ABOUT THIS BOOK

Electronic Organ Handbook was written for all who have an interest in organs—whether they be owners or potential owners of instruments, or technicians who desire to learn how organs work and how to maintain them.

The author, a graduate electrical and mechanical engineer and a music lover, became fascinated with electronic organs after becoming the owner of one, and has spent years studying their intricacies. With a background in both teaching and writing on technical subjects, Mr. Anderson felt a strong desire to prepare a book that would give others the benefit of his knowledge and experience on this modern instrument. In his own words, "It is my desire that this book will serve to simplify what has been considered by many to be a highly complicated electronic instrument." This desire has been fulfilled through the use of numerous block diagrams, schematics, drawings, photographs, and simple, down-to-earth explanations of many major brands of electronic organs.

ELECTRONIC ORGAN handbook

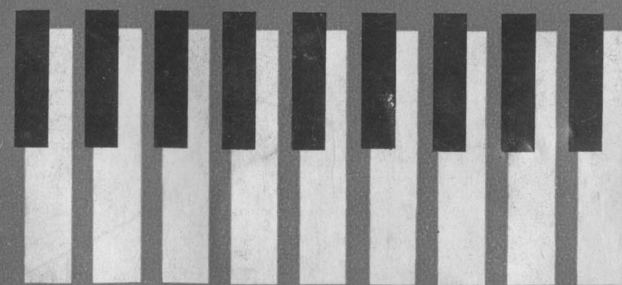
Anderson

FOULSHAM-SAMS

ELECTRONIC ORGAN handbook

by H. Emerson Anderson

How electronic organs work, plus specifications and descriptions, operating principles, circuit diagrams, and maintenance procedures.



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ELECTRONIC ORGAN HANDBOOK

ELECTRONIC ORGAN HANDBOOK

by

H. Emerson Anderson

With a specially written chapter for the guidance of the English reader by W. Oliver (G3XT)

FOULSHAM-SAMS

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It is essential that the English reader should read this chapter

There is a great deal more in this book that can be of interest to the British reader than a casual glance through its pages might lead one to suppose.

On the theoretical side, from a purely informative angle, the clear and simple explanations of how an electronic organ works will make fresh and fascinating reading for anyone who has not previously studied the subject.

On the practical side, the information given is perhaps more likely to be of value to British readers in an *indirect* than a *direct* way. Of those who read it, many may never have the opportunity to play – and fewer still have occasion to service – the actual American models of electronic organ dealt with herein.

But there is a lot of information both in the introductory chapter on "How Electronic Organs Work" and in the subsequent detailed discussions of individual manufactured organs which could come in surprisingly useful. Both amateur and professional readers in this country may well find that the technical descriptions, advice and practical servicing hints will be helpful in quite unexpected ways which are rather outside the intentional scope of the book.

As the author points out, an electronic organ is basically not such a formidably complicated instrument as at first it may appear to be.

A glance at the complete circuit of the electronic "works" gives a first impression of rather bewildering complexity. But a second look reveals the fact that the circuit is mainly composed of small individual sections which are not only reassuringly simple but are also of a basic design which is already familiar to almost every radio enthusiast, amateur or professional.

Indeed, anyone who has built an ordinary signal generator – an instrument in daily use the world over, by amateurs and skilled servicemen alike, for servicing radio and television sets – will immediately recognize the similarity between this and some of the basic circuits in an electronic organ.

Amateur transmitting enthusiasts, too, will notice at once the resemblance between the frequency-doubling stages of a transmitter and the units which serve a similar purpose in dividing or doubling the frequencies initiated by the master-oscillators in the tone-generator units.

This book, as you can see at a glance by just flicking over the pages, is mainly concerned with the various types of manufactured or professionally-built electronic organs on sale in the United States. Their design features, general construction, specialized components and servicing procedures are all discussed in detail.

As the average British reader may not have the opportunity to use, nor the need to service, these particular organs, one might think that this part of the book can only be of academic interest.

As far as the direct practical application in its narrowest sense is concerned, this may well be so. But if one takes a wider view of the subject it should be obvious that the mine of information in this book can also be of practical help to the non-professional and non-commercial designer or constructor of electronic instruments in the musical field.

Home-built electronic organs, or other electronic musical instruments, are obviously *not* within the *intended* scope of the present volume. But it does show how the various problems of design and construction have been tackled in different ways by professional designers and organ-builders; and this can hardly fail to be of help to any amateur who is tackling the same problems on a smaller scale.

Some British radio technical journals, from time to time, have published articles or series of articles dealing with electronic organs for home constructors to build. Some of the more recent designs incorporate fully transistorized circuits.

A complete electronic organ of orthodox design, having a number of "frills" over and above the essential fundamental circuitry, is a pretty ambitious project for the amateur and entails many, many hours of patient work to complete successfully.

Not everyone can tackle such an ambitious project; and not everyone would want to! But as we have already seen, the electronic organ is composed of very simple basic units. A basic master-oscillator can be made out of one suitable transistor, five miniature fixed resistors, four small mica and other fixed capacitors, an ordinary standard transistor driver transformer, a small pre-set potentiometer, and one or two other "bits and pieces" such as an offcut of paxolin for the baseboard and a few pieces of connecting-wire.

The whole assembly forming this oscillator unit can be made small enough to go into the palm of one's hand; and the cost can be in the region of a pound (or even much less, if one uses second-hand or surplus components).

A single oscillator or tone-generator is of course quite useless by itself as a musical instrument since it produces only one note! And it is a far cry from this primitive beginning to the ambitious collection of units found in a complete electronic organ – even of the simplest type designed for amateur construction.

But the fact that one can tackle the project in easy, inexpensive and – to some extent – independent stages gives it a big advantage over many other large-scale constructional schemes which have to be built "in one go."

Moreover, there is great scope for many hours of absorbing experimental work in trying out new ideas both in regard to the basic circuits which can produce musical notes electronically, and the various extra devices which can modify those generated tones in many ways – for instance, to enable them to imitate the sound of various orchestral instruments.

Where a transistorized circuit is used, a battery or unstabilized mains unit is apt to be unsatisfactory, as changes in voltage can cause frequency-drift and instability, giving tuning troubles and impaired tone. A simple stabilized mains unit can comprise a suitable mains transormer, a bridge rectifier a suitable transistor (OC72), a Zener diode (such as the OAZ207), a fixed resistor, a couple of high-capacity electrolytic capacitors of suitable working voltage, and a fuse-bulb – plus, of course, the usual bits and pieces such as terminals, connecting-wire and so on.

The transformer primary must of course be rated at your local mains voltage (probably in the region of 230–240 volts AC – but check this locally!), and the secondary can be around 12 volts for application to the bridge rectifier. The final stabilized output can be at 9 volts, assuming this to be the voltage required for the transistors in the organ.

These, however, are only quoted as typical figures, and in practice you must of course base your construction on the circuit and specification given by the designer of any electronic organ project you may select from the various plans that are published from time to time.

Should the reader construct a home-built electronic organ (or any allied instrument), the sections of this book which deal with "trouble-shooting" may provide some useful hints on fault-finding in this class of circuit. Despite the far more ambitious and elaborate constructional design of the professionally-built electronic organs, their basic similarity in certain respects to the amateur versions inevitably means that they can suffer from similar faults to some degree. Hence one can pick up some useful tips from the servicing instructions relating to manufactured organs which may in some cases be helpful in dealing with breakdowns in their "home-built cousins"!

Since this book is of American origin, some of the technical terms used in it are different from ours. For example, the word "tube" (vacuum tube) is used in all cases where British writers would generally use the word "valve."

Finally, a word of caution about mains differences. Should you have occasion to use any American apparatus designed for the American standard voltage of 110–120 volts AC at 60 cycles per second, bear in mind that it must be suitably adapted or converted before it can safely be plugged into our high-voltage mains which, in most parts of Britain, are now standardized at around 230–240 volts AC at 50 cycles per second.

Great care is also necessary in regard to the colour-coding of mains leads on any apparatus imported from abroad. Some countries use colour-codes which differ from the British standard (of Green for Earth, Red for Line and Black for Neutral) and it is imperative to check both ends of mains leads on any apparatus which is not of British manufacture to make sure that there is no danger of error in connecting up.

PREFACE

How many of you—whether service technician or prospective owner—have shied away from electronic organs, believing them to be complicated and costly musical instruments? Well, if you have, you're in for a delightful surprise. The reason for the organ's overwhelming popularity as a home music instrument in recent years is that anyone—even those with a "tin" ear—can learn to play a simple tune in just a few minutes. In fact, you're likely to find yourself sitting back and saying: "This can't be me!"

Mechanically, the electronic organ looks complicated. In reality, it isn't. Looking inside one, a technician will recognize the same resistors, capacitors, and tubes used in radio and TV receivers. Should the profusion of components deter him, he need only remember that the organ—like most other electronic devices—is composed of numerous circuits, some repeated over and over again. In fact, with his electronic knowledge plus the background information in this book, a competent technician should have little trouble putting the voice back into any electronic organ.

Assuming you are such a competent technician, your first question might be: "I can't even read music, let alone know how to play an organ."

Well, it isn't really necessary . . . in fact, many technicians can't even play "Mary Had a Little Lamb"! But those who have learned a tune or two, even if just a simple little ditty like this one, find their customers are definitely more confident when they wind up a servicing job by actually putting the organ through its paces.

You say you can't read music? Have you ever hummed a tune? Sang in a church choir? Chimed in with your contribution to "Auld Lang Syne" at New Year's? Then you have all the musical background you need. Sit down in front of the organ. Comfortable? Good! Run your fingers over the polished ivory and black keyboard. "So many keys!" you say to yourself. Well, don't fret about it. You don't have to worry about all of them right now. They are there to satisfy your own personal taste when you get to where you would like to add more tone color to your renditions. This is when you realize the organ is a creative musical instrument whose versatility knows no bounds. You'll also realize it's pretty hard to make an organ sound bad, no matter how hard you try.

If it's a chord organ, you'll notice fifty or so small buttons, and no foot pedals. Known as *chord buttons,* they do for you what it takes four fingers and thumb of your left hand to do on a piano. Here, however, you need only one finger. Each chord button blends three or four notes in accompaniment with the melody played by the right hand. For the right hand there is a simple device known as the *melody line note finder* on the keyboard. It shows you which note to touch with your right forefinger.

Organ music is much simpler to read than other kinds. Note names are shown . . . all you have to do is match the note name with the melody line note finder. By touching the melody note name and the proper chord button at the same time, you have a combination which can sound like the written music. After an hour or so of practice, you'll be fascinated by your ability. (This is no exaggeration!)

Just above the keyboard is a row of *tone tablets,* or *drawbars.* By proper selection, you can imitate almost any musical instrument—cello, English horn, tenor saxophone, mandolin, oboe, Hawaiian guitar, and many others. Another control, by regulating the vibrato, makes your organ boom forth like a church pipe organ. Your organ sheet music shows the recommended settings for these tone tablets. However, you may change them to suit your taste or mood. This is why the electronic organ is called a *creative* instrument . . . it allows you to create any instrument or combination of instruments you desire. A foot pedal controls the volume (known as the *expression*).

Of course, every organ will vary slightly, depending on model and brand. But basically they are pretty much alike . . . once you've learned to play one, you can play them all. This similarity becomes more evident in Chapter 1, which is an introduction to electronic organs. Later chapters describe specific organs in great detail. Circuit descriptions, servicing hints, and suggested tuning methods appear in each chapter. In addition, there is a general chapter on tuning electronic organs. A comprehensive glossary at the end of the book lets you instantly find the meaning of an unfamiliar term.

Every technical book is the product of the combined efforts of many. This one is no exception. Without the help of the following manufacturers, it would not be in your hands today:

Baldwin Piano Company, Cincinnati, Ohio; G. C. Conn, Ltd., Elkhart, Indiana; Gulbransen Company, Melrose Park, Illinois; Hammond Organ Company, Chicago, Illinois; Kinsman Manufacturing Company, Inc., Laconia, New Hampshire; Lowrey Organ Company, Chicago, Illinois; Thomas Organ Company, Sepulveda, California; Wurlitzer Company, De Kalb Illinois; and Electro-Music Company, Pasadena, California.

If this book makes the organist or organ owner appreciate his versatile instrument even more, or if it opens up new servicing vistas for the technician, I consider its purpose to have been fulfilled.

August, 1960 H. Emerson Anderson

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CHAPTER 1

HOW ELECTRONIC ORGANS WORK

Up until just a few years ago, there were only pipe organs. Their sounds (voices) depended on forcing air through pipes of various lengths. The more extensive the sets of pipes, the greater the versatility in pitch and tone.

Of course, a good pipe organ costs more than the average person cares to spend for a musical instrument—the lower-priced models ranging upward of $30,000. Fortunately, the miracles of electronics have made it possible for fine organs to be developed in price ranges within the reach of many family budgets. Instead of several tiers of metal pipes, the electronic organ has speakers—and instead of forced air, electronic circuits produce signals which "drive" these speakers. Furthermore, by using relatively inexpensive electronic components, of specific values and in specific combinations, an electronic organ can duplicate practically any tone or sound imaginable. For an understanding of how this is possible, a brief discussion concerning the reproduction of sound is necessary.

WHAT IS SOUND?

Every sound we hear is the result of *waves* of air reaching the eardrum and setting up vibrations. Sound waves travel through the air in much the same manner as water waves traverse a body of water. Consider, for example, what happens when a pebble is thrown into a

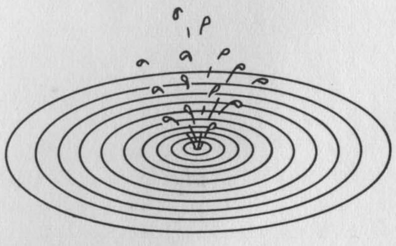


Fig. 1-1. Pattern of waves formed when a pebble is dropped into a body of water.

pond. As seen in Fig. 1-1, a series of ripples, or waves, emanate from the point of impact, radiating outwardly in a circular pattern.

Sound waves follow this same pattern of behavior. Any action which results in the movement of air causes it to "bunch up" in waves. Thus, an analysis of a sound-wave pattern would show areas contain-

Fig. 1-2. Sound waves are composed of a series of air waves.

ing more than the normal air mass, separated by areas containing less than the normal amount of air. (See Fig. 1-2.)

We all know that sound has differentiation qualities—characteristics which distinguish, for example, the difference in the "toot" of a whistle from the ringing of a bell or the beat of a drum. One of these characteristics is volume (loudness or softness), which depends on the amount of air massed in each wave. Another is frequency, or pitch, which is governed by the number of waves produced in a given period. Still a third quality is tone, or timbre, which has to do with the complexity of the waves. Suffice it to say, at this point, that tonal qualities are what make the differences between the sounds of a piano and a harp—even though the notes played may be identical in both pitch and volume.

Comparing a sound-wave pattern, in its simplest form, to the ripples in the surface of a body of water, we find it has the appearance of the wave pattern in Fig. 1-3. Many of

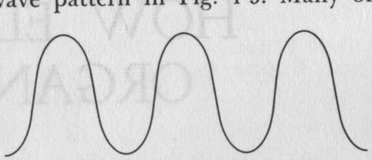


Fig. 1-3. A sine wave—the purest of all waves.

you will recognize this as being a sine wave—the purest and simplest of all waves. In this instance we can relate the topmost portions to those parts of a sound wave having the greatest air density, and the lower portions to those having the least density.

ELECTRONIC-ORGAN FUNDAMENTALS

Generating sound by electronic methods requires (1) the development of an electrical wave, and (2) a means by which its energy can be used to produce audible sensations.

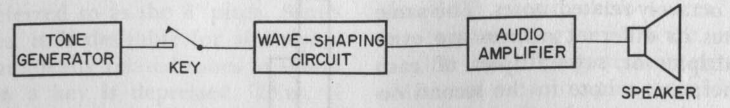


Fig. 1-4. Block diagram of the signal path in an electronic organ.

To generate sounds having specific pitches and tones, the electrical waves will have to be modified accordingly. Basically, this is what an electronic organ does. As shown in the block diagram of Fig. 1-4, an electronic circuit (tone generator) develops a basic electrical wave. (It may be a sine wave, or a more complex sawtooth or pulse wave.) This signal is fed to a waveshaping network designed to produce an electrical wave which, when amplified and applied to a speaker, produces a sound having a specific pitch and tone.

Of course, there's more to an electronic organ than is shown in Fig. 1-4, but basically the complexity centers around the use of several tone-generator and waveshaping circuits, and the numerous keying circuits needed for all notes to be produced by the instrument. To understand more fully the requirements of the component parts in an electronic organ, let's discuss each one in more detail.

Tone Generators

As mentioned previously, the tone generators originate all the electronic signals. Since the organ is a musical instrument, the resultant sounds must be related to notes of the musical scale; thus, the tone generators must produce signals having specific frequencies. Just to produce the notes of one octave (A, B, C, D, E, F, and G), along with the sharps and flats, the tone generators must produce 12 musically-related frequencies. If the organ is to encompass several octaves (usually about six), a tone-generator signal must be produced for each note in each octave.

Many different tone generator arrangements are used. In some, individual tone generators are employed for each tone on each generator. In others, a single tone generator will supply its tone to both manuals. Sometimes, when a particular key is depressed, more than one tone generator will sound. The combined output of the generators produce the desired effect. Many times, a single tone-generator chassis produces all the octavely-related notes of an organ (all the A's, for example). In this manner, one tube or transistor circuit generates the highest or lowest frequency in the range, and successive tube, transistor, or neon lamp circuits halve or double the preceding signal frequency. In Fig. 1-5, for example, the originating circuit or stage develops the highest A on the keyboard, the following stage produces a signal having half the frequency (also A,

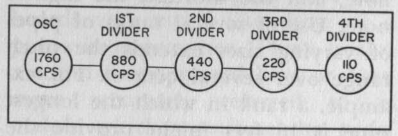


Fig. 1-5. How a tone generator develops octavely-related signals.

but an octave lower than the first), the third stage again halves the frequency to produce a lower-octave A, and so forth. (For those with little or no musical background, it should be pointed out that this mathematical relationship exists for all octavely-related notes. The same notes in different octaves are even multiples or submultiples of each other; i.e., a note in the second octave produces twice the number of sound vibrations or waves as the same note in the first octave, and a note in the third octave has twice the frequency as the same note in the second octave and four times the frequency of the note in the first octave.)

In speaking of frequency or pitch in connection with organ music, a carryover from pipe-organ terminology enters the picture. This has to do with *pitch length,* which refers to the approximate physical length of the pipes in the various ranks. Organ sounds are thus described according to *voice* (Clarinet, Flute, Oboe, Salicional, Tibia, etc.) and *pitch length* (16′, 8′, 4′, 2′, etc.). The type of voice describes the tonal quality, or timbre, which will be discussed in more detail a little later in this chapter. The pitch length refers to the octave, or frequency range, of the notes.

Anyone who has ever seen a pipe organ, or pictures of one, will recognize the drawing in Fig. 1-6 as representing a *rank* of organ pipes. Each pipe produces a note of the scale, the longest producing the lowest note, and the shortest, the highest note. Use of several ranks of pipes of varying sizes extends the pitch range over several octaves. For example, a rank in which the longest pipe is 16 feet might provide the lowest octave, another rank having a length of 8 feet for the longest pipe would provide the next highest octave, and a 4-foot length for the longest pipe in still another rank would provide the third highest octave.

In pipe organs, these sets of pipes are referred to as 16′, 8′, and 4′ ranks, the footage designations being derived from the approximate length of the longest pipe in each rank. Notice that the mathematical relationship between pipe lengths for adjacent octaves conforms to the requirements for octavely-related notes. Anyone who has ever blown across the mouth of an empty bottle will immediately recognize the relationship of pipe length to pitch. Further realizing that sound is a series of air waves, and that the repetition rate of these waves determines the pitch or frequency of sound, it immediately becomes evident that air traversing the length of a 16-foot pipe will produce half the number of waves obtained from an 8-foot pipe, and one-fourth the number from a 4-foot pipe.

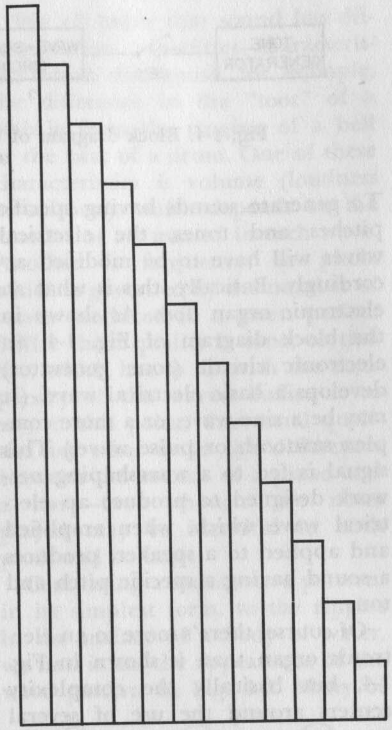


Fig. 1-6. A rank of organ pipes.

In electronic organs, the fundamental tone corresponding to a key is referred to as the 8′ pitch. Sometimes, it is desirable for additional harmonically related tones to sound when a key is depressed. Thus, if we depress the 4′ tab, a tone one octave above the normal tone for the note will sound. Likewise, a 16′ tab will cause a tone one octave below the normal tone to sound. Various combinations of tabs can be used. Many times, the pitch length and the voicing (to be discussed later) are combined on a tab, making it possible to select the desired voice at the desired pitch.

Waveshaping Circuits

As previously mentioned, the tone generators produce a specific type of electrical wave, which must be altered to imitate the various instruments or effects. Many of the more melodious musical tones, however, are said to be harmonious—that is, other frequencies, called harmonics or overtones, are present along with the original fundamental tone. A harmonic frequency is any whole multiple of the fundamental. A second harmonic has twice the frequency of the fundamental, and is referred to in music as the first overtone. You will also recognize that such a harmonic, or overtone, is octavely related to the fundamental.

In an electronic organ, a fundamental electrical wave can be modified to give it the desired harmonic content. The sound thus produced is known as a *voice* of the organ. It can be made to sound like any other musical instrument by merely using electronic circuits which will modify the fundamental tone-generator signal to the proper waveshape.

Most organ voices are classified as belonging to one of four broad categories—Diapason, Flute, String, or Reed. Two approaches are employed to obtain these voices. In one, waveshaping circuits are used to alter the tone-generator signal, which will be a complex waveform, such as a pulse or sawtooth, containing many harmonics. In the other approach, sine wave tone generators are used, and the outputs from two or more of them are mixed to produce the complex waveforms. Most organs have a number of voices, which can be switched in and out by control tabs within the organist's reach at one side of the keyboard.

To add additional desirable effects to musical renditions, other circuits are used to modify the signal waveforms. One of these effects is called *vibrato,* wherein the frequency of the fundamental wave is made to rise and fall slightly at a continuous rate. This is what a violinist does when he "rocks" his finger on a string. A closely related effect known as *tremolo* is produced when this variation is applied to the volume of a note. Volume can also be controlled with a foot-operated device identified as the *swell* or *expression* pedal.

Keying Circuits

To provide the organist with the means for controlling the notes produced, electronic organs have keyboards very much like those of a piano in appearance. There is also a set of foot-operated keys or bars, more accurately referred to as *pedals,* which constitute the *pedal division.* Most organs for home use have two keyboard divisions in addition to the pedals. The various manufacturers use different names for identifying the keyboards. Thus, the upper one may be called a *solo, swell,* or *upper manual,* while the lower one is referred to as the *accompaniment, great,* or *lower manual.* Usually, both manual divisions will have keys encompassing about four octaves each, and the pedal division will range from an octave to slightly over two octaves. The overall octave range of notes may extend from five to as many as eight octaves, the average being about six. The lowest notes are produced by the pedal division. Notes on the lower manual may extend from the second to the fifth or sixth octave, and the upper manual, from the second or third to the sixth or seventh. These ranges vary considerably, according to the versatility of the instrument. As a matter of fact, the number of divisions is not limited to the three just described. More elaborate instruments may incorporate four or five, or even more, manual and perhaps two pedal divisions. Such organs, of course, are out of the ordinary and not designed for average applications.

One other bit of terminology which should be explained in connection with this discussion of keyboard divisions and their ranges has to do with a device known as a *coupler*. When incorporated into an organ, a special control tab can be activated to permit the notes of one division to be played on the keys of another. Generally, the electrical connection thus provided permits notes on the upper manual to be played from the lower manual keyboard, or vice versa. The advantage is that both the range of octaves and the number of voices obtainable from one manual are extended.

Amplifier Circuits

Now that the tones have the desired waveshape, they must be intensified before going to the speaker. A conventional audio amplifier is used to amplify the signal to the required level. The foot-operated *expression,* or *swell,* control in the amplifier circuit performs the same function as the volume control in a conventional amplifier. Many times, additional amplifiers will be included in separate tone chambers located some distance from the organ. The output of the amplifier (or amplifiers) is coupled to the speakers, where the electrical energy is converted to mechanical energy and sound waves having the same characteristics as the electrical waves are produced.

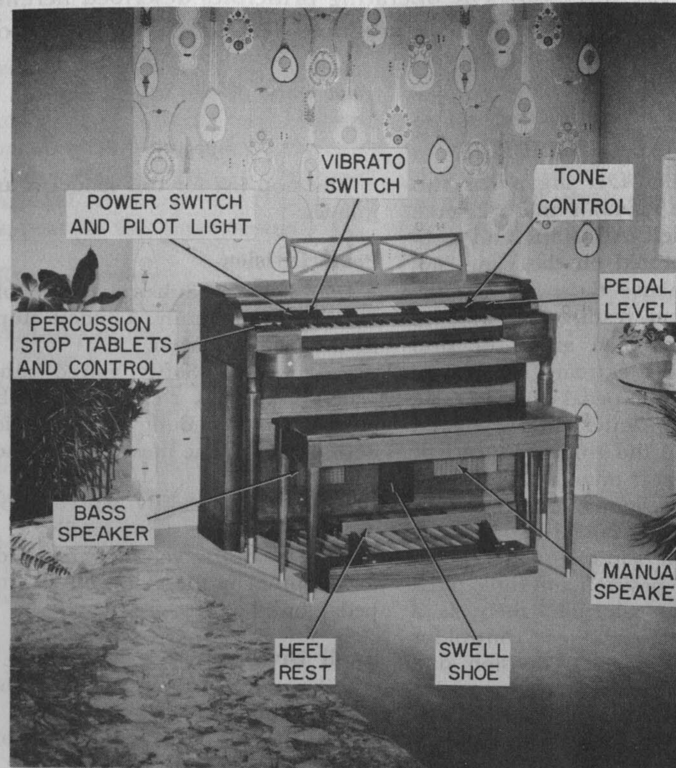


Fig. 2-1. The Baldwin Model 45H electronic organ.

CHAPTER 2

THE BALDWIN ELECTRONIC ORGAN

The photograph in Fig. 2-1 shows the Model 45H Baldwin electronic organ as an example of the full Baldwin line. While this model is primarily for home use and entertainment purposes, the Baldwin series of instruments extends from a small spinet model (with 44 notes on each manual and 13 pedals) to the large three-manual, concert-type organ with 59 stops and American Guild of

Organists' specifications. The operating principles described herein are characteristic of all models produced by The Baldwin Piano Company.

GENERAL DESCRIPTION

The Model 45H organ has two full 61-note manuals and a 25-note pedal clavier. All stops and controls are located on the panel immediately above the swell manual, making them readily accessible to the organist. The group of stop tablets to the extreme left of the panel is for the pedal division. The group in the center is for the swell manual, and the group to the right is for the great manual. Additional controls on the panel include the "off-on" switch, pilot light, and the four-position Vibrato switch which has an "off" position and three pitch Vibratos. In addition, there is a three-position pedal level control for regulating the pedal division output, and a continuously variable tone control which affects all voices of the instrument. With such an arrangement, numerous combinations of stops, suitable for all types of music, are available. The swell shoe, which controls the over-all volume, is located immediately above the pedal clavier near the center of the console.

The console contains all the electronic components necessary for proper operation of the instrument. It has a two-channel, 50-watt amplification system and two 15" speakers. Various accessories are available and may be added conveniently, as desired. These accessories include a percussion ensemble, a Baldwin-Leslie type tone cabinet and a Chora-tone projector tone cabinet. Additional tone cabinets may be conveniently connected where space requirements dictate the use of additional audio power.

STOPS

The stop list for this model is as follows:

Pedal Division

Diapason 16'—Sub-octave stop of the Diapason family. Loudest stop in the pedal division.

Bourdon 16'—Softly voiced sub-octave flute. Has a clear tone with only a small amount of harmonic development. The most used of the pedal stops.

Dulciana 16'—Softly voiced sub-octave stop of the string family.

Flute 8'—Softly voiced Flute used to compliment the Bourdon 16' in pedal build-up.

Swell Division

Tibia 16'—Medium loud, sub-octave Flute.

Diapason 8'—Fundamental stop of the Diapason family.

Tibia 8'—Loudly voiced 8' stop of the Flute family.

Salicional 8'—Basic string stop of the swell manual, supplying foundation for the entire string ensemble, as well as adding brilliance to full organ.

Saxophone 8'—Solo stop imitative of the orchestral Saxophone. Belongs to the reed family.

English Horn 8'—A very loud and brilliant trumpet-like stop of the reed family.

Clarinet 8'—Solo stop imitative of the orchestral Clarinet. Belongs to the reed family.

Oboe 8'—Solo stop imitative of the orchestral Oboe. Belongs to the reed family.

Tibia 4'—Medium loud 4' Flute. Rounds out the Tibia "chorus" or

ensemble basis of the swell manual.

Salicet 4'—Keenly but softly voiced string stop.

Great to Swell 16'—A lower manual to upper manual coupler (not a speaking stop). It couples the stops drawn on the lower to the upper manual an octave lower than they appear on the lower manual.

Great Division

Horn Diapason 8'—Basic foundation stop of the great manual.

Flute 8'—Softly voiced Flute stop. Ideal for accompanying the swell manual solo stops.

Dulciana 8'—Softly voiced, sweet-toned stop of the Diapason family. Softest stop of the great manual.

Tuba 8'—Loudly voiced reed stop. Has a penetrating tone similar to the trumpet, but not quite as brilliant.

Flute 4'—A brightly voiced super-octave Flute, with a somewhat imitative character.

Violina 4'—String stop at 4' pitch. Slightly louder than the Salicet 4' on the swell, but not quite as keen.

Loud and Soft—A nonspeaking stop that changes the relative volume of the great manual to the swell manual.

OPERATING PRINCIPLES

The block diagram in Fig. 2-2 shows the various sections of Models 45C and 45H2. It will be used in following the signals from their sources through the power amplifier to the speakers.

Generator

A total of 73 pitches, extending from the lower-most pedal "C" pitch (32 cycles) to the highest "C" at 4'

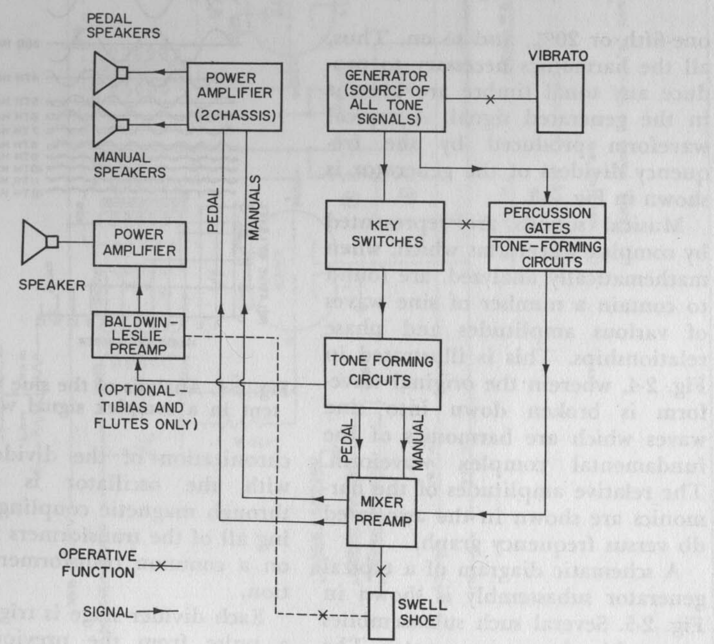


Fig. 2-2. Block diagram typical of sections used in Baldwin electronic organs.

pitch (2,093 cycles), are available on this instrument. The generator itself produces a sawtooth type signal which contains the fundamentals and all of its harmonics in gradually decreasing amplitudes. A mathematical analysis of the sawtooth wave would show that if the fundamental is considered as 100%, the percentage of second harmonic content is one-half or 50%, the third harmonic content is one-third or 33⅓%, the fourth harmonic is one-fourth or 25%, the fifth harmonic

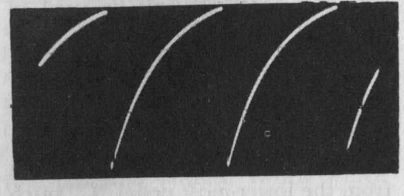


Fig. 2-3. Sawtooth type signal developed by tone generators.

one-fifth or 20%, and so on. Thus, all the harmonics necessary to produce any tonal timbre are present in the generated signal. A typical waveform produced by the frequency dividers of the generator is shown in Fig. 2-3.

