONNECT ORGAN OSCILLATOR ASSEMBLY TO KEYBOARD

ALL CONTROL TABLETS SHOWN IN OFF POSITION (PUSHED IN AT TOP)

A TABLE IS ON WHEN OCT IS VISIBLE

ALL VOLTAGES SHOWN ARE + FROM GROUND UNLESS OTHERWISE NOTED

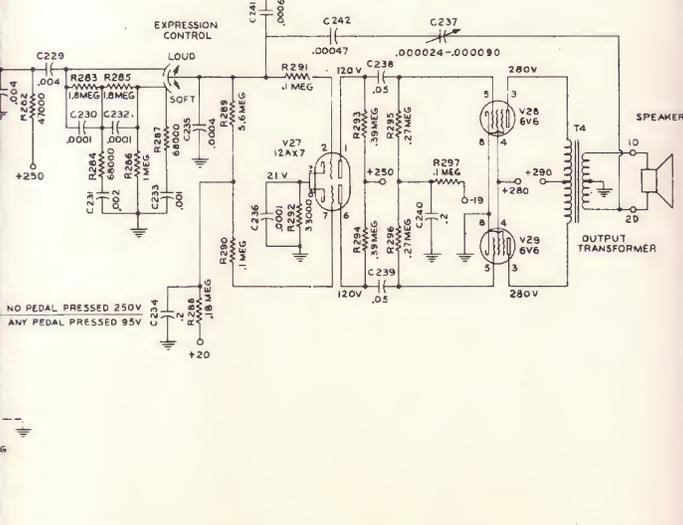
ALL VOLTAGES MEASURED WITH 20,000 OHMS-PER-VOLT METER

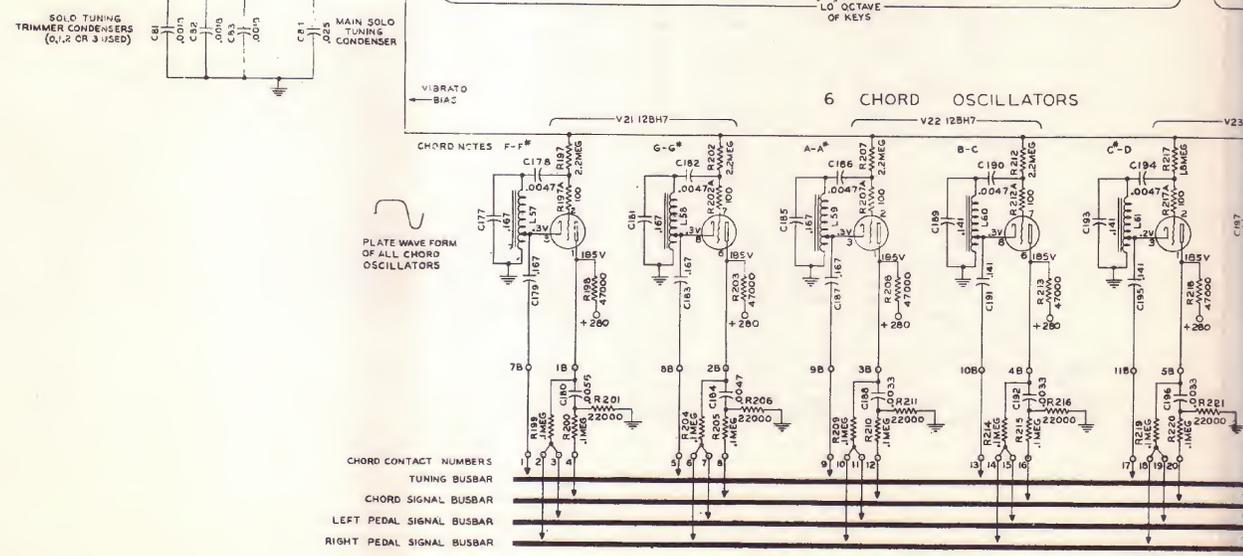
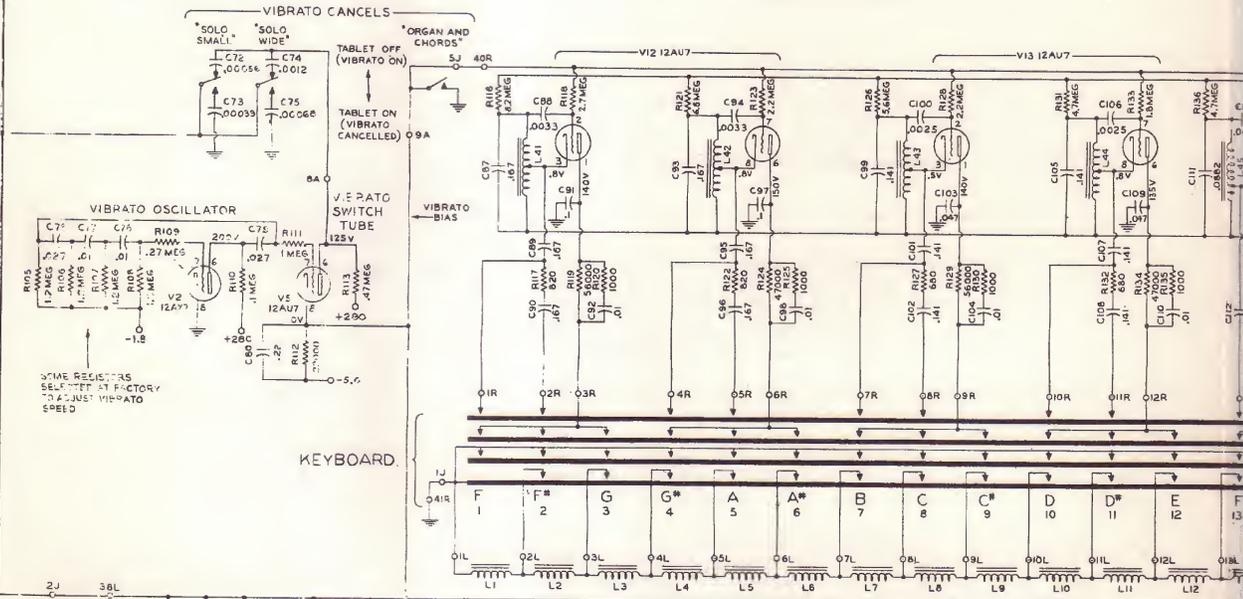
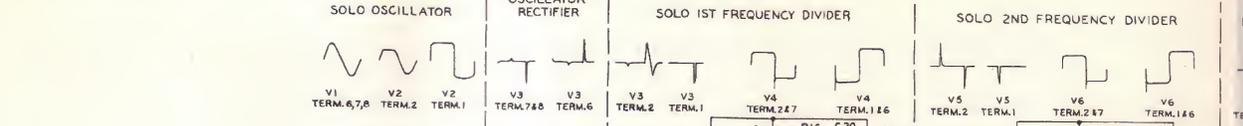
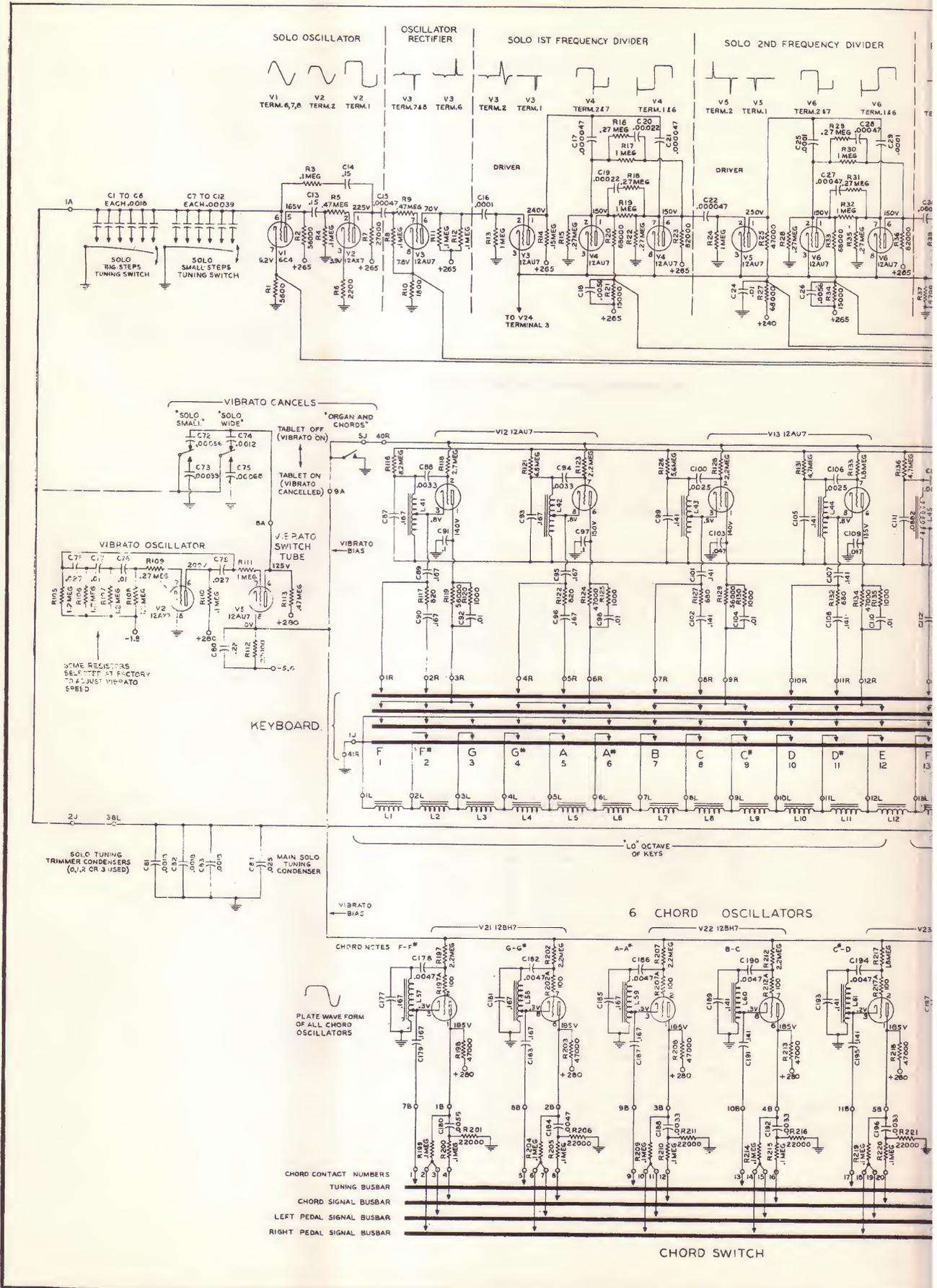
FOR TUBE LOCATIONS SEE FIGURES 12,15,20

