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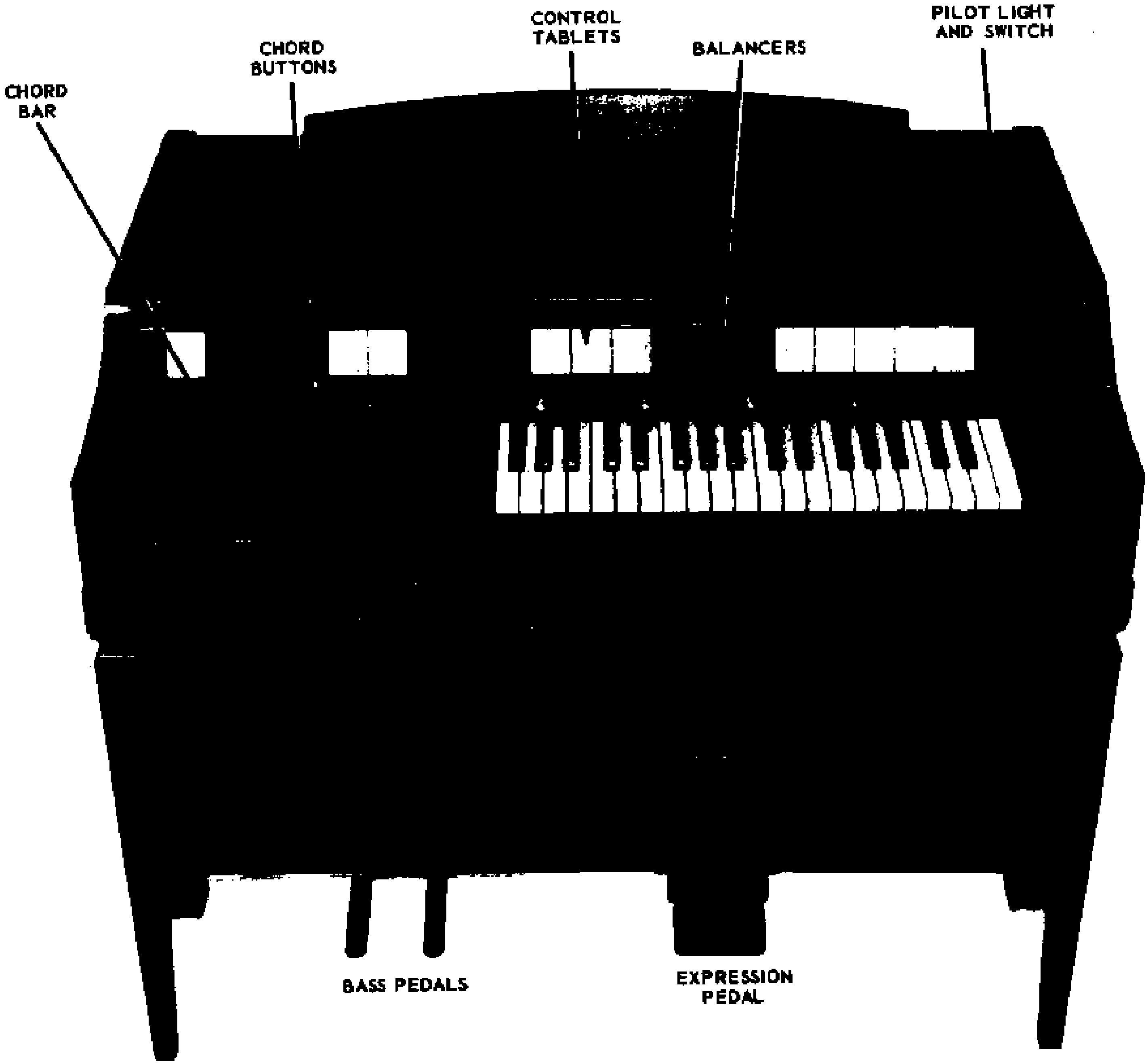



TYPICAL S100 SERIES INSTRUMENT
FIGURE 1 - FRONT VIEW

## HAMMOND CHORD ORGAN SERIES S-100

## 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 control to regulate the volume of the entire instrument. A fourth control to the left of the balancers controls the amount of reverberation signal.

## INSTALLATION AND MAINTENANCE

To install the Chord Organ it is necessary only 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.

## 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 $D^b$ (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.

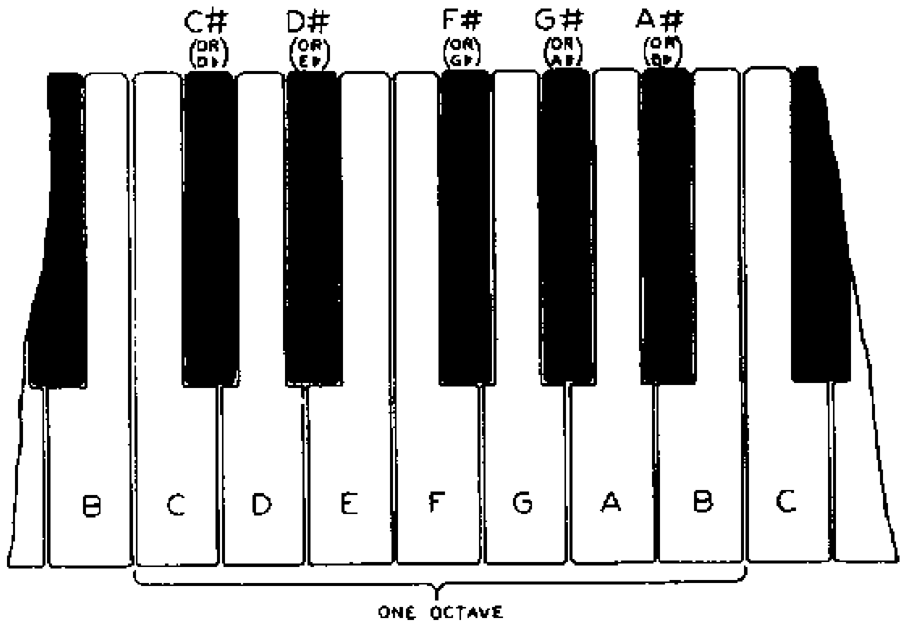



FIGURE 2 - ARRANGEMENT OF PLAYING KEYS IN AN OCTAVE

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, Percussion, and Sustain

"Attack" describes the promptness with which a note sounds after a key is pressed, and "decay" describes the rate at which it fades away. "Percussion" describes a note that sounds with fast attack and gradully fades away while the key is held down, such as a piano note or chime. "Sustained" notes do not fade away but remain at constant loudness. "Chord Sustain" refers to the effect of a chord sounding softly while the chord bar is not held down.

## 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, move the "on-off" switch, located on the right side, up. A pilot light indicates when the instrument is on. To turn off, move switch down.

## 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 Pedal, Balancers and Reverberation Control

The Expression Pedal serves to regulate the volume of the entire instrument.

The three Balancers are used to adjust the volume of tone produced by the "pedal", "organ", and "solo" divisions. A fourth knob to the left of the balancers controls the relative volume of the reverberation.

## 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

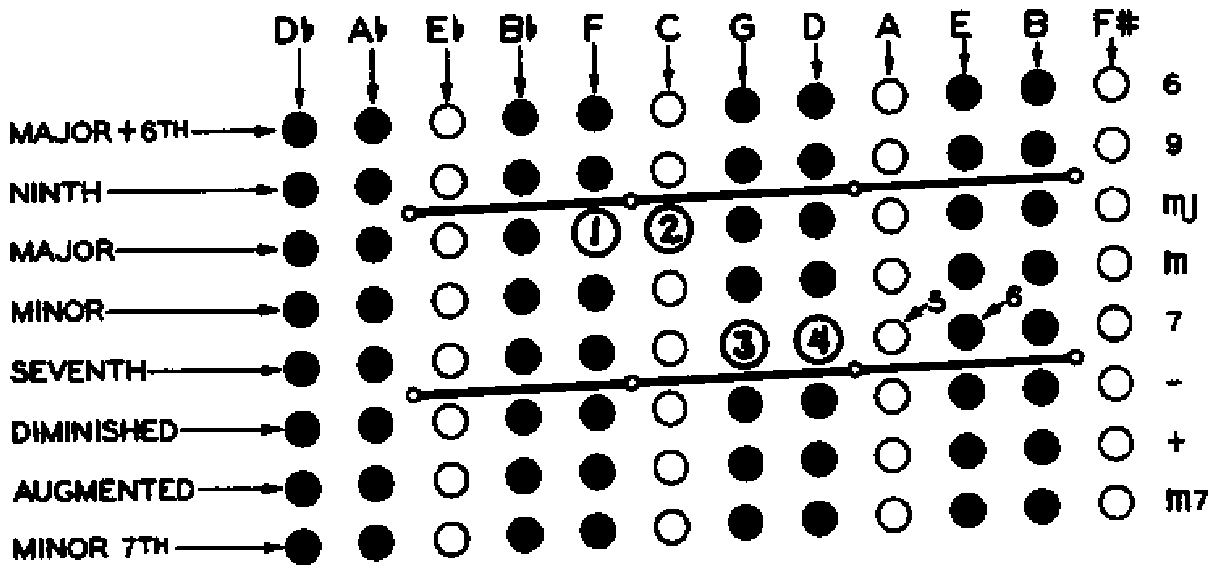



FIGURE 3 - CHORD BUTTONS, SHOWING BUTTON CAPS IN POSITION FOR LOCATING CHORDS IN KEY OF C

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, as well as at least one timbre control.