Musical sounds are represented by complex waveforms which, when mathematically analyzed, are found to contain a number of sine waves of various amplitudes and phase relationships. This is illustrated in Fig. 2-4, wherein the original waveform is broken down into sine waves which are harmonics of the fundamental complex waveform. The relative amplitudes of the harmonics are shown in the associated db versus frequency graph.

A schematic diagram of a typical generator subassembly is shown in Fig. 2-5. Several such subassemblies are used in the tone generator. The topmost pitch for each note of the chromatic scale is generated by the very stable oscillator circuit V1A. All other pitches which are octavely related are obtained by a frequency-dividing process. Thus, stage V1B delivers a signal at one-half the frequency of the original (signal #2). The signal frequency from V2A (signal #3) is half that from V1B (one-fourth the frequency of the fundamental), and so on down the line to signal #6, which is 1/32nd of the fundamental. Syn-

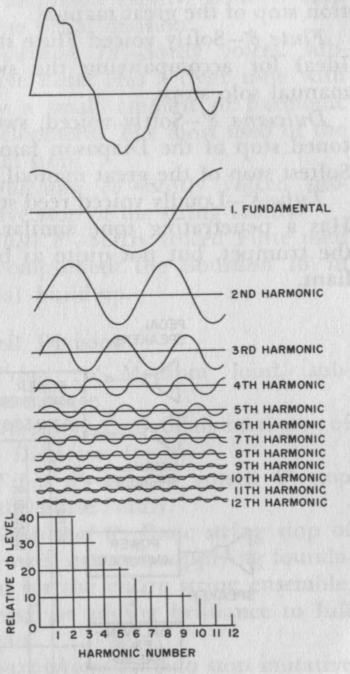


Fig. 2-4. Analysis of the sine wave content in a complex signal waveform.

chronization of the divider stages with the oscillator is obtained through magnetic coupling by having all of the transformers mounted on a common transformer lamination.

Each divider stage is triggered by a pulse from the previous stage, causing conduction to take place and grid current to flow. This grid

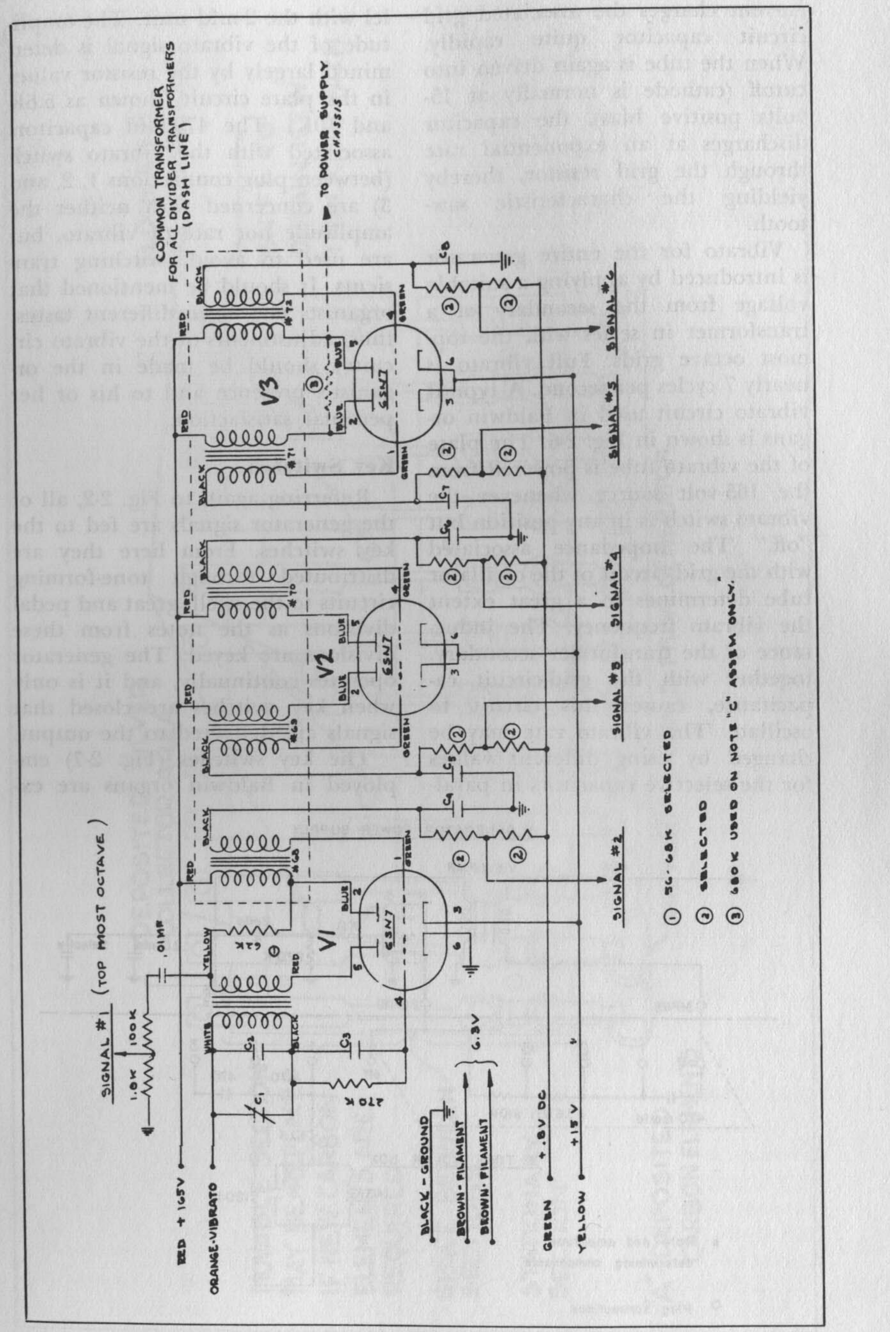


Fig. 2-5. Schematic diagram of a typical generator subassembly.

current charges the associated grid circuit capacitor quite rapidly. When the tube is again driven into cutoff (cathode is normally at 15-volts positive bias), the capacitor discharges at an exponential rate through the grid resistor, thereby yielding the characteristic saw-tooth.

Vibrato for the entire generator is introduced by applying a suitable voltage from the secondary of a transformer in series with the top-most octave grids. Full vibrato is nearly 7 cycles per second. A typical vibrato circuit used in Baldwin organs is shown in Fig. 2-6. The plate of the vibrato tube is powered from the 165-volt source whenever the vibrato switch is in any position but "off." The impedance associated with the grid circuit of the oscillator tube determines to a great extent the vibrato frequency. The inductance of the transformer secondary, together with the grid-circuit capacitance, causes this circuit to oscillate. The vibrato rate may be changed by using different values for the selective capacitors in parallel with the 2-mfd unit. The amplitude of the vibrato signal is determined largely by the resistor values in the plate circuit (shown as 5.6K and 10K). The 470-mfd capacitors associated with the vibrato switch (between plug connections 1, 2, and 3) are concerned with neither the amplitude nor rate of vibrato, but are used to avoid switching transients. It should be mentioned that organists may have different tastes; thus, adjustments of the vibrato circuitry should be made in the organist's presence and to his or her personal satisfaction.

Key Switches

Referring again to Fig. 2-2, all of the generator signals are fed to the key switches. From here they are distributed through tone-forming circuits to the swell, great and pedal divisions as the notes from these divisions are keyed. The generator operates continually, and it is only when key switches are closed that signals are delivered to the output.

The key switches (Fig. 2-7) employed in Baldwin organs are ex-

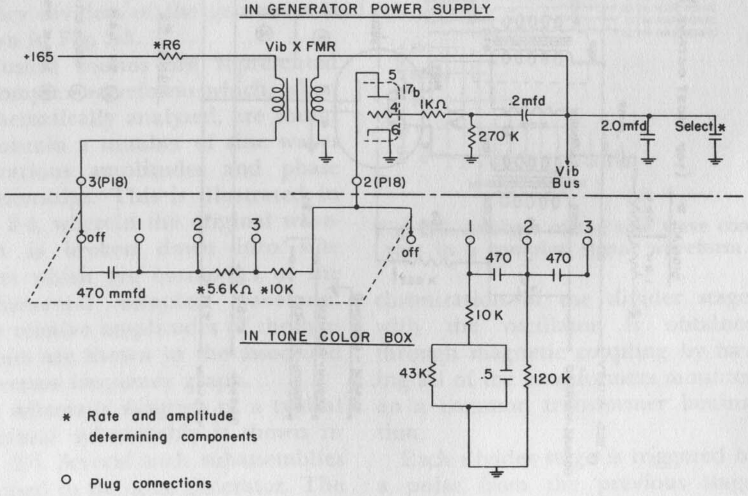


Fig. 2-6. Vibrato oscillator circuit complete with switch circuit arrangement.

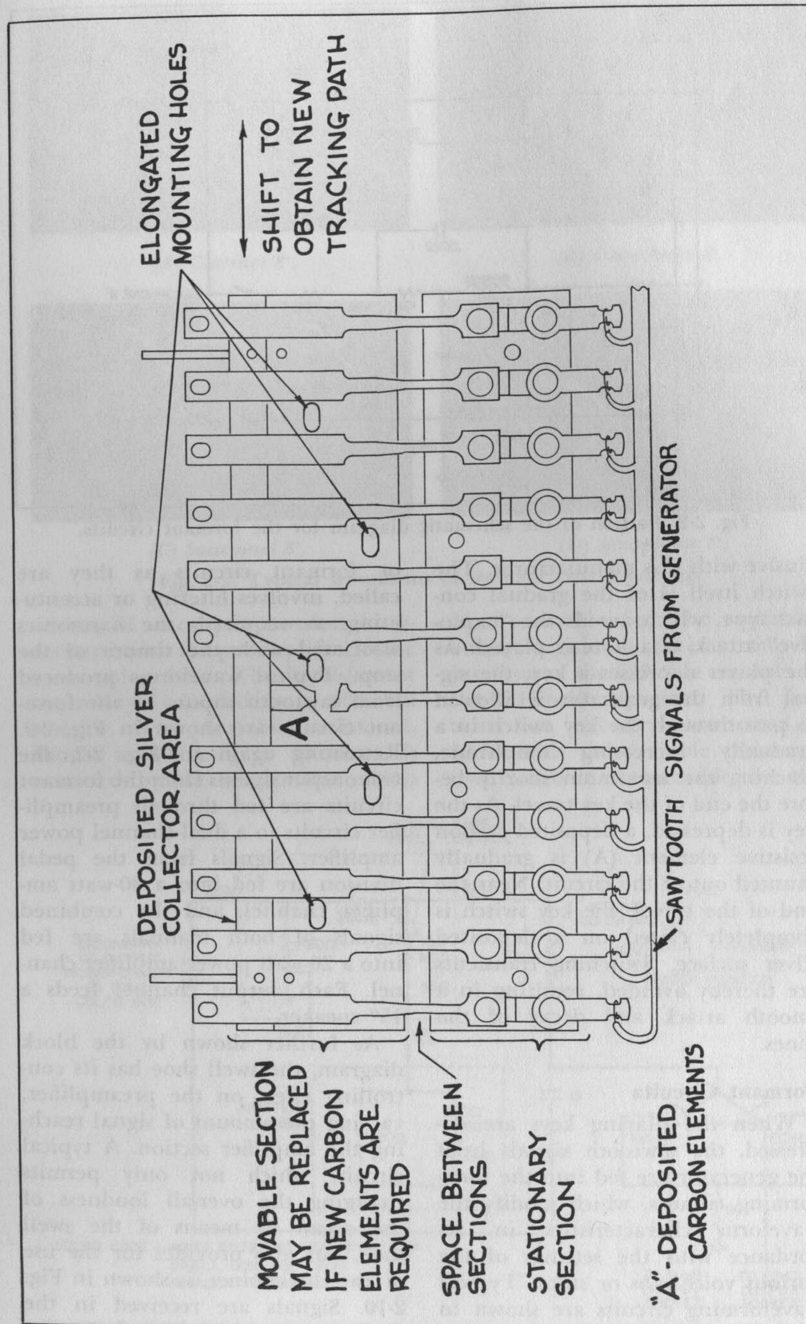


Fig. 2-7. Details of the Baldwin gradual contact key-switch arrangement.

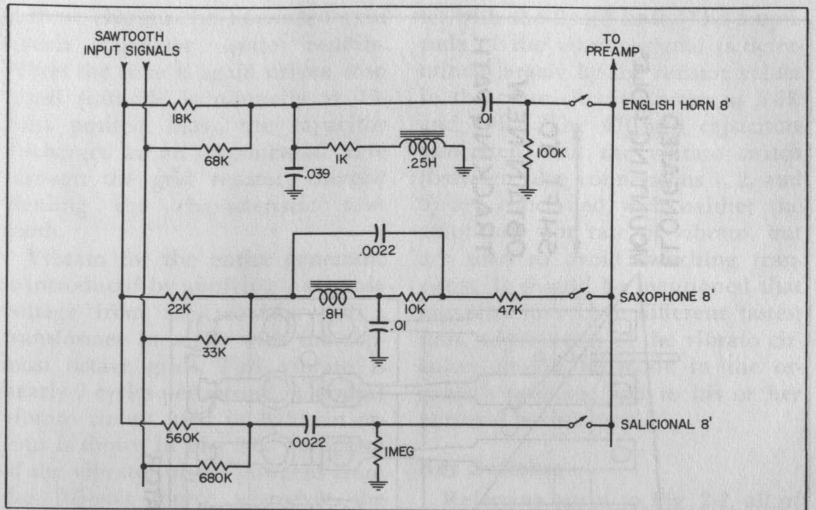


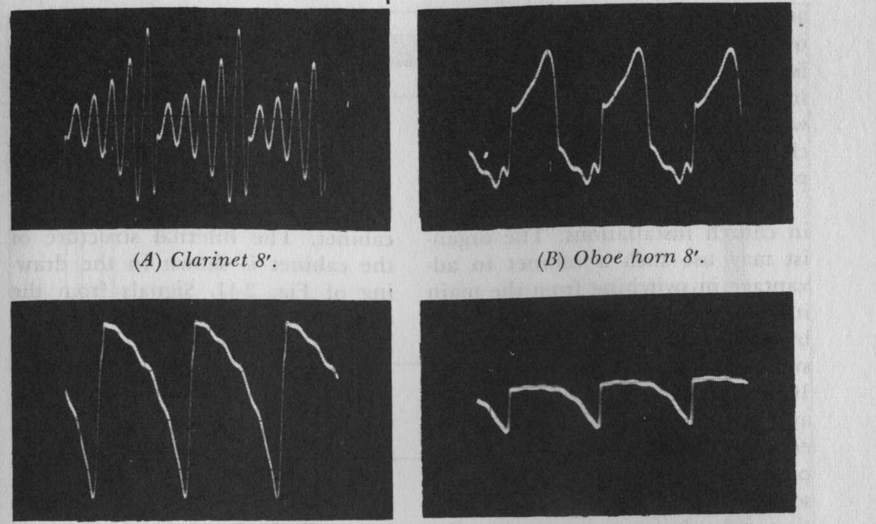
Fig. 2-8. Portion of the schematic diagram for the formant circuits.

clusive with this manufacturer. The switch itself is of the gradual contact type, which avoids the "explosive" attack as a note is played. As the player depresses a key, the signal from the generator is allowed to pass through the key switch in a gradually increasing amplitude, reaching the maximum shortly before the end of the key travel. As the key is depressed, a deposited carbon resistive element (A) is gradually shunted out of the circuit. Near the end of the travel, the key switch is completely closed on a deposited silver surface. Switching transients are thereby avoided, resulting in a smooth attack and decay of the tones.

Formant Circuits

When the playing keys are depressed, the sawtooth signals from the generator are fed into the tone-forming circuits, which modify the waveform characteristics in accordance with the settings of the various voice tabs or stops. Typical waveforming circuits are shown in Fig. 2-8. The action of these filter, or formant circuits as they are called, involves filtering or accentuating, as required, the harmonics associated with the timbre of the stop. Typical waveforms produced from sawtooth inputs by the formant circuits are shown in Fig. 2-9. Returning again to Fig. 2-2, the two output signals from the formant circuits are fed through preamplifier circuits to a dual-channel power amplifier. Signals from the pedal division are fed into a 30-watt amplifier channel, and the combined signals of both manuals are fed into a 20-watt power amplifier channel. Each output channel feeds a 15" speaker.

As further shown by the block diagram, the swell shoe has its controlling effect on the preamplifier, varying the amount of signal reaching the amplifier section. A typical circuit, which not only permits changing the over-all loudness of the organ by means of the swell shoe, but also provides for the use of an echo cabinet, is shown in Fig. 2-10. Signals are received in the swell shoe circuitry through the sec-



(*A*) *Clarinet 8'*. (*B*) *Oboe horn 8'*.

(*C*) *Salicional 8'*. (*D*) *Saxaphone 8'*.

Fig. 2-9. Typical waveforms of formant circuit outputs.

ondary of an output transformer associated with the preamplifier in the tone color box. The transformer secondary is loaded by a 680-ohm resistor. The variable resistance, shown as 100 meg to 35 ohms, is actuated by the mechanical action of the swell shoe. The controlled output signal is taken from the junction of the 680-ohm resistor and the 0.15-mfd capacitor. The junction box circuitry, connected in series with the variable resistor, is used for bass compensation so that

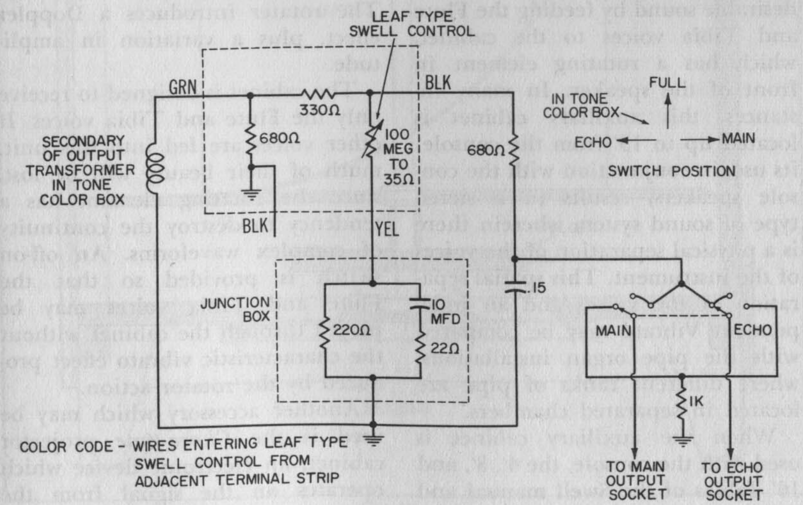


Fig. 2-10. Schematic of the swell shoe circuit.

adequate bass is sounded at low output levels. The variable resistor is actually a series of switch blades inter-connected in a resistive network so that successive contacts are closed to change the signal by approximately 1-db increments.

An echo cabinet is often desirable in church installations. The organist may use such a cabinet to advantage in switching from the main installation to echo, as called for by the music. The main-full-echo switch shown at the right in Fig. 2-10 accomplishes this switching operation. In the echo position, only the echo organ will sound. In the center position, both main and echo will sound, and in the right-hand position only the main organ installation will be heard. Note that all circuitry associated with the swell control and the main-full-echo switch is low impedance and, of course, not subject to extraneous radiation pick-up.

Auxiliary Equipment

The Baldwin-Leslie auxiliary tone cabinet may be used to produce a desirable sound by feeding the Flute and Tibia voices to the cabinet, which has a rotating element in front of the speaker. In many instances, this auxiliary cabinet is located up to 15′ from the console; its use, in conjunction with the console speakers, results in a stereo type of sound system wherein there is a physical separation of the voices of the instrument. This spatial separation of the voices and an independent Vibrato may be compared with the pipe organ installations, where different ranks of pipe are located in separated chambers.

When the auxiliary cabinet is used with the console, the 4′, 8′, and 16′ Tibias of the Swell manual and the 4′ and 8′ Flutes of the Great manual are separated from the other stops and fed into a separate preamplifier added within the console. The swell shoe is modified so that these voices may also be under expression. After being amplified by the preamplifier, the signal representing these voices is fed to a 20-watt amplifier within the auxiliary cabinet. The internal structure of the cabinet is shown in the drawing of Fig. 2-11. Signals from the amplifier feed a single 12″ speaker. As the speaker output radiates through the baffle, the sound energy is deflected by the rotating element which turns at a speed approaching seven revolutions per second. A pulley, mounted on the lower end of the shaft, is belt-driven by a small motor. Radiation from the back of the speaker is absorbed in the space in the upper part of the cabinet, and is not permitted to emerge because the sound waves would not properly blend with those acted upon by the rotating element. The sound energy, being operated upon mechanically by the rotater, emerges from three sides of the cabinet through suitable grille openings. The rotater introduces a Doppler effect, plus a variation in amplitude.

The cabinet is designed to receive only the Flute and Tibia voices. If other voices are fed into this unit, much of their beauty will be lost, since the rotating element has a tendency to destroy the continuity of complex waveforms. An off-on switch is provided so that the Flute and Tibia voices may be played through the cabinet without the characteristic vibrato effect produced by the rotator action.

Another accessory which may be used is the *Chora-tone* projector cabinet, an electronic device which operates on the signal from the manuals to produce a Celeste or Ensemble effect. The output of this

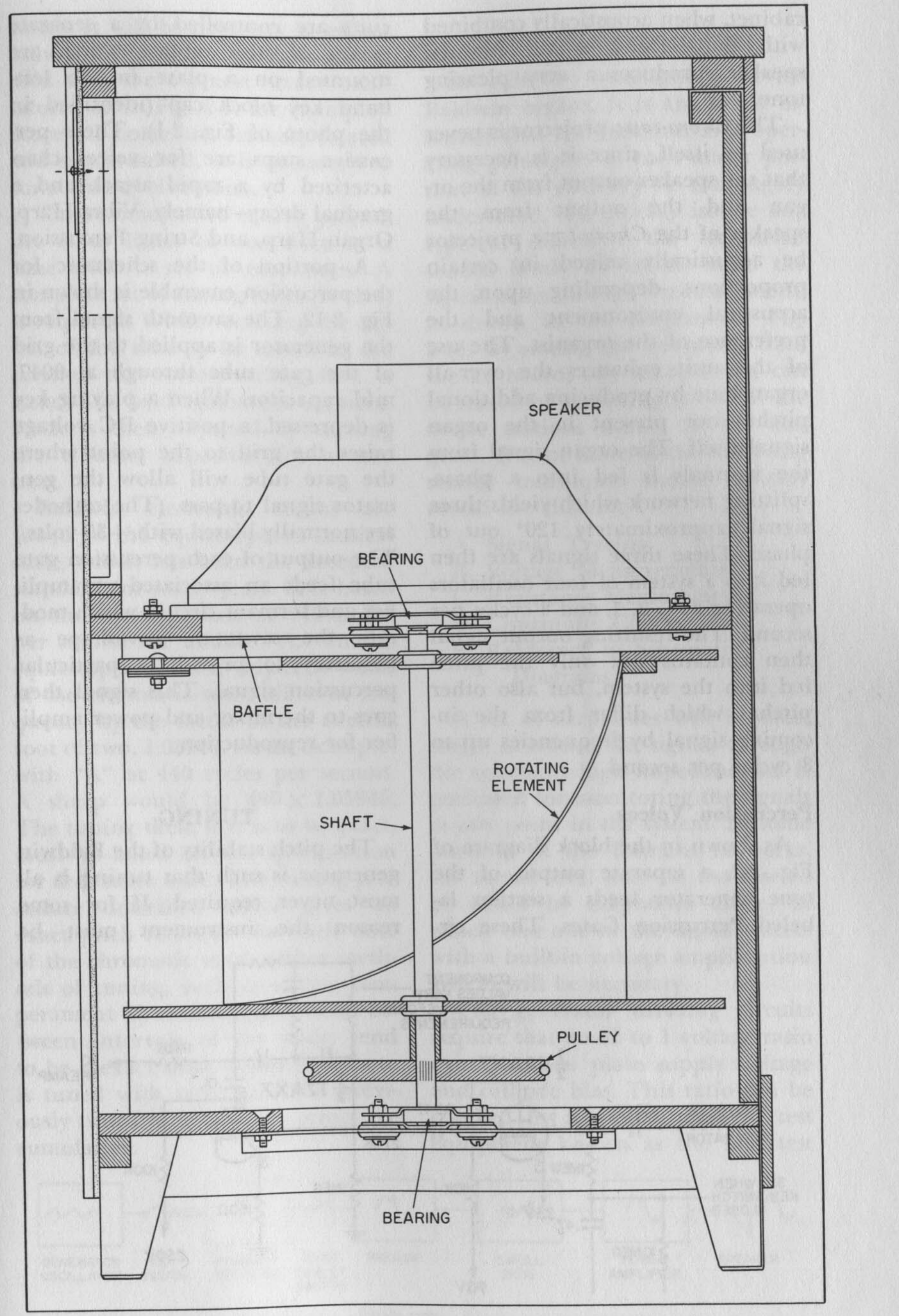


Fig. 2-11. Sketch showing the rear view of the Baldwin-Leslie auxiliary tone cabinet.

cabinet, when acoustically combined with the output of the manual speaker, produces a very pleasing tone.

The *Chora-tone* projector is never used by itself, since it is necessary that the speaker output from the organ and the output from the speaker of the *Chora-tone* projector be acoustically mixed in certain proportions, depending upon the acoustical environment and the preference of the organist. The use of this unit enhances the over-all organ tone by producing additional pitches not present in the organ signal itself. The organ signal from the manuals is fed into a phase-splitting network which yields three signals approximately 120° out of phase. These three signals are then fed into a system of four oscillators operating at 1, 2, 4, and 8 cycles per second. The resulting output signal then contains not only the pitch fed into the system, but also other pitches which differ from the incoming signal by frequencies up to 8 cycles per second.

Percussion Voices

As shown in the block diagram of Fig. 2-2, a separate output of the tone generator feeds a section labeled Percussion Gates. These circuits are controlled by a separate group of stop tablets, which are mounted on a plate in the left-hand key block cap (identified in the photo of Fig. 2-1). These percussive stops are for voices characterized by a rapid attack and a gradual decay—namely, Vibra Harp, Organ Harp, and String Percussion.

A portion of the schematic for the percussion ensemble is shown in Fig. 2-12. The sawtooth signal from the generator is applied to the grid of the gate tube through a .0047-mfd capacitor. When a playing key is depressed, a positive DC voltage raises the grid to the point where the gate tube will allow the generator signal to pass. (The cathodes are normally biased with +35 volts.) The output of each percussion gate tube feeds an associated preamplifier and formant circuit, which modifies the sawtooth waveshape as necessary to provide a particular percussion signal. This signal then goes to the mixer and power amplifier for reproduction.

TUNING

The pitch stability of the Baldwin generator is such that tuning is almost never required. If for some reason the instrument must be

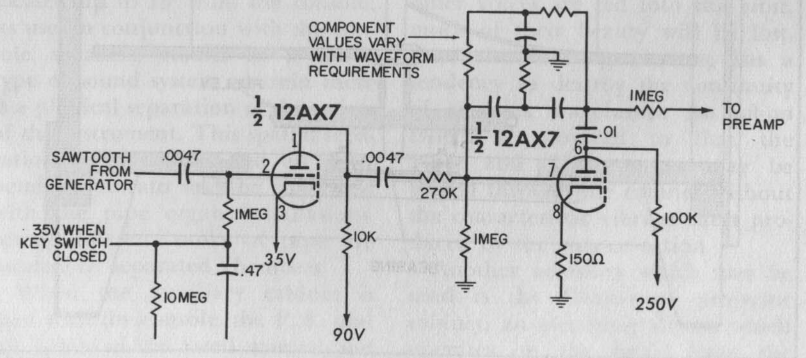


Fig. 2-12. Typical circuit used in the percussion preamplifier and formant circuits.

tuned, it will be necessary to adjust only the trimmer capacitors associated with the topmost octave oscillators (C1 in Fig. 2-5, for example). Since all notes are octavely related and synchronized, it is necessary to tune only twelve notes.

The recommended tuning procedure is to listen to one note at a time with a set of earphones. A complete set of tuning forks (twelve) is required. While receiving the signal of the note to be tuned in the phones, the corresponding fork is struck and held against the earpiece. Pitch is then adjusted by turning the trimmer capacitor for a zero beat.

Baldwin electronic organs are tuned to the equitempered musical scale, which has been the accepted standard for many years. It is based on the concert pitch of 440 cycles per second for middle "A." In the equitempered scale, adjacent notes of the chromatic scale differ in frequency by the factor of the twelfth root of two, 1.05946. As an example, with "A" at 440 cycles per second, A sharp would be 440×1.05946. The tuning then, if it is to be exact, must be based on this specification for the entire scale. The tuning procedure described above gives an exact pitch reference for each note of the chromatic scale. Other methods of tuning, such as setting temperament by counting the beats between intervals of the scale, tend to be inexact since nearly each note is tuned with reference to a previously tuned note and any errors are cumulative.

SERVICE TECHNIQUES

In order to intelligently service Baldwin organs, it is absolutely essential that the function and operating principles of each major portion of the circuitry be thoroughly understood. To quickly isolate any type of difficulty, the technician should firmly fix in his mind the signal paths through the instrument, as shown in the diagram of Fig. 2-13. By noting the symptoms from the keyboard, any malfunction can be traced by reasoning to one of the major sections shown in the diagram. One or more of the following service techniques should quickly reveal the difficulty:

A. Signal Tracing
B. Voltage Measurements
C. Resistance Measurements
D. Continuity Checks
E. Reference to Schematic Diagrams

A set of earphones will be most useful in tracing the signals through the system. A high impedance set is preferred for monitoring the signals at any point in the system. In some portions of the formant networks, the signal level may be too low to be heard by earphones alone, in which case one of the signal tracers with a built-in voltage amplification system will be necessary.

The generator dividing circuits require that an 11 to 1 voltage ratio exist between plate supply voltage and cathode bias. This ratio can be checked by a special piece of test equipment known as the bias test

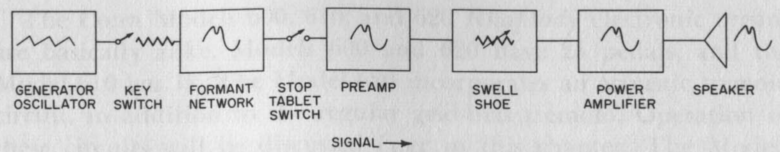


Fig. 2-13. Block diagram showing continuity of signal path in Baldwin organs.

box, which is furnished to authorized Baldwin technicians. This bias test box allows the ratio to be shifted in such a way that the condition of the tubes may be checked and the future performance of the divider circuits predicted. If for some reason the calibrated RC networks become faulty, the dividers may divide by three, instead of by two, in which case the fifth, instead of the octave, will be heard. Or, in some instances, the oscillator may be erratic in operation and may fail to yield a steady tone. When this occurs, the oscillator itself may have to be recalibrated. (Factory replacements for the generator chassis are available at a nominal charge.) A tube checker should not be used to determine the suitability of a tube for replacement in the generator. The generator itself should be used as the checking device.

Service to the key-switch assemblies usually involves nothing more than thorough cleaning with benzine. The use of a pipe cleaner will be convenient for this purpose. Should the deposited carbon surface become worn, a new track may be exposed simply by shifting the movable portion of the switch assembly.

The signal levels within the formant networks are on the order of millivolts and the nominal ratings of the resistors, capacitors, and chokes far exceed the circuit requirements. As a result, replacement of any of these components is very rarely necessary. Any change in value which may normally occur would not be of sufficient magnitude to noticeably affect the voicing of the stops.

The preamplifier circuitry is nothing more than several stages of amplifiers, and the design follows conventional practice. If signs of distortion appear, the first thing to do is check the tubes. If the tubes are satisfactory, plate and cathode voltage measurements should be made, and the plate coupling capacitors should be checked for any signs of leakage.

The swell shoe may cause some electrical noise if a steady tone is sounded when the swell shoe is moved back and forth. This can usually be traced to dirt particles on the gradual contact elements. Cleaning with benzine will usually clear up any difficulty. Adjustment for proper travel of the element is accessible only by removing the entire swell shoe assembly, which is held in the console with four wood screws.

The power amplifier follows conventional design, and the usual troubleshooting techniques may be employed. Tube checks and voltage measurements within the power amplifier will usually reveal any source of difficulty. Here again, plate coupling capacitors should be checked for leakage and replacements made as necessary.