FOR LOCATIONS OF COMPONENTS SEE FIGURES 13,14,16,18

FOR ROUTING OF WIRES SEE FIGURE 7

POWER AMPLIFIER





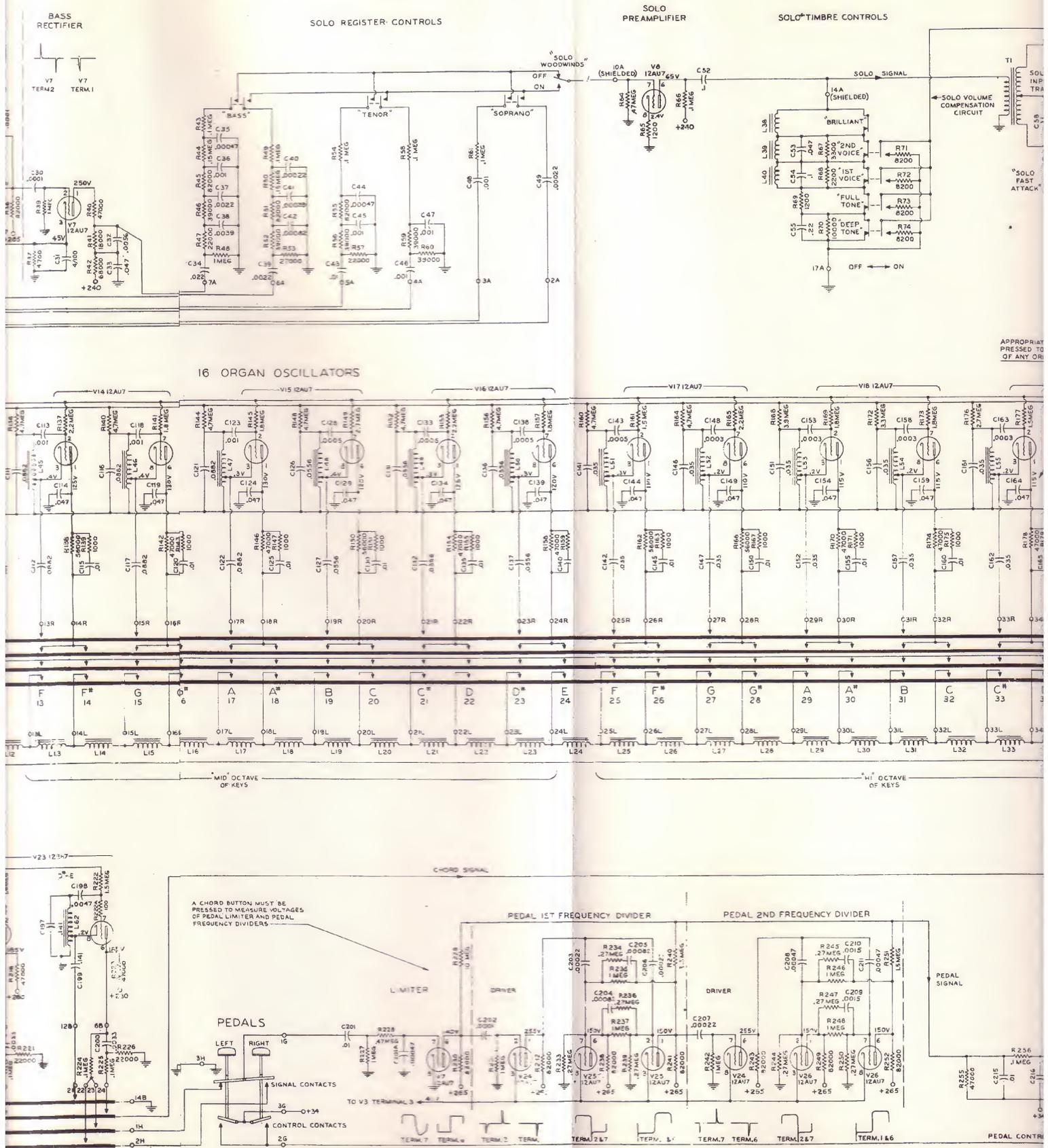
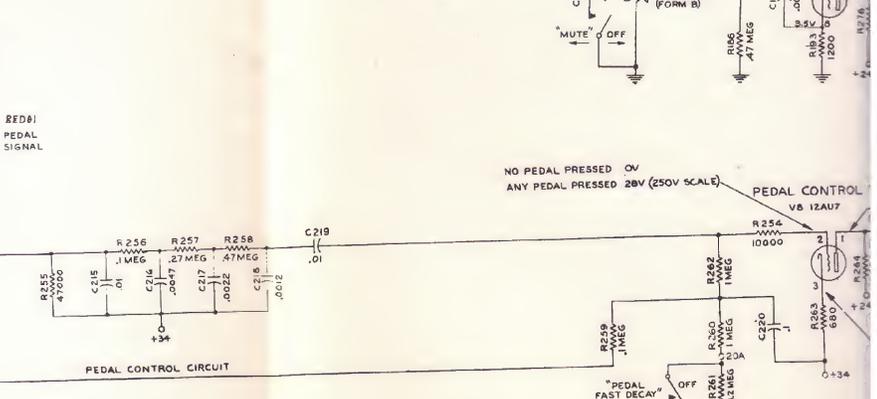
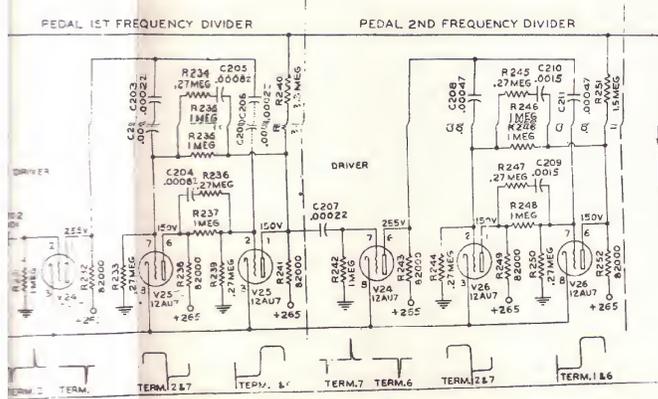
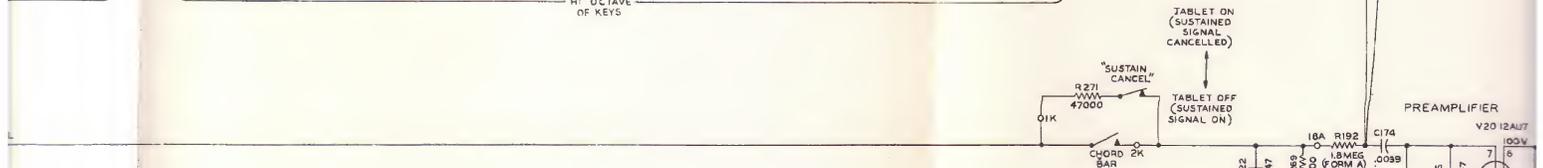
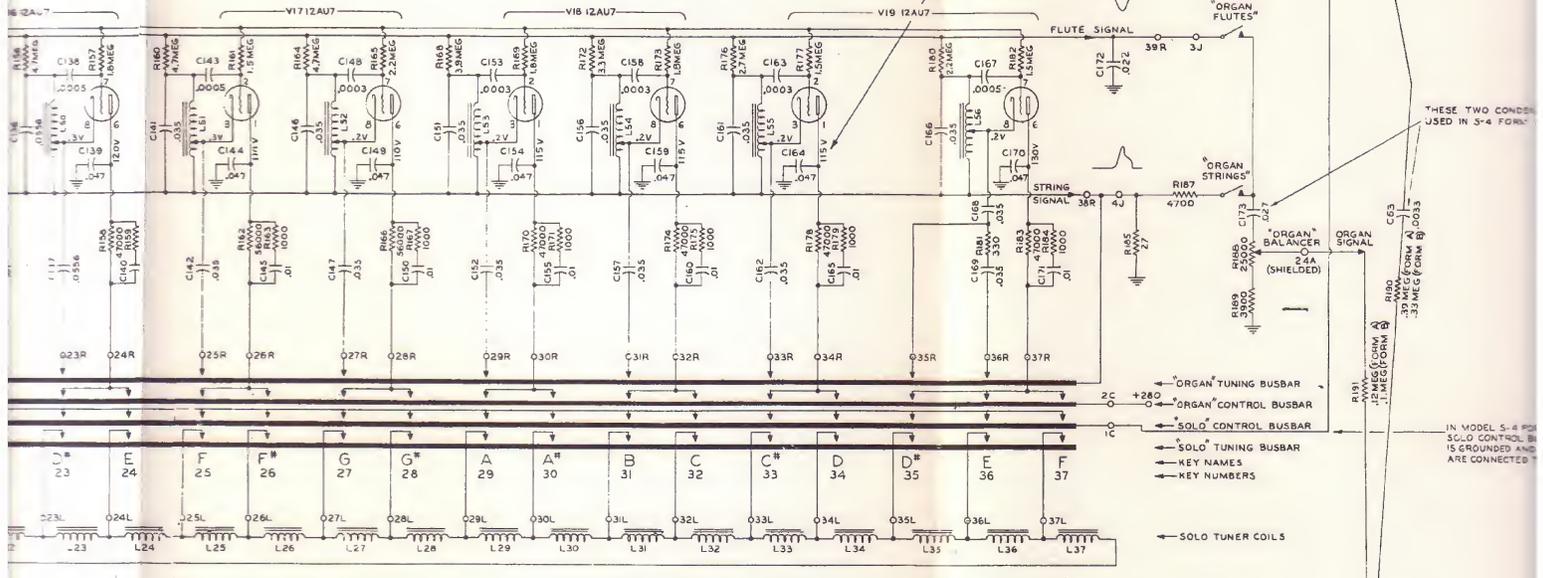
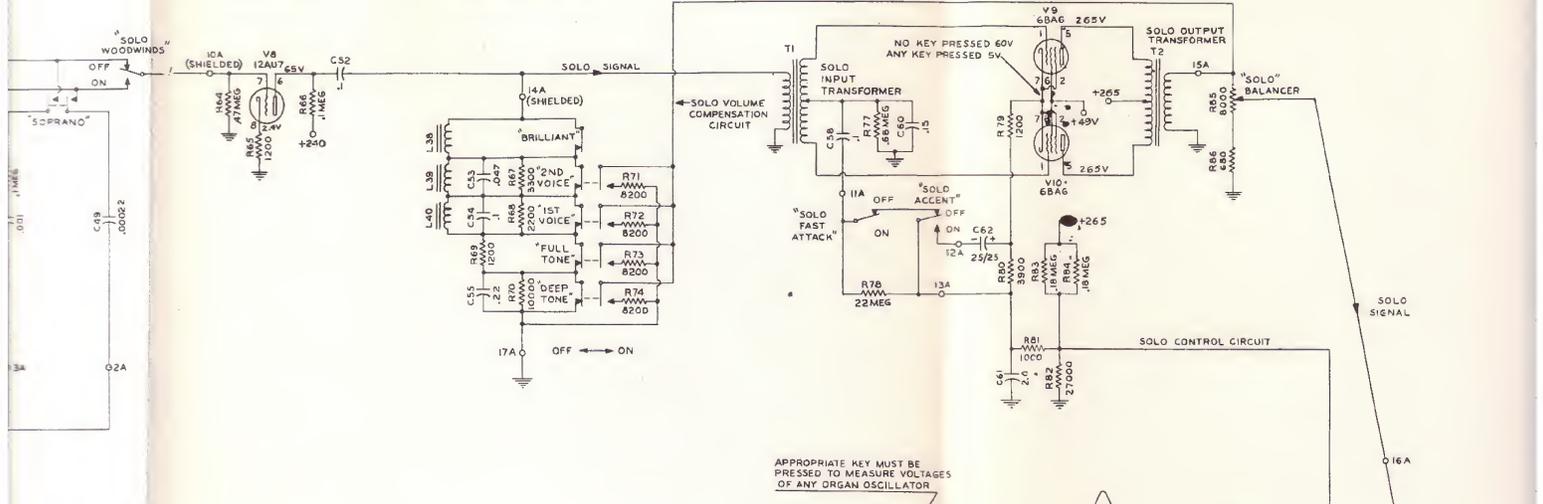