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 Percussion". 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 only "Solo Fast Attack" is used, the attack becomes very prompt and is useful for fast-moving melodies. When only "Solo Percussion" is used, the attack is fast and the note fades away slowly (while key is held down). When "Solo Fast Attack" is used with "Solo Percussion", the fading away becomes rapid. Any solo note will be percussive only if all keys are released before it is played.

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, as well as at least one solo register.

## 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 or emphasized 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 pedal before being reproduced by the loud speaker.

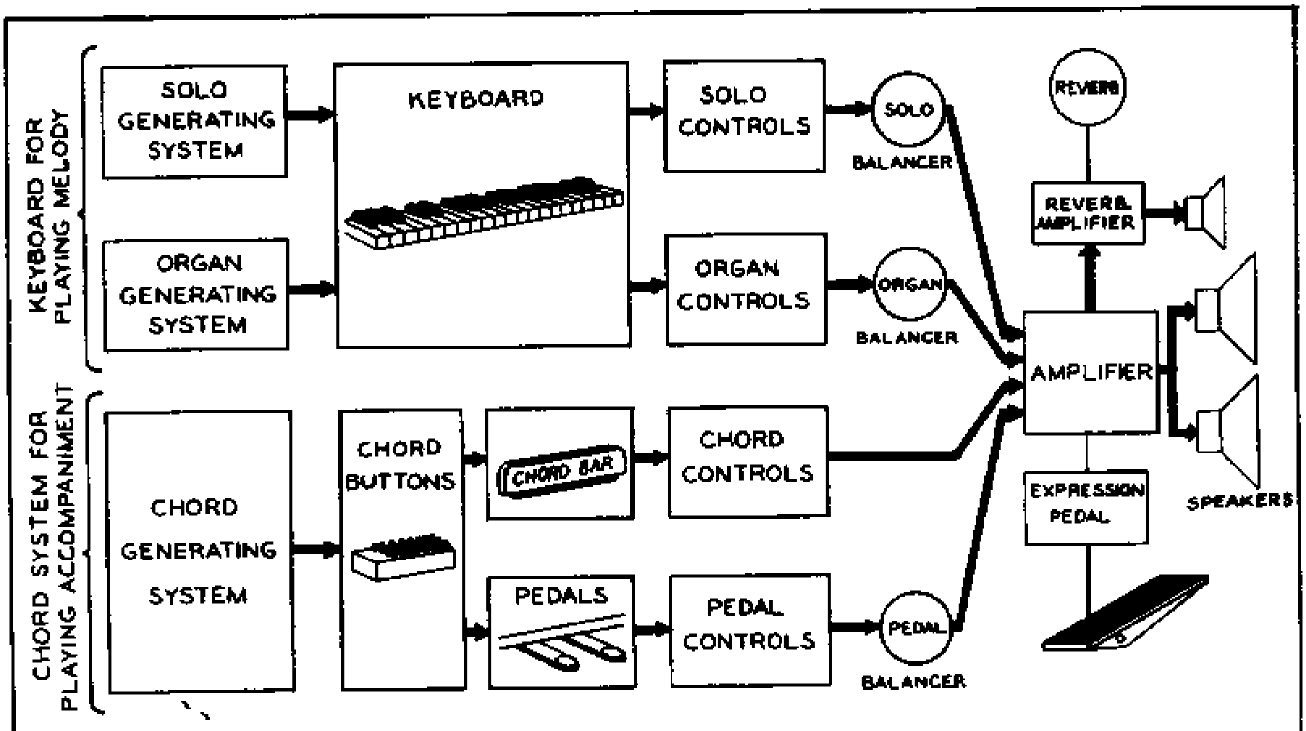



FIGURE 4 - SIMPLIFIED BLOCK DIAGRAM

## 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 20, shows all circuits in detail. It will be found helpful also to refer to the wiring diagram, figure 21, 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 20. 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 20), 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 only of 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 20) tune the entire solo division as a unit by placing small condensers across the tuned circuit. Several small trimmer condensers may be wired in parallel with the main tuning condenser (left end of figure 20) 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 of the triodes 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 about +5 volts while their cathodes are held at about +37 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 Percussion" 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.

With the "Fast Attack" tablet on, C58 is disconnected and the attack is comparatively fast.

## "Percussion"

When the "Solo Percussion" tablet is on and a key is pressed, the control tubes are turned on by removing the cutoff voltage from their cathodes and the note first sounds loudly; then a charging condenser in the control tube grid circuit causes the signal to fade away at a predetermined rate.

This percussion circuit operates as follows: With no key pressed, the control tube is cut off because its grids are at about +5 volts and its cathodes are at about +37 volts. When a key is pressed, the +37 volts on the cathodes drops to about +5 volts and the control tubes conduct until C60 charges through R75 to about -30 volts which cuts them off. The time it takes C60 to reach this cutoff voltage is the percussion decay time. The note no longer sounds, and it will not sound again until after all keys are released. When all keys are released, the control tube cathodes quickly rise to +37 volts (cutoff). Simultaneously the control tube grids return to +5 volts.

Slow decay can be changed to fast decay by pressing the tablet marked "Solo Fast Attack (also Fast Decay with Solo Percussion)," which adds R76 in parallel with R75 and thus reduces the time for C60 and the control tube grids to reach cutoff.

The percussion circuit uses three diodes in one tube. One is a rectifier for a separate ungrounded 30 volt supply. The other two are clamp and switch diodes which maintain a constant +5 volt potential on the control tube grids until a key is pressed.

When a key is pressed the plates of the clamp and switch diodes are reduced to -30 volts, making them both non-conducting and leaving C60 free to charge as described above.

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 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 6 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

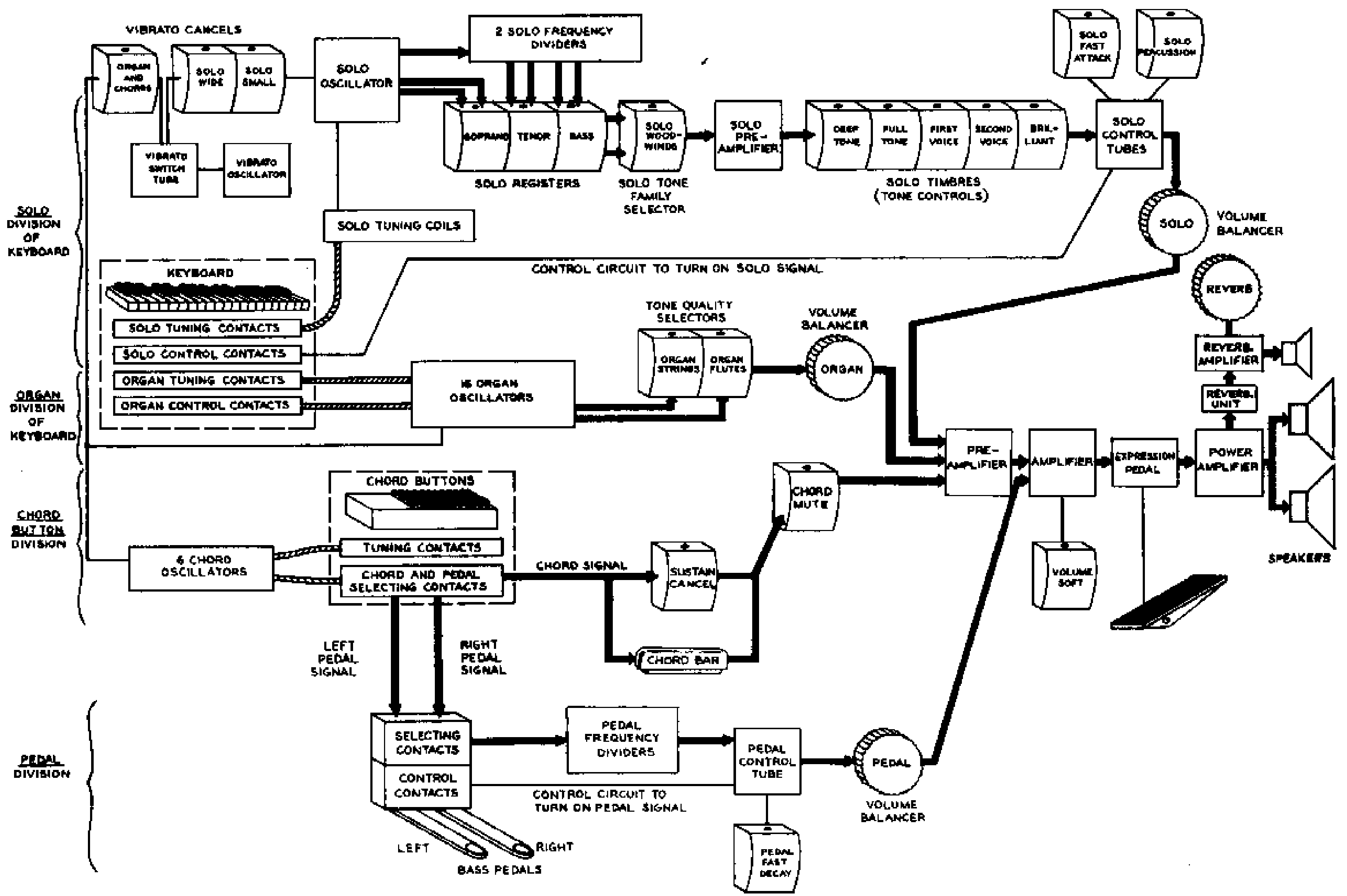



FIGURE 5 - COMPLETE BLOCK DIAGRAM - MODEL S-100

signal busbar carries the chord signal to the preamplifier; 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 preamplifier tube. When the "Mute" control is on, it makes the tone more mellow by shunting a condenser across this signal line.