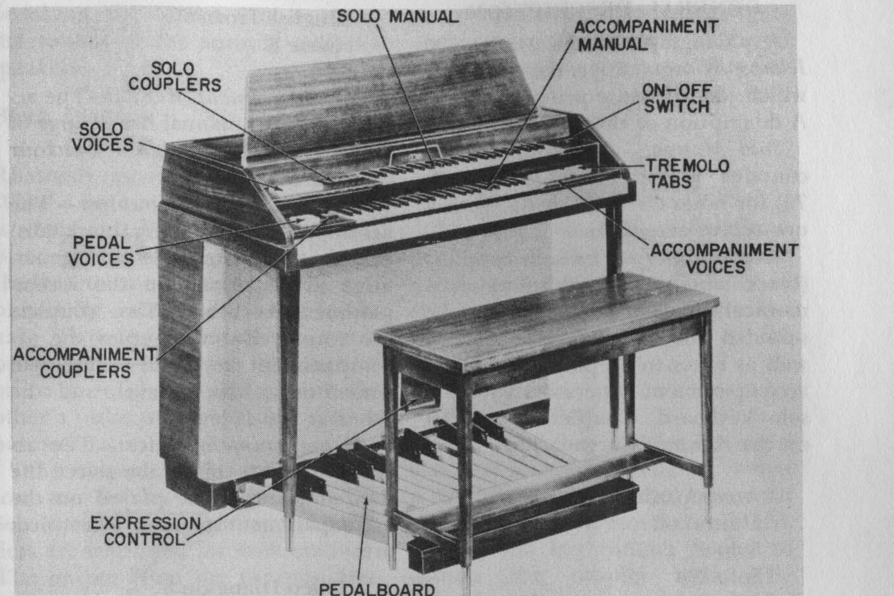


Fig. 3-1. The Conn *Rhapsody* organ.

CHAPTER 3

THE CONN ELECTRONIC ORGAN

The Conn Models 600, 610, and 620 *Rhapsody* electronic organs are basically alike. Models 600 and 620 have 25 pedals, and the Model 610 has 18. The Model 620 incorporates an acoustic tremolo circuit, in addition to the regular grid-bias tremolo. Operation of these circuits will be discussed later in this chapter. The Models 600 and 610 contain 62 tubes, and the Model 620 has 70. Three speaker—one 15-inch, one 10-inch, and one 6 × 9-inch—are used in the Models 600 and 610. The Model 620 has a 15-inch and a 6 × 9-inch speaker, plus two 5¼-inch speakers for the acoustic tremolo circuit.

GENERAL DESCRIPTION

A photograph of the Model 620 *Rhapsody* organ appears in Fig. 3-1, which identifies the principal parts. A description of these parts follows:

Solo Manual—The solo manual contains 49 keys (keys 25 through 73) for notes *C3* through *C7*, with a one-octave extension.

Solo Couplers—The solo couplers (black tabs) permit additional harmonically related tones to be sounded when a key is depressed, as well as tones to be played from the accompaniment generators with the solo keyboard. Couplers employed on the *Rhapsody* organs are:

Accompaniment to solo 16′
Unison off
Solo 4′
Solo 2⅔′
Solo 2′
Solo 1⅗′

The Unison Off coupler is on when it is level. It permits the solo keyboard to be played at the 8′ pitch level. When Unison Off is depressed (off), no notes will sound from the solo keyboard unless one of the other couplers is depressed.

Solo Voices—The solo voice tabs (white tabs) are depressed to select the desired voices. At least one voice tab must be depressed before a note can be sounded from the solo keyboard. The solo voices on the *Rhapsody* organ are:

Diapason 8′
Soft Flute 8′
Concert Flute 8′
Soft String 8′
Violin 8′
English Horn 8′
Oboe 8′

Accompaniment Manual—The accompaniment manual has a range of 49 keys (keys 13 through 61), or four octaves.

Accompaniment Couplers—The accompaniment couplers (black tabs) permit tones from the solo generators to be played on the accompaniment keyboard. Two couplers are employed—one couples the accompaniment keyboard to the solo generator at the 8′ level, and the other at the 4′ level.

Accompaniment Voices—The accompaniment voice tabs select the desired voices to be played on the accompaniment manual. The voices are:

Open Diapason 8′
Accompaniment Flute 8′
Flute 8′
Echo String 8′
Cello 8′
Reed 8′

Pedalboard—The pedalboard supplies the bass notes of the organ. Models 600 and 620 have 25 pedals (keys 1 through 25). Model 610 has 18 pedals (keys 1 through 18).

Pedal Voices—The pedal voices vary the character and the volume level of the pedal notes. The pedal voices are:

Echo Bass 16′
Sub Bass 16′
Major Bass 16′

Tremolo Tabs—Three tabs control the degree of tremolo. The "F" tab gives a heavy degree of tremolo; the "M" tab, medium; and the "L" tab, light.

Expression Control—A capacitor-type expression control is used in the *Rhapsody* organs to control the loudness (volume). An additional control, connected to the expression pedal on the Model 620, controls the volume of the acoustic tremolo speakers.

Block Diagram

A block diagram of the Conn Rhapsody organs is given in Fig. 3-2. When a key on one of the keyboards is depressed, B+ is applied to the plate of the tone-generator tube. (Individual tone generators are employed for each tone on each manual.) Two basic musical tones are produced by the tone generator—one a pure (flute) quality, and the other a pulse (string quality) rich in harmonics.

The outputs of the tone generators are fed to the preamplifiers. Separate pulse and flute preamplifiers are employed for each manual. The output from the preamplifiers is then applied to the formant-type voicing filters, where the waveshaping circuits produce the proper output waveforms for the various voices.

The outputs of the voicing filters are summed and then coupled to the amplifier input. The expression control is connected in the input circuit of the amplifier, and the amplifier output is connected to the three speakers. The operating voltages for the organ are supplied by the power supply. A voltage-regulator tube holds the plate-voltage supply of the tone generator at 75 volts.

The tremolo generator supplies a voltage, which varies at the rate of 6 to 7 cycles per second, to the grid circuit of the tone generators to produce the tremolo effect. In addition, the Model 620 incorporates the stages shown in the dotted lines, to further reinforce the tremolo. This is the acoustic tremolo circuit. A portion of the voicing-filter output is amplified by the tremolo channel amplifier and applied to the tremolo-speaker voice coils. The output voltage from the tremolo generator is applied to the field coil of the tremolo speakers so that the output from the speakers will vary at the tremolo rate.

CIRCUIT DESCRIPTION

The block diagram of the Conn organs was given in Fig. 3-2. We shall now examine the circuits in each of these blocks and follow the signal through the organ to the speaker.

Keyboard System

The operation of the keyboard assembly is shown in Fig. 3-3. When a key is depressed, the key-switch post (on the right) moves downward, causing the key contact fingers to contact the coupler rods. The coupler rods are connected to the 75-volt line. When the key contact finger "makes" with the coupler rod, the 75 volts is conducted to the connections at the rear of the key-switch assembly, where it supplies the B+ for the tone generator.

Coupler Rods—In Fig. 3-3 all couplers are shown in the "on" position. Fig. 3-4 shows an end view of the coupler rods, which consist of a bus bar with a covering of insulation over all the bar except the projecting ridge. When the key contact finger moves against the rod in the "on" position, as shown in Fig. 3-4A, the finger will contact the projecting ridge of the bus bar, and B+ will be connected to the oscillator, causing the note to sound. When a coupler tab is turned off, the coupler rod is mechanically rotated to

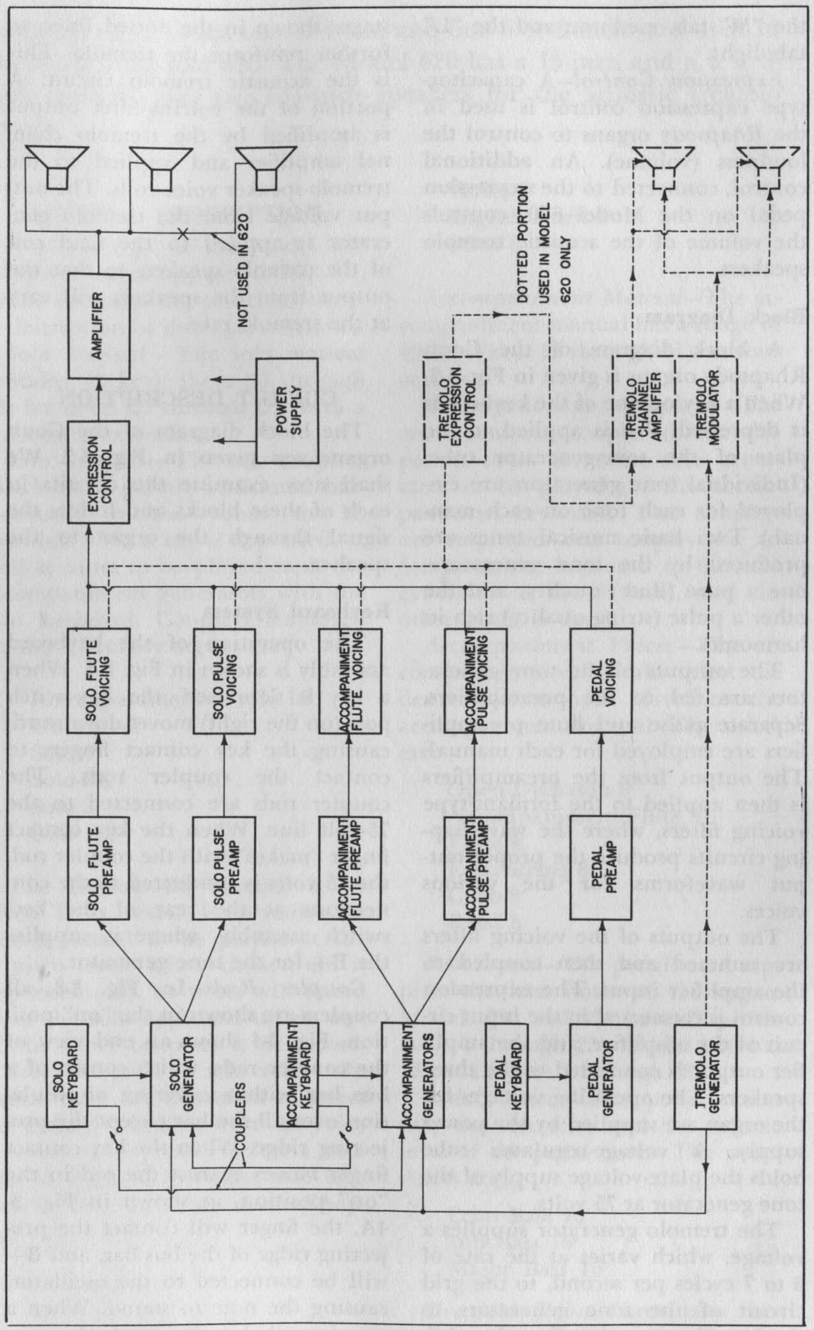
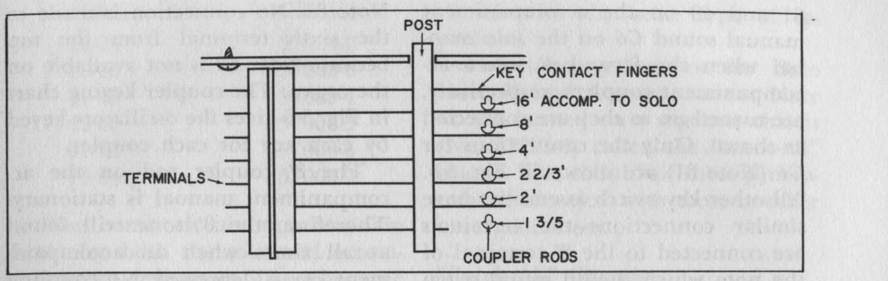
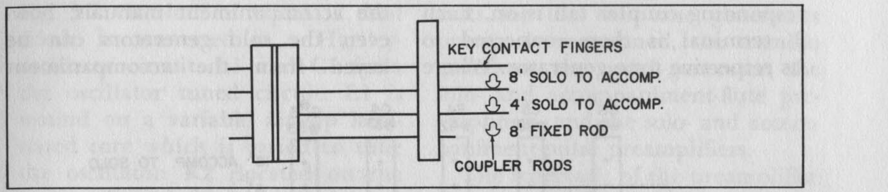


Fig. 3-2. Block diagram of the Conn *Rhapsody* organ.



(*A*) *Solo* (*upper*) *keyboard.*



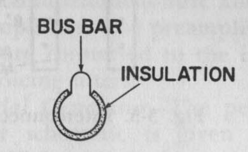
(*B*) *Accompaniment* (*lower*) *keyboard.*

Fig. 3-3. Side view of the key-switch assembly.

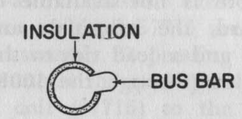
the position shown in Fig. 3-4B. With the rod in this position, the key contact finger strikes the insulated portion of the coupler rod and no tone will sound.

The coupling connections for a single note (*C6*—Note 61) are given in Fig. 3-5. This is a rear view showing the ends of the key contact fingers (hereafter called terminals) extending through the rear post on the key-switch assembly in Fig. 3-3. The top post on the left is for coupling the accompaniment generator No. 49 to solo key No. 61. The second terminal from the top is the 8′ terminal. Thus, when the Unison Off tab is on, the 8′ coupler rod is in the position shown in Fig. 3-4A; and when key 61 on the solo manual is depressed, the key-contact finger will contact the projecting ridge of the coupler rod and connect the 75 volts to this terminal. From this terminal, the path is through the 100K resistor to the plate of the tone generator.

The third terminal from the top is the 4′ terminal. When the solo 4′ coupler is depressed, its coupler rod will move to the position shown in Fig. 3-4A. When key 49 (*C5*) is played with the 4′ coupler on, *C6* should also sound. Therefore, a connection is made from the 4′



(*A*) *"On" position.*



(*B*) *"Off" position.*

Fig. 3-4. End view of coupler rod.

terminal on the Note 49 key-switch assembly to the 8′ terminal on Note 61, and on to the oscillator as before. Likewise, key 42 (*F4*) played at $2\frac{2}{3}'$, key 37 (C4) played at 2′, and key 33 (G#3) played at $1\frac{3}{5}'$, sound Note C6, so they are connected as shown in Fig. 3-5. In addition, keys

61 and 49 on the accompaniment manual sound *C6* on the solo manual when the 8′ and 4′ solo-to-accompaniment couplers, respectively, are turned on so they are connected as shown. Only the connections for *C6* (Note 61) are shown in Fig. 3-5. All other key-switch assemblies have similar connections—the terminals are connected to the 8′ terminal of the note which should sound when the key is depressed and the corresponding coupler tab is on. Each 8′ terminal is then connected to its respective tone generator. Where

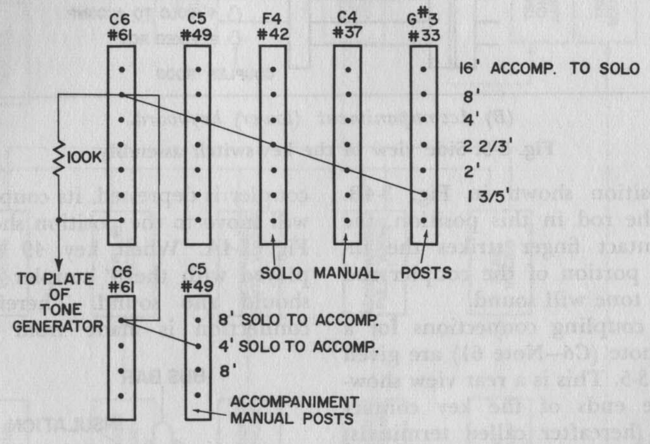


Fig. 3-5. Interconnecting leads between keying fingers for Note 61 (C6).

the note is not available on the keyboard, the terminals are connected and a lead ties to the tone generator (through the 100K resistor).

Therefore, the top terminal on the rear post for Note 61 (Fig. 3-5) is connected to the 8′ terminal of key 49 on the accompaniment manual. The third terminal is connected to the 8′ terminal on key 73. The fourth terminal from the top is connected through a 100K resistor to the tone generator for Note 80, and the fifth terminal is similarly connected to the tone generator for Note 85. No connection is made to the sixth terminal from the top because Note 89 is not available on the organ. The coupler keying chart in Fig. 3-6 gives the oscillators keyed by each key for each coupler.

The 8′ coupler rod on the accompaniment manual is stationary. Therefore, the 8′ tone will sound at all times when an accompaniment key is depressed. No coupling is employed between the notes on the accompaniment manuals; however, the solo generators can be keyed from the accompaniment manual with the two solo-to-accompaniment couplers.

Tone Generators

All manual tone generators (except Note 85 on the solo manual and Note 61 on the accompaniment manual) are located on the nine tone-generator chassis. Each chassis contains six 12AU7 dual-triode tubes which serve as the tone generators for the 12 notes of one octave. Separate tone generators are used for each manual. The chassis are identified by chassis numbers, as follows:

Notes	*Chassis*
13-24	57000-2
25-36	57000-3
37-48	57000-4
49-60	57000-5
61-72	57000-6
73-84	57000-7

The same chassis numbers are used for both the solo and accompaniment generators. The schematic of a single tone-generator is given in Fig. 3-7. One-half of a 12AU7 dual triode is connected in a Hartley-oscillator circuit. L1 and C1 form the oscillator tuned circuit. L1 is wound on a variable air-gap laminated core which is varied to tune the oscillator. R2 (located on the keyboard) and C3 "damp" the key clicks by introducing a short time-delay before the note sounds after a key is depressed. A positive bias, which varies from 7.5 volts for Notes 13 to 24 to 2.0 volts for Notes 73 to 85, is applied through R1 to the grid of the tube. When tremolo is used, the tremolo voltage is also applied at this point.

Each oscillator supplies two outputs—one a sine wave or flute in character, and the other a pulse waveform for the reed and string voicing.

The schematic of a tone-generator chassis is given in Fig. 3-8. Notice that each oscillator stage is alike. The only differences are in the part numbers of the tone-generator coils and the values of the components. The leads from the key switches are color coded for each octave, as shown here. That is, all *"C"* generators have red leads, all *"C#'s"* gray, etc. The resistors labeled R2 are located on the keyboard and are all 100K units. All R1's are 1 meg. The values for C1, C2, C3, and R3 for each generator are given in Table 3-1. (NOTE: C1 has a special temperature coefficient and must be replaced with the same type of capacitor.)

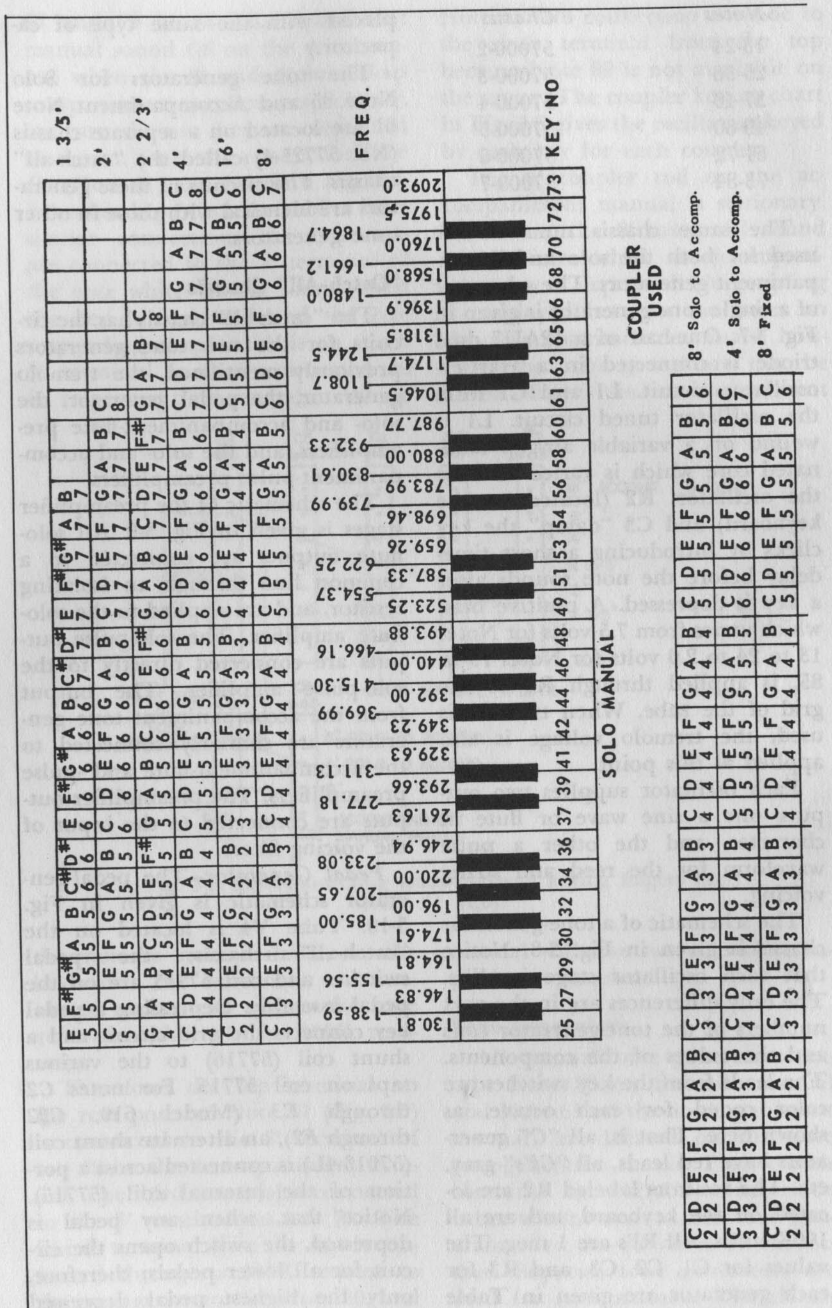
The tone generators for Solo Note 85 and Accompaniment Note 61 are located on a separate chassis (No. 57725-4) called the "catch-all" chassis. The circuits of these generators are identical with those in other tone generators.

"Catch-All" Chassis

The "catch-all" chassis has the circuits for the two tone generators previously mentioned, the tremolo generator, the pedal generator, the solo- and accompaniment-flute preamplifiers, and the solo- and accompaniment-pulse preamplifiers.

The schematic of the preamplifier stages is given in Fig. 3-9. All solo-flute outputs are connected to a common line through an isolating resistor, and are applied to the solo-flute amplifier. The solo-pulse outputs are connected directly to the solo-pulse amplifier. The output from the accompaniment tone generators are similarly connected to the accompaniment-flute and -pulse preamplifiers. The preamplifier outputs are connected to the input of the voicing filters.

Pedal Generator—The pedal-generator schematic is given in Fig. 3-10. Tube V4 is located on the "catch-all" chassis; the pedal switches and coil 57715 are on the pedal assembly. Depressing a pedal key connects the grid circuit and a shunt coil (57716) to the various taps on coil 57715. For notes *C2* through *C3* (Model 610, *C#2* through *F2*), an alternate shunt coil (57013-4L) is connected across a portion of the internal coil (57715). Notice that, when any pedal is depressed, the switch opens the circuit for all lower pedals; therefore, only the highest pedal depressed will sound a note. The pedal voicing tabs are also shown in Fig. 3-10.



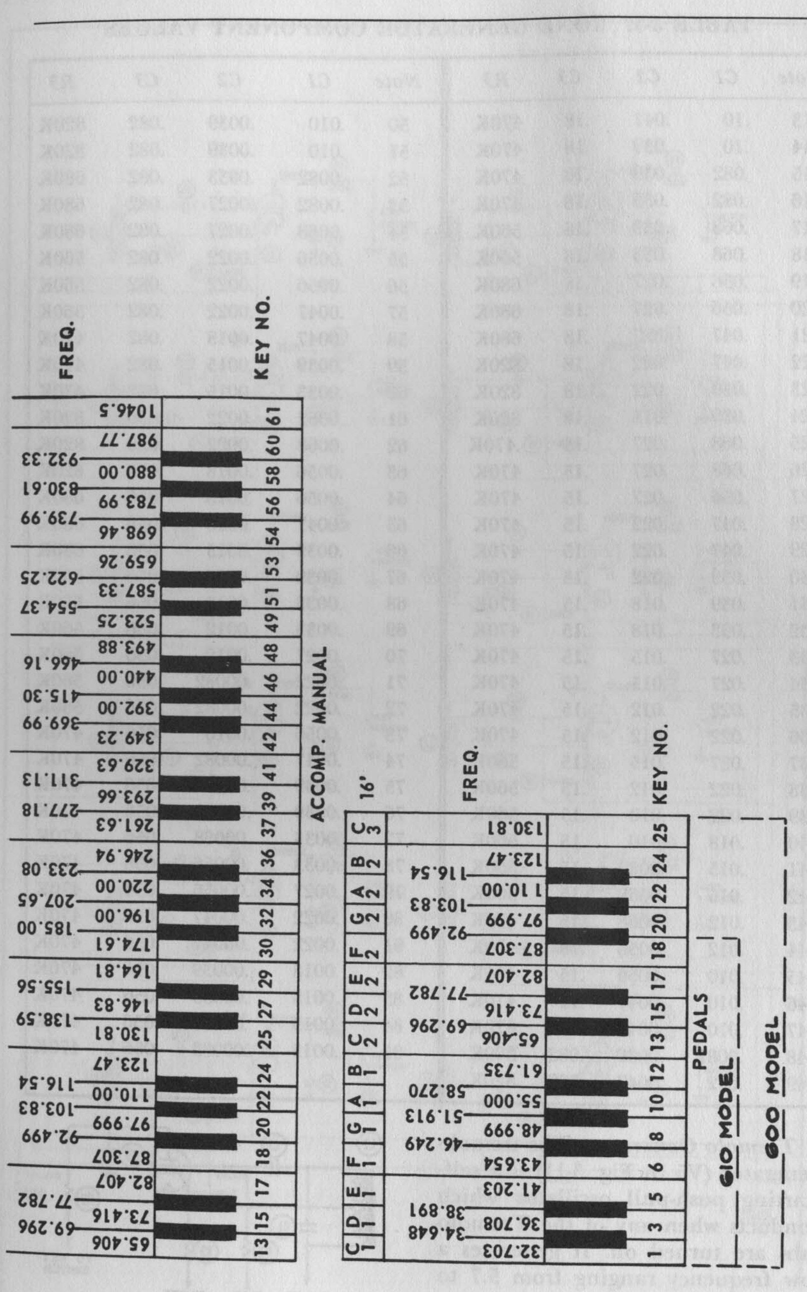


Fig. 3-6. Coupler keying chart.

TABLE 3-1. TONE GENERATOR COMPONENT VALUES

Note	C1	C2	C3	R3	Note	C1	C2	C3	R3
13	.10	.047	.18	470K	50	.010	.0039	.082	820K
14	.10	.039	.18	470K	51	.010	.0039	.082	820K
15	.082	.039	.18	470K	52	.0082	.0033	.082	680K
16	.082	.033	.18	470K	53	.0082	.0027	.082	680K
17	.068	.033	.18	560K	54	.0068	.0027	.082	680K
18	.068	.033	.18	560K	55	.0056	.0022	.082	560K
19	.056	.027	.18	680K	56	.0056	.0022	.082	560K
20	.056	.027	.18	680K	57	.0047	.0022	.082	560K
21	.047	.027	.18	680K	58	.0047	.0018	.082	470K
22	.047	.022	.18	820K	59	.0039	.0015	.082	470K
23	.039	.022	.18	820K	60	.0033	.0015	.082	470K
24	.039	.018	.18	820K	61	.0082	.0022	.056	820K
25	.068	.027	.15	.470K	62	.0068	.0022	.056	820K
26	.068	.027	.15	470K	63	.0056	.0018	.056	820K
27	.056	.027	.15	470K	64	.0056	.0018	.056	680K
28	.047	.022	.15	470K	65	.0047	.0018	.056	680K
29	.047	.022	.15	470K	66	.0039	.0015	.056	680K
30	.039	.022	.15	470K	67	.0039	.0015	.056	560K
31	.039	.018	.15	470K	68	.0033	.0012	.056	560K
32	.033	.018	.15	470K	69	.0033	.0012	.056	560K
33	.027	.015	.15	470K	70	.0027	.0010	.056	560K
34	.027	.015	.15	470K	71	.0022	.00082	.056	560K
35	.022	.012	.15	470K	72	.0022	.00082	.056	560K
36	.022	.012	.15	470K	73	.0056	.0010	.056	470K
37	.027	.015	.15	560K	74	.0047	.00082	.056	470K
38	.022	.012	.15	560K	75	.0039	.00082	.056	470K
39	.022	.010	.15	560K	76	.0039	.00068	.056	470K
40	.018	.010	.15	560K	77	.0033	.00068	.056	470K
41	.015	.0082	.15	560K	78	.0033	.00056	.056	470K
42	.015	.0068	.15	560K	79	.0027	.00056	.056	470K
43	.012	.0068	.15	470K	80	.0022	.00047	.056	470K
44	.012	.0056	.15	470K	81	.0022	.00047	.056	470K
45	.010	.0056	.15	470K	82	.0018	.00039	.056	470K
46	.010	.0047	.15	470K	83	.0018	.00039	.056	470K
47	.010	.0047	.082	470K	84	.0015	.00033	.056	470K
48	.0082	.0039	.082	390K	85	.0015	.00033	.056	470K
49	.012	.0047	.082	820K					

Tremolo Generator—The tremolo generator (V5 in Fig. 3-11) is a self-starting push-pull oscillator which conducts when any of the Tremolo tabs are turned on. It generates a low frequency ranging from 5.7 to 7.3 cps. The secondary of the tremolo transformer is connected to the tone-generator grid-bias network, as

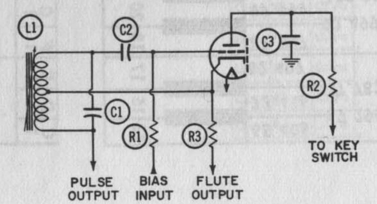


Fig. 3-7. A single tone-generator stage.

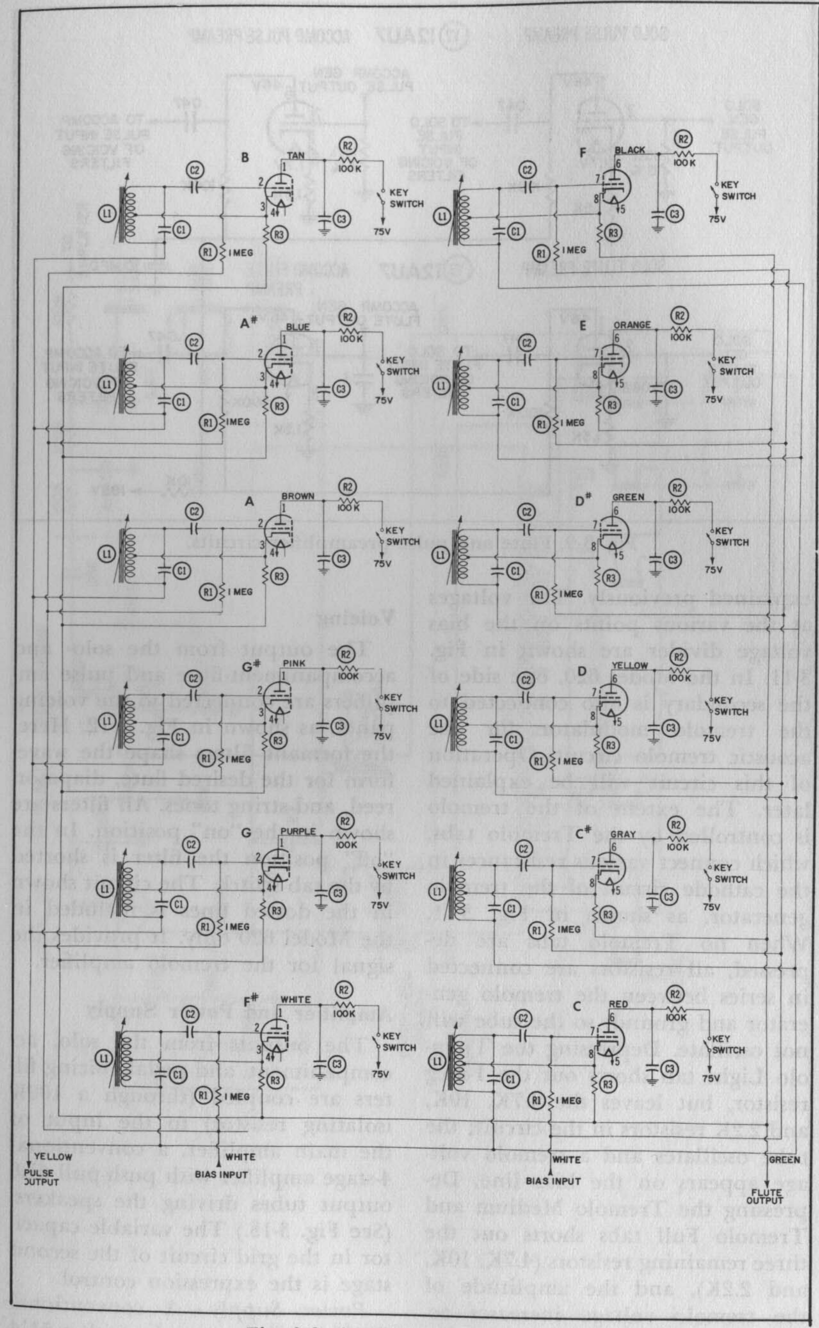


Fig. 3-8. A tone-generator chassis.