FIGURE 60-SCHEMATIC CIRCUIT DIAGRAM OF CHORD ORGAN MODEL S-4 (FORM 1 AND FORM 2)

SOLO PREAMPLIFIER

SOLO TIMBRE CONTROLS

SOLO CONTROL TUBES



RAY OF CHORD ORGAN MODEL S-4

45





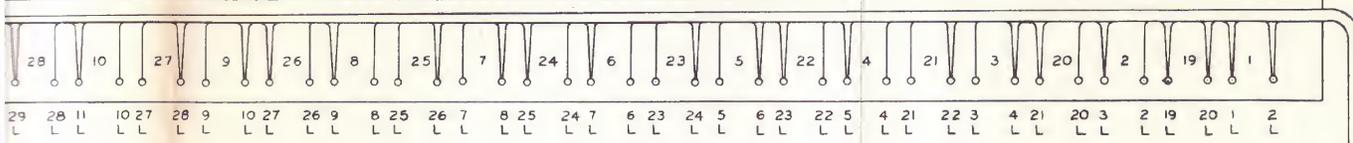




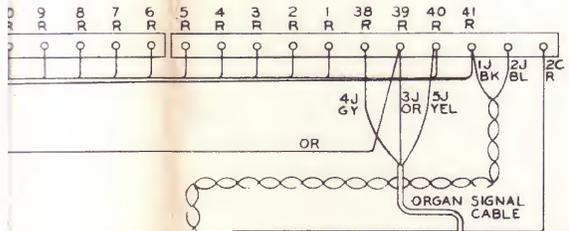




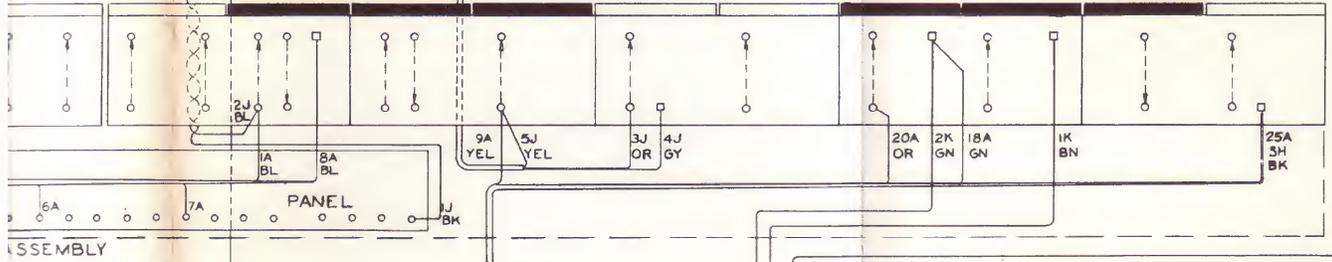
SOLO TUNER ASSEMBLY--(REAR VIEW)



MAIN STRIP (REAR VIEW)

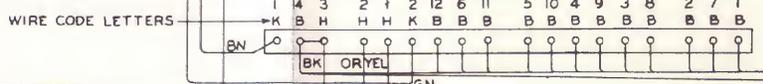


SOLO TUNER CABLE INTO KEYBOARD



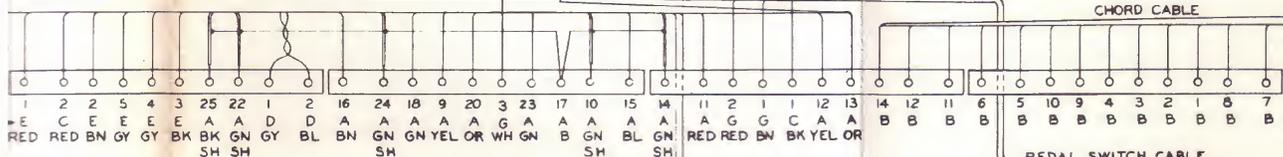
KEYBOARD ASSEMBLY

CHORD SWITCH TERMINAL STRIP (VIEWED FROM REAR)



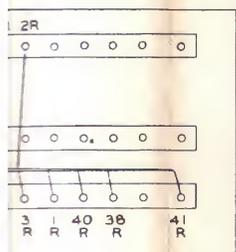
WIRE CODE LETTERS

POWER CABLE

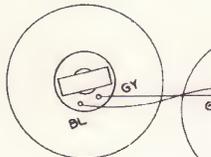


CHORD CABLE

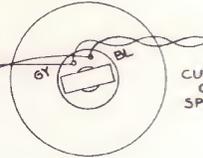
PEDAL SWITCH CABLE



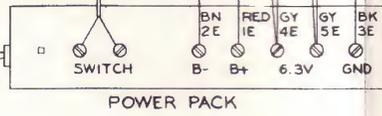
STRAIGHT CONE SPEAKER



CURVED CONE SPEAKER



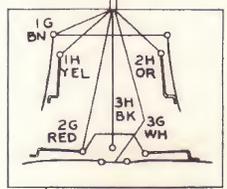
LINE CORD



POWER PACK

COLOR CODE - WIRES BLACK UNLESS OTHERWISE MARKED

- B BARE
- BK BLACK
- BN BROWN
- RED RED
- OR ORANGE
- YEL YELLOW
- GN GREEN
- BL BLUE
- VIO VIOLET
- GY GREY
- WH WHITE
- SH SHIELDED