## Chord Bar and "Sustain Cancel"

When the chord bar is depressed, the chord signal passes directly to the preamplifier. When the chord bar is not depressed, part of the chord signal reaches the preamplifier through R271, resulting in the chord tones sounding faintly, 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, the bypass circuit is disconnected and the chord tones sound only when the chord bar is pressed.

## 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 6).

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.

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

Figure 6 -- Chord Button Chart

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

When the pedal keying wire is connected to +32 volts by pressing a pedal, it removes the bias from the pedal control tube 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.

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.

## Swell or Expression Control Unit

After passing through a stage of amplification the signal is sent to the swell control unit. With the pedal in "loud" position the plate signal of V20 goes directly to V29, while in the "soft" position it goes through a tone-compensated attenuating network.

## Reverberation

To produce a reverberation effect within the chord organ a signal is taken from the "direct speaker" through an attenuation network that drives the Hammond type 4 reverberation unit. From its output the signal is directed through a three stage amplifier V27, V28 which drives the reverberation speaker. A control on the panel permits individual selection as to balance.

## Power Output Stage

Tube V29(2) is a class A amplifier with variable cathode bias, due to inverse feed back from the output transformer, that drives V29(1) a common-cathode-impedance phase inverter which in trun drives the two output tubes.

## 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 7, 8, and 9.

### 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; all the control tubes and amplifier tubes; reverberation amplifier and portions of the power supply.

This chassis is pivoted between the keyboard chassis blocks (figure 7). By removing two screws (see figure 7) it can be unfastened so that it will swing down (as shown in figure 8) to expose the components inside the chassis. The instrument can be operated with the generator in this position.

Figure 10, showing the outside of the chassis, identifies all external components, and figure 22 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 11 identifies the external components and figure 12 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.

### 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.

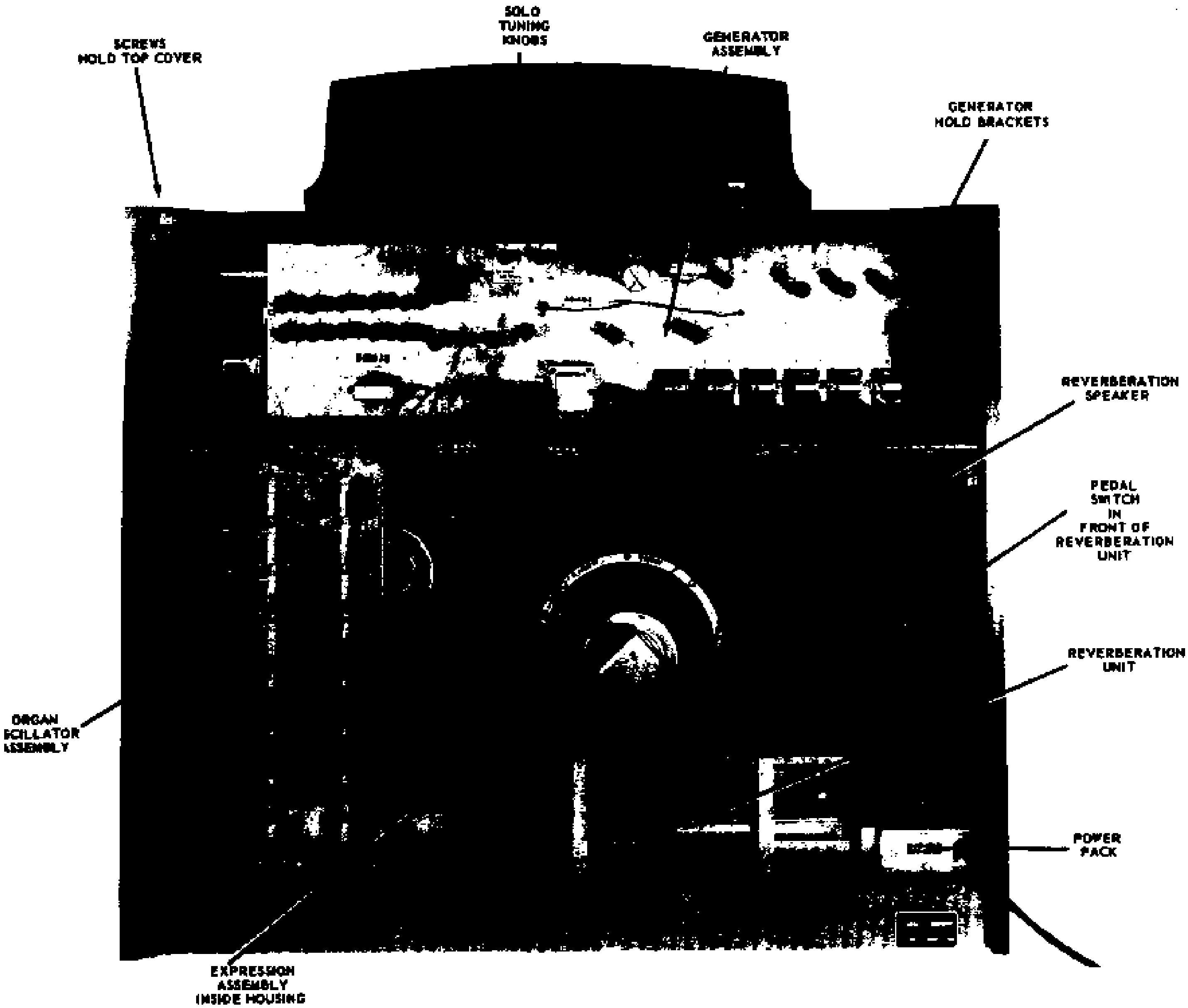



FIGURE 7 – BACK VIEW.