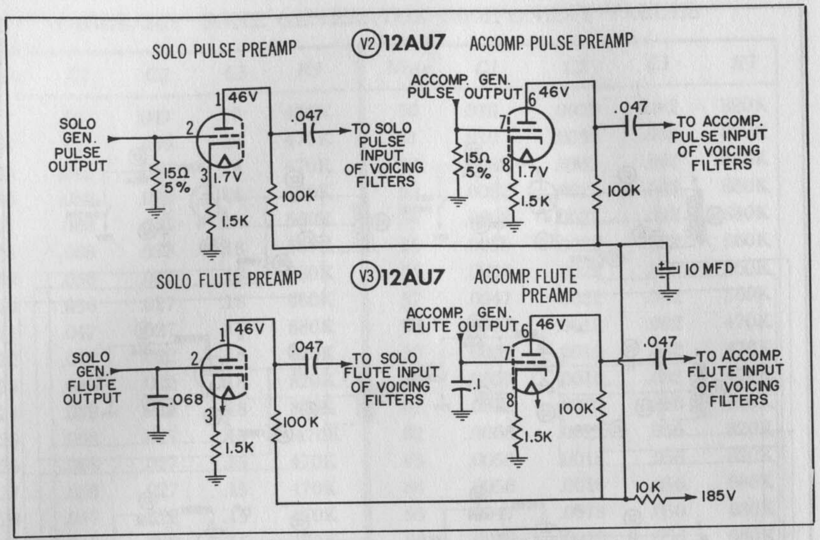


Fig. 3-9. Flute and pulse preamplifier circuits.

explained previously. The voltages at the various points on the bias voltage divider are shown in Fig. 3-11. In the Model 620, one side of the secondary is also connected to the tremolo modulator for the acoustic tremolo circuit. Operation of this circuit will be explained later. The extent of the tremolo is controlled by the Tremolo tabs, which connect various resistances in the cathode circuit of the tremolo generator, as shown in Fig. 3-11. When no Tremolo tabs are depressed, all resistors are connected in series between the tremolo generator and ground; so the tube will not oscillate. Depressing the Tremolo Light tab shorts out the 1-meg resistor, but leaves the 4.7K, 10K, and 2.2K resistors in the circuit; the tube oscillates and a tremolo voltage appears on the bias line. Depressing the Tremolo Medium and Tremolo Full tabs shorts out the three remaining resistors (4.7K, 10K, and 2.2K), and the amplitude of the tremolo voltage increases accordingly.

Voicing

The output from the solo- and accompaniment-flute and pulse amplifiers are connected to the voicing panel, as shown in Fig. 3-12. Here, the formant filters shape the waveform for the desired flute, diapason reed, and string tones. All filters are shown in the "on" position. In the "off" position the filter is shorted by the tab switch. The circuit shown in the dotted lines is included in the Model 620 only. It provides the signal for the tremolo amplifier.

Amplifier and Power Supply

The outputs from the solo, accompaniment, and pedal voicing filters are coupled (through a 100K isolating resistor) to the input of the main amplifier, a conventional 4-stage amplifier with push-pull 6L6 output tubes driving the speakers. (See Fig. 3-13.) The variable capacitor in the grid circuit of the second stage is the expression control.

Power Supply – A conventional full-wave power supply, with a 5U4

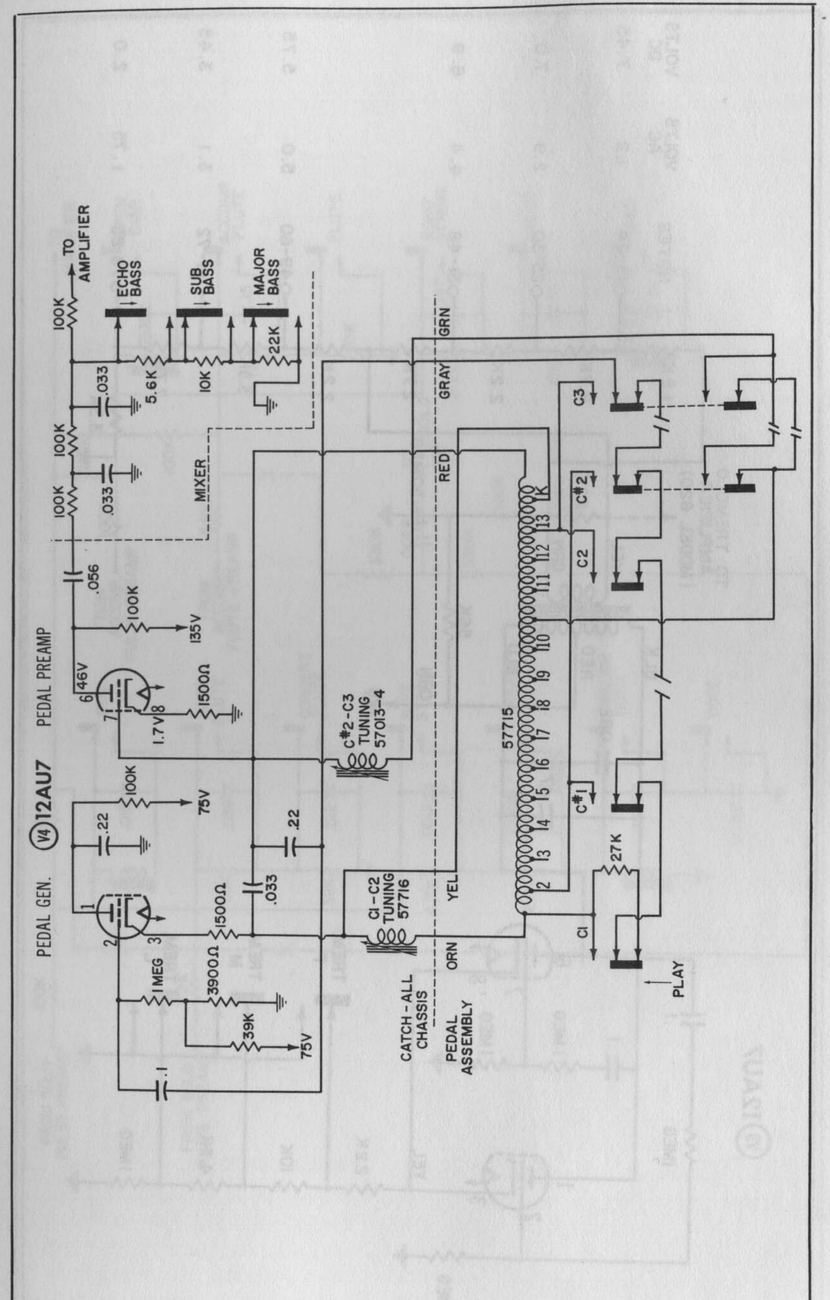


Fig. 3-10. The pedal circuit.

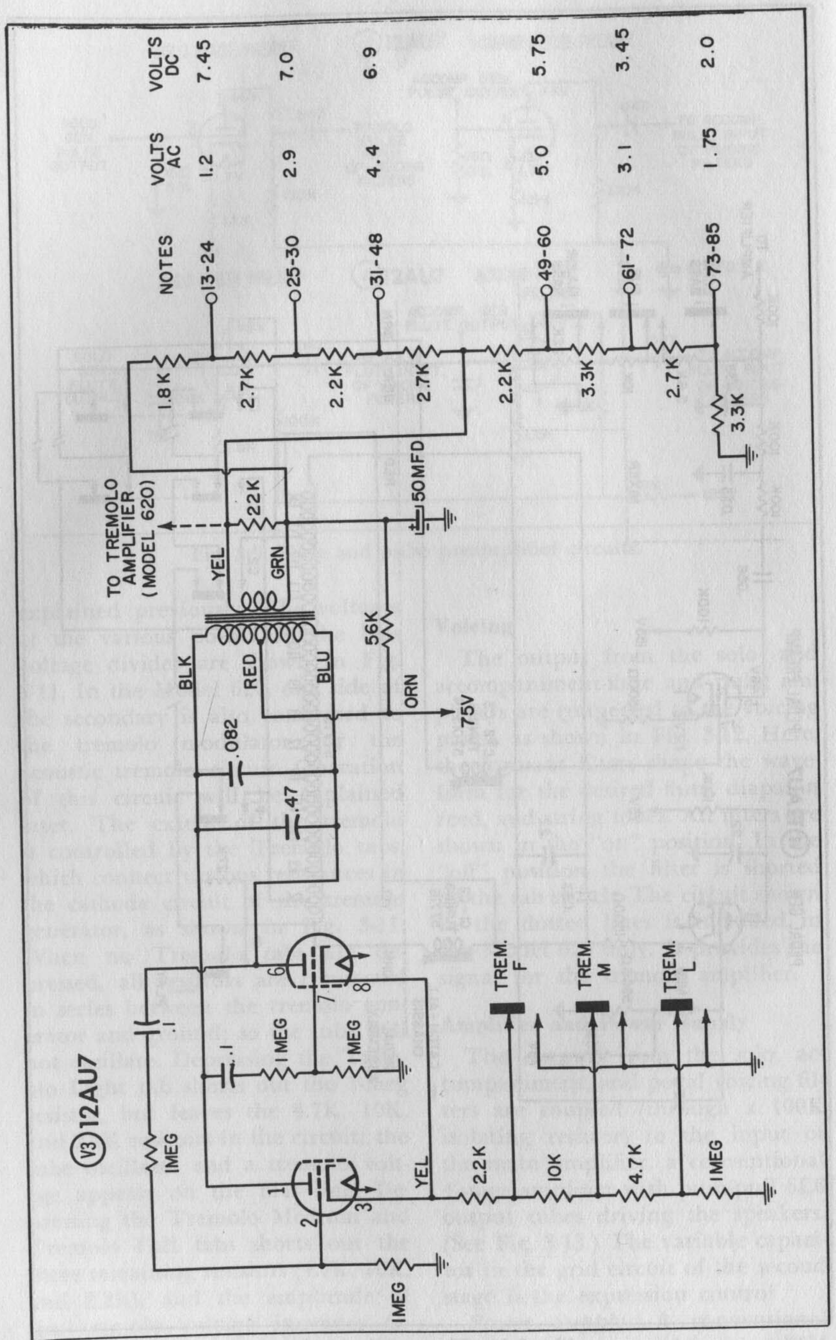


Fig. 3-11. The tremolo circuit.

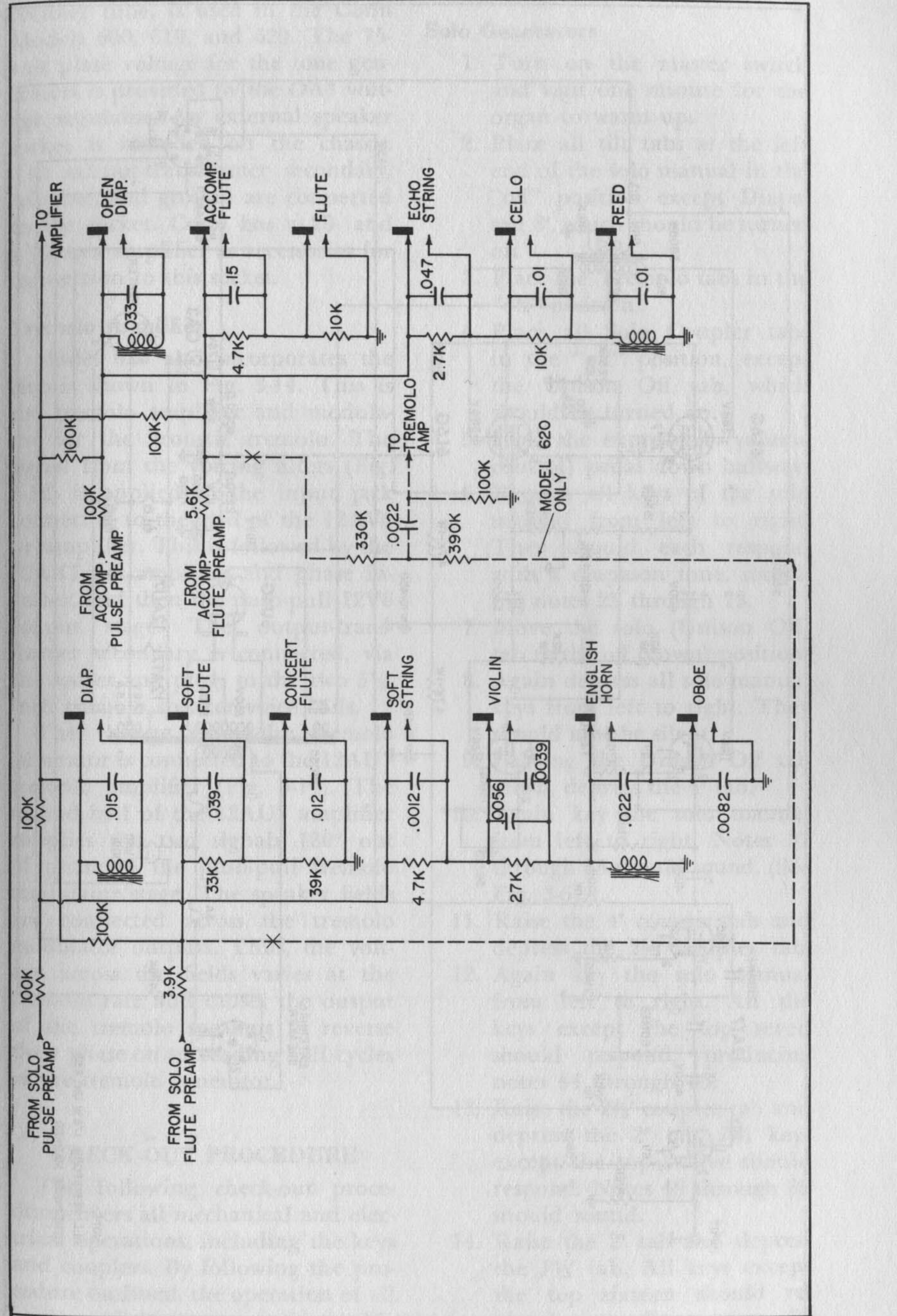


Fig. 3-12. The voicing circuits.

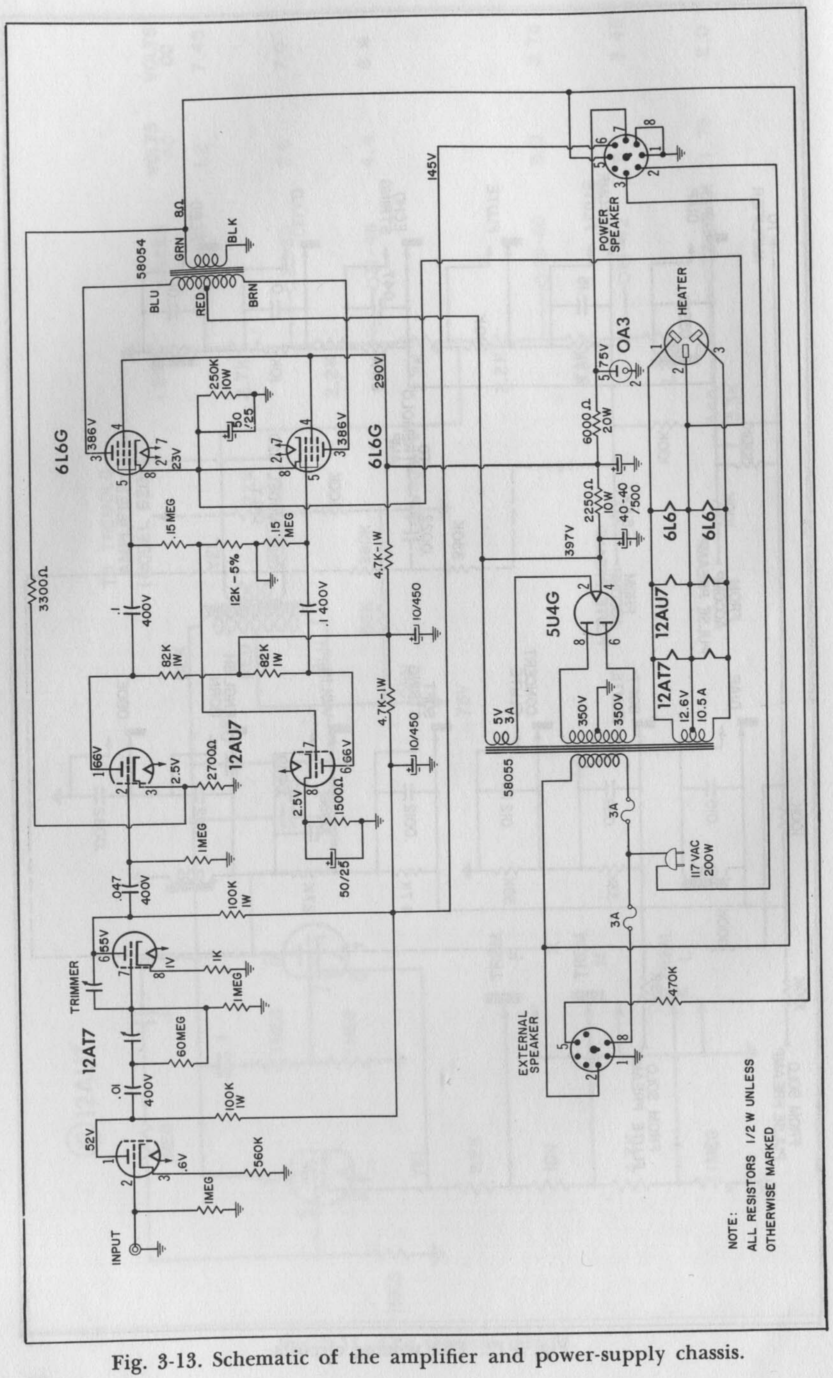


Fig. 3-13. Schematic of the amplifier and power-supply chassis.

rectifier tube, is used in the Conn Models 600, 610, and 620. The 75-volt plate voltage for the tone generators is provided by the OA3 voltage regulator. An external speaker socket is included on the chassis. The output-transformer secondary, AC line, and ground are connected to the socket. Conn has a 20- and a 40-watt amplifier as accessories for connection to this socket.

Tremolo Amplifier

Model 620 also incorporates the circuit shown in Fig. 3-14. This is the tremolo amplifier and modulator for the acoustic tremolo. The signal from the voicing filters (Fig. 3-12) is applied to the input jack connected to the grid of the 12AV6 preamplifier. This is followed by the 12AX7 AF amplifier and phase inverter, and then the push-pull 12V6 output stage. The output-transformer secondary is connected, via the socket and plug, to the two 5¼-inch tremolo speaker voice coils.

The voltage from the tremolo generator is connected to the 12AU7 tremolo amplifier (Fig. 3-14). The second half of the 12AU7 amplifier supplies the two signals 180° out of phase to the push-pull tremolo modulator stage. The speaker fields are connected across the tremolo modulator outputs. Thus, the voltage across the fields varies at the tremolo rate and causes the output of the tremolo speakers to reverse their phase on succeeding half cycles of the tremolo generator.

CHECK-OUT PROCEDURE

The following check-out procedure covers all mechanical and electrical operations, including the keys and couplers. By following the procedure outlined, the operation of all sections of the organ can be readily checked.

Solo Generators

1. Turn on the master switch and wait one minute for the organ to warm up.
2. Place all tilt tabs at the left end of the solo manual in the "off" position except Diapason 8′, which should be turned on.
3. Place the Tremolo tabs in the "off" position.
4. Place all Solo Coupler tabs in the "off" position, except the Unison Off tab, which should be turned on.
5. Hold the expression (volume control) pedal down halfway.
6. Depress all keys of the solo manual from left to right. They should each respond with a diapason tone, sounding notes 25 through 73.
7. Move the solo (Unison Off) tab to the off (down) position.
8. Again depress all solo manual keys from left to right. They should now be silent.
9. Leaving the Unison Off tab down, depress the 4′ tab.
10. Again key the solo manual from left to right. Notes 37 through 85 should sound. (See Fig. 3-6).
11. Raise the 4′ coupler tab and depress the 2⅔′ coupler tab.
12. Again key the solo manual from left to right. All the keys except the top seven should respond, producing notes 44 through 85.
13. Raise the 2⅔′ coupler tab and depress the 2′ tab. All keys except the top twelve should respond. Notes 49 through 85 should sound.
14. Raise the 2′ tab and depress the 1⅗′ tab. All keys except the top sixteen should respond, sounding notes 54 through 85.

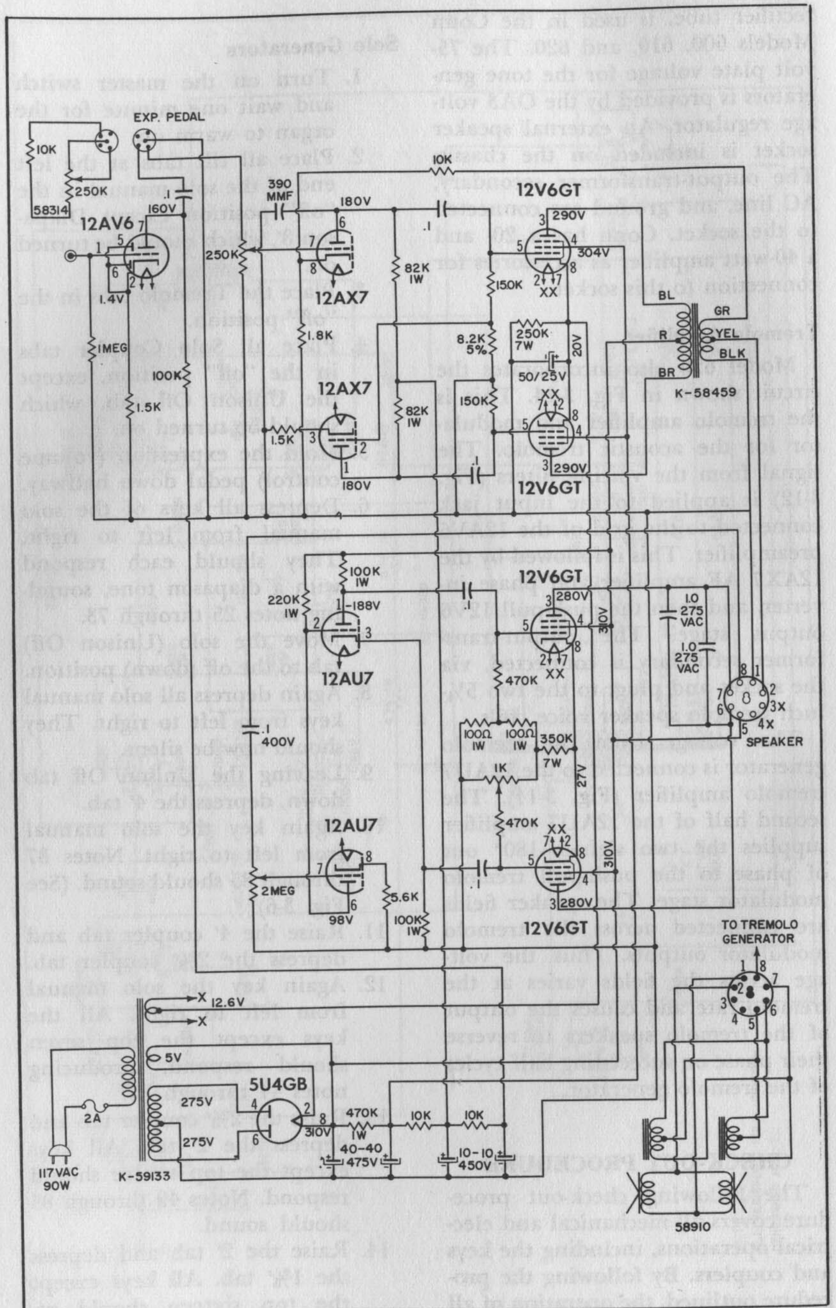


Fig. 3-14. Schematic of the tremolo amplifier and modulator used in the Model 620.

Solo Voice Tablets

1. Hold any key down on the solo manual.
2. Make sure all Solo Coupler tabs are up.
3. While holding the key, depress the Solo Voice tablets, one at a time, from left to right. Each voice should respond with a different tone or volume.
4. While playing a note toward the top of the keyboard in the diapason voice, depress the Tremolo tab lettered "F." The note should respond with a heavy degree of tremolo at a frequency of six to seven cycles.
5. Change from the "F" to the "M" tremolo tab. The note should respond with a medium degree of tremolo at nearly the same frequency as for "F."
6. Change from the "M" to the "L" tremolo tab. The note should respond with a light degree of tremolo at nearly the same frequency as for "M."

This completes the testing of the solo manual except for the accompaniment-to-solo coupler, which will be covered later.

Accompaniment Generators

1. Place all accompaniment voice tabs in the "off" position except Flute 8′.
2. See that the solo-to-accompaniment tabs are off (level).
3. Key the accompaniment manual from left to right. All keys (13 through 61) should respond.
4. While holding any key down on the accompaniment manual, move the accompaniment voice tablets down, one at a time, from left to right. Each voice tablet should respond with a different tone and different volume.
5. While sounding a note toward the upper end of the accompaniment keyboard, again place the tremolo tabs down, one at a time, and observe the change in the tremolo as you move the "L" and "F" tremolo tabs. The amplitude and frequency should be about the same as for the solo (upper) manual.

Intermanual Couplers

1. Depress the solo-to-accompaniment 8′ tab and select some voice on the solo manual such as Diapason 8′.
2. Key the accompaniment manual from left to right. All keys should respond with a diapason tone sounding notes 13 through 61.
3. Turn the solo-to-accompaniment 8′ tab off and depress the solo-to-accompaniment 4′ tab. Leave the Diapason tab on the solo manual on.
4. Key the accompaniment manual from left to right, all keys should respond with a diapason tone sounding notes 25 through 73.
5. Turn the solo-to-accompaniment 4′ tab off and depress the accompaniment-to-solo 16′ tab on the solo manual. Turn the diapason tab on the solo manual off, and select a voice tab on the accompaniment manual such as Flute 8′.
6. Key the solo manual from left to right. All keys should respond with a flute tone sounding notes 13 through 61.

Pedal Generator

1. Depress a pedal voice tab, such as Major Bass, and key all the pedals from left to right. Each pedal should respond, sound-

ing notes 1 through 25 on Models 600 and 620 and notes 1 through 18 on Model 610.

2. While holding a pedal note down, change the voice tabs from Major Bass to Sub Bass, and then to Echo Bass. Each voice should respond in a different character and volume.

Expression Control

The expression-control pedal regulates the total volume of the organ. The more this pedal is depressed, the louder the volume. It is placed in the over-all circuit, just ahead of the power amplifier. When up (off), this pedal diminishes the volume to its lowest level; and when down, it gives the full power output of the organ. Its operation should be free of mechanical drag and any electrical noise.

Miscellaneous

All organs have some peculiarities which may be noticeable from time to time. These are normal characteristics and do not interfere with the playing of the organ. For example, when voice tabs are depressed while notes are being played, a click may be heard in the speaker. This is a normal condition found in most electronic organs. It can be avoided by setting the registration (tabs) before depressing any keys.

Conn's pedal generator consists of one master generator which produces all the pedal notes. Because only one pedal note can be played at a time, the organist cannot produce a discordant tone by depressing more than one pedal key at the same time.

The pedal division has some other characteristics which should be explained. When two keys are depressed at one time, only the higher note sounds. If a pedal key is depressed very slowly, a position will be reached where the note is off key or pitch. This is due to the mechanics of the pedal switch; it will not occur during normal playing.

TUNING

Connect the Conn *Strobotuner* to the speaker terminals in order to pick up a signal from the organ.

The tone generators are divided as follows: solo, 61 notes (keys 25 through 73); accompaniment, 49 notes (keys 13 through 61) and pedals (note 1 through 25 in Models 600 and 620 and 1 through 18 in the Model 610). Each manual tone generator has a separate tuning-nut adjustment on top of each tone-generator coil. The coils are grouped twelve to a chassis (except those for the highest notes). These coils are located to the right and left of their respective tubes and are accessible from the back. Each one is identified by a number and a note.

The organ is tuned to the equally tempered scale, using A440 cps as the pitch standard. It is tuned to an approximate zero beat between octaves, from the lowest note to the highest. Octaves should not be "stretched" as on a piano because of the octave couplers used in many of the registrations.

The coupler keying chart in Fig. 3-6 will clarify the keying and octave coupling. In this chart, notes are identified by number and frequency; also shown are the octave notes brought in by the couplers.

When tuning the organ with the *Strobotuner*, follow these steps:

1. Allow the instruments to warm up for 10 or 15 minutes.
2. Tune the equally tempered scale of A440 cps.
3. All couplers except Unison must be off, or up. Be sure the Unison coupler is on. Otherwise, no notes will sound on the manual.
4. Make sure all Tremolo tabs are off.
5. Turn the tuning nuts clockwise to flatten the note, counterclockwise to sharpen it. The best procedure is to sharpen the note, and then flatten it until it is brought into tune. This takes up any thread play.

Solo Manual

The tone generators for the solo (upper) manual are located on the left, facing the back of the organ. Chassis 57000-3, 57000-4, 57000-5, 57000-6, 57000-7, and 57725-4 are used for the solo tone generators. Select one of the solo voices (such as Diapason), key the manual, and tune the respective tone generator coil. Repeat this procedure for each key on the solo manual, tuning notes 25 through 73.

The extended octave (notes 73 through 85) are now tuned by turning off the Unison Off coupler and turning on the 4′ coupler. Notes 73 through 85 (*C7* through *C8*) will now sound when keys 61 through 73 are depressed. (See Fig. 3-6.) The tuning coil for note 85 (C8) is located on Chassis 57725-4.

Accompaniment Manual

The tone generators for the accompaniment (lower) manual are located on the right, facing the back of the organ. Chassis 57000-2, 57000-3, 57000-4, 57000-5, and 57725-4 are used for the accompaniment tone generators. Select one of the accompaniment voices, key the accompaniment keys, and tune the corresponding tone generator coils. The coil for note 61 (C6) will be found on Chassis 57725-4. (There is no extended octave for the accompaniment manual.)

Pedals

Only two tuning adjustments are required for the pedal generator. They are located on Chassis 57725-4. Select one of the pedal voices (such as Sub Bass) and depress pedal 7 (*F#1*). Tune coil 57716. Then depress pedal 19 (*F#2*) and tune coil 57013-4.

Tuning Hints

The *Strobotuner* is a very sensitive instrument which will detect practically any deviation in pitch. However, it is not advisable to tune any organ to the exact pitch (the point where the patterns on the *Strobotuner* appear stationary) because the generators themselves will vary slightly in operation. Therefore, striving to obtain exact pitch at all times is impractical. Furthermore, exact tuning destroys, to some extent, the fine musical qualities of the organ. Experience has proved that an instrument held to within one-fourth to one-half per cent of perfect pitch receives better customer acceptance than one with perfect pitch.

Any deviations are more noticeable in the upper than in the lower registrations. Hence, these octaves should be given greater attention. One-fourth per cent of a high-frequency note results in more beats than the same percentage in the middle register.

MALFUNCTIONS

Conn organs, like all mechanical and electrical devices, require occasional adjustments. The following paragraphs will explain the recommended procedures in case of a malfunction. Table 3-2 will aid in checking the various transformers and coils.

TABLE 3-2. TRANSFORMER AND COIL DATA

Coil or Transformer Part No.	*DC Resistance (Ohms) Between Leads* Black and Red	Blue and Red
57013-1 (L & R)	680	2100
57013-2 (L & R)	360	1200
57013-3 (L & R)	200	700
57013-4 (L & R)	140	420
57013-6 (L & R)	95	120
57013-8 (L & R)	35	40
56274*	1600	2000
57715	End-to-End — 2200	
57716	End-to-End — 2200	

* Green to yellow 725 Ohms.

Complete Failure

If the organ is dead, first check the power-circuit (house) fuse and then the organ power-supply fuse. Both may be blown. A dead organ could also mean a defective amplifier or power tube, an amplifier plug not making proper connection, or a defective on-off switch. Needless to say, any defective fuses, tubes, or switches must be replaced.

Solo Manual (Upper Keyboard) Failure

If the solo manual is dead, several things could be wrong. It is possible that no keying voltage is being supplied to the coupler keying rods. If so, look for a broken connection or dirty contact at the ends of the keyboards, where the voltage is applied to the rods. (See the paragraph, at the end of the chapter, about access to the keyboard contacts and keying rods.)

A defective tube in the console power supply or in the preamplifier chassis, at the right end of each generator bank, will also kill the upper keyboard. In addition, watch out for a bad signal line or connection to the speakers.

Accompaniment Manual (Lower Keyboard) Failure

The remedies for a dead accompaniment manual are the same as for the solo manual.

Pedal Failure

Dead pedals mean a defective 12AU7 on Chassis 57725-4, a faulty signal line to the amplifier, or a defective speaker package amplifier.

Note Failures on One or More Couplers

Note failure on one or more couplers means a 12AU7, or a capacitor or coil in the generator circuit, is defective. Another cause is a dirty key contact (see the paragraph later on access to the keyboard). NEVER use abrasives on the silver plating of the keying rods. If necessary, the fingers may sometimes be bent slightly so they contact the rod at the right or left of the original position. Sometimes, it is necessary to replace the rod or the key switch assembly.