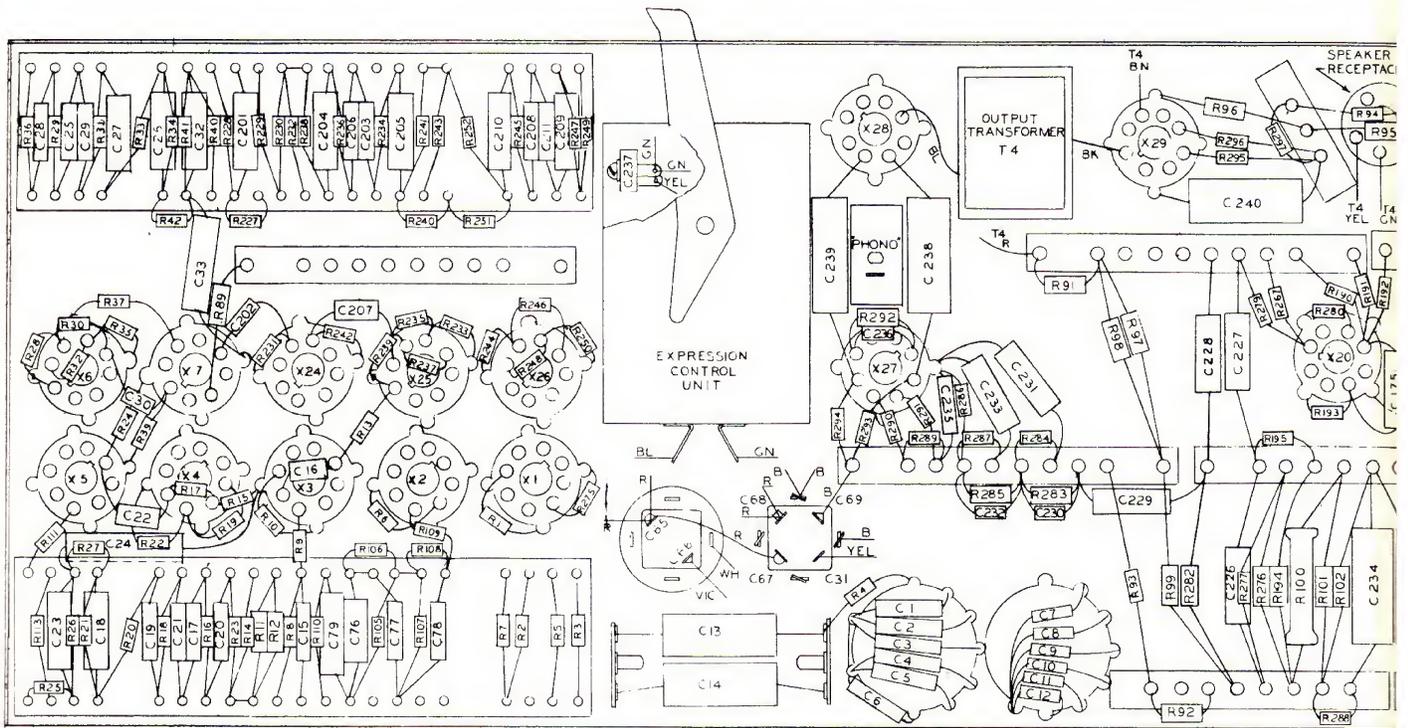


PEDAL SWITCH

WIRE CODE LETTERS

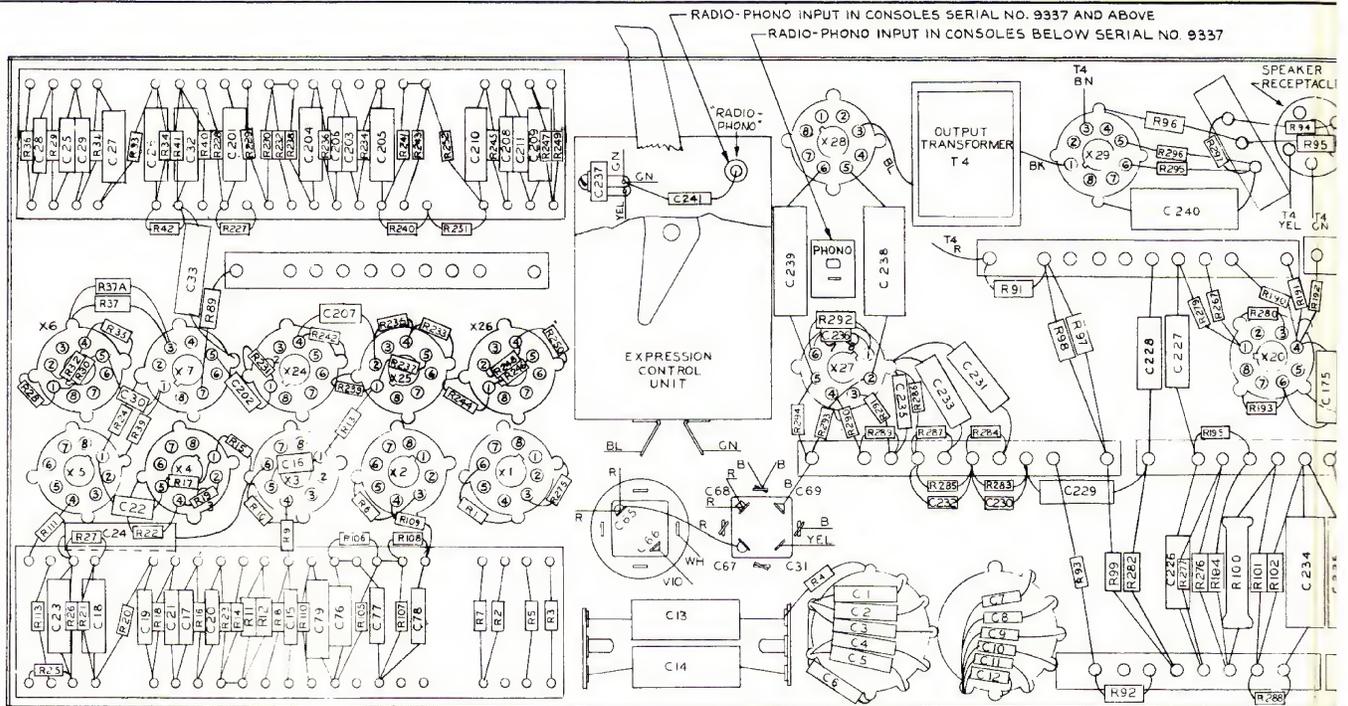
- A WIRES CONNECT GENERATOR TO CONTROL ASSEMBLY
- B WIRES CONNECT GENERATOR TO CHORD SWITCH
- C WIRES CONNECT GENERATOR TO KEYBOARD
- D WIRES CONNECT GENERATOR TO SPEAKER
- E WIRES CONNECT GENERATOR TO POWER PACK
- G WIRES CONNECT GENERATOR TO PEDAL SWITCH
- H WIRES CONNECT CHORD SWITCH TO PEDAL SWITCH
- J WIRES CONNECT KEYBOARD TO CONTROL ASSEMBLY
- K WIRES CONNECT CHORD SWITCH TO CONTROL ASSEMBLY
- L WIRES CONNECT KEYBOARD TO SOLO TUNER ASSEMBLY
- P WIRES CONNECT ORGAN OSCILLATOR ASSEM. TO POWER PACK
- R WIRES CONNECT ORGAN OSCILLATOR ASSEM. TO KEYBOARD

WIRING DIAGRAM OF ORGAN MODEL 4 (FORM B)