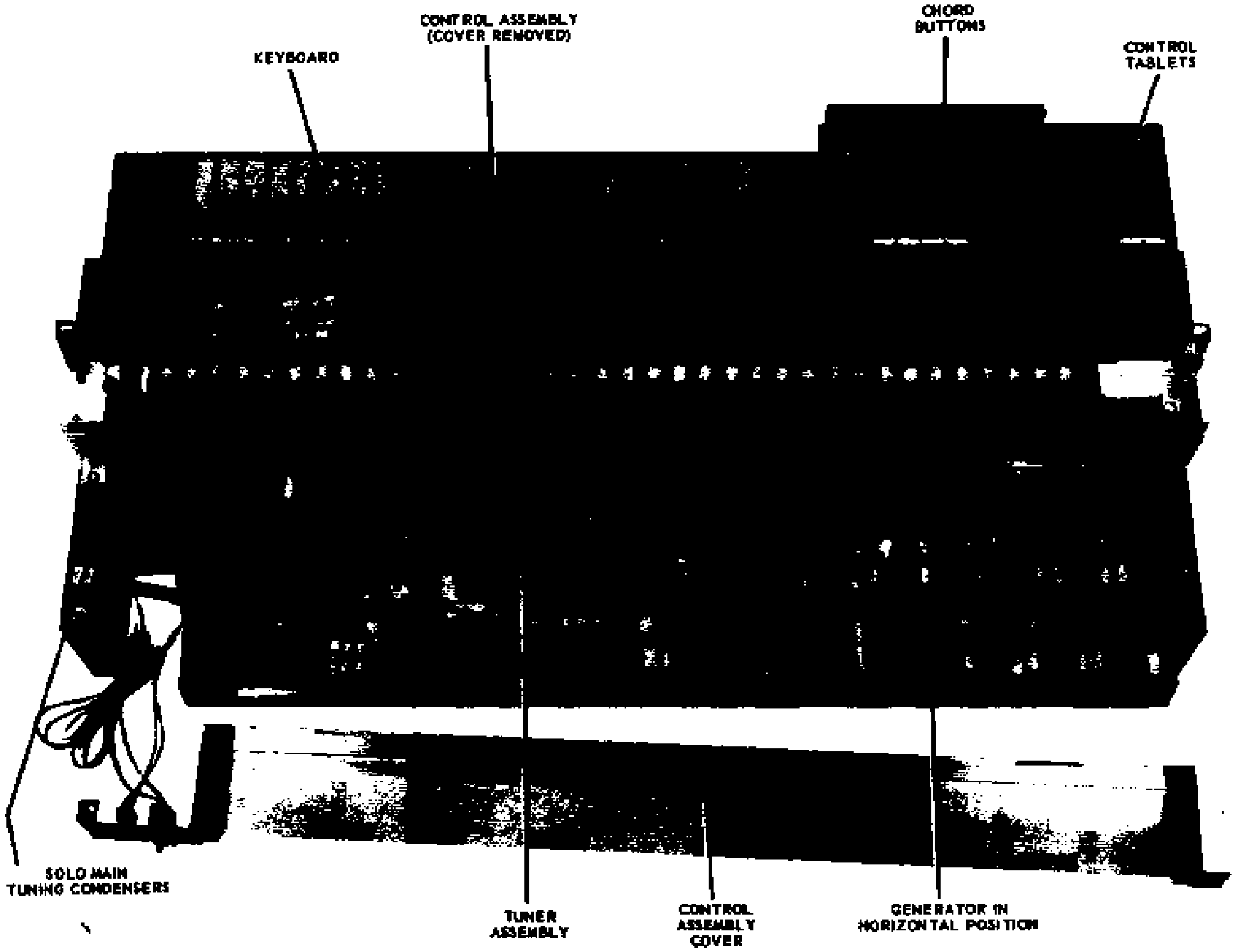



FIGURE 8 – GENERATOR, TUNER ASSEMBLY, AND CONTROL ASSEMBLY EXPOSED

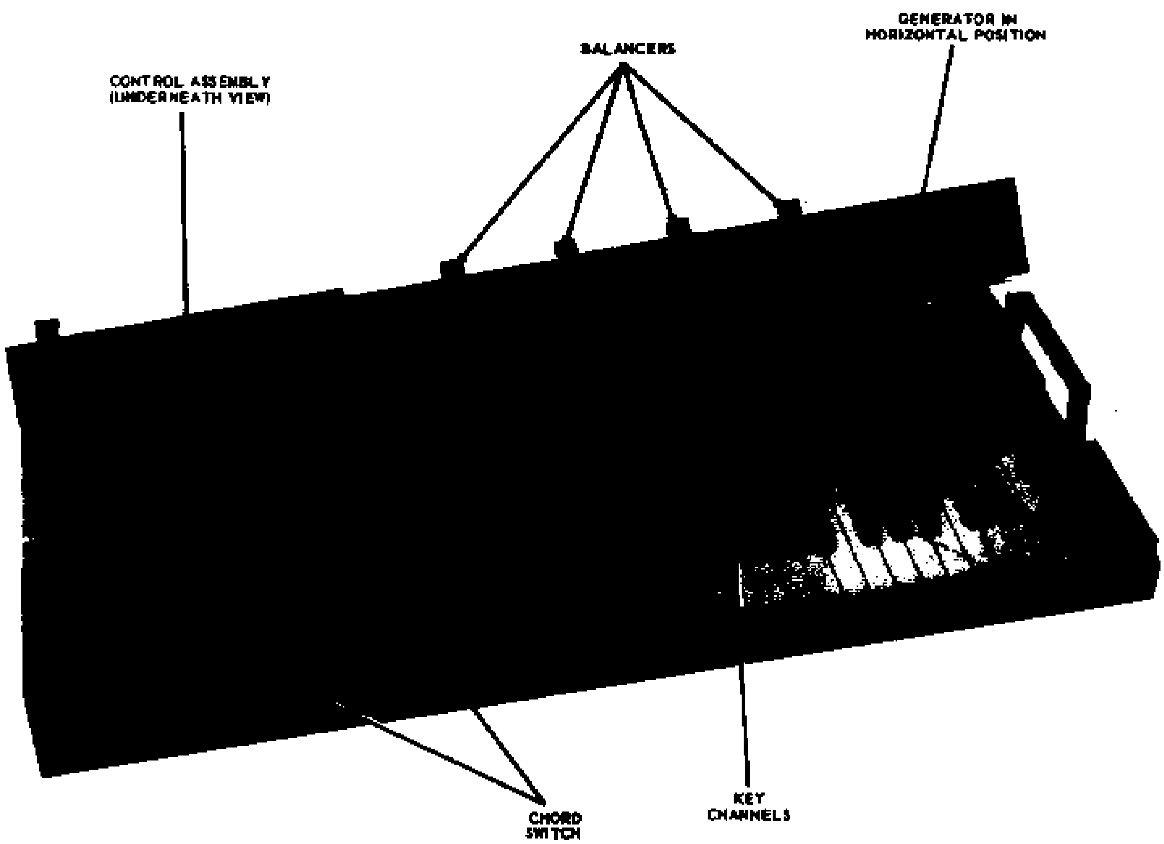



FIGURE 9 – KEYBOARD, CHORD SWITCH, AND BALANCERS EXPOSED

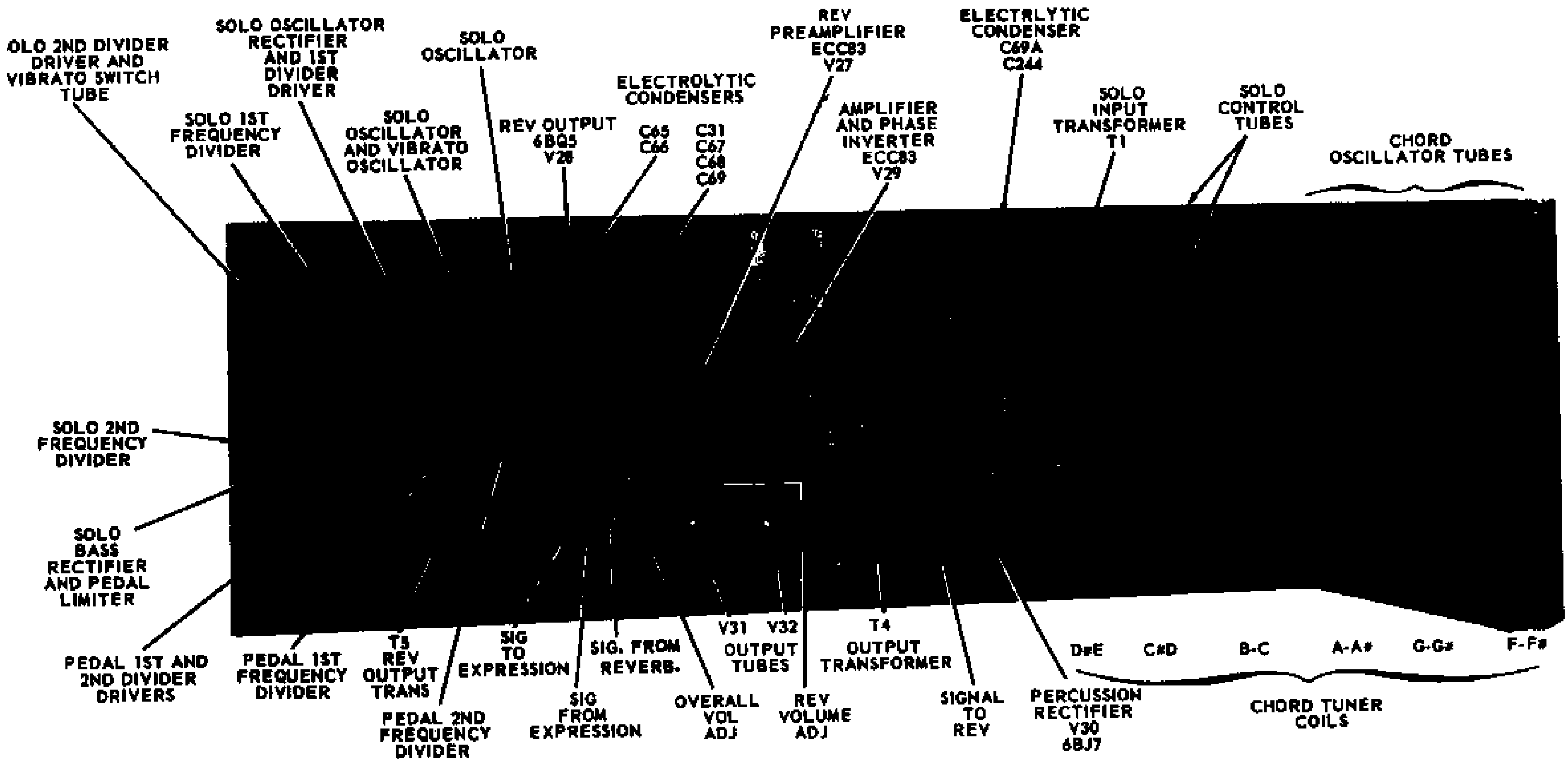



FIGURE 10 GENERATOR – MODEL S100 SERIES

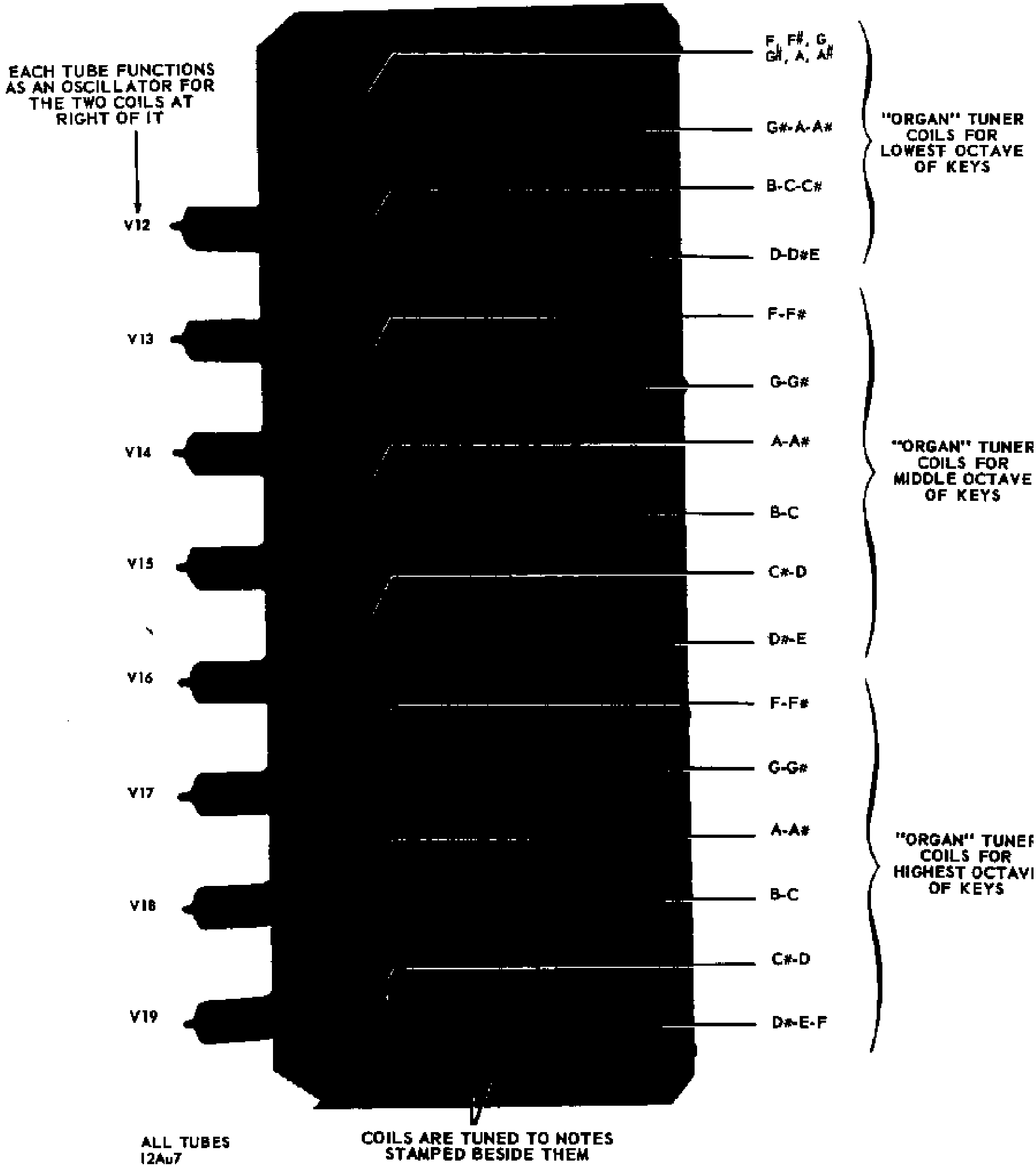



FIGURE 11 – ORGAN OSCILLATOR ASSEMBLY

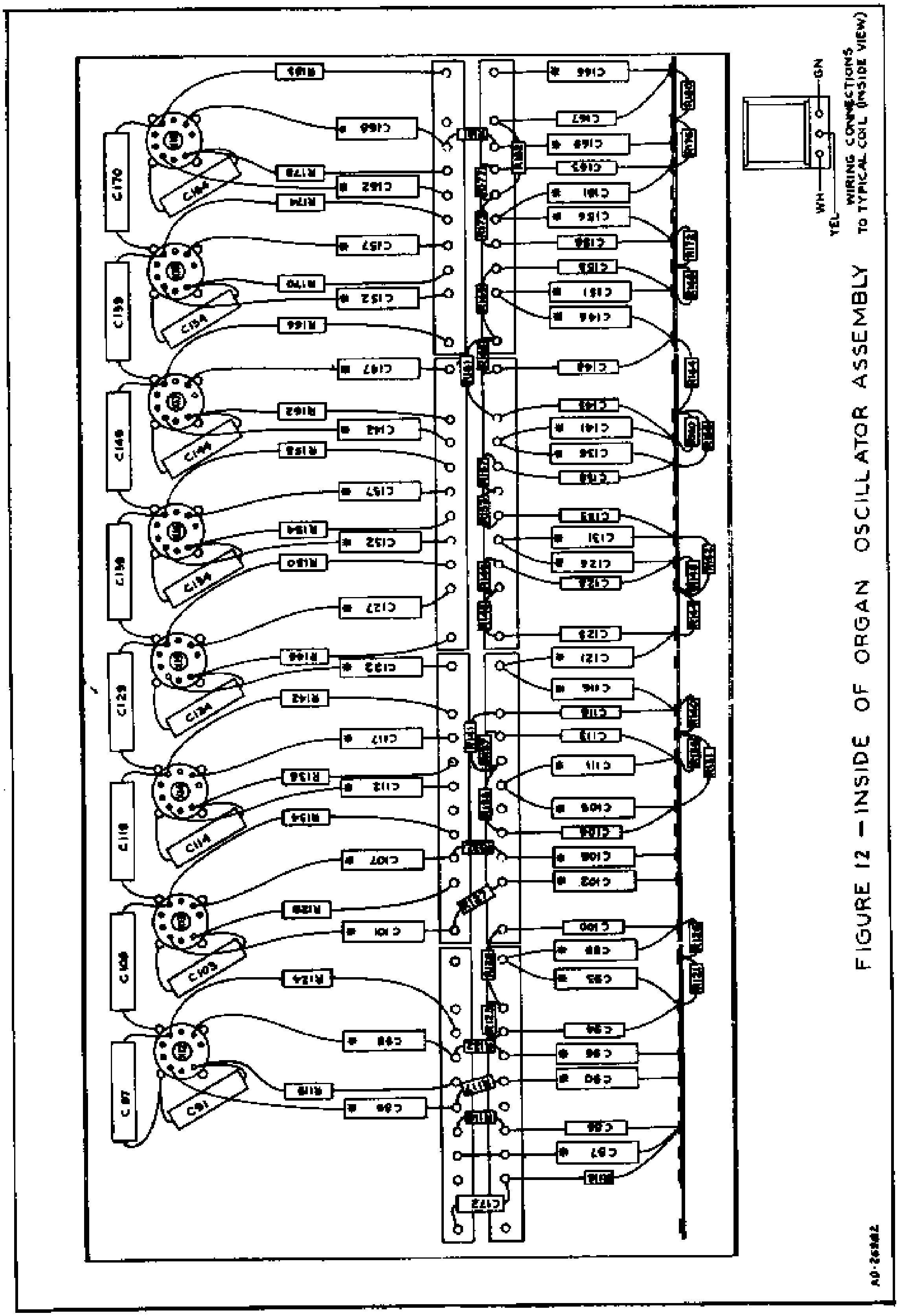



FIGURE 12 – INSIDE OF ORGAN OSCILLATOR ASSEMBLY


FIGURE 13 – UNDERSIDE OF KEYBOARD

## 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 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 Pedal Assembly

The foot operated expression pedal assembly is attached to the lower part of the console. A variable resistor operated by a gear and sector gear assembly controls the volume of all divisions of the organ.

## Pedals and Pedal Switch

The two bass pedals are attached to the underside of the wood case, and bakelite strips extending up from the pedals operate contact springs in the pedal switch. Figure 15 shows details of the pedal switch.

## Power Pack

The power pack includes only the power transformer, the rectifier tube, and one resistor. Figure 10 shows its internal connections.