Pedal Note Failures

When a pedal note is dead, look for a dirty switch contact under a

pedal key. Also check for a defective pedal oscillator transformer (No. 57715, located under the keyboard) or pedal tuning transformer (No. 57716 or 57013-4 on Chassis No. 57725-4). If all notes fail, look for a defective 12AU7 tube on Chassis 57725-4.

Mechanical Noises in the Pedalboard

If the pedalboard squeaks or knocks, the screws holding the sharp crowns or other parts in place may be loose. Touch the felts at the key stops. If they feel packed or hard, replace them.

Notes Not Holding Pitch

When a note varies from its true pitch, several things may be the cause. Capacitor C1 in the generator could be defective, a defective tube in the generator or a defective oscillator coil might be the fault, or there may be resistance in the keying circuit due to dirty switch contacts.

The voltage-regulator circuit must produce a constant 75 volts for the keying circuit. If not, an off-pitch note will result. Check the voltage-regulator tube (OA3) plus the 40-40-475 and 10-450 filter capacitors.

Noisy or Off-Color Notes

If a note sounds off-color or noisy, first check capacitors C1 and C2. Then look for a defective coil or connection in the generator.

Notes Other Than the Ones Keyed Sounding

One of the most common causes of the wrong note sounding is a dirty keying rod. First, clean the rods under the key that produces the *desired* note. If the couplers are dirty across the insulated portion of the rod, it is possible for a keying voltage to be obtained via this conductive dirt, even when the coupler is off. Extra notes will then sound, just as if the coupler were being operated.

When the extra note is of an entirely different pitch from the one corresponding to the coupler, conductive material (wire clippings, corrosion, etc.) is shorting out the adjacent keying fingers. This defect is located most easily with an ohmmeter. Also look for shorted interconnecting wiring in the laced cables. To remedy, loosen the lacing and separate the cables. When shorts occur in the manual keyboard wiring, and loosening and separating the cables does not disclose the cause, disconnect the circuit and install new wires and interconnecting leads. (The white wires interconnect the keying fingers to provide the different note combinations for the couplers.)

Some or All Flute Notes Fail

When some or all flute notes are dead, the 12AU7 (V3) on Chassis 57725-4 is defective or an open exists in the wiring common to the flute signal.

Some or All String and Reed Tones Fail

When some or all string and reed tones are dead, look for a defective 12AU7 (V2) on Chassis 57725-4, or an open or short in the pulse signal leads or diapason, string, and reed voicing circuits.

No Tremolo

When there is no tremolo, the tremolo generator obviously is not functioning. The reason may be a defective 12AU7 or transformer No. 56274. In Model 620, also check the tremolo amplifier and modulator Chassis.

Tab Switches Inoperative

If a tab switch fails, the contacts are probably dirty and should be cleaned. (Don't use abrasives!)

Distorted Notes, or Frying and Cracking Noises From the Speaker

Raucous notes or frying and cracking noises from the speaker could mean a defective tube in the generator, amplifier, or power supply. To locate, place all tabs down and depress the expression pedal all the way. Then lightly tap each tube until you find the ones that are microphonic.

Check all cable connections and wiring. Look for poor solder connections, particularly in the voice-coil, signal-line, and DC power circuits. A harder trouble to find is a plug connector that has rosin flux on the prongs or other places which depend on a good mechanical joint for electrical conductivity.

Note Sounds Without Being Keyed

A note sounding when no key is depressed (cipher) is probably caused by improperly adjusted keying fingers. Another cause is conductive material (dirt) or worn insulation on the keying rod.

Abnormal Notes, Especially With Tremolo

When notes sound abnormal, especially with tremolo, suspect a defective coil or capacitor in the generator.

Distorted Notes in a Chord at Low Volume

Notes in chords may sound distorted at low volume. If so, the cause is the same as in the previous paragraph.

Too Much Volume

When the organ "booms" forth, the trimmer capacitor in the expression (volume) control circuit is not adjusted properly.

Distorted Tones at High Volume

When tones are distorted at high volume, the gain of the power amplifier may be set too high. Also, check for defective tubes in the power amplifier, power supply, and preamplifier.

Key-Switch Tension Adjustment

The key switches should be adjusted so the notes begin sounding when the key is about halfway down. This position is controlled by a tab (toward the front of the key channel) that contacts the key-switch post. Insert a pointed tool in the hole in the tab, and carefully bend the tap up or down as needed.

The keys are tightened in the same way by means of a second tab (toward the rear of the key channel) that contacts the key spring. All keys are adjusted at the factory for a tension of approximately three ounces.

DISASSEMBLY INSTRUCTIONS

When the back is removed from the console, all tubes are accessible. The following instructions will aid in gaining access to the keyboard contacts, generator components, and pedalboard mechanism.

Keyboard Contacts

1. Remove the back panel from the console.
2. Unfasten the console top latches (on the front, under each end).
3. Raise the top of the console and tilt it to the rest position.
4. Tilt the solo manual keyboard by lifting slightly at each end of the keystop rail.
5. Tilt the accompaniment manual by lifting slightly at each end of the keystop rail, until the manuals clear this console trim. Then pull the assembly forward. This gives enough clearance at the rear of the keyboard ends to allow the assembly to be tilted.

Pedalboard Mechanism

1. Remove the console back.
2. Remove the complete amplifier and power supply by first taking out the four wood screws at the end of the chassis.
3. Remove the cable from the channel, and the bolts at the base of the console, over the pedalboard assembly. Then slide the pedalboard forward.

NOTE: When reinstalling the amplifier and power supply, make sure the chassis shield (metallized paper) lies flat on the console base. Otherwise, short circuits may occur under the chassis.

Generator Components

Each generator chassis is held in position by four screws. By loosening the top two and removing the bottom two, the chassis can be lowered for maintenance.

NOTE: Once the chassis is loosened from the channel, the lower edge can be hooked over the lower-channel edge to hold it in position for changing components or for testing.

NOTE: When reinstalling the amplifier and power supply, make sure the chassis stand (elevated spacer) lies flat on the console base. Otherwise short circuits may occur under the chassis.

Generator Components

Each generator chassis is held in position by four screws. By loosening the top two and removing the bottom two, the chassis can be lowered for maintenance.

NOTE: Once the chassis is loosened from the channel, the lower edge can be hooked over the lower channel edge to hold it in position for changing components or for testing.

4. Tilt the solo manual keyboard by lifting slightly at each end of the keystop rail.
5. Tilt the accompaniment manual by lifting slightly at each end of the keystop rail until the manuals clear the console trim. Then pull the assembly forward. This gives enough clearance at the rear of the keyboard ends to allow the assembly to be tilted.

Pedalboard Mechanism

1. Remove the console back.
2. Remove the complete amplifier and power supply by first taking out the four wood screws at the end of the chassis.
3. Remove the cable from the channel, and the bolts at the base of the console, over the pedalboard assembly. Then slide the pedalboard forward.

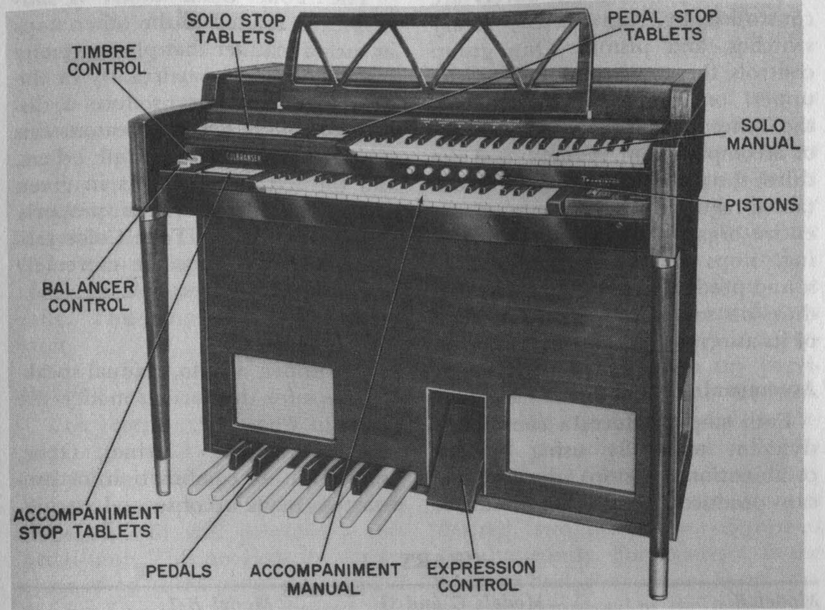


Fig. 4-1. The Gulbransen Model B-2 transistor organ.

CHAPTER 4

THE GULBRANSEN TRANSISTOR ORGAN

The Gulbransen (Models B, C, G, and B-2) electronic spinet organs employ transistor oscillator tone-generating systems. The tone generators contain 72 or 84 transistors—one for each available pitch. Each manual has 44 keys, and the pedal clavier has 13. Fig. 4-1 is a photograph of the Gulbransen Model B-2 electronic organ.

STOP TABLETS AND CONTROLS

The many voices and effects are controlled by stop tablets, rotary switches, and pistons. One group controls the tone produced by the upper, or solo, manual; another, the tones produced by the lower, or accompaniment, manual; and the third, the pedal tones. The Tremolo tablet regulates the tremolo of the entire organ. The white, or speaking, stops determine the type of sound produced. A manual will produce no sound unless at least one of its associated speaking stops is on.

Accompaniment Manual

Each stop produces a completely different tone. By using various combinations of stops, the organist can produce literally hundreds of entirely different tone qualities. The stops for the various models are given in Chart 4-1.

The Tone Color tablet is harmonically related to the other stops in such a manner that playing many common chords, particularly in the lower register, can produce a discordant effect. For this reason, this stop is to the right of all others, and the lettering on it is in green instead of black. When properly used, however, the Tone Color tablet makes possible some extremely desirable solo voices.

Solo Manual

The upper, or solo, manual speaking stops for the various models are given in Chart 4-2.

The Diapason, Clarinet, Oboe, and Glock are combination, or preset, stops made up of several pitches.

CHART 4-1.

Model B	*Models C and G*	*Model B-2*
Flute 8′	Flute 8′	Flute 8′
Flute 4′	Flute 4′	Flute 4′
Nazard 2⅔′	Nazard 2⅔′	Nazard 2⅔′
Piccolo 2′	Piccolo 2′	Piccolo 2′
Tierce 1⅗′		Tierce 1⅗′
Tone color		Fife 1′

CHART 4-2.

Model B	*Model C*	*Model G*	*Model B-2*
Bourdon 16′	Bourdon 16′	Bourdon 16′	Bourdon 16′
Tibia 8′	Tibia 8′	Tibia 8′	Tibia 8′
Tibia 4′	Tibia 4′	Tibia 4′	Tibia 4′
Nazard 2⅔′	Nazard 2⅔′	Nazard 2⅔′	Nazard 2⅔′
Piccolo 2′	Piccolo 2′	Piccolo 2′	Piccolo 2′
Diapason	Tierce 1⅗′	Tierce 1⅗′	Tierce 1⅗′
Oboe		Diapason	Fife 1′
Clarinet		Oboe	Diapason
Glock		Clarinet	Oboe
Chimes		Glock	Clarinet
			Glock
			Chimes
			Quint 5⅓′

These stops are lettered in red. The Diapason stop is made up of the Bourdon 16′, Tibia 8′, and Tibia 4′. The Clarinet is made up of Tibia 8′, Nazard 2⅔′, and Tierce 1⅗′. On the solo manual of the Model B organs, the Tierce 1⅗′ stop cannot be played separately; it must be brought in automatically as part of a combination stop. The Oboe is made by combining Tibia 4′, Nazard 2⅔′, and Piccolo 2′. The Glock consists of Bourdon 16′, Tibia 4′, and Nazard 1⅗′. The Chimes, another of the speaking stops, produces a unique tone. This stop will be discussed later.

Pedals

The intensity, or volume, of the pedal tones is controlled by the Pedal Soft, Medium, and Full stops. Depressing a pedal with all pedal stops off will still produce a soft pedal tone. This provides the equivalent of an extra pedal stop tablet: when no pedal tone is desired, the foot is merely removed from the pedal board.

Other Controls

The Omega and Tremolo tablets are nonspeaking stops. In other words, they do not produce any tone. Rather, they modify the ones produced by the speaking stops.

Omega is the term applied to the large family of reverberation and percussion effects. These effects require long decay periods—in some instances, up to two seconds or more. These long decay times are made possible by the omega unit and are adjustable by the Omega control.

The Tremolo stop varies the pitch and amplitude approximately seven times a second. The tremolo effect is obtained by passing the sound through a special sound channel which includes a motor-driven mechanical system that rotates at about 400 rpm when the Tremolo tablet is on.

The Timbre switch affects the frequency response of the amplifier.

Chimes

In the Model B, a chime tone is produced on keys 8 through 32 on the solo manual when the Chimes tablet is depressed. The stop tablet controls the chimes tone quality only—the decay characteristics are controlled by the Omega control.

In the Model B-2 organ, the chimes range covers the entire solo manual. The Chimes stop is a preset piston which cancels any previously set stops and the tremolo. When the Chimes piston is depressed, the solo manual will produce a chime tone with a long decay characteristic. If a shorter decay is desired, two pistons are depressed simultaneously. For example, if the Chimes and Percussion Short pistons are depressed at the same time, the decay time will be percussion short. When the Chimes piston is depressed, the Timbre control is rendered inoperative and a "bright" organ tone is produced. The organ can be restored to its previously set combination by depressing any other piston. This releases the Chimes piston.

GENERAL DESCRIPTION

Stop tablets control a group of switches operated from the playing keys. These switches permit a number of harmonically related oscillators to be sounded from any key. There is one oscillator for each pitch. The ones that operate when a key is played depend on what stop tablets are in operation.

Fig. 4-2 is a block diagram showing how the main parts of the organ are associated. The tone generators

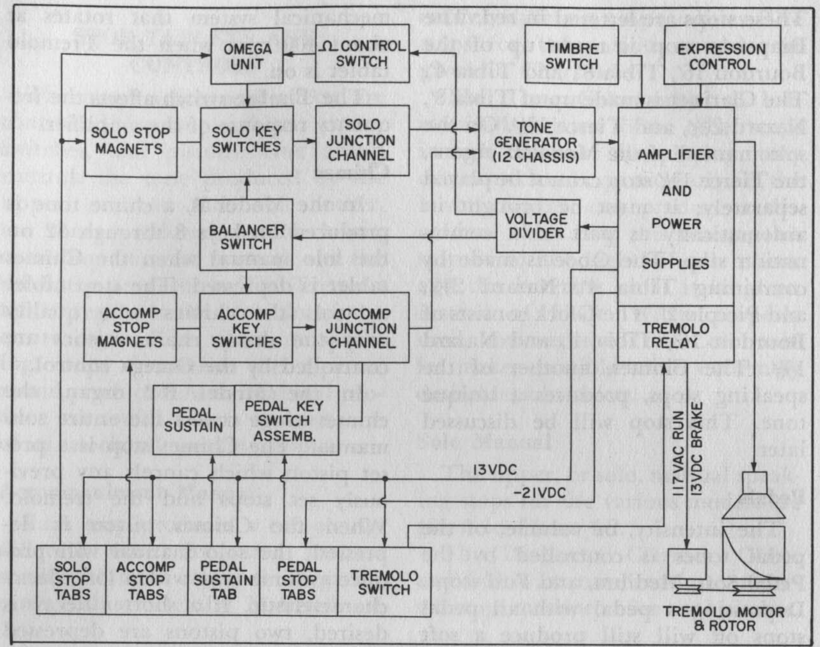


Fig. 4-2. Block diagram of the Gulbransen organ.

are mounted on 12 printed board chassis, each containing oscillators for the six (or seven) octaves of a note. However, each oscillator is entirely separate from the others and can be tuned individually.

When a key on one of the manuals is depressed and the stop tablets are set for a certain group of oscillators, approximately 9 volts is applied through the key switch and junction channel to the oscillator circuit. The normally inoperative oscillator now begins to function. All tones produced by the tone generators are absolutely pure, devoid of any natural harmonics. They are amplified by a conventional five-tube amplifier. The amplifier output is converted into sound by a speaker in a bass-reflex type enclosure (at the right end of the console). The tremolo motor and rotor are mounted directly below the speaker enclosure.

TECHNICAL DESCRIPTION

A more complete discussion of the various sections of the Gulbransen organs follows. Operation of the various circuits and their function in the over-all operation of the organ are also discussed.

Tone Generators

All 12 tone-generator chassis are alike except for the values of the tuning coils and capacitors and a few other minor variations. Fig. 4-3 is the schematic for the oscillators comprising a tone-generator chassis. Fig. 4-4 shows a rear view of a tone-generator chassis and the locations of the various parts.

The cable from the manual supplies a keying voltage, which is applied to the collector (Fig. 4-3). Notice that the short cable is for the solo manual and the long one is for the accompaniment manual; the pin numbers on the cable plug correspond to the octave which is keyed when a voltage is applied to that pin.

Perhaps the most important feature of the transistor oscillators is that they will remain in perfect tune, even though the keying voltage varies widely. The strength of the oscillator signal is a function of the applied keying voltage. The same oscillator, keyed from one keyboard with a —3 volt potential, will sound softly; whereas if keyed from the other keyboard at a potential of —9 volts, it will produce a much stronger signal. This keying voltage depends on the setting of the Balancer control. Some oscillators can also be keyed from the pedal board at a still higher voltage to produce a very strong signal. This is true for octaves 1 and 2 in Fig. 4-5. If keyed from more than one voltage at the same time, the oscillator will sound at the loudest level. Diodes in the keying circuits prevent different power-supply voltages from being mixed while keying an oscillator from two or three different voltages. By conducting current in one direction only, the diodes keep the higher voltage from being short-circuited to the lower one. Most series keying diodes are on the tone-generator chassis. In notes *C1* through *G2*, however, the accompaniment and pedal diodes are on the accompaniment junction channel because they are keyed by the pedal board as well as by the manuals. In Models B-2 and G-1, all manual keying diodes are located on the circuit boards of the tone generator.

Stop Tablets

The stop tablets, when closed, apply 13 volts to a series of magnets. The magnets in turn rotate a series of coupling rods that determine which oscillator will function when a key is depressed.

The operation of the stop-tablet contacts can be clarified by referring to Fig. 4-6. Stop tablet (601) pivots on rod (602) and is retained in either operating position by toggle spring (603). One end of contact wires (611) is secured in phenolic printed circuit board (614). Phosphor bronze contact plate (610) is carried by a stop tablet. When the tablet is operated, the phosphor bronze plate is brought diagonally up against contact wires (611), completing the circuit between the contact wires. In the combination stops on the solo manual, up to three wires are shorted together by the contact plate, as shown at (613). In the combination stops, the contact plate is "pigtailed" (622) to the 13-volt supply so the combined current of the three magnets does not have to travel through one of the contact wires. Printed circuit board (614) interconnects the contact wires. Also attached to it are 330-ohm resistors (615), which are wired across the stop magnets to suppress arcing at the stop-tablet switch contacts. Capacitors (616) and resistors (617) are used in connection with the pedal stop tablets.

Manual Key-Switch Assemblies

The key switches connect the voltages to the oscillators as the organist plays. On the lower (accompaniment) manual, six oscillators can be sounded from a single key. For this reason, six switch contacts are provided for each key. This group of switch contacts is called a key-switch assembly.

Since the player does not always want *all* six tones to sound when a key is depressed, the switches function selectively. Fig. 4-7 shows a manual key-switch assembly. Note the six insulated rods designated

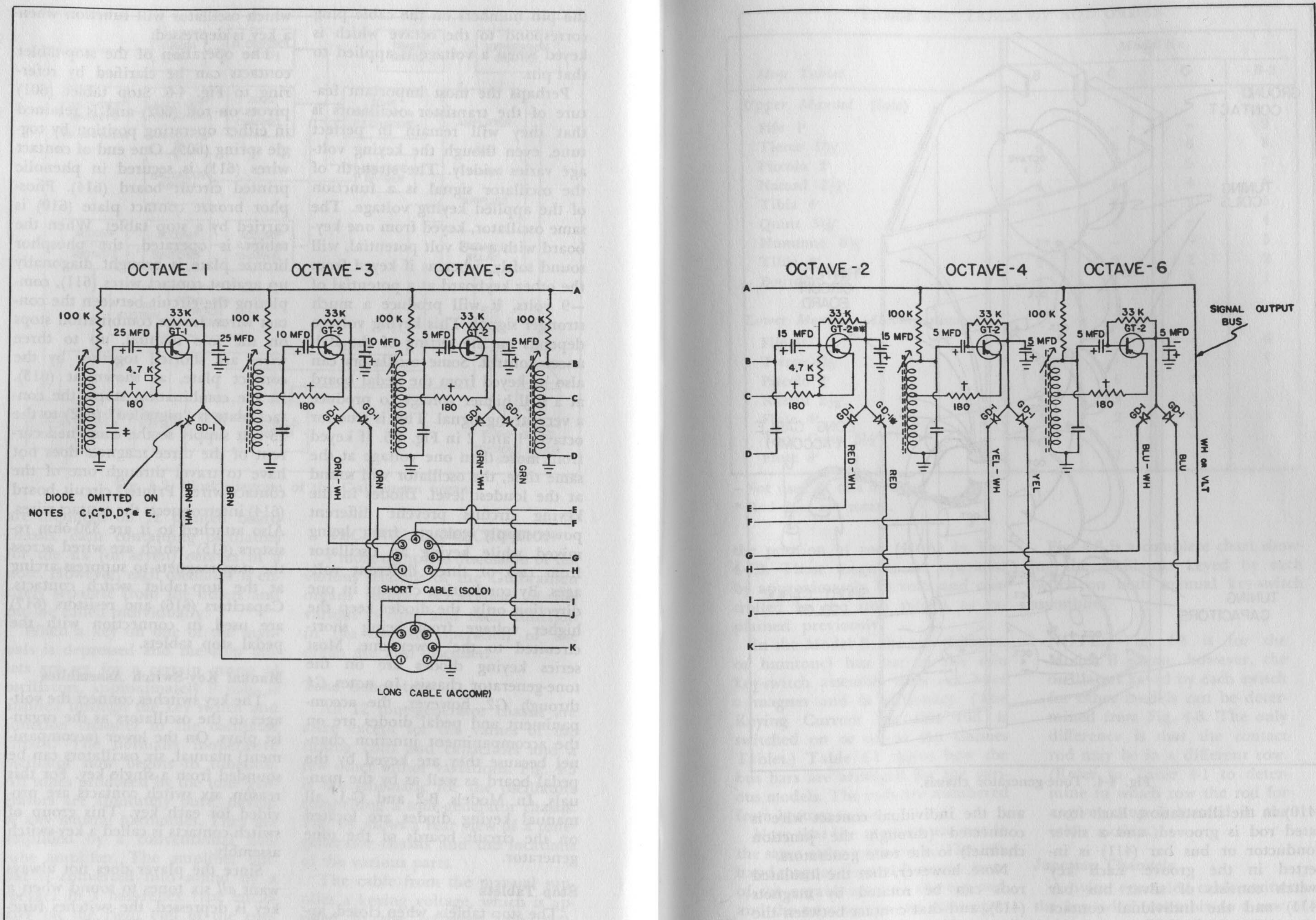


Fig. 4-3. Schematic of the tone generators used in Models B and C.

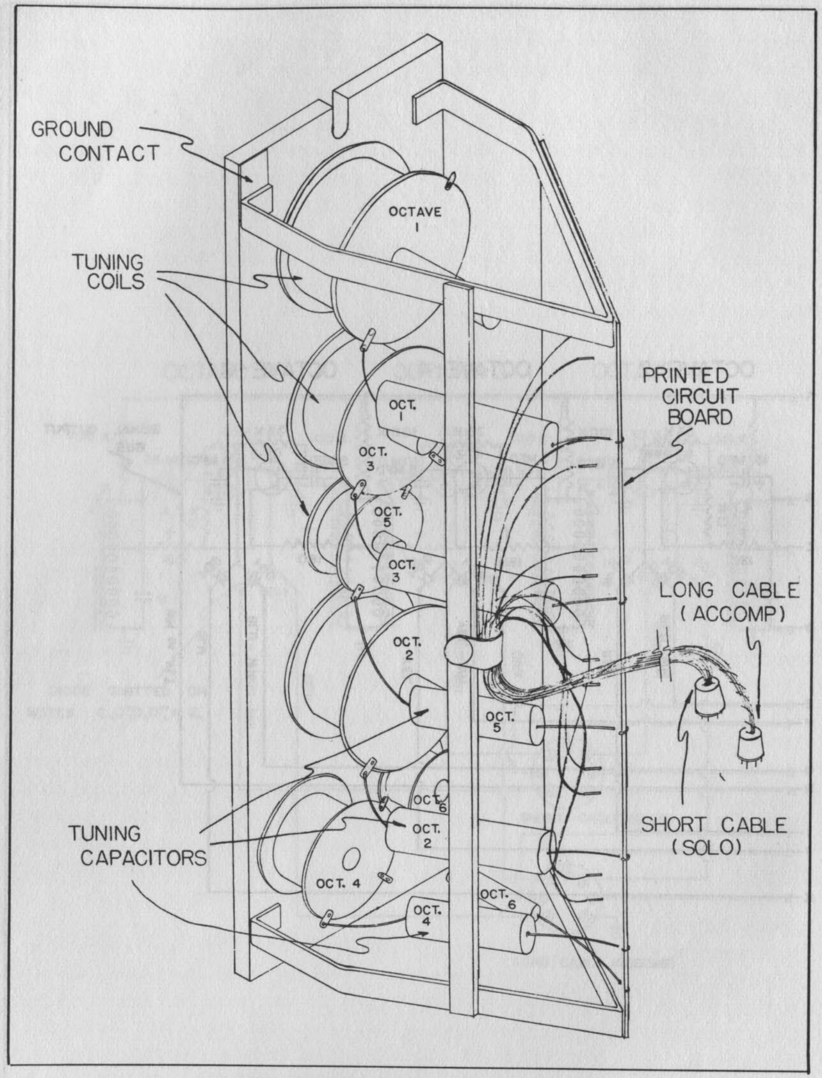


Fig. 4-4. Tone-generator chassis.

(410) in the illustration. Each insulated rod is grooved, and a silver conductor or bus bar (411) is inserted in the groove. Each key switch consists of silver bus bar (411) and the individual contact wire (412), which touch when a key is depressed. The keying-voltage source is connected to the bus bar, and the individual contact wire is connected (through the junction channel) to the tone generators.

Note, however, that the insulated rods can be rotated by magnets (413), and that contact between the silver bus bar and the *contact wires* can be made only when the rod carrying the bus bar is rotated into

TABLE 4-1. TABLE OF ROD ORDER

Stop Tablet	*Model No.* B	C	G	B-2
Upper Manual (Solo)				
Fife 1′	–	–	–	9
Tierce 1⅗′	6	6	6	8
Piccolo 2′	5	5	5	7
Nazard 2⅔′	4	4	4	6
Tibia 4′	3	3	3	5
Quint 5⅓′	–	–	–	4
Humtone 6⅖′	7*	–	–	3
Tibia 8′	2	2	2	2
Bourdon 16′	1	1	1	1
Lower Manual (Accompaniment)				
Fife 1′	–	–	–	6
Tierce 1⅗′	6	–	–	5
Piccolo 2′	5	4	4	4
Nazard 2⅔′	4	3	3	3
Flute 4′	3	2	2	2
Tone Color 5⅓′	2	–	–	–
Flute 8′	1	1	1	1

– Not used in this model.
* Rod does not rotate.

the position of rod (410A) in Fig. 4-6B. These magnets are operated by approximately 13 volts and controlled by the stop tablets as explained previously.

In the Model B, the top (Chimes, or humtone) bus bar in the solo key-switch assembly does not have a magnet and is stationary. (The Keying Current for this rod is switched on or off at the Chimes Tablet.) Table 4-1 shows how the bus bars are arranged for the various models. The rods are numbered from bottom to top.

Note that the magnets are not in the same order as the rods. The left-hand magnet (viewed from the front of the organ) operates the top rod, and the next one to the right operates the third rod from the top. The magnet arrangement is shown in Fig. 4-7.

Fig. 4-8 is a complete chart showing the oscillators keyed by each switch on both manual key-switch assemblies.

NOTE: Fig. 4-8 is for the Model B organ; however, the oscillators keyed by each switch for other models can be determined from Fig. 4-8. The only difference is that the contact rod may be in a different row. (Refer to Table 4-1 to determine in which row the rod for a given stop is located in the other models.)

Junction Channels

A nylon enameled cable connects the key-switch assembly to a row of sockets into which the tone-generator chassis are plugged. These sockets are mounted on a junction chan-

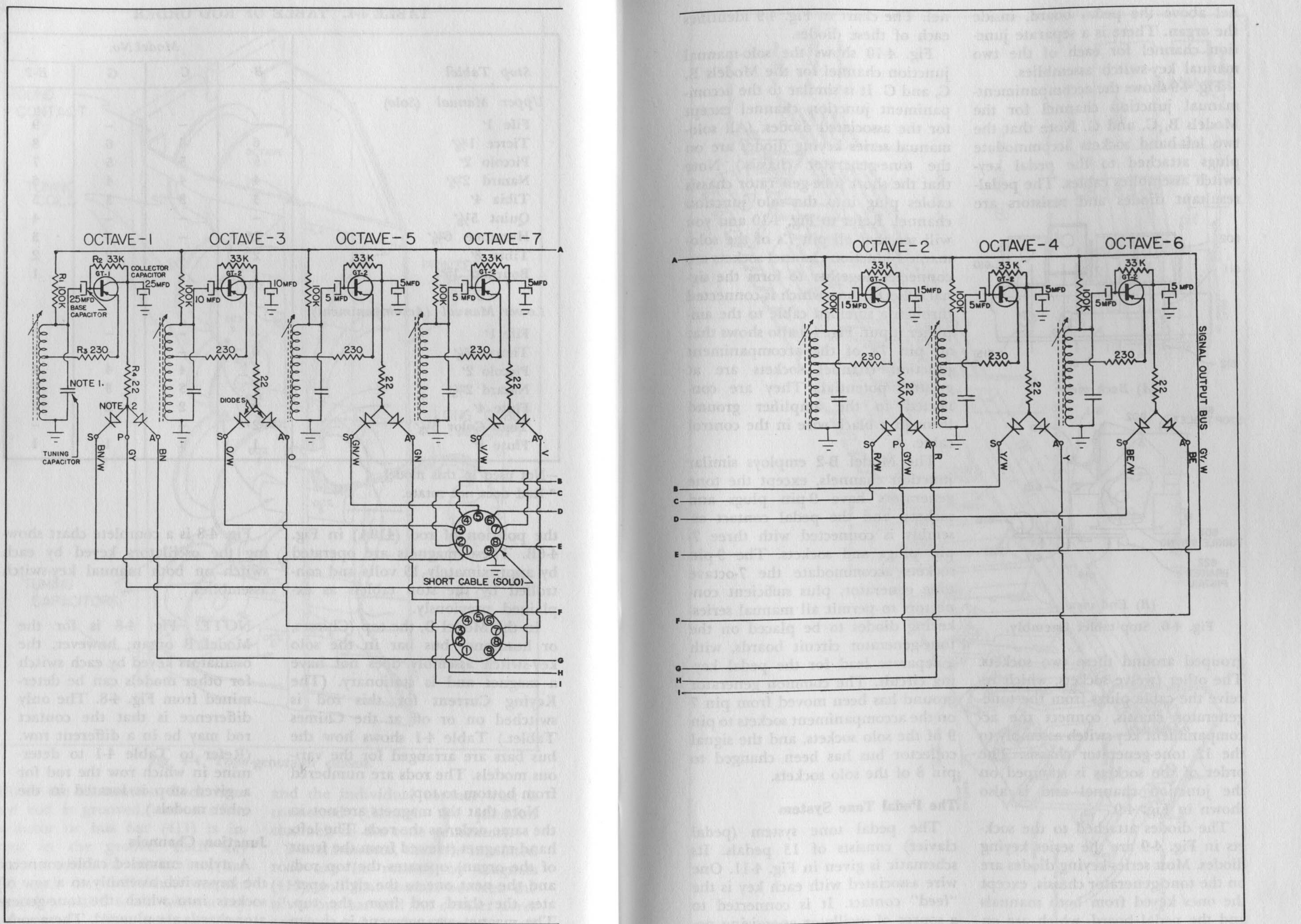
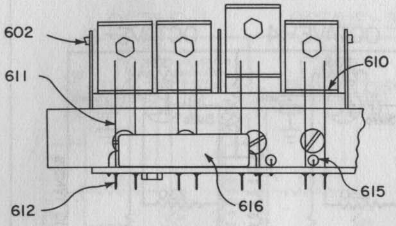


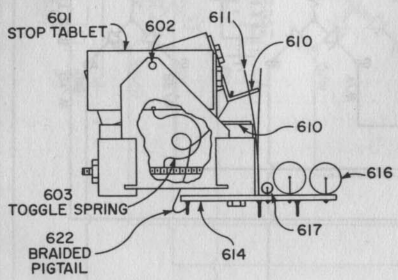
Fig. 4-5. Schematic of the tone generator used in the Model B-2 organ.

nel above the pedal board, inside the organ. There is a separate junction channel for each of the two manual key-switch assemblies.