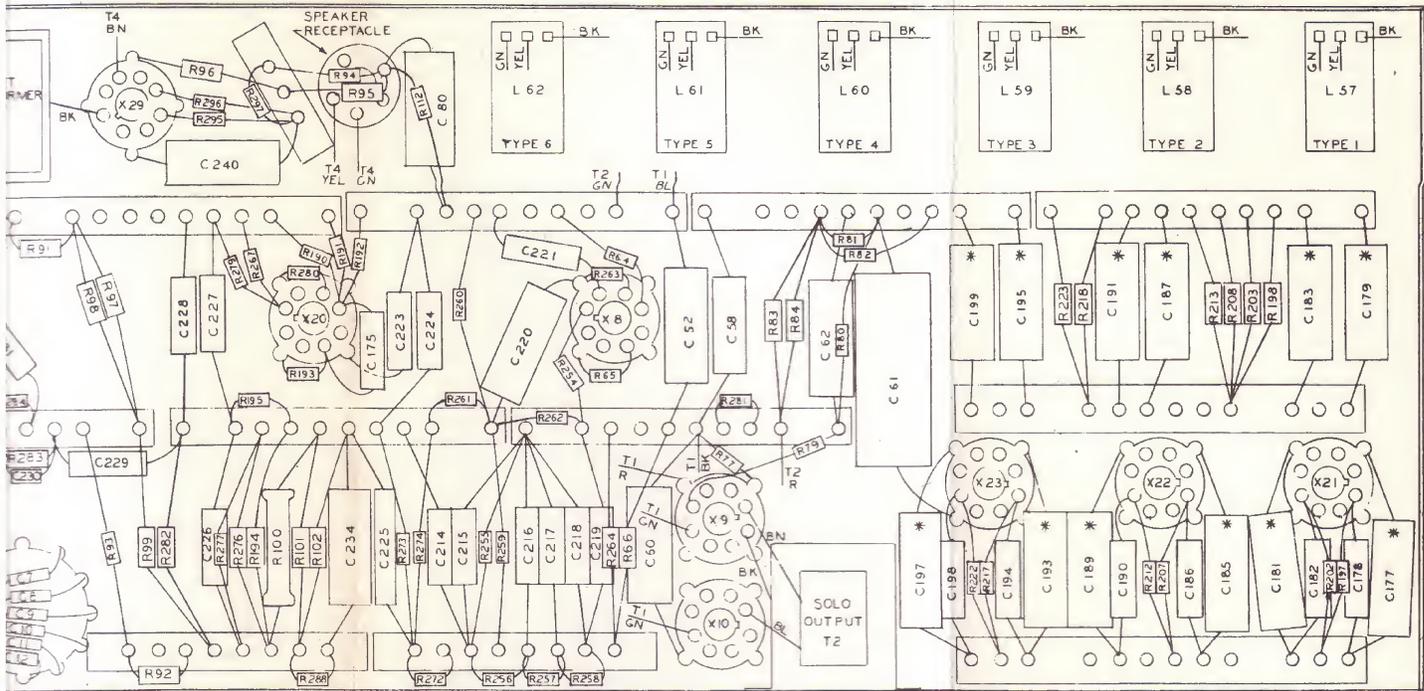
REFERENCE SYMBOLS FOR COMPONENTS REFER TO SCHEMATIC DIAGRAM FIG

FIGURE 13 - INSIDE OF GENERATOR



REFERENCE SYMBOLS FOR COMPONENTS REFER TO SCHEMATIC DIAGRAM FIG

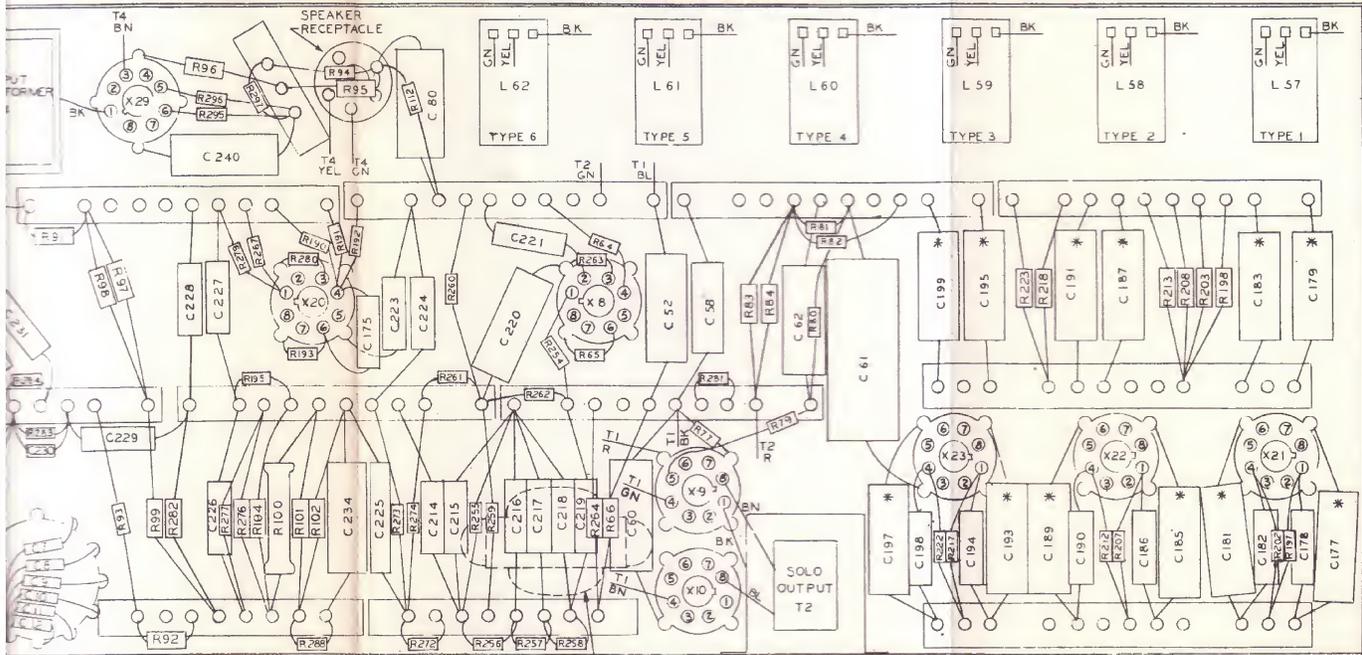
FIGURE 13A - INSIDE OF GENERATOR



- INSIDE OF GENERATOR

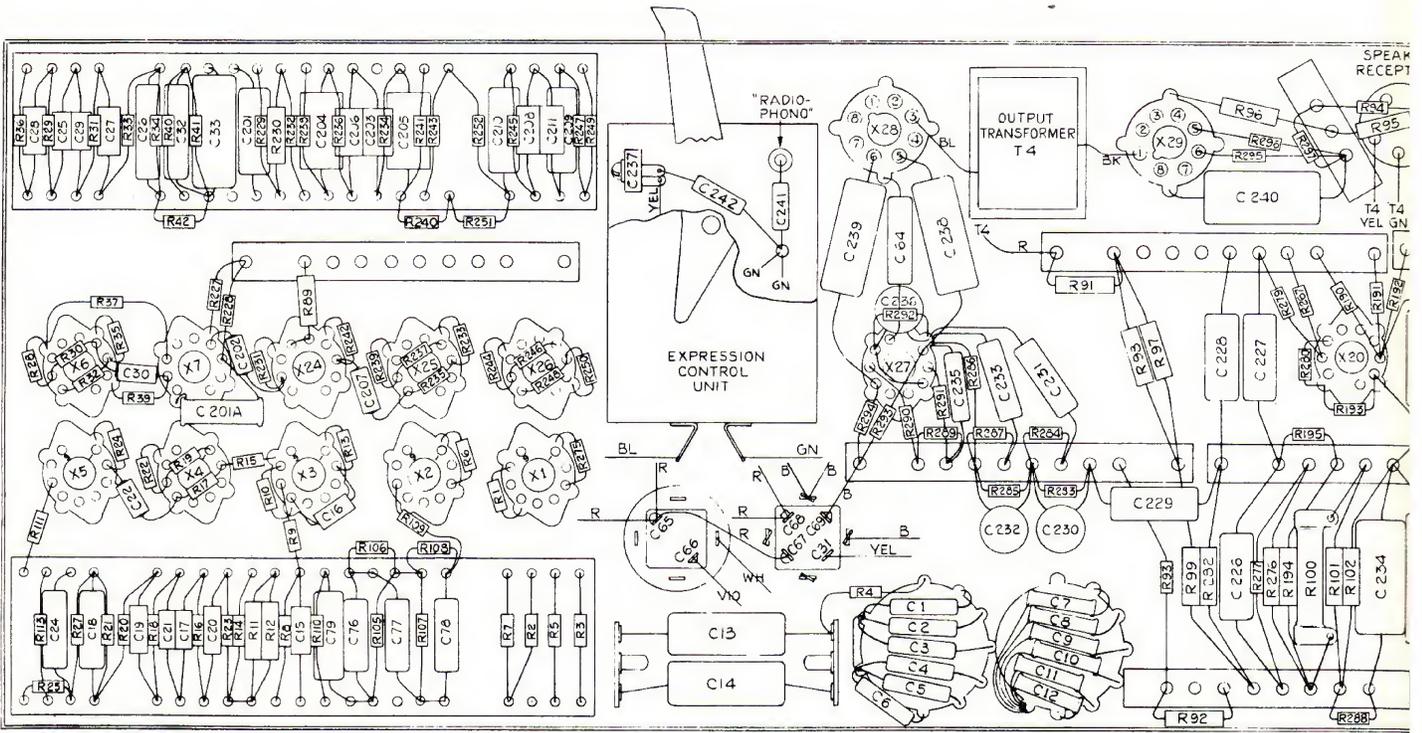
MODEL S - SERIAL NUMBERS BELOW 3500

SERIAL NO. 9337 AND ABOVE  
 UNITS BELOW SERIAL NO. 9337



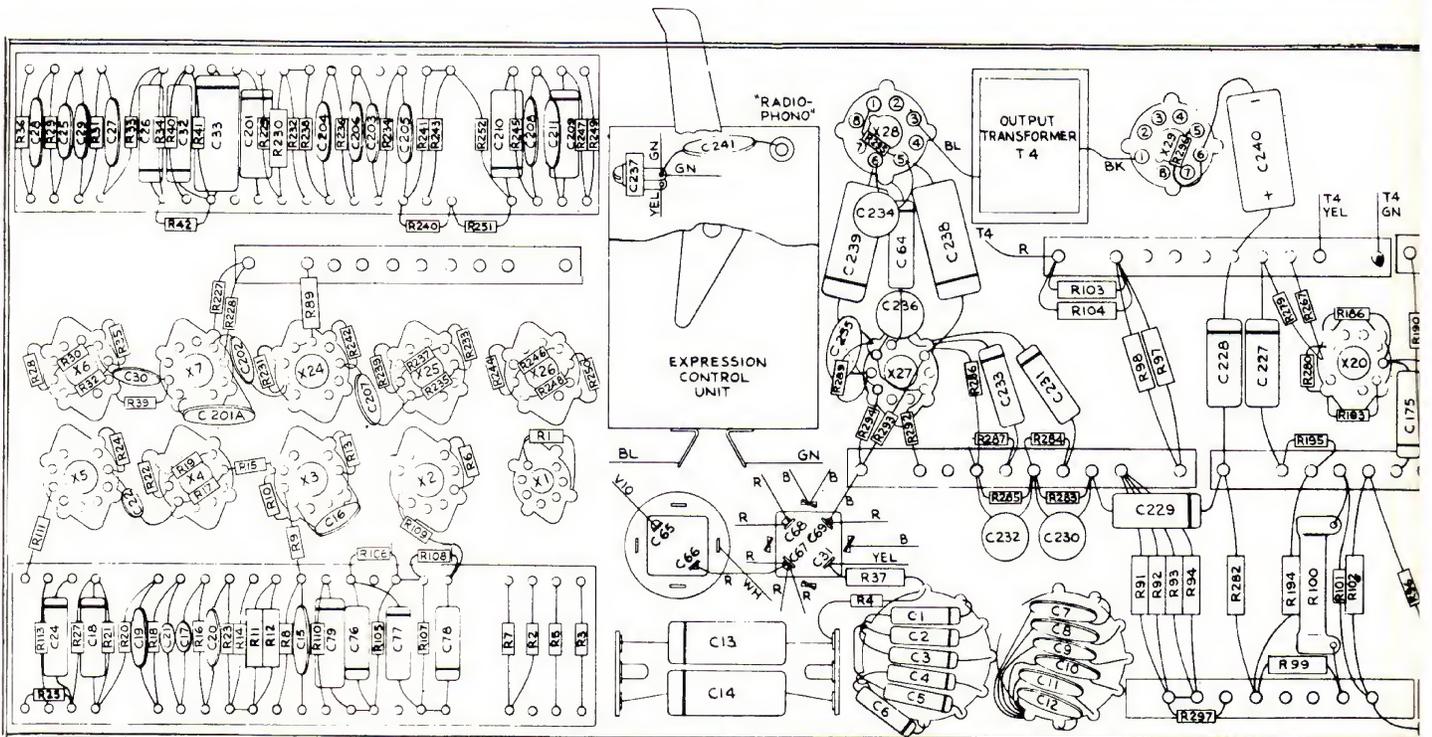
3A - INSIDE OF GENERATOR-MODEL S

SERIAL NUMBER 3500 AND ABOVE