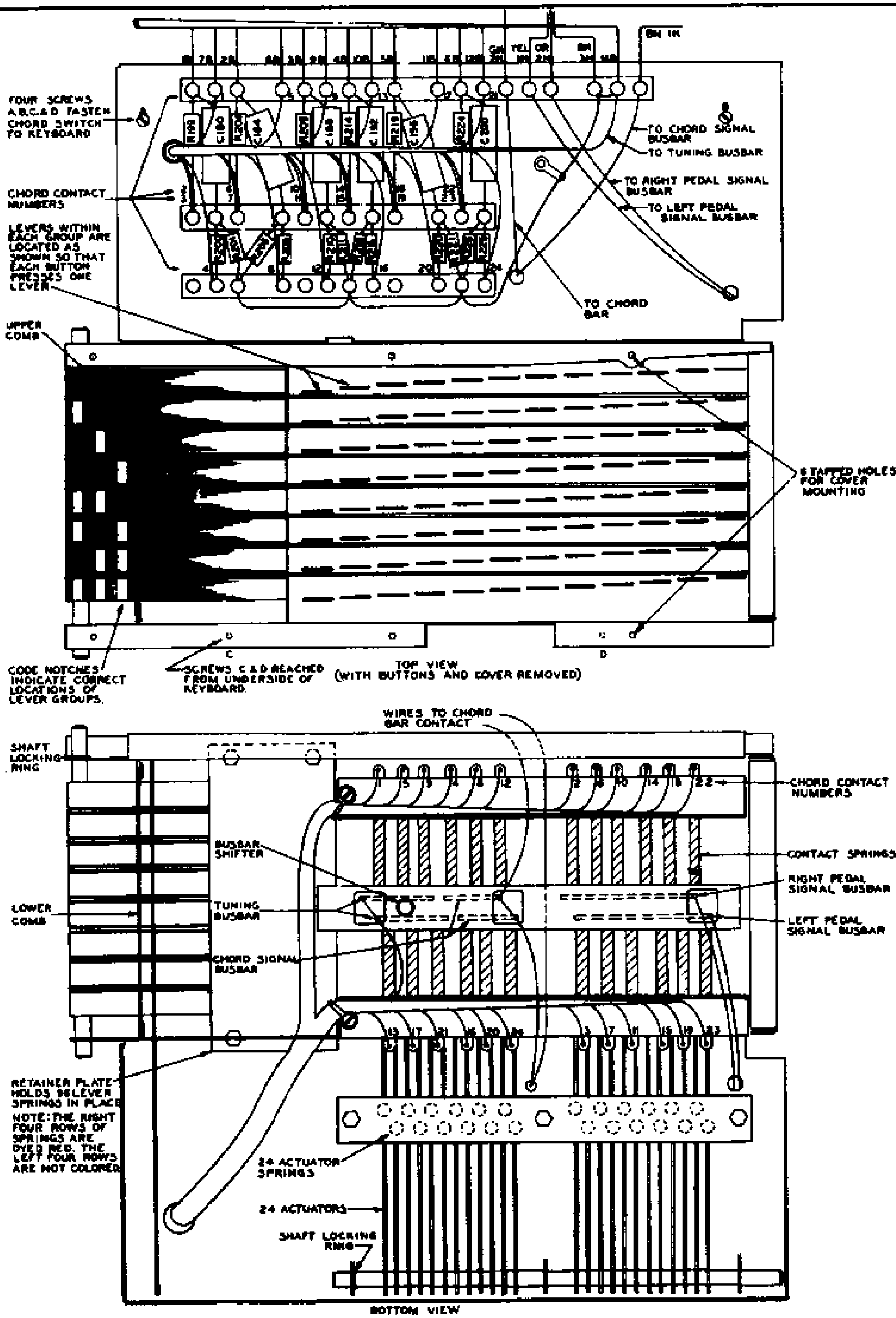



FIGURE 14 – CHORD BUTTON SWITCH

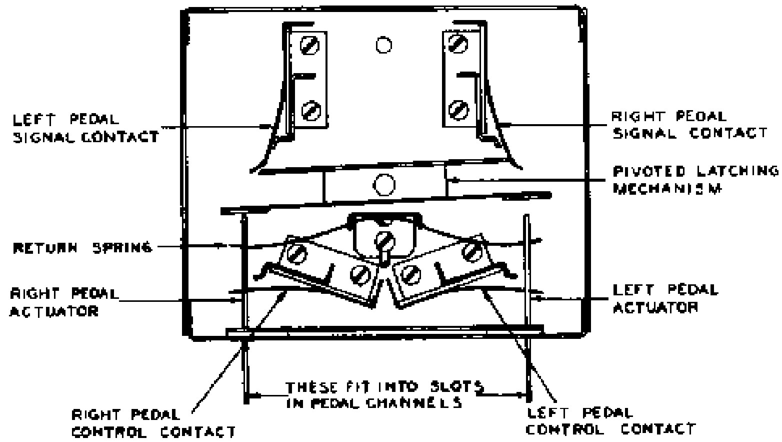



FIGURE 15 – PEDAL SWITCH

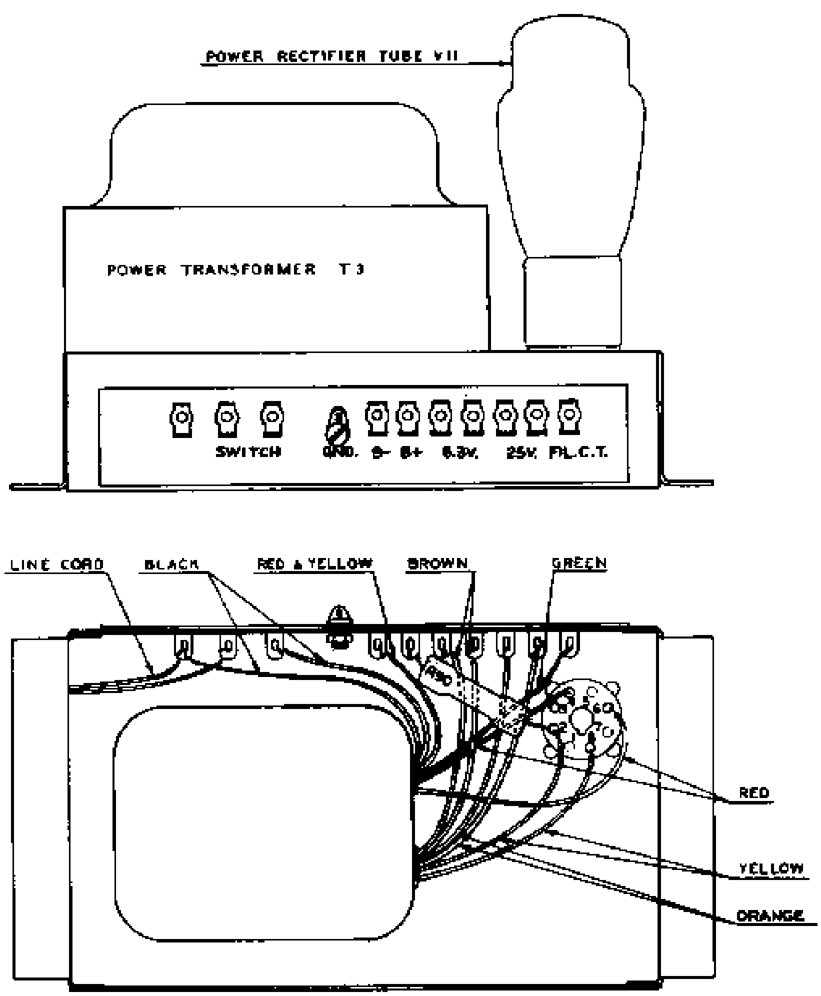



FIGURE 16 – POWER PACK

05-2029

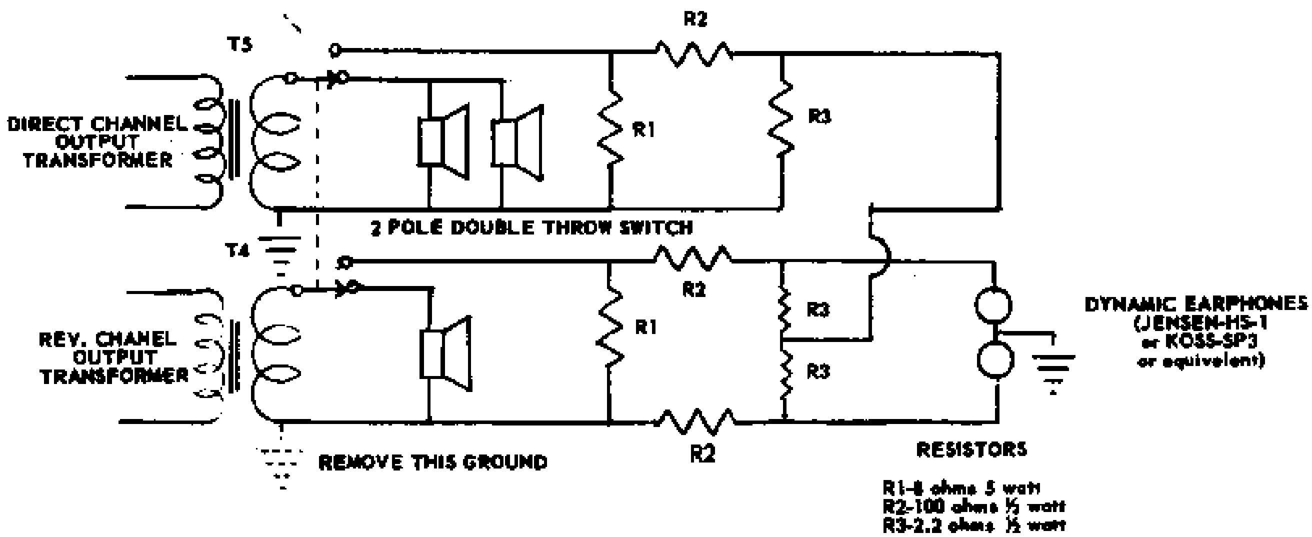
## SPECIAL EQUIPMENT

Record Player, Radio or Microphone

A record player, radio or microphone will play through and with the organ if these items are equipped with a preamplifier having an output voltage of about 1 to 1-1/2 volts. Attachment is made by first removing the blue phono type plug that is approximately in the center of the upper chassis and inserting a "Y" connector (Switchcrafte #330 FI) at this point. This item will simultaneously permit reinserting the removed plug and receive the phono plug from the preamplifier mentioned above. If the output impedance of the preamplifier is less than 10,000 ohms, insert a 10,000 ohm 1 watt resistor in series with the preamplifier output line. This will prevent loss of organ volume. The preamplifier must have its own volume control as the organ swell will not effect these items.

Earphones

The schematic below shows how a dynamic stereo headset can be connected to the organ. It will provide a very delightful stereo reverberation effect, and it can also be used for practicing without disturbing others (Jensen HS1 or Koss SP-3 headsets have been found to work satisfactory). The only items required in addition to the resistors listed is a stereo headphone jack and a double pole double throw switch.




## 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. <u>Tubes and Other Electrical Components</u>

As in other electronic devices, the vacuum tubes are among the most likely causes of unsatisfactory operation. The tubes are all standard radio and television 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.

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. Many 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 have special capacity values 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.

All condensers in bakelite or white ceramic cases have a plastic film dielectric which is chosen because of its exceptional resistance to humidity. If it becomes necessary to replace one, we recommend that you order it from the factory.

## 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. The two shifters are visible in figure 13. Turn the slotted stud about two turns in either direction. This will slide the busbars endwise so that they present a clean contact surface. In extreme cases, it may be necessary to hold down the key or button while turning the stud, in order to wipe the contact clean.

## 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. Tuning Instructions

The Chord Organ has been accurately tuned before leaving the factory and can be expected to remain in tune indefinitely under normal circumstances. However, after long use under extremely adverse humidity conditions, it is possible that some notes may not be exactly in tune with each other. Before concluding that retuning is necessary, be absolutely sure that the notes are actually far enough out of tune to make them unsatisfactory. Remember that small differences in tuning are highly desirable because they add a "chorus effect" which gives added richness to the tone. This "chorus effect" accounts for the tonal beauty of large choirs of singing voices or of many violins playing in unison.

4A. Adjustment of Solo Tuning

The Chord Organ may be tuned in several different ways. The simplest tuning may be done by merely turning the solo tuning knobs which are located inside at the back on the generator assembly (see Figure 10). These knobs tune all solo notes up or down simultaneously.

The tuning knobs should first be set in their "last setting" positions, as marked in the space provided on the tuning instruction plate under the tuning knobs. In case they had been moved by accident, it may be found that no tuning is required.