Fig. 4-9 shows the accompaniment-manual junction channel for the Models B, C, and G. Note that the two left-hand sockets accommodate plugs attached to the pedal key-switch assemblies cables. The pedal-resultant diodes and resistors are



(A) *Back view.*



(B) *End view.*

Fig. 4-6. Stop-tablet assembly.

grouped around these two sockets. The other twelve sockets, which receive the cable plugs from the tone-generator chassis, connect the accompaniment key-switch assembly to the 12 tone-generator chassis. The order of the sockets is stamped on the junction channel and is also shown in Fig. 4-9.

The diodes attached to the sockets in Fig. 4-9 are the series keying diodes. Most series-keying diodes are on the tone-generator chassis, except the ones keyed from both manuals and the pedal board, which are on the accompaniment junction channel. The chart in Fig. 4-9 identifies each of these diodes.

Fig. 4-10 shows the solo-manual junction channel for the Models B, C, and G. It is similar to the accompaniment junction channel except for the associated diodes. (All solo-manual series keying diodes are on the tone-generator chassis.) Note that the short tone-generator chassis cables plug into the solo junction channel. Refer to Fig. 4-10 and you will see that all pin 7's of the solo-manual junction channel sockets are connected together to form the signal collector bus, which is connected through a shielded cable to the amplifier input. Fig. 4-9 also shows that all pin 7's of the accompaniment junction channel sockets are at ground potential. They are connected to the amplifier ground through a black wire in the control cable.

The Model B-2 employs similar junction channels, except the tone generators have 9-pin plugs and sockets, and the pedal contact assembly is connected with three 7-pin plugs and sockets. The 9-pin sockets accommodate the 7-octave tone generator, plus sufficient connectors to permit all manual series-keying diodes to be placed on the tone-generator circuit boards, with a separate lead for the pedal keying circuit. The common generator ground has been moved from pin 7 on the accompaniment sockets to pin 9 of the solo sockets, and the signal collector bus has been changed to pin 8 of the solo sockets.

The Pedal Tone System

The pedal tone system (pedal clavier) consists of 13 pedals. Its schematic is given in Fig. 4-11. One wire associated with each key is the "feed" contact. It is connected to a source of oscillator energizing potential which varies between 7.5 and

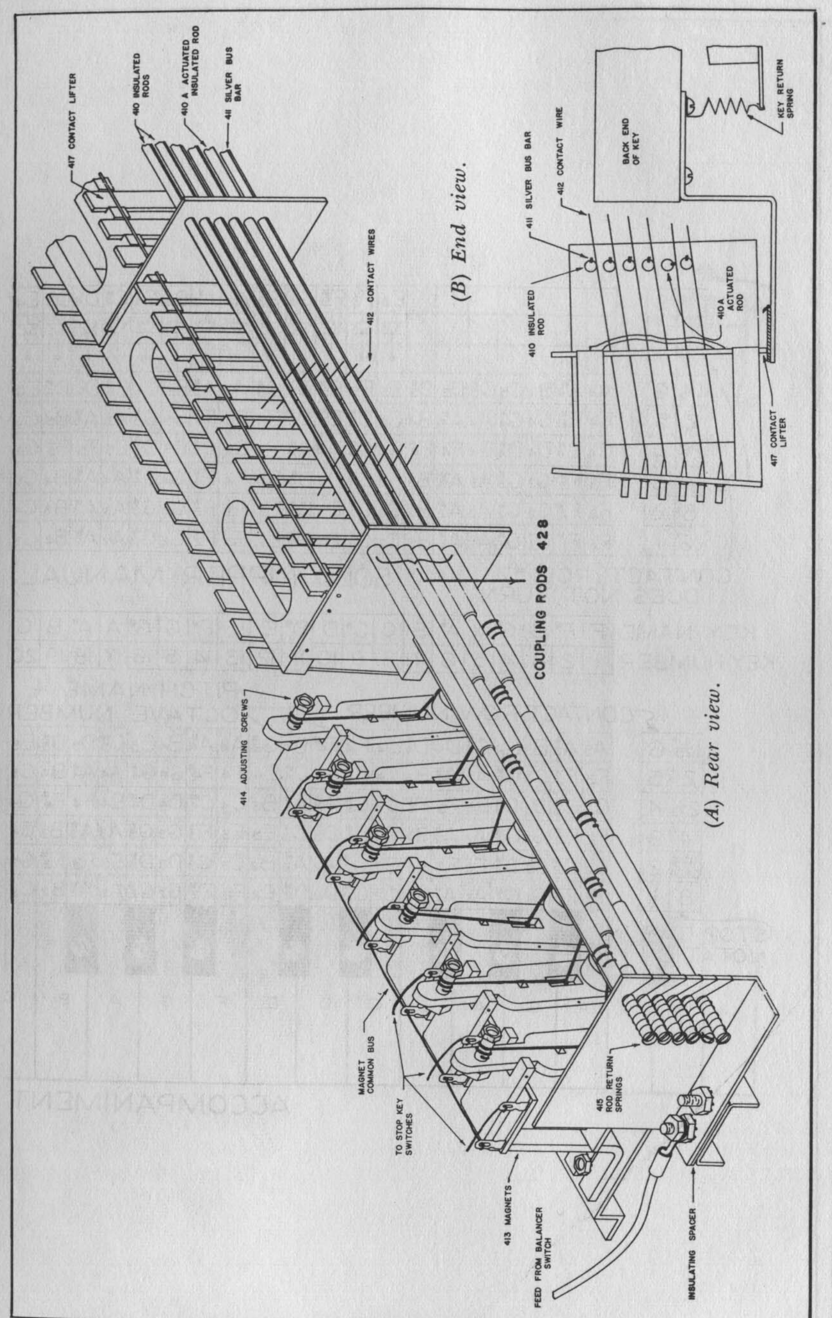


Fig. 4-7. Key-switch assembly.

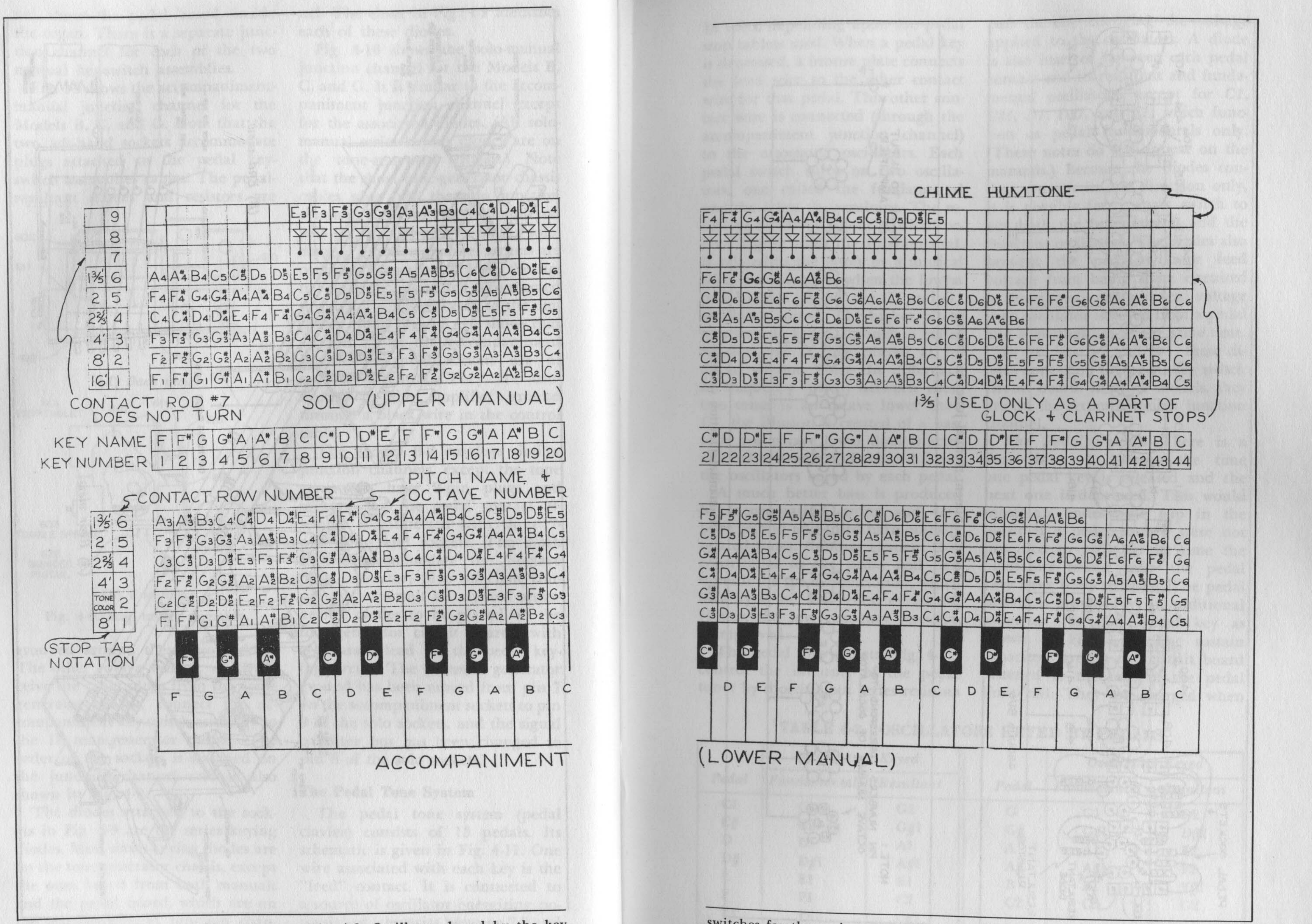


Fig. 4-8. Oscillators keyed by the key switches for the various stop tabs.

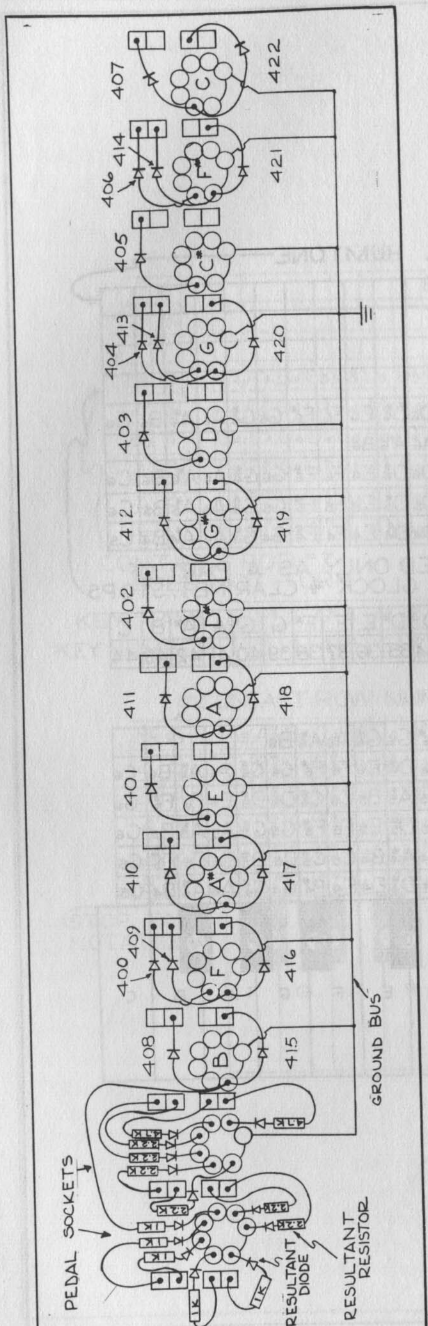


Fig. 4-9. Accompaniment-manual junction channel.

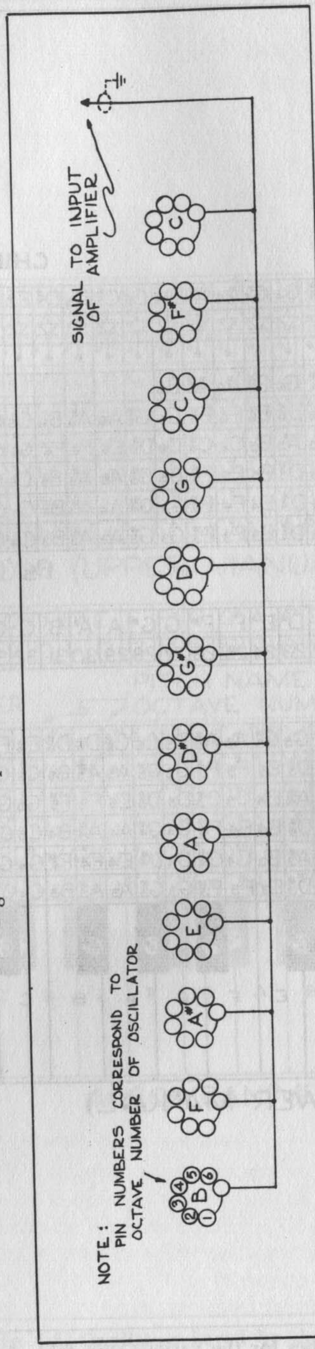


Fig. 4-10. Solo-manual junction channel.

18 volts, depending upon the pedal stop tablets used. When a pedal key is depressed, a bronze plate connects the feed wire to the other contact wire for that pedal. This other contact wire is connected (through the accompaniment junction channel) to the associated oscillators. Each pedal switch turns on two oscillators, one called the fundamental and the other the resultant. The resultant oscillator, about one-half octave higher than the fundamental, is related to the latter by a musical fifth. For example, when the lowest pedal key is played, the *C1* and *G1* oscillators sound. The higher pitch, however, is keyed through a series resistor and is thus played at reduced volume. Since the difference in frequency (pitch) between these two tones is an octave lower than *C1*, the illusion is created of a bass tone one octave lower than is actually being sounded. Table 4-2 shows the oscillators keyed by each pedal.

A much better bass is produced by incorporating strong and very pure second and third harmonically related tones. Another element that contributes to the pedal and bass tones is the speaker enclosure, which is a type of bass-reflex enclosure. Hence, the low-frequency response is improved.

The pedal stop tablets (Fig. 4-11) control the intensity of the pedal tones by shorting out series resistors and thereby changing the voltage applied to the oscillators. A diode is also inserted between each pedal contact and its resultant and fundamental oscillators, except for *C1*, *C#1*, *D1*, *D#1*, and *E1*, which function as pedal fundamentals only. (These notes do not appear on the manuals.) Because the diodes conduct current in one direction only, it is possible for a single switch to key both the fundamental and the resultant oscillators. The diodes also prevent the pedal-oscillator feed voltage from being short circuited to the manual-oscillator feed voltage if an oscillator is keyed from a pedal and a manual key at the same time.

In Models B-2 and G-1, these diodes appear on the pedal key switch circuit board. In other models, they are on the accompaniment junction channel.

The Pedal Sustain—There is a short interval between the time one pedal key is released and the next one is depressed. This would cause an undesirable gap in the music if a pedal sustain were not provided to prolong the time the oscillators sound after the pedal keys have been released. The pedal sustain is provided by an additional capacitor for each pedal key as shown in Fig. 4-11. The sustain capacitors are on the circuit board fastened to the rear of the pedal limit rail. They are charged when

TABLE 4-2. OSCILLATORS KEYED BY PEDALS

Pedal	*Oscillators Keyed*		Pedal	*Oscillators Keyed*	
	Fundamental	*Resultant*		*Fundamental*	*Resultant*
C1	C1	G1	G	G1	D2
C#	C#1	G#1	G#	G#1	D#2
D	D1	A1	A	A1	E2
D#	D#1	A#1	A#	A#1	F2
E	E1	B1	B	B1	F#2
F	F1	C2	C2	C2	G2
F#	F#1	C#2			

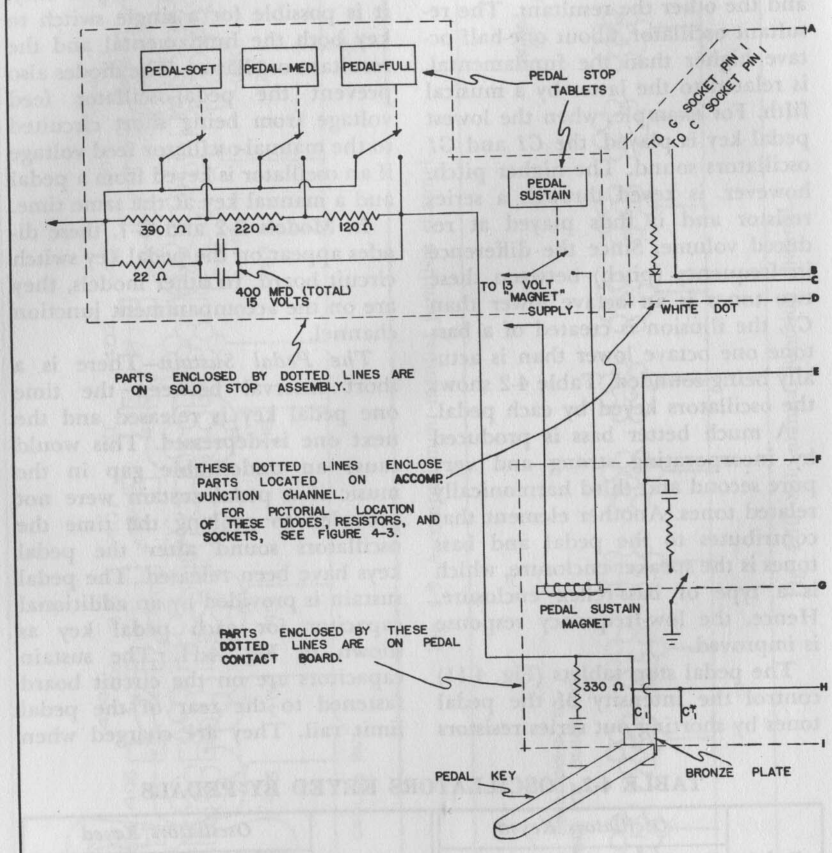
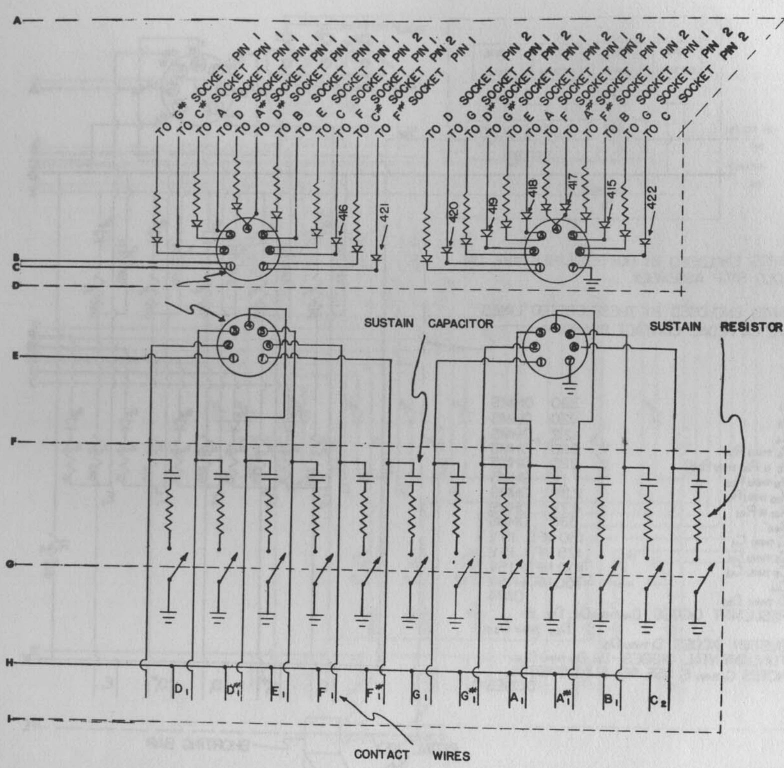


Fig. 4-11.



Pedal system.

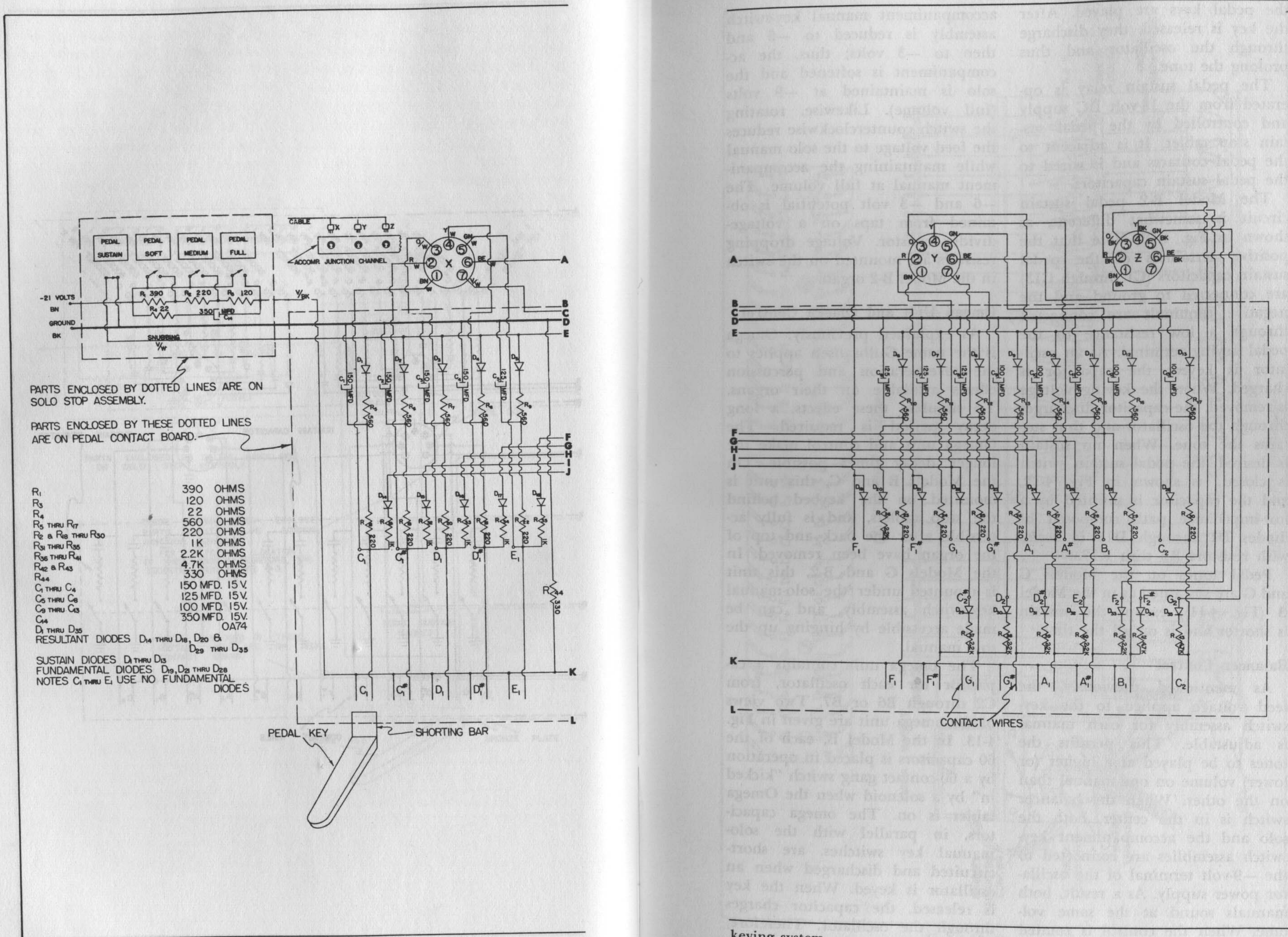


Fig. 4-12. Pedal keying system.

the pedal keys are played. After the key is released, they discharge through the oscillator and thus prolong the tone.

The pedal sustain relay is operated from the 13-volt DC supply and controlled by the pedal sustain stop tablet. It is adjacent to the pedal contacts and is wired to the pedal sustain capacitors.

The Model B-2 pedal sustain circuit is somewhat different, as shown in Fig. 4-12. Note that the positive terminals of the pedal sustain capacitors (C1 through C13) are connected to ground and the negative terminals are connected through a low resistance to the pedal keying terminal. As an oscillator is keyed, the capacitor is charged. When the keying voltage is removed, the capacitor discharges through the oscillator and thus sustains the tone. When no sustain is desired, the pedal sustain switch is closed, as shown in Fig. 4-12, and the capacitor is shunted by a low-impedance path composed of diodes D1 through D13 in series with resistors R5 thru R17.

Pedal tones on the Models C and G are sustained as in the Model B (Fig. 4-11), except the sustain is shorter and is on all the time.

Balancer Control

As mentioned previously, the feed voltage applied to the key-switch assembly for each manual is adjustable. This permits the tones to be played at a higher (or lower) volume on one manual than on the other. When the balancer switch is in the center, both the solo and the accompaniment key-switch assemblies are connected to the −9-volt terminal of the oscillator power supply. As a result, both manuals sound at the same volume. When the control is rotated clockwise, the feed voltage to the accompaniment manual key-switch assembly is reduced to −6 and then to −3 volts; thus, the accompaniment is softened and the solo is maintained at −9 volts (full volume). Likewise, rotating the switch counterclockwise reduces the feed voltage to the solo manual while maintaining the accompaniment manual at full volume. The −6 and −3 volt potential is obtained from taps on a voltage-divider resistor. Voltage dropping resistors are mounted on the switch in the Model B-2 organ.

Omega Unit and Omega Control

As explained previously, Omega is the name Gulbransen applies to the reverberation and percussion effects available on their organs. To simulate these effects, a long decay period is required. The Omega unit and control make the longer decay times possible. On the Models B and C, this unit is mounted on the keybed behind the stop tablets, and is fully accessible after the back and top of the organ have been removed. In the Models G and B-2, this unit is mounted under the solo-manual key-switch assembly, and can be made accessible by hinging up the solo manual.

The omega unit contains a capacitor for each oscillator, from C2 through B6 or B7. Two views of the omega unit are given in Fig. 4-13. In the Model B, each of the 60 capacitors is placed in operation by a 60-contact gang switch "kicked in" by a solenoid when the Omega tablet is on. The omega capacitors, in parallel with the solo-manual key switches, are short-circuited and discharged when an oscillator is keyed. When the key is released, the capacitor charges through the oscillator. Therefore, oscillation continues until the ca-

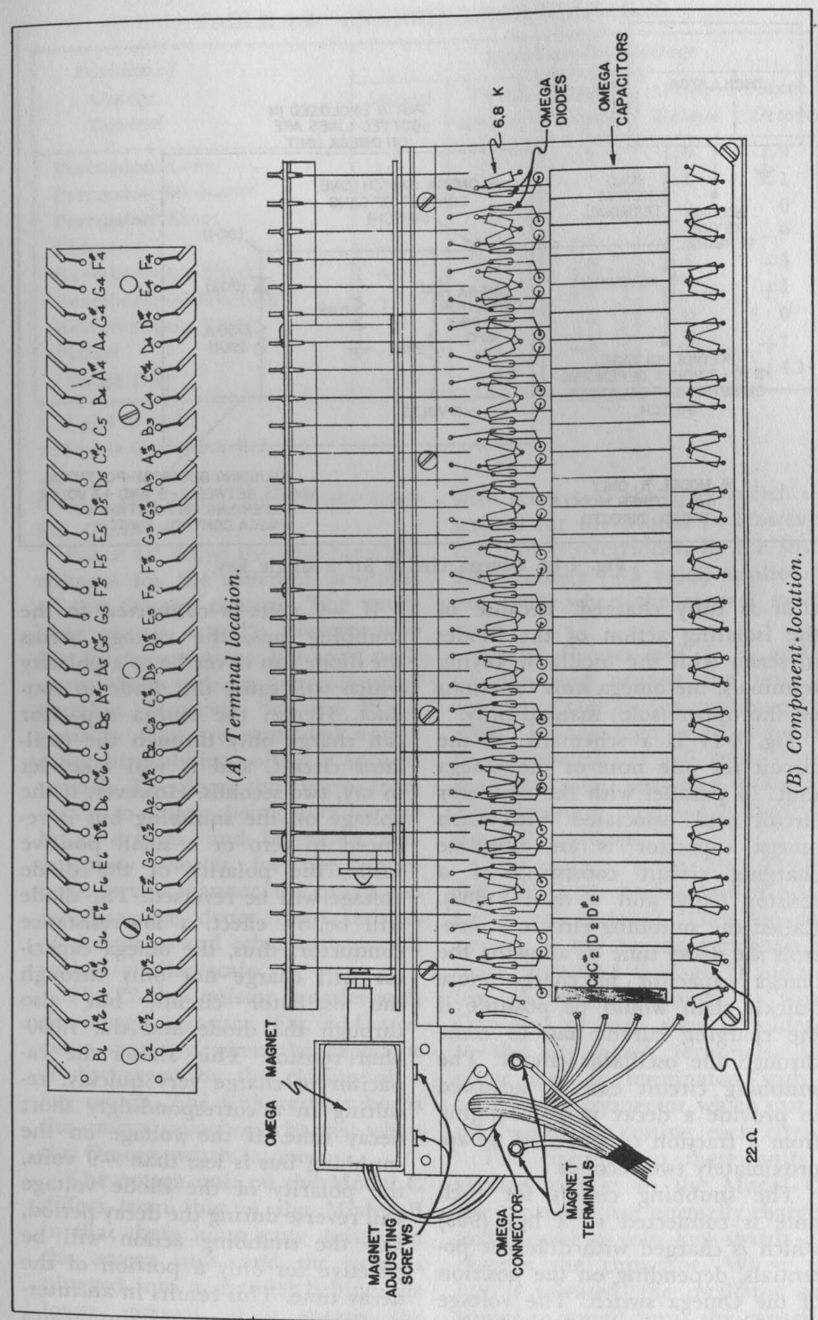


Fig. 4-13. Omega unit.

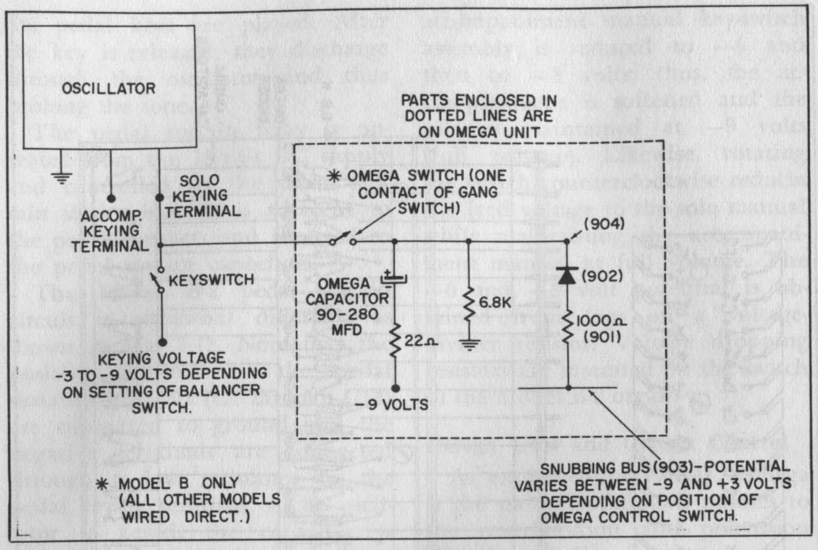


Fig. 4-14. Omega circuit for a single key.

citor is fully charged. Because of the isolating action of the diodes in series with the oscillator keying terminals, the omega unit functions on the upper (solo) manual only.

Fig. 4-14 is a schematic of the circuit for one note of the omega unit. In parallel with the oscillator circuit and associated with each omega capacitor is an alternate charging circuit consisting of a resistor (901) and a diode (902). Called the snubbing circuit, it controls the decay time by allowing the omega capacitor to charge more quickly than would be possible if the charging curent had to come through the oscillator circuit. The snubbing circuit can be adjusted to provide a decay period ranging from a fraction of a second to approximately two seconds.

The snubbing circuit for each note is connected to a bus (903) which is charged with different potentials, depending on the position of the Omega switch. The voltage at point (904) must always be between −9 and 0 volts.

If −9 volts is connected to the snubbing bus, the voltage across the diode can never be of a polarity which will cause the diode to conduct. Hence, the omega capacitor can charge only through the oscillator circuit, and it will take, let us say, two seconds. However, if the voltage on the snubbing bus is reduced to zero or a small positive value, the polarity of the diode voltage will be reversed. The diode will be, in effect, a low-resistance conductor; thus, the omega capacitor will charge not only through the oscillator circuit, but also through the diode and the 1,000-ohm resistor. This allows the capacitor to charge very quickly, resulting in a correspondingly short decay time. If the voltage on the snubbing bus is less than −9 volts, the polarity of the diode voltage will reverse during the decay period, and the snubbing action will be effective for only a portion of the decay time. This results in an intermediate decay time and also creates a decay characteristic similar to

TABLE 4-3. SNUBBING-BUS VOLTAGES

Position of Omega Control	*Snubbing-Bus Voltage* Second Octave	Third Octave	Fourth Octave	Fifth Octave	Sixth Octave
Percussion Long	−9	−9	−9	−9	−9
Percussion Medium*	−1	−1	−1	−1	−1
Percussion Short	0	0	0	0	0
Chimes	−9	−9	−9	−9	−9
Reverberation Short	+3	+3	+3	+3	+3
Reverberation Medium*	+1	+1	+1	+1	+1
Reverberation Long	0	0	0	0	0
Piano*	−3	−1	−1	0	+1
Omega Off†	+4.1	+4.1	+4.1	+4.1	+4.1

* Model B only.
† Models C, G, and B-2.

that of chime bars or the like with felt dampers.