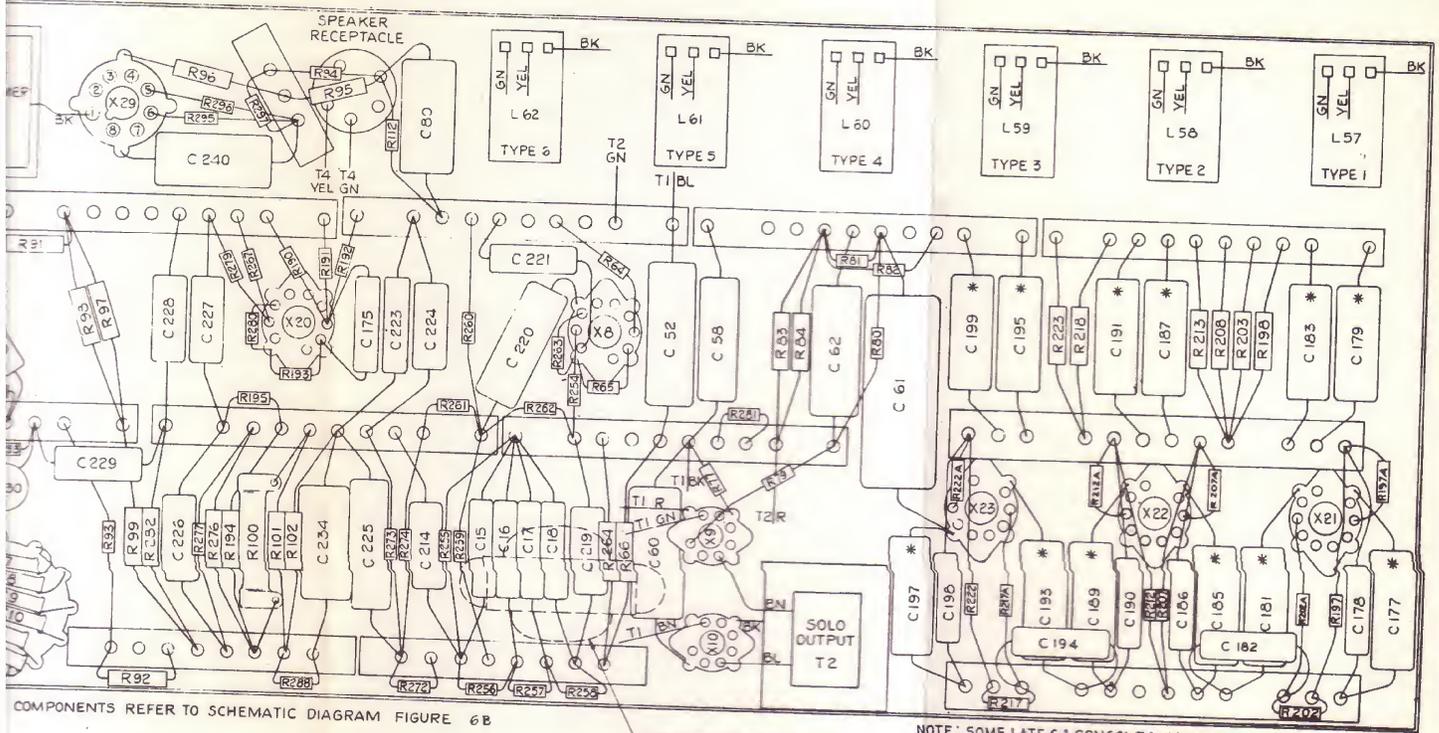
REFERENCE SYMBOLS FOR COMPONENTS REFER TO SCHEMATIC DIAGR

FIGURE 13B — INSIDE OF GENERATO



REFERENCE SYMBOLS FOR COMPONENTS REFER TO SCHEMATIC DIAGR

FIGURE 13C — INSIDE OF GENERATO

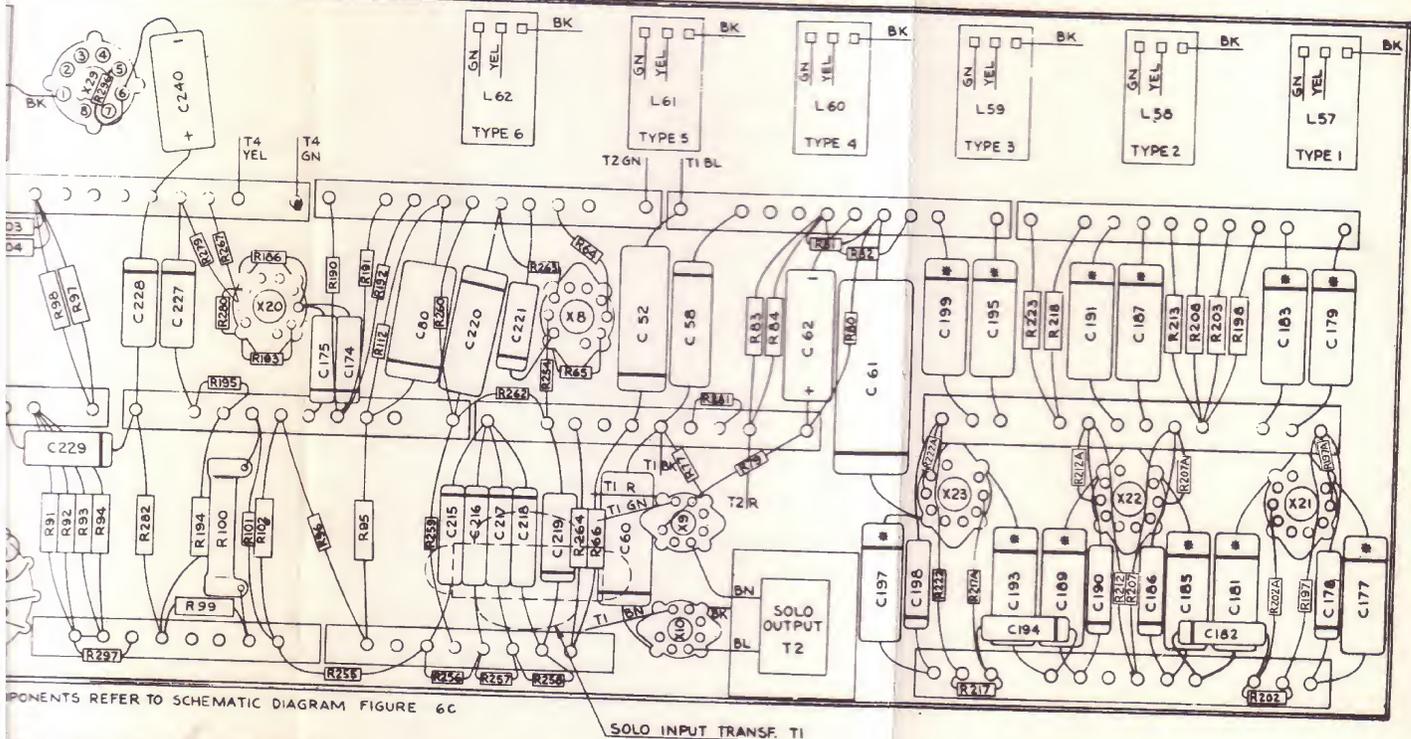


COMPONENTS REFER TO SCHEMATIC DIAGRAM FIGURE 6B

INSIDE OF GENERATOR MODEL S-1

NOTE: SOME LATE S-1 CONSOLES HAVE RESISTORS R197A, R202A, R207A, R212A, R217A, AND R222A AS SHOWN FOR MODEL S-4

SERIAL NUMBER 12,000 AND ABOVE

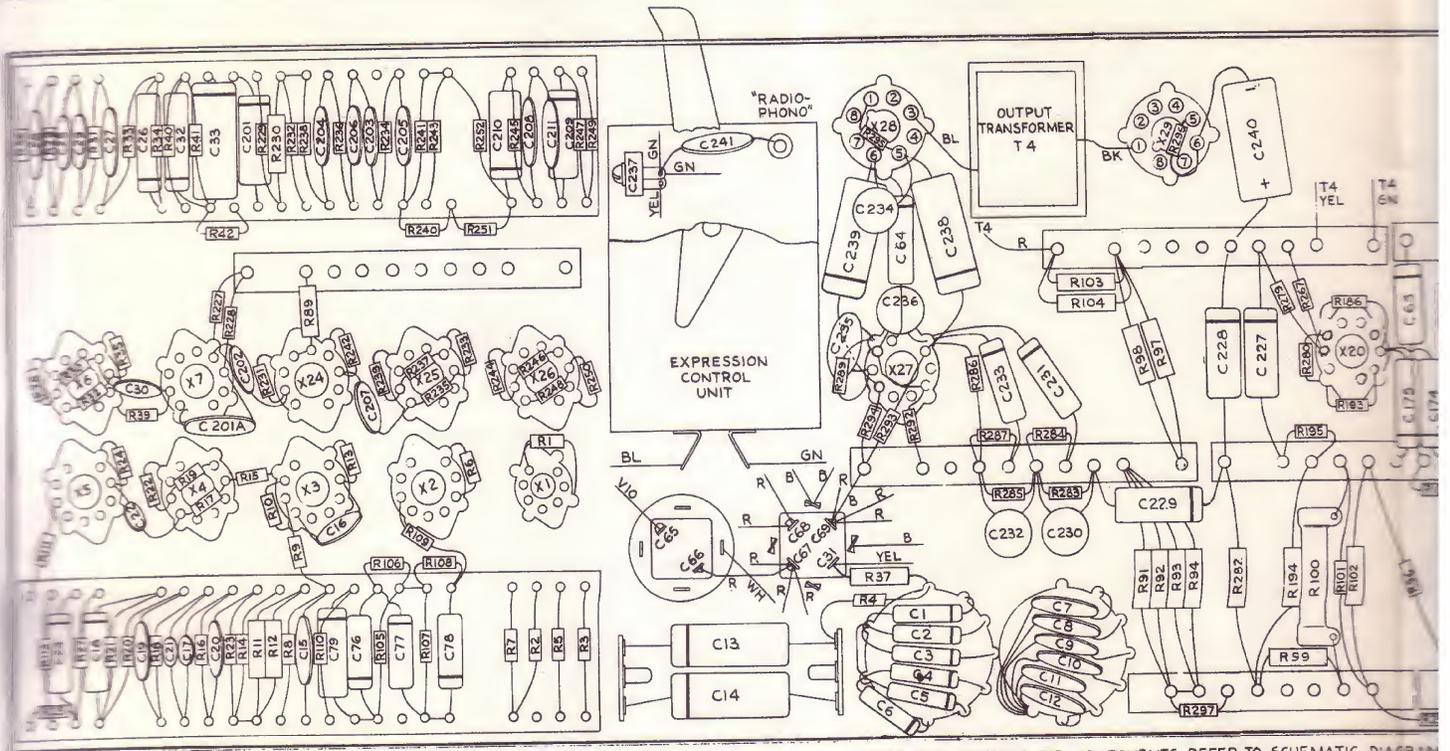