To adjust the solo tuning, set up the following registration of stops (first setting the balancers so that the white dots are straight up).

Now press the middle A# key on the keyboard (eighth black key from the left end). When this key is pressed, two different notes will be heard together. They are close together, and the object is to bring them exactly together so they sound like one good note. As they get closer, a "beating" sound will be heard. The beats get slower and slower as the two notes get closer and closer, and stop completely when perfectly tuned. Merely find the position where the beat rate is the slowest.

In tuning, first turn the "SMALL STEPS" control to position 4. Next turn the "BIG STEPS" control to the position which best tunes the two notes to each other. Then turn the "SMALL STEPS" control until the beat rate is the slowest. This is the position for best tuning. If the "SMALL STEPS" control comes up to one end, it will be necessary to turn the "BIG STEPS" control one step in the same direction and then readjust the "SMALL STEPS" control. Six steps on the "SMALL STEPS" control are approximately equal to one step on the "BIG STEPS" control.

The player may sometimes wish to introduce a "chorus effect" in the tones of the Chord Organ. This can easily be done by turning the "SMALL STEPS" knob to the next higher marking.

After following the above procedure check the tuning on other notes of the keyboard. Some notes may tune with the "SMALL STEPS" tuning knob set one or two steps higher or lower than the setting for the middle A# key.

This is of no consequence because one step on the "SMALL STEPS" knob changes the tuning by only one twelfth of a semitone. This change in pitch is so small that it can be detected only by the "beats" which can be heard when the tone is sounded along with another note. Tuning the Chord Organ so there are no beats on any key would make the instrument less pleasing.

5. Tuning Individual Organ and Chord Notes

If, after tuning as above described, it is considered that some notes are far enough out of tune to be unsatisfactory, the individual notes of the keyboard may be tuned by adjusting the coils located in the organ oscillator assembly as shown in Fig. 11. As here shown, each coil is marked with the corresponding keyboard note with which it should be tuned. Note that there are many more notes on the keyboard than there are coils. Each coil simultaneously tunes at least two adjacent notes on the keyboard and some coils tune three adjacent notes. Thus, if there is any particular note (or group of adjacent notes) on the keyboard which seem to be out of tune, you can determine which coil to tune by using Fig. 11. Steps 1, 2, 3, and 4 below explain how to tune the keyboard notes.

All the notes produced by the Chord Buttons and pedals are tuned by adjustment of the six coils in the generator assembly. Steps 5, 6, 7 and 8 explain how these are tuned.

STEP 1. Adjust tuning knobs as described above. This consists in finding the setting of the tuning knobs which gives the slowest rate of beats on Middle A# as explained previously.

Note the readings of the two knobs (for instance "2 - 3") and remember this number or write it down, if it is different from "last setting" on the tuning plate.

The object is now to tune various notes, as described below, so that each one is best on this same setting, or a setting which is one small step higher or lower.

STEP 2. Press the Lowest F# key on the keyboard and wedge it down with a pencil at the back of the key so that the note will continue to sound. Hold the expression control in a position to secure adequate volume (for instance, by placing a chair against it). If the "beats" are very slow, this coil does not require tuning adjustment.

If in doubt, turn the Small Steps knob one step either way. If two or more steps are required in either direction to find the best tuning, then that particular note needs tuning. Otherwise not.

If the note is to be tuned, turn the knob back to the position you have noted and observe which direction was required to do this. That is the direction in which the note will be tuned as described hereafter.

STEP 3. If the tuning is not satisfactory, it is remedied by an adjustment of the position of the iron in the "LO F#" coil in the organ oscillator assembly. Coils are marked with corresponding keyboard notes.

The position of the iron laminations in the coils is easily adjusted with great accuracy, provided the construction of these units is understood. BEFORE DOING ANY ADJUSTING, HOWEVER, BE SURE THAT THE TUNING KNOBS ARE SET AT THE POSITIONS PREVIOUSLY NOTED IN STEP 1.

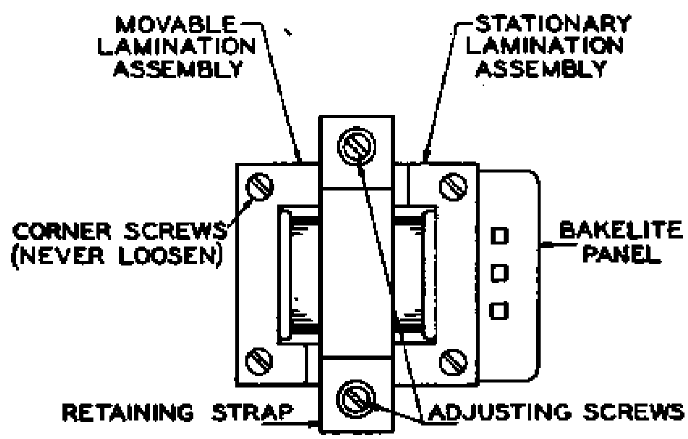



**FIGURE 17**

Figure 17 shows a typical coil and lamination assembly in the organ oscillator assembly. The movable lamination assembly is to the left, and the stationary assembly is to the right. The two assemblies are held in place by a retaining strap, secured by the two adjustment screws.

Never loosen the corner screws on any coil.

In order to tune, first loosen the two adjustment screws holding the strap by two or three turns, but not more. A plain washer and a strong split steel lockwasher are located under the head of each screw. Loosen the two screws to the point where each lock-washer is partly open but still exerts a moderate pressure to hold the assembly in place. In this condition the laminations cannot readily be moved with the fingers, but may be tapped with a small hammer or similar hard object. Each small tap moves the movable assembly by an invisibly small amount which is nevertheless entirely adequate to change the tuning, and makes very precise tuning possible.

To lower the pitch, that is to make the note more flat, tap on the left end of the laminations, as shown in Figure 18.

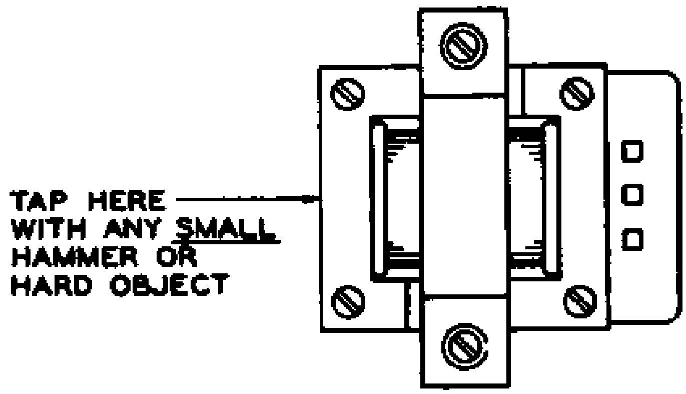



FIGURE 18

If the note being tuned was too sharp, each small tap will make the beats slower. When the beats stop, tighten the screws gently, but only to the point which closes the lock-washers. It is unnecessary to tighten the screws more than this, and tightening the screws too much may disturb the tuning.

If the note is too flat, the object is then to tap the movable assembly away. This is done with a screw driver, as shown in Figure 19.

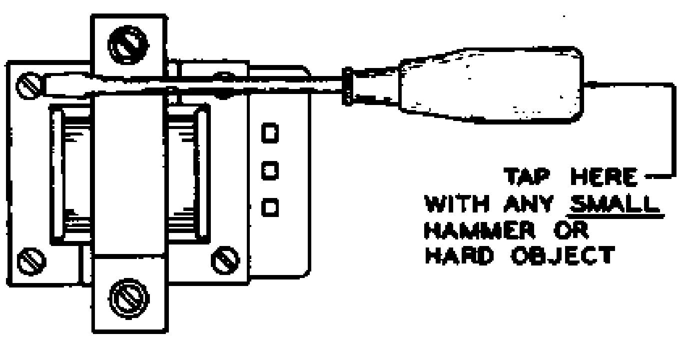



FIGURE 19

Hold a screw driver against the side of one of the left corner screws, tap gently on the end of the handle of the screw driver, and listen to the beat rate. Do not use the same corner screw all the time, but alternate between the two left screws. Tapping on the screw driver in this position makes the note sharper. Very little practice is necessary to find out how to tune in this manner.

Note: It is important not to make the mistake of tapping a coil which is not associated with the note to be tuned. To avoid this mistake, it is a good idea to touch the end of a screw driver to the MIDDLE terminal on the bakelite panel, at the same time touching the side of the screw driver to the iron laminations. If this is the correct coil, a sudden reduction in volume will be heard. HOWEVER, BE SURE TO TOUCH ONLY THE CENTER TERMINAL.

STEP 4. Repeat STEP 3 for any other coils which require tuning in the organ section.

Do NOT adjust the "Mid A#" coil, which is marked "TUNING STANDARD". (It does not need adjustment because it is the coil to which the middle A# note was tuned in STEP 1.)

STEP 5. Set up the following registration:

STEP 6. Press the middle F# key on the keyboard and wedge it down with a pencil at the back of the key so that the note will continue to sound. Hold the expression control in a position to secure adequate volume. Now remove the tuning pin from its clip on the generator assembly and insert it into the center hole on the bakelite panel of the coil marked F# (see Figure 10.) The added tone which is heard is one of those used for the Chord Buttons. If the "beats" are very slow, this coil does not require tuning adjustment.

STEP 7. If the notes are not in tune, the F# coil is to be tuned by the same procedure that was used in STEP 3 for tuning the coils in the organ oscillator assembly. The adjustment is the same except that the coils on the generator are vertical instead of horizontal.