Table 4-3 shows the snubbing-bus voltages for the different positions of the Omega control. The snubbing bus is actually divided into five 1-octave sections. For most positions, these sections are connected together. However, for the Piano position they are separated and a different snubbing voltage is applied to each. The decay time varies from octave to octave, being long for the lower octaves, and becoming progressively shorter for the upper ones. In this manner, the organ can simulate the decay characteristics of the piano and other instruments with a similar scale.

The 22-ohm resistor in series with the omega capacitor (Fig. 4-14) prevents sparking when the capacitor is discharged by the closing of a key switch. The 6.8K resistor keeps the omega capacitors charged when the Omega switch is open.

The omega unit on the Model C differs from that of the Model B in that there is no gang switch on the omega unit, and the unit is plugged into a channel behind the lower manual. This means the omega unit is connected at all times, with respect to the gang switch described for the Model B. However, the unit is overridden by the snubbing voltage (+3 volts) applied to bus (903) when the control switch is off.

Model C uses pin 7, 8, and 9 of the plug nearest the unit to supply voltage to the snubbing bus (903). This voltage, selected by the Omega switch, is −9 (pin 7) for the Percussion, zero (pin 8) for the Reverberation, and +3 (pin 9) for the Off positions.

The omega units for Models B-2 and G are underneath the solo key switch channel. They are connected to the keying terminals by black (octaves 5 through 7) and yellow (octaves 2 through 4) wires. One end of each wire is soldered to the key switch terminals. The other end is terminated with a board edge connector which can be unplugged for testing each circuit.

The circuitry in these units is similar to that in the Model C—the capacitors are normally charged, and closing a solo key switch discharges the capacitor. When the key is released, the oscillator continues to sound until the capacitor is charged.

The charging time can be decreased by changing the DC voltage applied to the snubbing bus from −9 to +4 volts. In the Models B, C, and G, this voltage is selected by a rotary switch, and in the Model B-2, by depressing one of the Omega pistons under the solo manual keyboard. These pistons control the effects created by the omega unit, and also the chimes. There are six in all. Beginning at the left, they are the Omega Off, Reverberation Short, Reverberation Long, Percussion Short, Percussion Long, and Chimes Solo. These switch assemblies, which are latching-type push buttons, can be viewed by lifting the solo manual.

Depressing the Omega Off piston connects +4.1 volts to the omega snubbing bus (Fig. 4-14) giving the solo manual a normal decay. Depressing any other piston releases the Omega Off piston and changes the snubbing voltage, thereby lengthening the decay time. In a few early Model B-2 organs, the Percussion Long piston, in addition to conecting −9 volts to the snubbing bus, activated the tremolo relay to stop the rotor.

All pistons can be released by pushing a piston in about half way and then releasing it. When no piston is down, −9 volts is connected to the omega snubbing bus. As a result, the upper manual will have a long decay time.

The Omega unit for the Model G organ was shown in Fig. 4-13. The circuits are in groups of twelve; each group corresponding to one octave of oscillators. The left front group (viewed from the front of the organ with the Solo manual hinged up) is associated with octave 2; the center front group, with octave 3; the right front group, with octave 4; the left rear group, with octave 5; the center rear, with octave 6; and the right rear, with octave 7 (Model B-2 only). In all groups, the first note on the left is *C* and the last one on the right is *B*.

Chimes Circuits

Chime and bell tones (unlike other musical instruments) contain pitches or partials that are not strictly harmonically related. The reason is that the sound vibrations are set up in metal bodies which vibrate in more than one direction.

A typical chime tone contains a series of harmonically related partials, together with another somewhat lower tone called the *humtone*. The organ chime tone is synthesized by sounding four oscillators from each key throughout the range of the Chimes stop (Notes 8 through 32). Table 4-4 gives the oscillators sounded for each key. Three of the pitches are harmonically related; they are produced by the 4′ Tibia, 2⅔′ Nazard, and 2′ Piccolo stops. A fourth oscillator supplies a pitch eight semitones lower than the 4′ Tibia, called the humtone.

Fig. 4-15 shows the operation of the chimes stop. The Chimes tablet operates a compound switch. One section has three poles which (when the Chimes tablet is operated) connect 13 volts from the magnet supply to Tibia 4′, Nazard 2⅔′, and Piccolo 2′ stop magnets and thus activates these stops. The other section feeds the voltage (−3, −6, or −9 volts, depending on the Balancer switch setting) from the solo-manual oscillator to the chimes contact bus (the stationary top bus bar in the solo-manual key switch assembly). When the Chimes tablet is on, playing a key within the range of the chimes stop will sound Tibia 4′, Nazard 2⅔′, and Piccolo 2′ in the usual fashion. In addition,

TABLE 4-4. OSCILLATORS KEYED FOR CHIME NOTES

Key	*1st Partial (Tibia 4′)*	*2nd Partial (Nazard 2⅔′)*	*3rd Partial (Piccolo 2′)*	*Humtone*
8	C4	G4	C5	E3
9	C#4	G#4	C#5	F3
10	D4	A4	D5	F#3
11	D#4	A#4	D#5	G3
12	E4	B4	E5	G#3
13	F4	C5	F5	A3
14	F#4	C#5	F#5	A#3
15	G4	D5	G5	B3
16	G#4	D#5	G#5	C4
17	A4	E5	A5	C#4
18	A#4	F5	A#5	D4
19	B4	F#5	B5	D#4
20	C5	G5	C6	E4
21	C#5	G#5	C#6	F4
22	D5	A5	D6	F#4
23	D#5	A#5	D#6	G4
24	E5	B5	E6	G#4
25	F5	C6	F6	A4
26	F#5	C#6	F#6	A#4
27	G5	D6	G6	B4
28	G#5	D#6	G#6	C5
29	A5	E6	A6	C#5
30	A#5	F6	A#6	D5
31	B5	F#6	B6	D#5
32	C6	G6	C6	E5

the humtone oscillator will be energized through the chimes contact bus, contact, and diode.

In the Model B, the chimes diodes prevent voltage from being fed to the chimes contact bus when the Chimes tablet is off. The chimes diodes, on the back of the solo-manual key switch asembly, are wired from the chimes contact terminal to a tie-point terminal connected to the humtone oscillator.

In the Model B, the Chimes tablet sets up the tone quality only; the decay characteristics are determined by the Omega control.

In the Model B-2, the Chimes control is a preset piston and the range has been increased to cover the entire solo manual. This Chimes piston cancels any previously set stops on the solo manual, and in some early models, also stops the tremolo. Depressing the chimes piston sets the solo manual for chimes, with a decay characteristic of Percussion Long. However, for a shorter decay, (such as for a damped chime), two pistons are depressed simultaneously.

The Timbre switch is inoperative when the Chimes piston is depressed, giving a "bright" organ tone.

Amplifier and Power Supply

The amplifier and power supply (shown schematically for the Model B in Fig. 4-16) are mounted on the same chassis, directly above the speaker enclosure.

The Amplifier Circuit—The conventional amplifier circuit has a

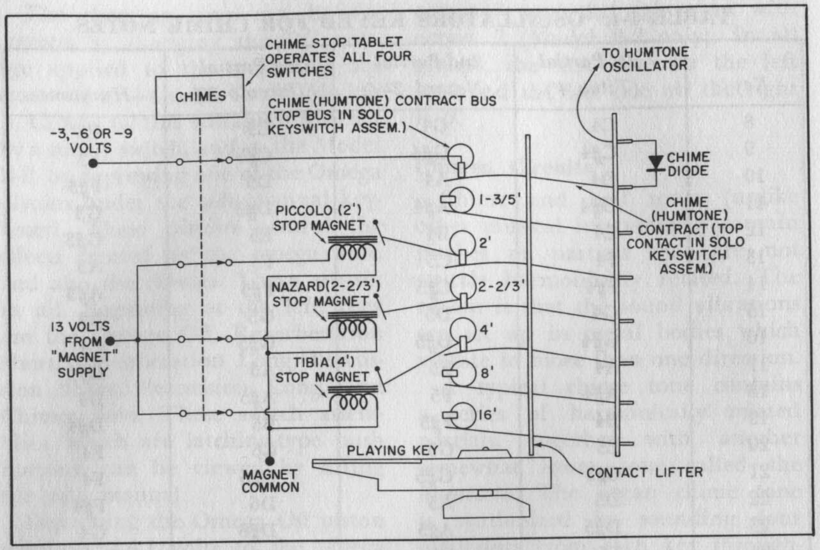


Fig. 4-15. Operation of a chimes stop.

12AX7 first audio amplifier and a 12AU7 second audio amplifier and phase inverter. Two 6L6GB tubes form the push-pull output stage. The maximum volume control (a potentiometer in the input circuit of the first audio amplifier) is adjustable from the top of the amplifier chassis. It should be set so that, with all stops on, the expression control wide open, and the Balancer on full, the amplifier will not overload and cause distortion. This control setting will be about twenty per cent lower than maximum. When the organ is to be played in a small room, it is desirable to further limit the maximum volume. In this way, the full range of the expression control can be utilized without making the organ too loud for its environment.

The amplifier is conventional except for the expression control, which is a patented circuit using voltage-sensitive resistors called *Varistors* (abbreviated VSR on the schematic in Fig. 4-16). *Varistors,* which are made of specially prepared silicon carbide, have the property of varying their resistances with the applied voltage. Even with a low DC voltage (such as 30 or 40 volts) this resistance change is substantial. The volume is controlled by the *Varistors,* which form part of an audio-frequency voltage divider inserted between the first- and second-amplifier stages.

A DC voltage, regulated by the expression control, is applied to the *Varistors* in order to change their resistance and thereby control the signal attenuation through the voltage divider.

Stated another way, the amplifier gain is controlled by varying the resistance of one section of a series divider. In Fig. 4-16 the series divider consists of resistor (313), capacitor (301), and the parallel combination of the two *Varistors.* [It is a parallel combination because one *Varistor* is grounded and one terminal of the other *Varistor* is at ground potential for signal voltages because of bypass capacitor (306).] When the input to the following stage is con-

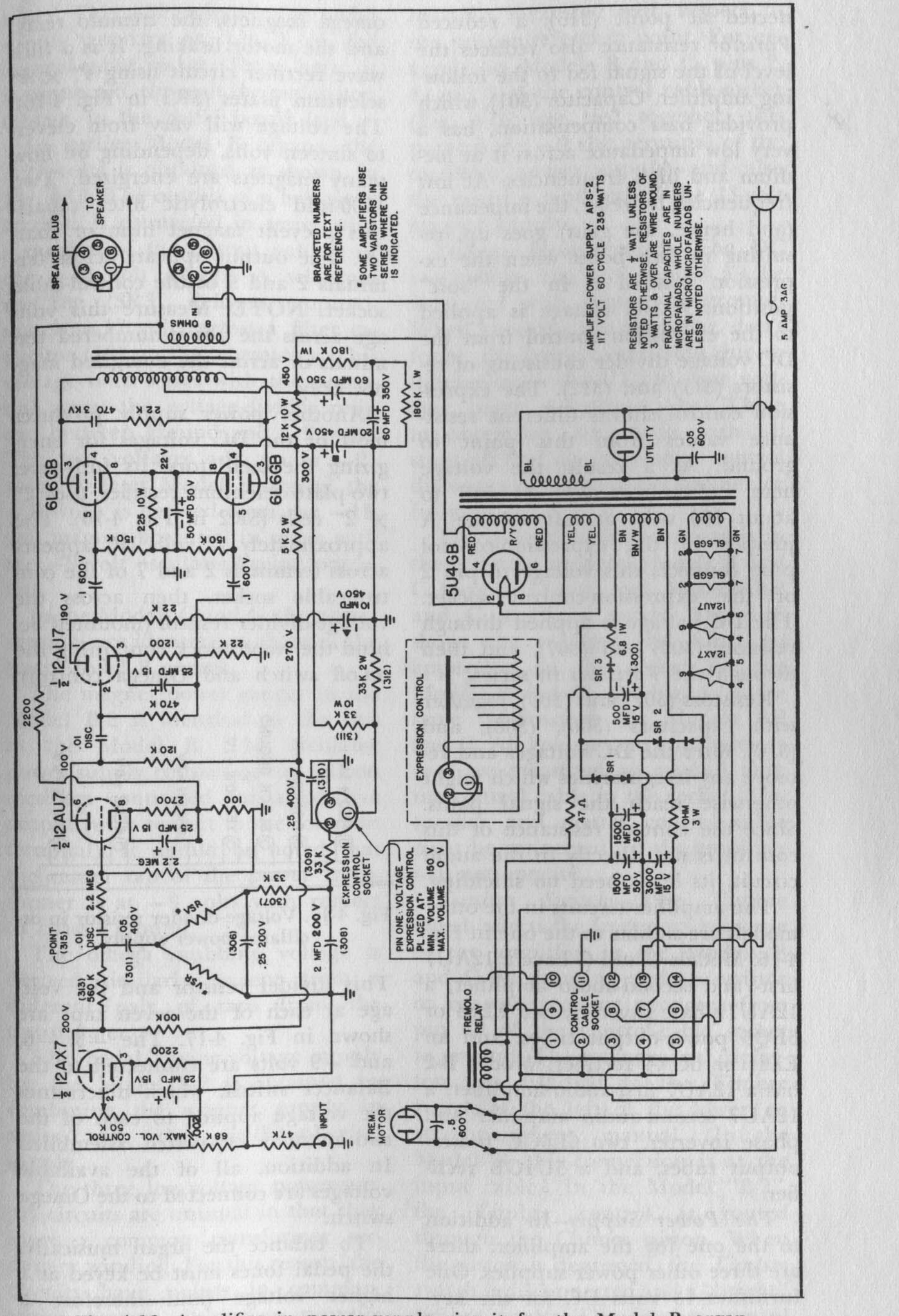


Fig. 4-16. Amplifier in power-supply circuit for the Model B organ.

nected at point (315), a reduced *Varistor* resistance also reduces the level of the signal fed to the following amplifier. Capacitor (301), which provides bass compensation, has a very low impedance across it at medium and high frequencies. At low frequencies, however, the impedance (and hence, the gain) goes up, resulting in bass boost when the expression control is in the "soft" position. A DC voltage is applied to the expression control from the DC voltage divider consisting of resistors (311) and (312). The expression control shunts different resistance values from this point to ground. As a result, the voltage here varies from zero at full to about 150 volts at soft volume. A jumper in the expression-control plug connects this voltage to pin 2 of the expression-control socket. The DC voltage is applied through resistors (309) and (307), and then through the *Varistors* in series.

Resistors (307) and (309), together with capacitors (306), (308), and (310), filter the DC voltages and remove any irregularities which might otherwise reach the signal paths. Since the contact resistance of this control is not directly in the audio circuit, its leads need no shielding.

The amplifier circuits in the other models are similar to the one in Fig. 4-16. Models C and G have a 12AU7 first- and second-audio amplifier, a 12AU7 phase inverter, two EL84 or 6BQ5 power-output tubes, and an EZ81 or 6CA4 rectifier. Model B-2 has a 12AU7 first-audio amplifier, a 12AU7 second-audio amplifier and phase inverter, two 6L6GC power-output tubes, and a 5U4GB rectifier.

The Power Supply—In addition to the one for the amplifier, there are three other power supplies. One furnishes 13 volts DC for the key-switch assembly, pedal sustain and omega magnets, the tremolo relay, and the motor braking. It is a full-wave rectifier circuit using 4″ × 4″ selenium plates (SR1 in Fig. 4-16). The voltage will vary from eleven to sixteen volts, depending on how many magnets are energized. Two 1500-mfd electrolytic filter capacitors prevent magnet hum or chatter. The output appears across terminals 2 and 9 of the control-cable socket. NOTE: Measure this voltage across the above-numbered terminals or across the energized magnet only.

Another power supply produces most of the DC voltages for energizing the oscillators. Its full-wave, two-plate selenium rectifier uses 2″ × 2″ cells (SR2 in Fig. 4-16). The approximately 12 volts DC appears across terminals 2 and 7 of the control-cable socket, then across the voltage-divider resistor (mounted behind the wood block containing the on-off switch and Omega control).

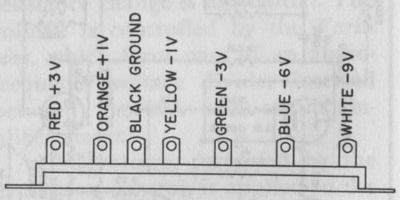


Fig. 4-17. Voltage-divider resistor in oscillator power supply.

This divider resistor and the voltage at each of the seven taps are shown in Fig. 4-17. The −3, −6, and −9 volts are connected to the Balancer switch, which determines the voltage applied to each of the two manual key-switch assemblies. In addition, all of the available voltages are connected to the Omega switch.

To balance the organ musically, the pedal tones must be keyed at a higher voltage (and therefore a louder volume) than the manual

tones. This −21 volts for the pedal supply appears on pin 1 of the control-cable socket. From here, it is connected, through the pedal stop tablets, to the pedal board feed.

In earlier Model B organs, the −21 volts is obtained as shown in Fig. 4-16. The output of a half-wave rectifier is connected in series with a portion of the output voltage of the −12 volt supply. A selenium rectifier (SR3) delivers approximately −12 volts across a filter capacitor (*300* on the schematic). This voltage is in series with the potential across the voltage-divider resistor, between ground and −9 volts. The two voltages add up to −21 volts. In later Model B organs, the −21 volts is derived from the −13-volt magnet potential in series with the −9 volt oscillator-keying potential.

In the Models C and G, the power supplies are identical to those of the later Model B organs.

The magnet power supply in the Model B-2 is identical to the one in the Model B. The oscillator power supply consists of two silicon rectifiers connected for a positive output (with respect to the common terminal). It should be noted that the center tap of the power transformer is at −9 volts with respect to chassis ground.

The omega snubbing voltage is derived similarly, except from a different pair of taps from the transformer.

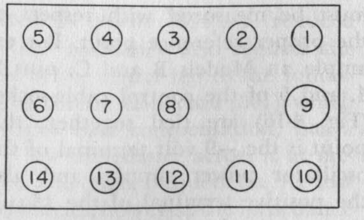
The pedal keying-voltage supply for the Model B-2 is obtained by combining the magnet supply in series with the oscillator-keying supply.

The three low-voltage power-supply circuits are unusual in that they share a common transformer secondary winding. For this reason, the circuits have points in common, which means all power supplies must be measured with respect to the proper reference point. For example, in Models B and C, pins 2, 4, and 5 of the control cable-socket (Fig. 4-16) are tied together; this point is the −9 volt terminal of the oscillator power supply—and also the positive terminal of the 13-volt magnet supply.

Voltage Measurements—The DC voltages in Fig. 4-16 should all be measured with respect to ground. When checking the amplifier, don't forget the normal variations due to differences in the VTVM, line voltage, parts tolerances, etc. These measurements are made with all stops off and the expression control disconnected from the amplifier or fully on.

The control-cable socket varies in the different models. Models B and C have a 14-pin, and Models B-2 and G a 12-pin socket. Fig. 4-18 shows the voltages and functions appearing on the socket for the Models B and C, and Fig. 4-19, the same information for Models B-2 and G. All voltages are approximate and are measured to ground with the control cable in the socket. The speaker and master control cable must be connected, or the amplifier will not operate.

Timbre Switch—The Timbre switch affects the frequency response of the amplifier in the Models B and C by shunting various resistor or resistor-capacitor networks from pin 10 of the control-cable socket to ground. The resistors and capacitors are attached to the Timbre switch at the left of the lower, or accompaniment, manual. (In the Model G, this connection is at the input cable.) In the Model "B-2", the Timbre control is routed through the Chimes piston. When the piston is depressed, the Timbre switch is disconnected and a "bright" timbre results. The Timbre control



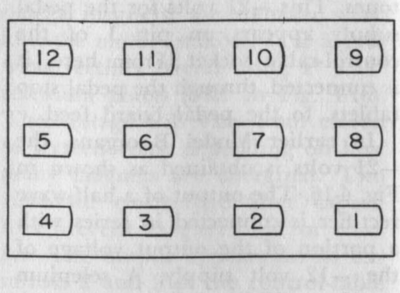
(A) Socket.

Pin	Voltage	Function
1	—21V	To pedal stop tablets.
2*	—9V	To voltage divider resistor, etc.
3	6.3VAC† OV‡	Model B—AC to pilot light (Do not measure to ground). Model C—No connection.
4*	—9V	Positive terminal of 13V magnet supply; connected to accomp. stop tablet switches.
5*	—9V	Same as pin 4 except connected to solo stop tablets.
6	OV	No connection.
7	+3V	To voltage divider resistor.
8	6.3VAC† OV‡	Model B—AC to pilot light (Do not measure to ground). Model C—No connection.
9	—22V	Negative terminal of 13 volt magnet supply —common to all magnets.
10	—	Signal to the timbre switch.
11	Common	Ground.
12	—	Shorted together by
13	—	main on-off switch.
14	—9V§	Connects tremolo relay to tremolo stop tablet switch.

* These pins connected together.
† Model B. ‡ Model C.
§ Tremolo off.

(B) Voltages present on socket terminals.

Fig. 4-18. Control-cable socket for Models B and C.



(A) Socket.

Pin	Voltage	Function
1	OV	No connection.
2	OV	No connection.
3	—	Model B-2—Low voltage AC to pilot light. Model G—No connection.
4	—22V*	Connects tremolo relay to tremolo stop tablet switch.
5	—22V	To magnets and relays.
6	—20V	To pedal stop tablets.
7	—9V	To balancer switch.
8	+4V	To pistons (Omega Snubbing).
9	Common	Ground.
10	117VAC† OV‡	Model G—AC to pilot light. Model B-2—No connection.
11	—	Shorted together by
12	—	main on-off switch.

* Tremolo off.
‡ Model B-2.
† Model G.

(B) Voltages present on socket terminals.

Fig. 4-19. Control-cable socket for Models B-2 and G.

is operative when the chimes piston is not depressed.

Tremolo Relay—The tremolo motor runs only when the Tremolo tablet is on. When the tablet is off, approximately 13 volts DC is applied to the tremolo motor for braking. The Tremolo tablet operates a relay (in the amplifier and power supply chassis; see Fig. 4-20) which switches the motor between the 117-volt AC "run" position and the 13-volt DC brake supply. This power is fed to the motor through an outlet on the back of the amplifier. Make sure the motor is plugged into the outlet marked "tremolo." If it is plugged into the "utility" outlet, the motor will run all the time and cannot be controlled by the Tremolo tablet.

If the amplifier chassis is handled roughly, the tremolo DPDT relay contacts may become bent. This can prevent the tremolo from operating properly, or else cause clicks in the speaker when the Tremolo tablet is on. Both movable contacts should break from one set of stator contacts before either one makes with its other stator contact.

A 0.5-mfd capacitor across the tremolo-motor socket suppresses clicks which would otherwise develop when the DC braking voltage is applied to the motor. A 330-ohm resistor (on the printed circuit board for the solo-manual stop tablet assembly) is wired across the tremolo relay magnet coil to prevent clicks from this source.

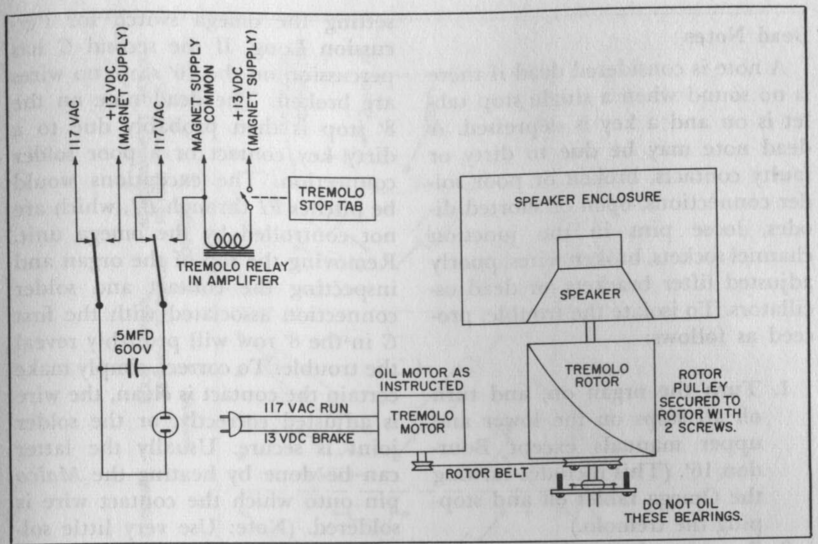


Fig. 4-20. Tremolo circuit.

SERVICING THE GULBRANSEN ORGAN

The Gulbransen organ should present few servicing difficulties to the technician. Fundamentally, it consists of either 72 or 84 audio oscillators which produce either six or seven octaves of tones. The proper tones are selected by the key-switch assemblies. The oscillator output is amplified by the amplifier and applied to the speaker.

The possible causes for a particular trouble can be determined by referring to the block diagram in Fig. 4-2. For instance, a completely dead organ would be caused by failure of the amplifier or power-supply stage. Likewise, if the tones on one manual cannot be softened with respect to the other, look for a defect in the balancer-switch circuit.

Dead Notes

A note is considered dead if there is no sound when a single stop tablet is on and a key is depressed. A dead note may be due to dirty or faulty contacts, broken or poor solder connections, open or shorted diodes, loose pins in the junction channel sockets, broken wires, poorly adjusted lifter brackets, or dead oscillators. To isolate the trouble, proceed as follows:

1. Turn the organ on, and turn off all stops on the lower and upper manuals except Bourdon 16′. (This includes turning the Omega tablet off and stopping the tremolo.)
2. Run the chromatic scale, and note any silent keys.
3. Repeat this procedure, using only the Tibia 8′, then only the Tibia 4′, etc.
4. Again repeat this procedure for the lower manual, using only one stop at a time, and note any silent keys.
5. See Fig. 4-8 to correlate this information.

The following cases are typical examples of dead notes. Suppose you get no sound when only Tibia 8′ is turned on and the first *C* key is depressed, but you do when the 16′ stop is on and the second *C* is depressed. Referring to Fig. 4-8, you will note that the pitch produced by depressing the second *D* while using only the 16′ stop is the same as the one for the first *C* with only the 8′ stop. Therefore, the fact that this pitch is available at only one point on the same manual would indicate a faulty contact, poor soldering, or a broken wire. On the upper (solo) manual, you can determine if a wire is broken by turning on the omega unit and setting the omega switch for Percussion Long. If the second *C* has percussion on the 16′ stop, no wires are broken. The dead note on the 8′ stop is then probably due to a dirty key contact or a poor solder connection. The exceptions would be pitches *F1* through *B1*, which are not controlled by the omega unit. Removing the top of the organ and inspecting the contact and solder connection associated with the first *C* in the 8′ row will probably reveal the trouble. To correct, simply make certain the contact is clean, the wire is adjusted correctly, or the solder joint is secure. Usually the latter can be done by heating the *Malco* pin onto which the contact wire is soldered. (Note: Use very little solder in this or any solder work.)

Lifter-Bracket Adjustment—If no note sounds when a key is depressed and one or more stop tablets are on, the lifter bracket is not adjusted properly or the key-switch contact wires are bent. The remedy will be given later in this chapter.

Open Diode—A diode is open when, on the *upper* manual . . .

third *A* is dead when only 4′ tibia is on,
fourth *A* is dead when only 8′ tibia is on,
second *D* is dead when only 2⅔′ is on,
second *A* is dead when only 2′ is on, and
all notes are normal on the *lower* manual.

According to Fig. 4-8, *A5* should be produced each time in the foregoing example. Fig. 4-21 shows how the solo-manual diodes are arranged on the tone-generator circuit boards. To make certain the trouble is the tone-generator diode, unplug the generator in question, in this instance *A*, and plug the adjacent

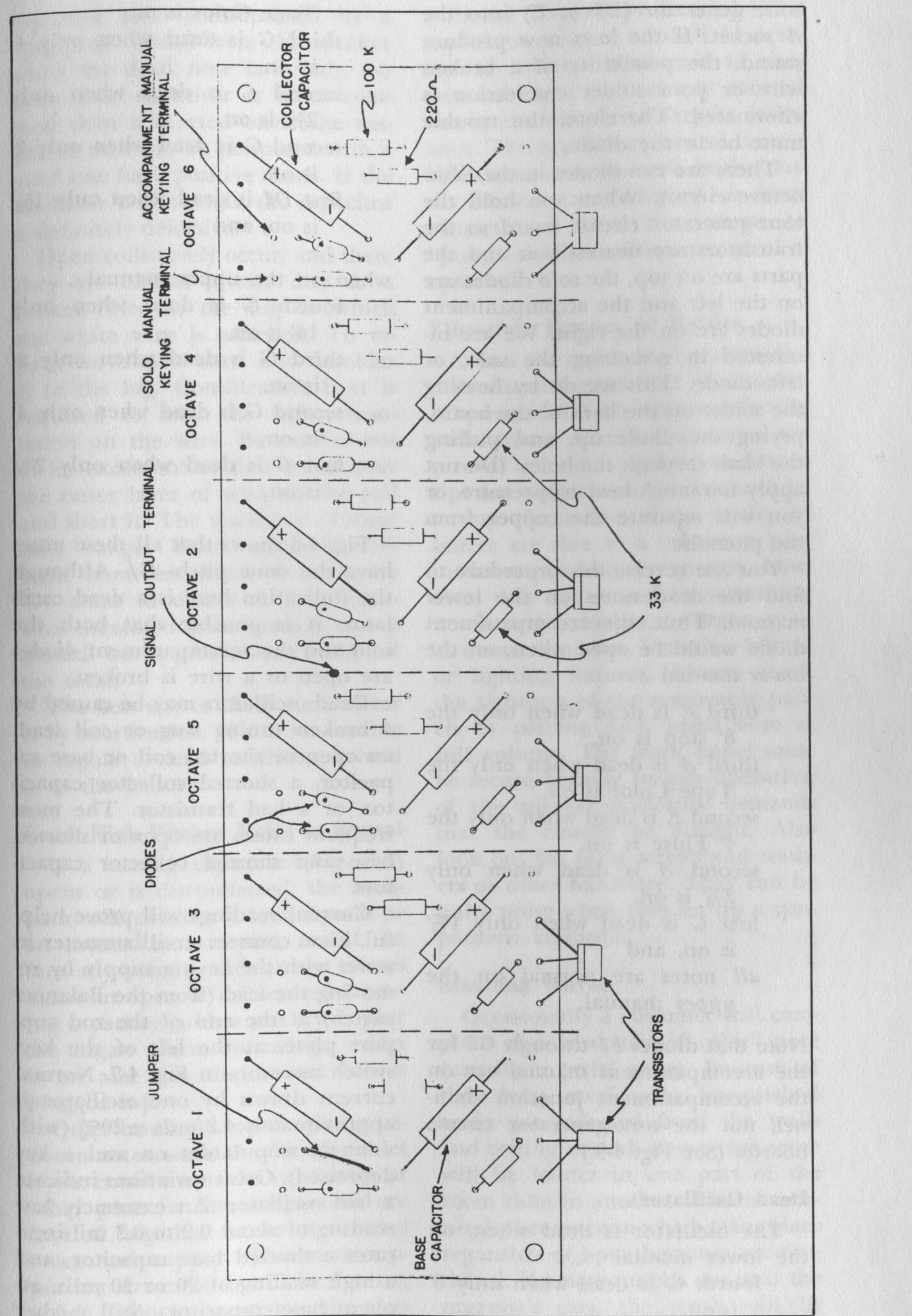


Fig. 4-21. Component location on tone-generator circuit board.

tone generator (*D#* or *E*) into the *A* socket. If the keys now produce sound, the possibility of a broken wire or poor solder connection is eliminated. Therefore, the trouble must be in the diode.

There are two diodes in the fifth-octave circuit. When you hold the tone-generator circuit board so the transistors are nearest you and the parts are on top, the solo diodes are on the left and the accompaniment diodes are on the right. We are interested in removing the solo, or left, diode. This we do by heating the solder on the back of the board, prying the diode up, and pulling the leads through the holes. (Do not apply too much heat or pressure, or you will separate the copper from the phenolic.

You can reverse this procedure to find the dead notes on the lower manual. Thus, the accompaniment diode would be open when, on the *lower* manual . . .

third *E* is dead when only the 8′ stop is on,
third *A* is dead when only the Tone Color is on,
second *E* is dead when only the 4′ Flute is on,
second *A* is dead when only 2⅔′ is on,
first *C* is dead when only 1⅗′ is on, and
all notes are normal on the *upper* manual.