COMPONENTS REFER TO SCHEMATIC DIAGRAM FIGURE 6C

INSIDE OF GENERATOR MODEL S-4 FORM A

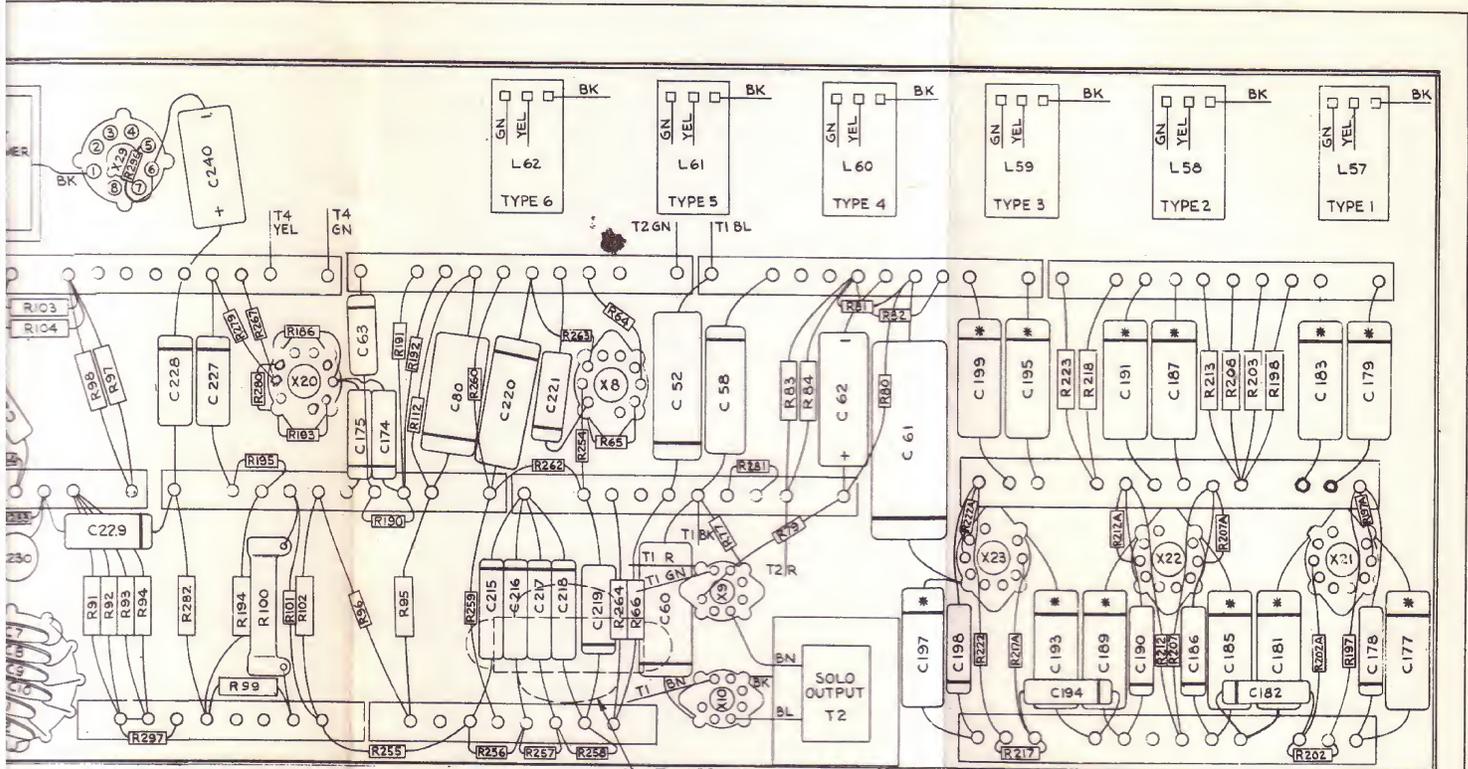
SERIAL NUMBER 20500 AND ABOVE

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REFERENCE SYMBOLS FOR COMPONENTS REFER TO SCHEMATIC DIAGRAM

FIGURE 13D - INSIDE OF GENERATOR



COMPONENTS REFER TO SCHEMATIC DIAGRAM FIGURE 6D

SOLO INPUT TRANSF. T1

— INSIDE OF GENERATOR MODEL S-4 FORM B

SERIAL NUMBER 23000 AND ABOVE

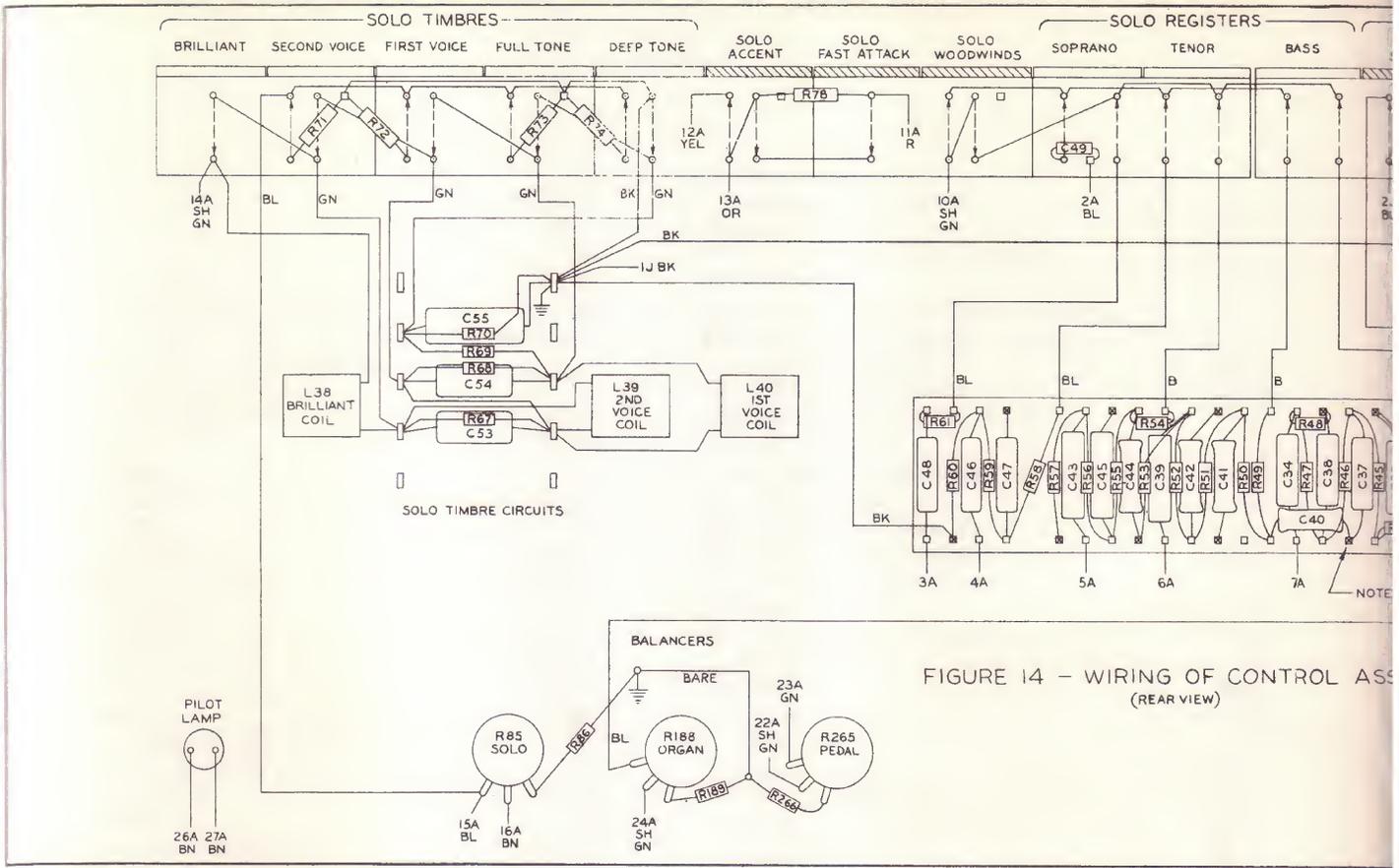


FIGURE 14 - WIRING OF CONTROL ASS (REAR VIEW)