STEP 8. Repeat STEP 7 for any of the other five chord oscillator coils which require tuning, using the middle G#, A#, C, D, and E notes on the keyboard.

6. Tuning of Individual Solo Notes

The solo tuning system is particularly stable in regard to the musical interval between notes. 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. A note generally requires retuning of the "Small Stops" 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 oscillator 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 preset 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 set up the following registration.

(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 21 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.

(j) Retune organ and chord section as outlined in paragraph 4 and 5.

Note: A Chord Organ Tuning Standard may be used instead of a Hammond Organ. Contact the Service Department of the Hammond Organ Company regarding this portable device.

## SPECIFIC SERVICE SUGGESTIONS

The interior of the Chord Organ may appear complex, but a careful study of the circuit diagram (figure 20) 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 20). 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 20). 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 V29.

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.

## SPECIFIC SERVICE SUGGESTIONS FOR SOLO DIVISION

10. All solo notes fail to play or are weak. One of the solo oscillator tubes (either V1 or half of V2) or the solo preamplifier tube (half of V8) may be defective.

11. Solo and organ and chord divisions fail to play or are weak. The preamplifier tube (half of V20) is probably defective.

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 15 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 whereever it occurs on either pedal or in the chords. (See chord chart, figure 6). 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).

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 6) 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.

| REFERENCE SYMBOL | CAPACITY MFD. | VOLTAGE | TYPE | REPLACEMENT PART NUMBER |
|---|---|---|---|---|
| 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 | | |
| C69A | 50 | 450 | Electrolytic | AO-22568-1 |
| C244 | 50 | 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 |

* 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 or coil becomes defective, it is preferable that the tuning coil and the two or three condensers associated with it be replaced with a matched set from the factory.

## RESISTORS

| REFERENCE SYMBOL | OHMS | TYPE | REPLACEMENT PART NUMBER |
|---|---|---|---|
| R85 | 8000 | Variable | AO-20293-35 |
| R90 | 30 | 5 watt power resistor | AO-18933-3 |
| R91 | 140 | 10 watt power resistor | AO-19124-9 |
| R103 | 150 | 10 watt power resistor | AO-19124-11 |
| R100 | 16,000 | 10 watt power resistor | AO-19124-108 |
| R115 | 1500 | 5 watt power resistor | AO-18933-50 |
| R188 | 25,000 | Variable | AO-20293-47 |
| R265 | 1 meg | Variable | AO-20293-37 |
| R311 | 500 K | Variable | AO-20293-48 |
| R286, R311A | 250 K | Variable | AO-20293-46 |
| R501 | 250 K | Variable (expression control) | AO-24286-0 |

## TRANSFORMERS

| REFERENCE SYMBOL | FUNCTION | REPLACEMENT PART NUMBER |
|---|---|---|
| T3 | Power (117V 60 cycles)<br>(117V 50-60 cycles)<br>(234V 50-60 cycles) | AO-27118-1<br>AO-27118-2<br>AO-27118-3 |
| T1 | Solo input | AO-24928-0 |
| T2 | Solo output | AO-24931-0 |
| T4 | Output | AO-24926-0 |
| T5 | Reverberation output | AO-27158-0 |

## PROCEDURE FOR REMOVING PARTS IN NEED OF REPAIR OR REPLACEMENT

Note: Some procedures that are listed below require the following preliminary steps.

1. Top must be removed (4 screws) and the back.
2. Some units require removal of angle brackets to which top is fastened to lay control panel on generator.
3. On some units to remove generator take out "C" washer at left end of generator and push generator assembly to right to unhook from other pivot.

To Replace Pilot Lamp

(a) Pull burned out bulb up, remove hood and replace with #12 (6.3V.25 AMP) miniature 2 pin bulb. Position hood on new bulb so light falls on back of jewel.

To Remove a Control Tablet or Namestrip

(a) Loosen outermost screw in bracket fastened to each end of generator and swing generator into horizontal position.

(b) Remove four screws at ends of tuner assembly (figure 8), slide tuner assembly back, lift off and carefully rest it on generator.

(c) Remove two screws at each end in base of control assembly.

(d) Remove six screws in top which also secure namestrip and loosen six screws in back of control assembly cover (figure 8) and lift off. To avoid scratching woodwork, slip a piece of cardboard in at each end of console. Prop up control and base so that ends of tablet assemblies are accessible.

(e) 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.

(f) Carefully hold tablets in alignment when sliding rod back.

(g) If more than one tablet is removed, be sure to replace all tablets in their original positions.

To Remove a Balancer Potentiometer

(a) Loosen outermost screw in bracket fastened to each end of generator and swing generator into horizintal position.

(b) Remove four screws in tuner assembly (figure 8), slide tuner assembly back, lift off and carefully rest it on generator.

(c) 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.

(d) Pull off balancer knob of control to be replaced after turning it to its minimum position (counterclockwise) and noting position of dot to insure replacement in correct position.

(e) Detach potentiometer by removing retaining nut, being careful not to scratch panel.

(f) Unsolder wires from faulty potentiometer and remove it. Refer to wiring diagram (figure 21) when reconnecting wires.

(g) Turn potentiometer to its minimum position (counterclockwise) to insure replacement of knob in correct position.

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) Loosen outermost screw in bracket fastened to each end of generator and swing generator down into horizontal position.

(b) Remove four screws at ends of tuner assembly (figure 8), slide tuner assembly back, lift off and carefully rest it on generator.

(c) 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.

(d) Unsolder cable and wires from terminal strip at rear of chord switch. Refer to wiring diagram (figure 21) to reconnect cable and wires.

(e) Remove four screws fastening chord switch to keyboard (figure 14) and lift out chord switch.

(f) For access to coil springs, refer to figure 14.

To Remove Generator Assembly

(a) Loosen outermost screw in bracket fastened to each end of generator and swing generator down into horizontal position.

(b) Unsolder all external wires from generator terminal strip.

(c) 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 22 when reconnecting wires.

To Remove On-Off Switch

(a) Unsolder two black wires from "switch" terminals on power pack (figure 16).

(b) Remove wires from cabling.

(c) Press retaining springs which secure switch to front panel and withdraw switch from front.

(d) To install new switch reverse above procedure.

To Remove a Playing Key

(a) Loosen outermost screw in bracket fastened to each end of generator and swing generator into horizontal position.

(b) Remove four screws in tuner assembly (figure 8), slide tuner assembly back, lift off and carefully rest it on generator.

(c) 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.

(d) 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.

(e) To remove a white key loosen its key mounting screw at rear of keyboard, and those of adjacent black keys. Unhook these keys from screws, push them back, and lift out white key.

## To Remove Keyboard

(a) Loosen outermost screw in bracket fastened to each end of generator and swing generator into horizontal position.

(b) Remove keyboard terminal strip cover by taking out eight screws (figure 13).

(c) Unsolder all wires from keyboard terminal strip, and unsolder solo tuner cable from solo tuner assembly. Refer to wiring diagram (figure 21) when resoldering these wires.

(d) Remove four screws holding tuner assembly (figure 8), slide tuner assembly back, and lift out.

(e) Unsolder cable and wires from terminal strip at rear of chord switch. Refer to wiring diagram (figure 21) when reconnecting cable and wires.

(f) Remove four screws fastening chord switch to keyboard (figure 14) and lift out chord switch.

(g) Unsolder pedal switch cable wires from generator terminal strip.

(h) Disconnect cable from power pack.

(i) Take out pivot screw at left end of generator and push generator assembly to left to unhook from other pivot.

(j) Remove two screws at each end in base of control assembly, carefully rest control assembly on generator, and lift out both assemblies.

(k) Remove two brackets (to which control assembly and tuner assembly were attached) from keyboard chassis mounting blocks by taking out four screws.

(l) Detach keyboard assembly from console by taking out four hexagonal bolts from keyboard chassis mounting blocks. These are accessible from rear at each end.

(m) Remove front rail screw and clip (figure 13) which fastens front rail to keyboard.

(n) Lift out keyboard assembly with chassis mounting blocks attached.

## To Remove Organ Oscillator Assembly

(a) Remove two 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. Back can be removed by taking out eight hex head screws.

(b) If necessary to disconnect completely, remove keyboard terminal strip cover by taking out eight screws (figure 13). Unsolder organ oscillator cabling from keyboard terminal strip. Refer to wiring diagram (figure 21) 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 12 when reconnecting wires.

To Remove Pedal Switch

(a) Place suitable pad on floor and tip console over on side farthest from pedals.

(b) Remove four bolts securing pedal assembly to console.

(c) Remove back cover of pedal switch by taking out four screws.

(d) Take out two screws fastening pedal switch to lower shelf and carefully lift out.

(e) Unsolder wires. See wiring diagram (figure 21) when reconnecting wires. Refer to figure 19 for details of contact assemblies.

(f) When replacing pedal switch, be sure to seat actuators (figure 15) into pedal slots carefully.

To Remove a Pedal

(a) Place suitable pad on floor and tip console over on side farthest from pedals.

(b) 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.

(c) Lift off pedal carefully to avoid damaging bakelite actuators in pedal switch.

To Remove and Make Repair or Adjustment to Swell Assembly

(a) Remove two leads with white and blue coded ends from generator assembly.

(b) Remove eight screws securing swell housing cover to baffle and shelf and remove housing.

(c) Remove four screws securing swell assembly to case work. Swell assembly is now loose and can be picked up and removed from back.

(d) Swell potentiometer can be removed at this time if necessary and will require an Allen 1/16" wrench.

# SERVICE MANUAL

# S-100

HAMMOND ORGAN