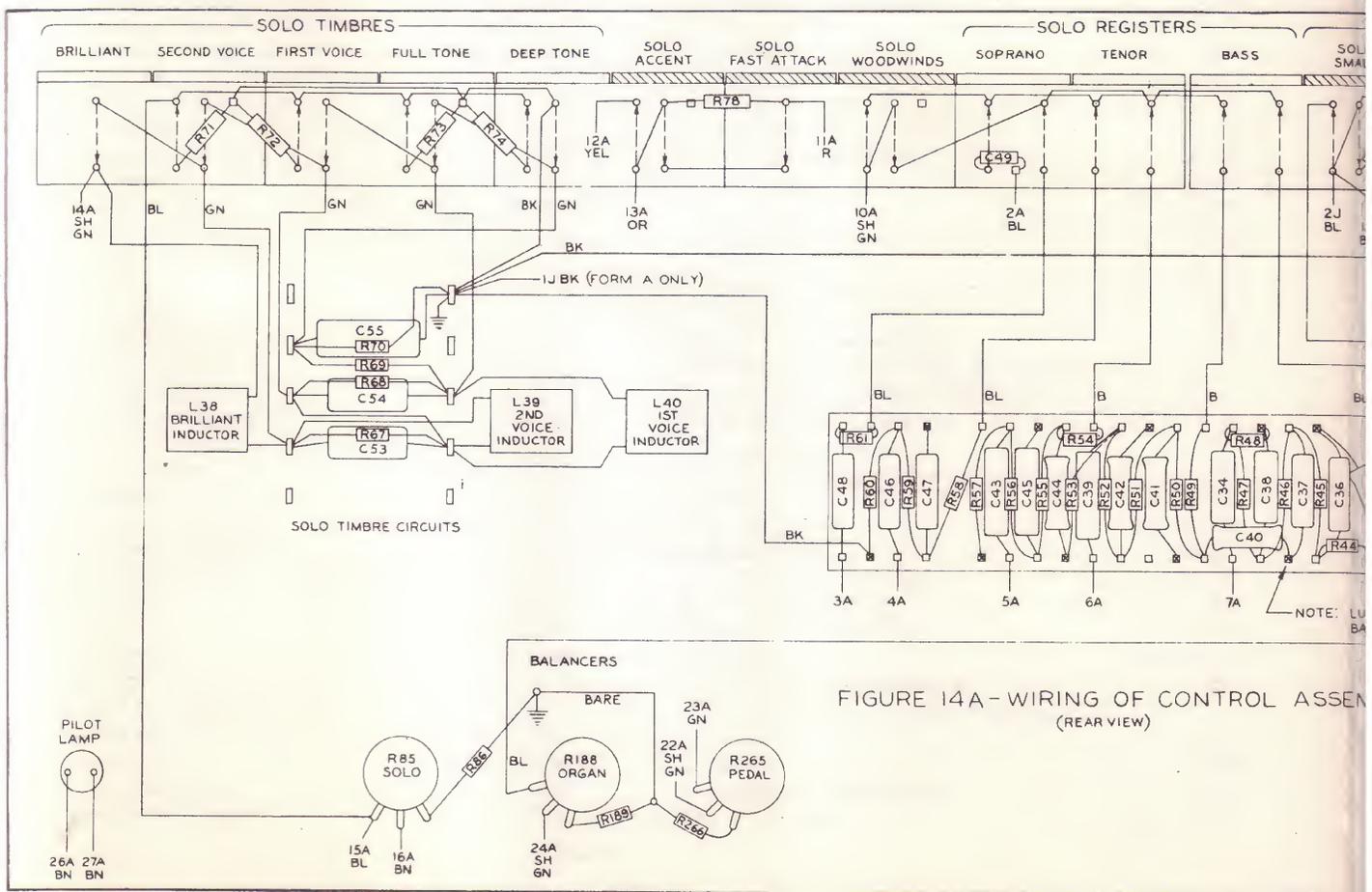
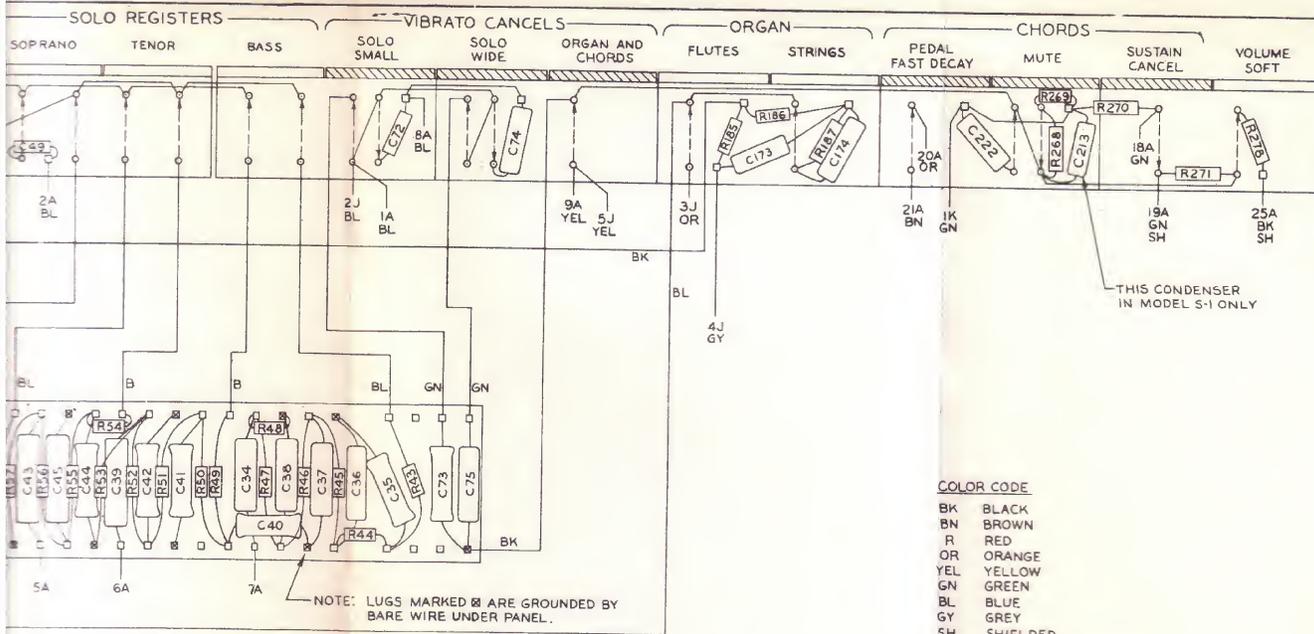


FIGURE 14A - WIRING OF CONTROL ASSEM (REAR VIEW)

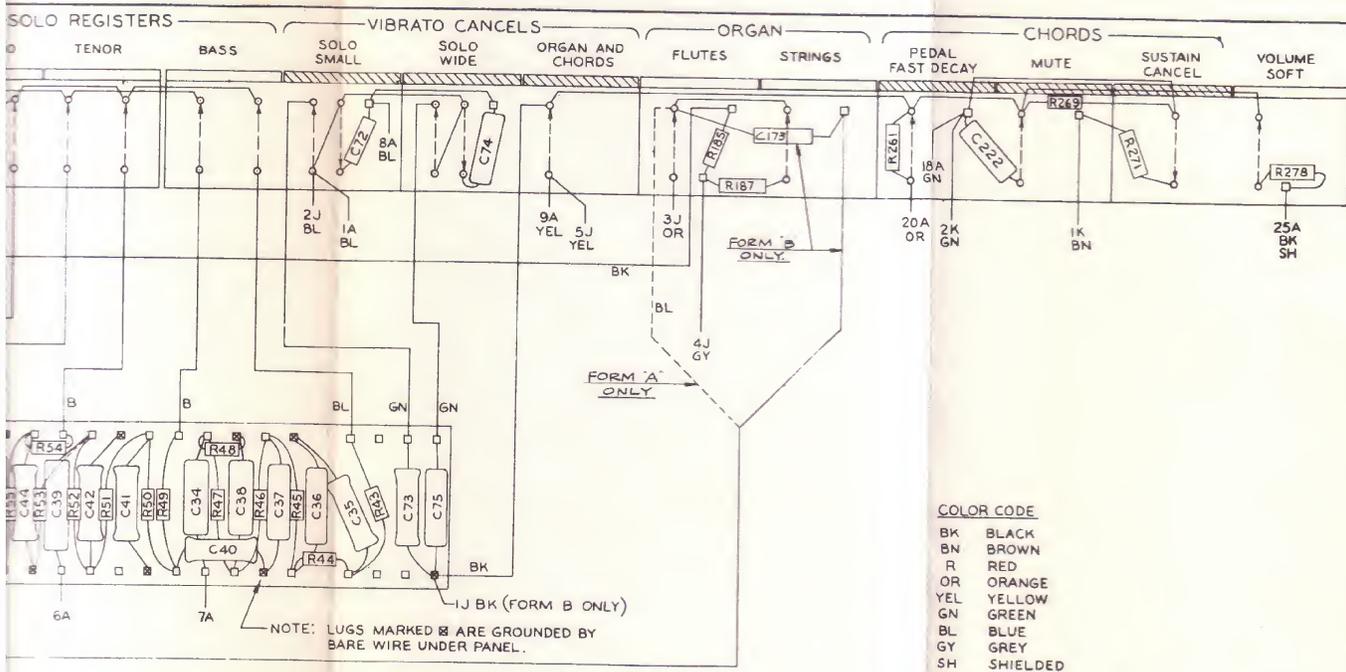
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WIRING OF CONTROL ASSEMBLY - MODEL S AND S-1  
(REAR VIEW)

- COLOR CODE**
- BK BLACK
  - BN BROWN
  - R RED
  - OR ORANGE
  - YEL YELLOW
  - GN GREEN
  - BL BLUE
  - GY GREY
  - SH SHIELDED

SEE FIGURE 7 FOR MEANING OF WIRE CODE LETTERS



WIRING OF CONTROL ASSEMBLY - MODEL S-4  
(REAR VIEW)

- COLOR CODE**
- BK BLACK
  - BN BROWN
  - R RED
  - OR ORANGE
  - YEL YELLOW
  - GN GREEN
  - BL BLUE
  - GY GREY
  - SH SHIELDED

SEE FIGURE 7 FOR MEANING OF WIRE CODE LETTERS

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