Note that diodes *F1* through *G2* for the accompaniment manual are on the accompaniment junction channel, not the tone-generator circuit boards. (See Fig. 4-9.)

Dead Oscillator

The oscillator is dead when, on the lower manual . . .

fourth *G* is dead when only 8′ is on,
third *C* is dead when only the Tone Color is on,
third *G* is dead when only 4′ is on,
second *C* is dead when only 2⅔′ is on,
second *G* is dead when only 2′ is on,
first *D#* is dead when only 1⅗′ is on, and . . .

when on the upper manual . . .

fourth *G* is dead when only 16′ is on,
third *G* is dead when only 8′ is on,
second *G* is dead when only 4′ is on,
first *C* is dead when only 2⅔′ is on.

Fig. 4-8 shows that all these notes have the same pitch—*G4*. Although the indication here is a dead oscillator, it is possible that both the solo and the accompaniment diodes are open or a wire is broken.

Dead oscillators may be caused by a broken tuning slug or coil lead, an open or shorted coil or base capacitor, a shorted collector capacitor, or a bad transistor. The most frequent causes are open or shorted base and shorted collector capacitors.

Current readings will prove helpful. First, connect a milliammeter in series with the keying supply by removing the lead (from the Balancer switch) at the end of the rod support plate, at the left of the key-switch assembly in Fig. 4-7. Normal current drawn by one oscillator is approximately 4.2 mils ±20% (with a *single* stop tablet on and a key depressed). Great variations indicate a bad oscillator. An extremely low reading of about 0.2 to 0.3 mil indicates a shorted base capacitor, and a high reading of 20 or 30 mils, an open base capacitor. Still higher readings indicate a shorted collector capacitor (also accompanied by a "popping" sound from the speaker when the dead note is keyed). An *open* base capacitor is more common than a shorted one. The suspected unit can be jumpered with a good one for a positive check. If the oscillator now sounds, the capacitor is definitely defective.

Open coils rarely occur, and then, they are almost always due to a broken wire at the lug to which the white wire is attached. To repair, unwrap a turn and resolder it to the lug. Considerable heat is required to melt the nylon insulation on the wire. Be careful not to let excess solder flow down over the outer layer of wire on the coil and short it. The resistance of these coils ranges from approximately eight ohms in octave 6 to nearly 400 ohms in octave 1. The resistance measured from ground to tap should be approximately 60% of the total.

The best way to check a transistor is by substitution. If you are unable to repair a dead oscillator, return it to the factory.

Loud, High-Pitched Noise or Squeal

If a tuning capacitor (Fig. 4-5) opens or is disconnected, the oscillator will produce a loud squeal or an intermittent rasping sound. In fact, any weird sounds almost always mean an open or dsiconnected tuning capacitor (unless you try to play the organ when the omega tablet is on and the omega unit is not plugged in).

Other unusual cross couplings between notes, when the Omega tablet is on, could mean the capacitors or other parts in the omega unit are shorted together or to the metal omega-unit support. This metal supporting structure should be floating —that is, not connected to the electrical circuit in any way.

Erratic Expression Control—The expression control consists of a series of resistors connected to contacts which are selectively shorted out by the control to vary its resistance. The expression control cannot introduce noise or static in the music. However, misaligned or bent contacts can cause the volume to "jump" as the expression control is operated.

Vibration, Buzzes, or Rattles

When the organ is played loudly, it produces a great deal of accoustical power. This is even truer for the pedal tones. Also, the sustained nature of its tones makes conditions ripe for sympathetic vibrations to be set up. Sometimes these rattles or buzzes are due to a vibrating part in the organ case. Frequently, however, they are caused by something not in or attached to the organ, such as doors, windows, Venetian blinds, or lighting fixtures. Always check the tightness of the removable panels by playing each pedal note at full volume. The front panel must be secure because proper operation of the speaker enclosure demands that the closure be airtight. Also look out for loose screws and washers or other hardware. They can be quite noisy when they set up a sympathetic vibration.

Standing Waves

Occasionally a customer will complain of a weak or "off-color" note (usually a pedal note). Because of their long wavelengths, low-pitched tones are reflected from the walls and ceiling in such a way that some will be louder in one part of the room than in another. This is a natural phenomenon which takes place regardless of how the tones are produced. If a note cancels out near the organist's ears, the result will be quite annoying. The only cure is to move the organ a few feet to alter the standing-wave pattern slightly.

This phenomenon is not very troublesome in the middle and higher pitches because their wavelengths are short enough that, even if one ear is in a dead spot, the other one will pick up the sound.

Ciphers

A cipher is a tone that is produced when no keys are depressed. It can be caused by a sticking key or contact lifter, a poorly adjusted contact wire, or a shorted or leaky omega diode or capacitor.

To isolate a cipher, turn the organ on and allow the amplifier to warm up. With all the lower stops off and the tremolo stopped, turn on only the Bourdon 16′ stop and listen for ciphers. Repeat this procedure for each stop, up to Piccolo 2′, and for each stop on the lower manual.

The Model B 1⅗′ magnet on the upper manual can be operated by hand, or in combination with other magnets, when either the Glock or Clarinet stop is turned on. The humtone bus can be energized separately by jumpering from the lug at the end to the metal end plate of the upper manual.

If a cipher is noted, depress each key on the manual concerned until the pitch produced by the depressed key matches the pitch of the cipher. The cause of the cipher, then, is a contact wire that is touching its respective bus at all times. This wire is located in the vertical row of wires directly behind its respective key. The key, lifter bracket, contact lifter, or contact wire must then be adjusted. Visual inspection will determine the culprit.

Shorted or leaky omega diodes or capacitors will also cause a cipher. To check, turn on the Omega tablet only, and place the Omega switch in Percussion Long. If you hear a cipher, one of the capacitors on the omega-unit board is leaky or shorted.

To determine which diode or capacitor is the offender, gently push back the contact wires, one by one, from the contact pins on the circuit boards. The moment the cipher stops, the diode or capacitor associated with the contact wire just pushed back is at fault and should be replaced.

If the cipher occurs only on percussion, the associated diode should be changed. If it also occurs on reverberation, the associated capacitor is shorted or leaky. The cipher should cease when this part is removed. Replace with the correct value of capacitor. When removing a part from the circuit boards, leave enough of the old lead so the new part can be spliced in easily.

ADJUSTMENTS

Ordinarily the organ requires no further adjustment after it leaves the factory. However, information is provided for those rare instances when, because of damage or other causes, adjustment is necessary. Before attempting any adjustments, be absolutely sure you understand the operation of the various parts, and then proceed with caution.

Key Switches

If any key switch fails to operate, in all probability a piece of dust or dirt has lodged on a bus bar. This can be easily cleared up by holding the key down and operating the stop tablet in question several times. The rotation of the bus bar causes a sliding or nubbing action that cleans the contact. In a new organ, an occasional contact may seem dirty because a small quantity of rosin has been deposited on the bus

bar as a result of the dip-soldering process used in assembly. These contacts can be cleaned very easily by the process just mentioned, and once cleaned, will not give further trouble.

NOTE: Do not use chemical contact cleaners because they will leave a film which attracts dust or dirt, nor carbon tetrachloride, because it will leave an oxide film.

If a series of notes on the same stop do *not* operate, or if, when the keys are depressed, notes sound with no stops on, examine the rod rotation to make sure the "on" and "off" positions are as shown in Fig. 4-7. Rod (410A) is shown in the "on" position, and rods (410), in the "off" positions. If the position of a rod is not correct, turn adjusting screw (414) until it is. Be particularly careful about the "on" position because it is the more critical one. The "off" position is satisfactory as long as no notes can be played with all stops off.

Springs (415) return the rods to the "off" position. These springs should not be so weak they prevent the rod from returning fully, nor so strong they prevent the magnet from pulling the rod in. This operation should be checked with all other magnets on because the voltage for the magnets will vary somewhat, depending on how many are in operation. To increase the spring tension, pull the end loop of the spring out of the slot in the end of the rod, and rotate the spring one-half turn clockwise. To reduce the tension, turn it counterclockwise.

Individual contact wires should never require adjustment unless accidentally bent. Then it is generally best to rebend the wire carefully, at the point where it is attached to the Bakelite strip at the back of the key-switch assembly. Bending the wire upward will make the contact come on later; bending it down will make it come on earlier. If all contacts for a certain key come on too soon, or too late, bracket (416) (Fig. 4-22) should be bent very carefully with a pair of long-nose pliers until, with the key up, Bakelite contact lifter (417) returns to its "off" position. There should be no more than 1/32 inch clearance between the lifter and bracket. Otherwise, the contacts may come on too late or operate erratically.

Key Leveling

Key leveling is adjusted by screws (420) (Fig. 4-22) near the front and below the keyboards. These screws

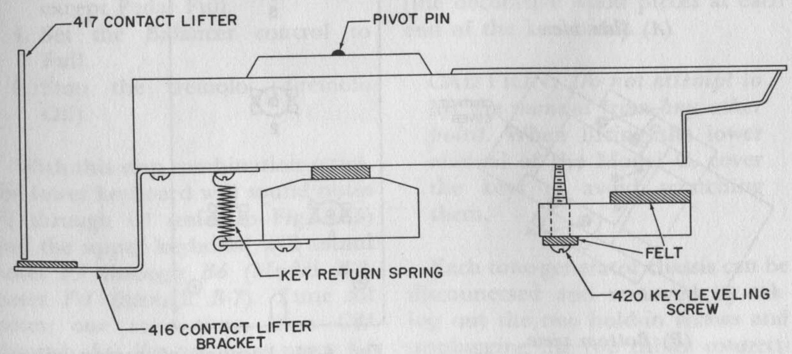


Fig. 4-22. Contact-lifter and key-leveling adjustments.

go through holes in the keyboard frame and then up into the keys. Access is gained by hinging up the keyboard. After leveling, make sure the key leveling screws do not scrape against the sides of the clearance holes. Even a small amount of scrape will be very annoying to the organist. If a screw scrapes, bend it slightly with the long-nose pliers.

Key Dip

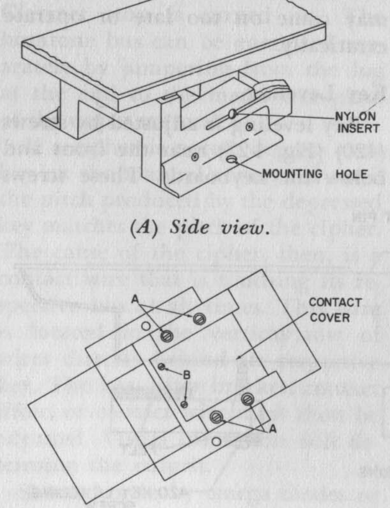
Key dip is the total up and down travel of the white keys. It should be between 5⁄16 and 3⁄8 inch, measured at the end of the key. Excessive key dip can cause the contact wire to flex excessively and eventually break. The key dip is adjusted by the key leveling screws.

Omega Unit

As shown in Fig. 4-13, the omega magnet is mounted so it can be shifted back and forth a fraction of an inch. If this magnet is not adjusted properly, all omega contacts might not be drawn against the silver-plated contact pins; or if adjusted too far in the other direction, the magnet may not pull in when the voltage is low. Be sure to test with all stops on because the magnet supply voltage will be lowest under these conditions.

Expression Control

The expression control (Fig. 4-23) is plugged into a socket in the amplifier chassis. It can be removed by unplugging the connector and removing the two machine screws at the bottom of the organ case. (First, remove the front of the organ.) Four screws adjust the nylon bearing friction, which should be enough to give the control a positive feel. Make sure all four screws (A) are tightened equally. A few early organs used felt bushings. Nylon bushings will be supplied upon request.



(A) Side view.

(B) Bottom view.

Fig. 4-23. Expression control.

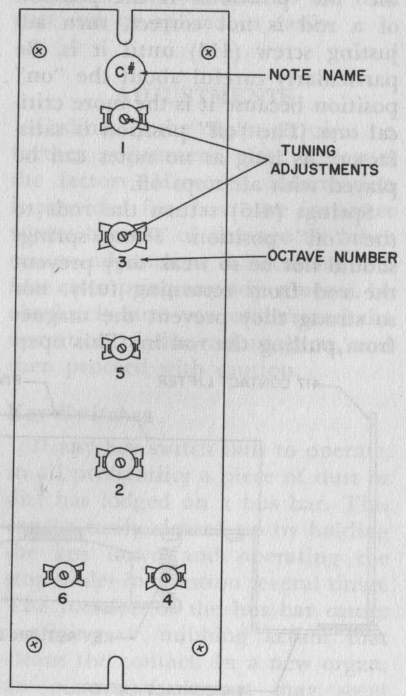


Fig. 4-24. Location of tuning adjustments on tone-generator board.

The cover over the contacts can be removed by taking out screws (B) to expose the control contacts.

TUNING

Each oscillator tone-generator assembly includes a tuning coil with an adjustable core. The position of the core determines the exact pitch of the oscillator. Each core has an adjusting screw (Fig. 4-24) slotted at one end to accommodate a conventional alignment tool.

The organ should not be tuned like a piano (that is, by setting a temperament and beating octaves, fourths, and fifths) because beats are almost completely absent due to the purity of the organ tones. An electronic tuning instrument, such as the Conn *Strobotuner* or Peterson Chromatic Tuner, is strongly recommended. (Electronic organ tuning devices are discussed in Chapter 11.)

To tune the organ properly, observe the following procedure:

1. Turn off all stops on the upper keyboard except 4′ Tibia (Model B-2, 2′ Piccolo).
2. Turn off all stops on the lower keyboard except 8′ Flute.
3. Turn off all pedal stop tablets except Pedal Full.
4. Set the Balancer control to Full.
5. Stop the tremolo (Tremolo Off).

With this stop combination setup, the lower keyboard will sound notes *F1* through *C5* (refer to Fig. 4-25) and the upper keyboard will sound notes *F3* through *B6* (Model *B-2*, notes *F-4* through *B-7*). Tune all notes, one at a time, from *C#2* through *B6*. Do not tune notes *C1* through *C2* until later. After tuning notes *C#2* through *B6* (or *B7*, depending on the organ model, turn off the tuning instrument; it is not used for tuning the lowest 13 notes (pedal keys). Depress pedal key *C2*, the highest pedal note. (See Fig. 4-26.) Each pedal key sounds two oscillators. The upper one, associated with pedal key *C2*, is note *G3* which has already been tuned. Now tune oscillator *C2* to eliminate any beat between it and *G3*. Next, depress pedal *B* and tune oscillator *B1* to zero beat. Do the same with pedal *A#* and oscillator *A#1*, and the rest of the pedal notes (*A*, *G#*, *G*, *F#*, *F*, *E*, *D#*, *C#*, and *C* in that order).

DISASSEMBLY

All parts are readily accessible for servicing. The 12 tone-generator chassis, the amplifier, and the omega unit are serviced from the back of the organ by removal of nine screws, as shown in Fig. 4-27. Access to the amplifier and the key switches is gained by removing the top of the organ, taking out the three screws (Fig. 4-27), and sliding the top forward while lifting upward to expose the upper keyboard contacts. To reach the lower keyboard contacts and the underside of the keyboards, hinge both manuals up by lifting them from the key cheeks (the decorative wood pieces at each end of the keyboard).

> CAUTION: *Do not attempt to lift the manual from any other point.* When lifting the lower manual of the Model C, cover the keys to avoid scratching them.

Each tone-generator chassis can be disconnected and removed by taking out the two hold-in screws and unplugging the two cables connecting the tone-generator chassis to the

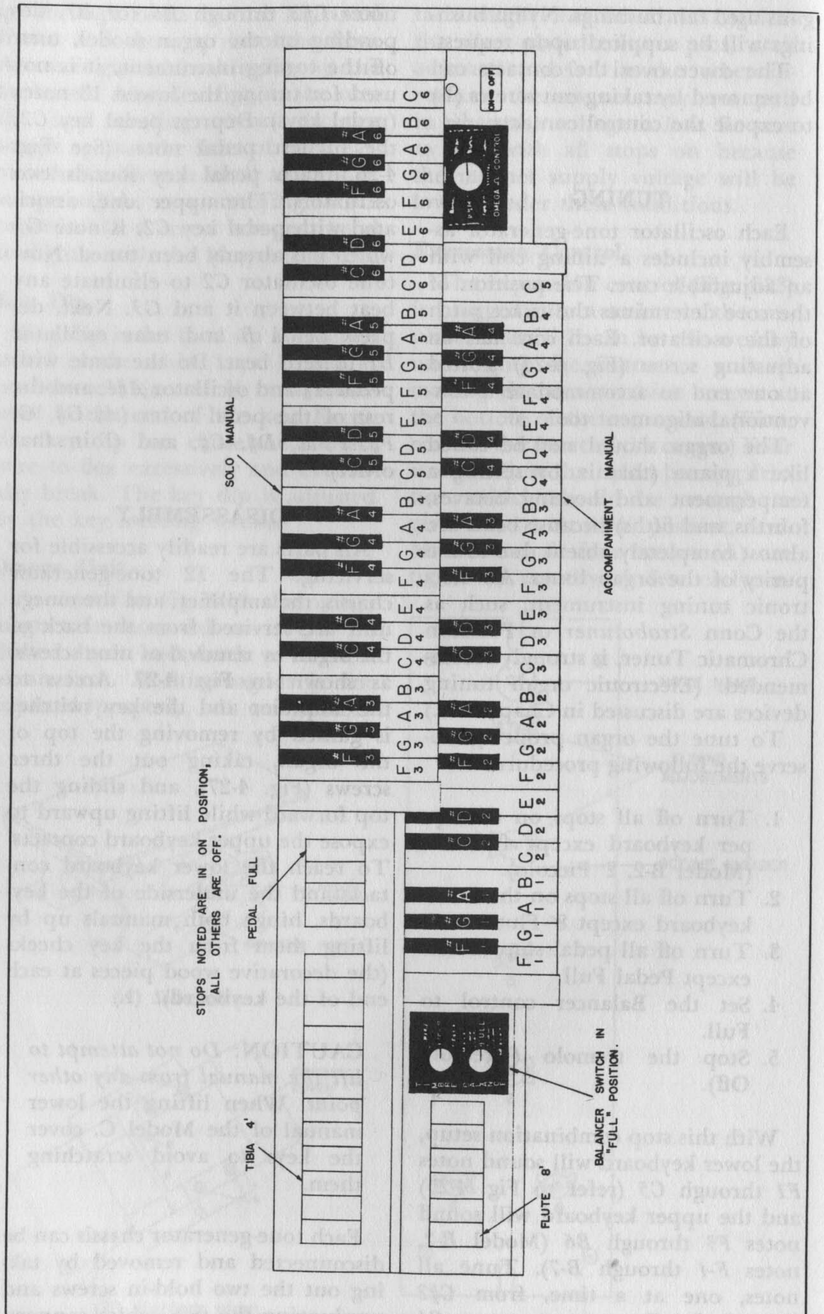
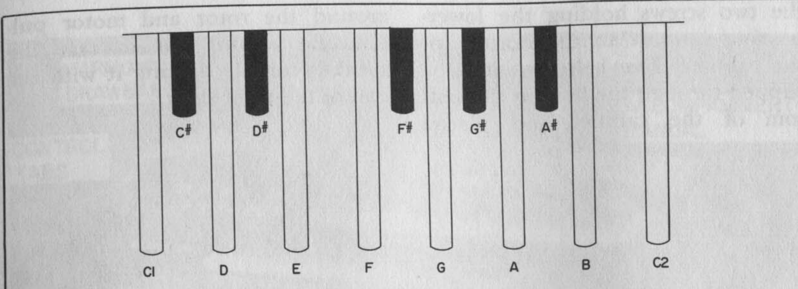


Fig. 4-25. Setup for tuning the organ.



PEDAL	OSCILLATORS KEYED	PEDAL	OSCILLATORS KEYED
CI	CI AND GI	G	GI AND D2
C#	C#I AND G#I	G#	G#I AND D#2
D	DI AND AI	A	AI AND E2
D#	D#I AND A#I	A	A#I AND F2
E	EI AND BI	B	BI AND F#2
F	FI AND C2	C2	C2 AND G2
F#	F#I AND C#2		

Fig. 4-26. Pedal keys.

upper- and lower-manual junction channels. (The junction channels, mounted in front of the tone-generator chassis, connect the tone generator to the two key switch assemblies.) The pedal contact assembly also plugs into the accompaniment junction channel.

The bottom of a junction channel can be serviced by removing the upper screw in each of the two wood junction-channel supporting blocks and swinging the channels into an accessible position.

The pedal board and contacts, the expression control, the junction channels, and the speaker are serviced by removing the three brass screws at the top of the front panel and lifting it up and out.

To replace the tremolo rotor belt, tip the organ on end and take out

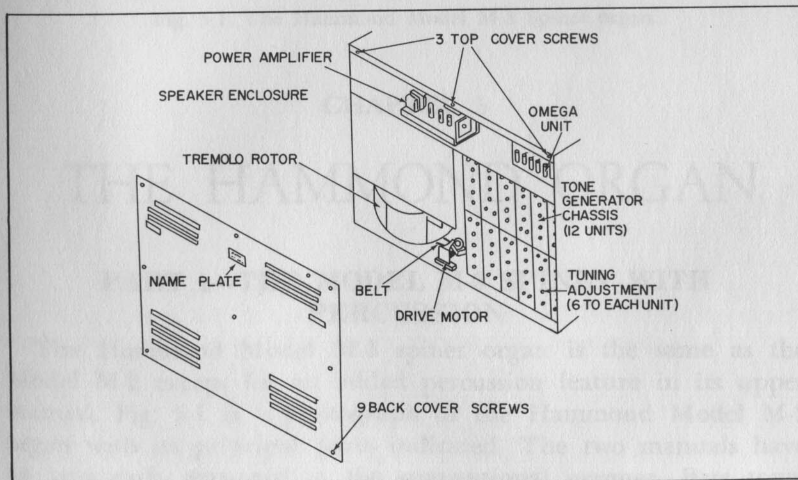


Fig. 4-27. Rear view of the organ.

the two screws holding the lower-bearing support to the bottom of the cabinet. The belt can then be slipped through the hole in the bottom of the cabinet and placed around the rotor and motor pulleys. Be careful not to tear the speaker cone by hitting it with the end of the rotor shaft.

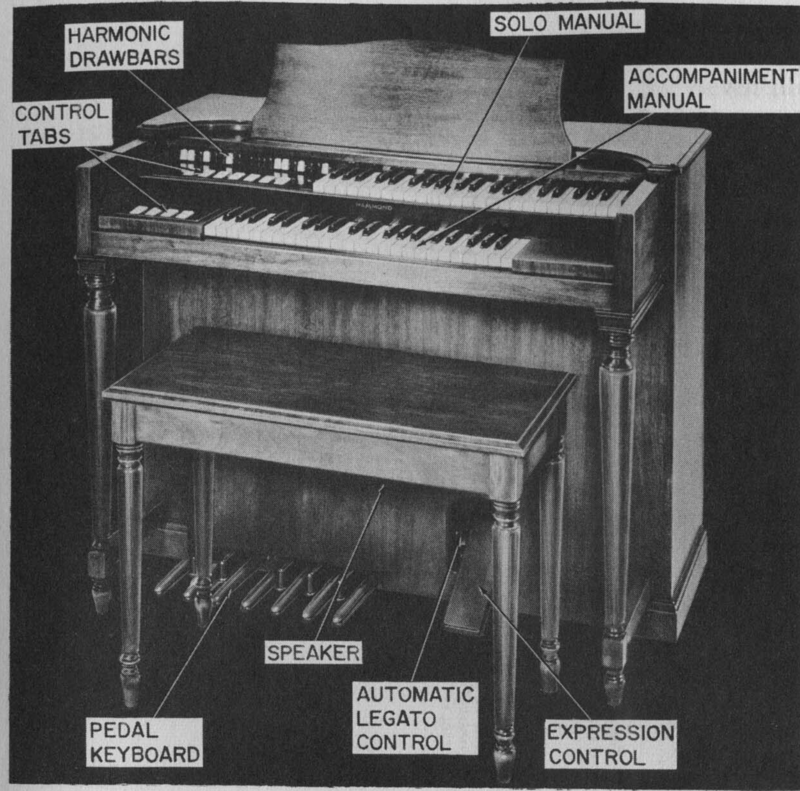


Fig. 5-1. The Hammond Model M-3 Spinet organ.

CHAPTER 5

THE HAMMOND ORGAN

PART 1—THE MODEL M-3 SPINET WITH PERCUSSION

The Hammond Model M-3 spinet organ is the same as the Model M-2 except for an added percussion feature in its upper manual. Fig. 5-1 is a photograph of the Hammond Model M-3 organ with its principal parts indicated. The two manuals have 44 keys each, arranged in the conventional manner. Bass tones are supplied by the 12-note pedal keyboard. All tones are produced

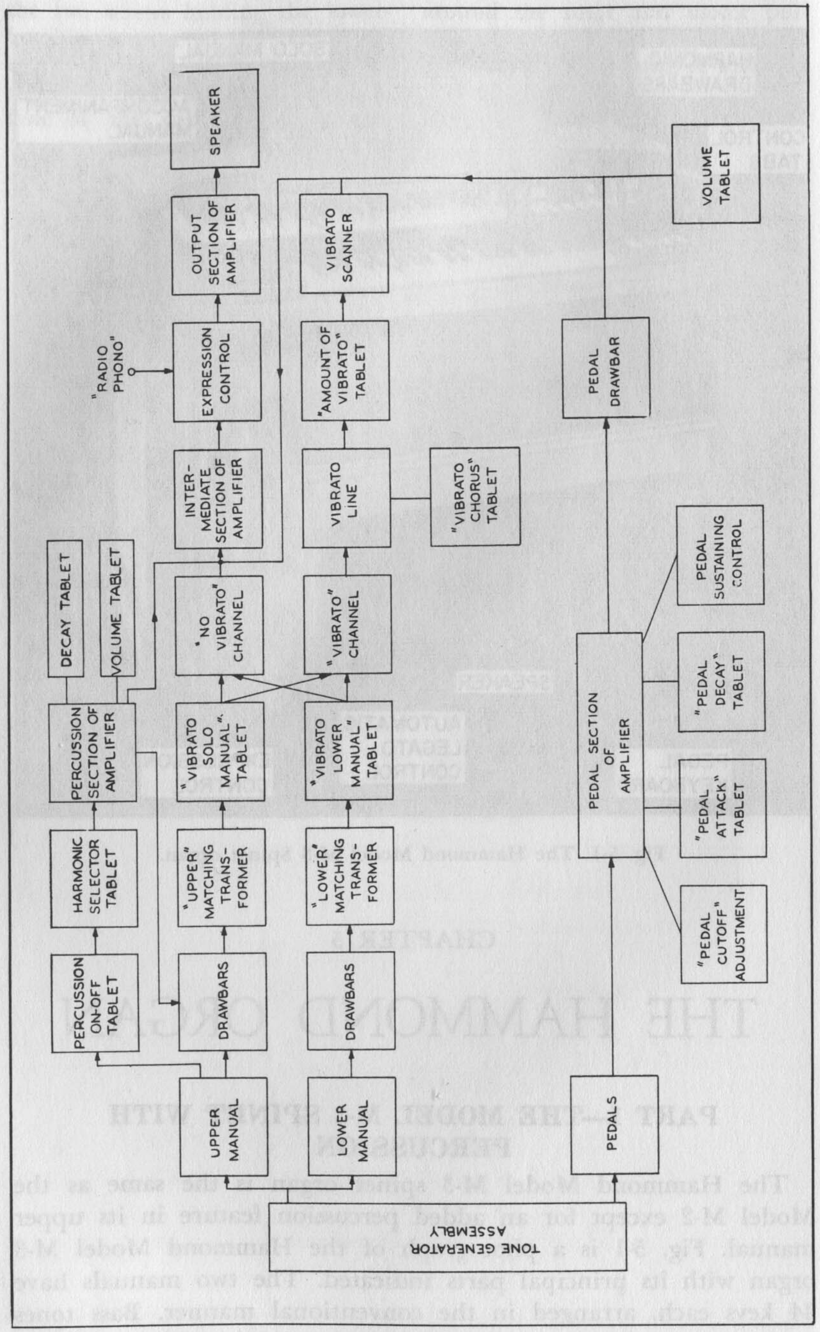


Fig. 5-2. Block diagram of the Hammond Model M-3 Spinet.

by electromagnetic tone generators. Tone colors are selected by the 18 harmonic drawbars. One set of nine harmonic drawbars is for the upper manual, eight are for the lower manual, and one is for the pedals. Other characteristics are controlled by the eleven tilting control tablets. The upper group of seven tabs controls the volume, pedal attack and decay, and vibrato; the lower group of four tabs controls the percussion effects. The control labeled "Automatic Legato" is operated with the side of the foot. This control causes each pedal note to continue sounding until another note is sounded, giving an unbroken pedal effect. The Expression control regulates the volume for both manuals and the pedals.

GENERAL DESCRIPTION

Usual tone sources (such as strings, reeds, or pipes) produce complex tones. The Hammond tone-producing device generates individual frequencies which can be combined, by means of harmonic drawbars, to produce any tone quality desired. The block diagram in Fig. 5-2 shows the chief components of the instrument, plus the progression of a tone or signal from its original generation, until it is amplified and transformed into sound and delivered by the console speakers or an external tone cabinet.

Electrical impulses of various frequencies are produced in the tone-generator assembly, which contains a number of tone wheels driven at predetermined speeds by an electrical motor and gears. Each tone wheel is a steel disc which might be likened to a gear, with high and low spots (somewhat resembling a cam) around the edge (see Fig. 5-3). As the tone wheel rotates, the teeth pass near a permanent magnet. Variations in the magnetic field induce a voltage in a coil wound on the magnet. When suitably filtered, this small voltage produces a note, its pitch depending on the number of teeth passing the magnet each second.

Any note played on either manual consists of a fundamental pitch, plus a number of multiples of the fundamental. The fundamental and eight harmonics are available on each playing key and can be controlled with the drawbars. In this way, the player can vary the tone colors.

Mixed tones from the upper and lower manuals go through either the vibrato or the no-vibrato channel, depending on the position of the vibrato selector tablet. The tones are then combined and passed through the expression control and other amplification stages before reaching the speakers.

Percussion tones are produced by borrowing the second or third harmonic signal from the corresponding solo manual drawbar and amplifying it, then returning part of

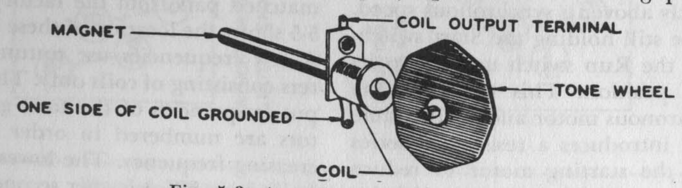


Fig. 5-3. A typical tone generator.

the same signal to the same drawbar and passing the balance through push-pull control tubes, which control its decay. The signal is then combined with the one from the manuals after the vibrato system, but before the expression control. The control tubes are keyed through the eighth harmonic key contacts and bus bar.

The pedal tones do not require drawbars for varying the tone color. The tones are produced as complex ones by special tone wheels. From the pedals, these tones go to a pedal amplifier, where the attack and decay characteristics are controlled. The single pedal drawbar adjusts the volume of the pedals relative to that of the manuals. The pedal signal is combined with the one from the manuals after it passes through the vibrato system, but before the expression control.

MECHANICAL AND ELECTRICAL CONSTRUCTION

Motors and Power Switches

The tone-generator assembly is driven at a constant speed by a synchronous motor (at the left as you look at the back of the console). Attached to the motor is the vibrato scanner. Because the motor is not self-starting, it is brought up to speed by a starting motor at the opposite end of the generator.

To turn on the organ, push the Start switch up (this switch is at the front of the console, near the right side), and hold it for eight seconds. This will bring the generator to slightly above its synchronous speed. While still holding the Start switch, push the Run switch upward to its "on" position. This turns on the synchronous motor and, at the same time, introduces a resistor in series with the starting motor to reduce the power. Hold the Start switch for about four seconds longer and then release it. During this time the braking action of the synchronous motor, together with the reduction in power of the starting motor, brings the system to synchronous speed. The synchronous motor will now carry the load. (During cold weather, it may be necessary to hold the Start switch longer.) To turn the organ off, push the Run switch down.

Tone Generator

All tones originate as electrical signals in the tone-generator system, which contains 86 toothed tone wheels plus gears for driving them at various speeds from a main shaft. Each pair of tone wheels is mounted on a shaft and separated by a *Bakelite* gear held between two coil springs. The gear, which forms a mechanical vibration filter, is not rigidly attached to the shaft. Therefore, should any pair of wheels be stopped accidentally, the others will continue to operate. Adjacent to each tone wheel is a magnetized rod on which is wound a pickup coil. These magnets extend through the front and back of the generator, and are held by set screws which can be loosened for adjustment. Fig. 5-4 shows where to find the magnet for any frequency number. The dotted lines indicate the frequencies that have tone wheels on the same shaft. On top of the tone-generator assemblies are small transformers and capacitors which form tuned filters for the higher frequencies. If a filter fails, both the transformer and capacitor must be replaced with a matched pair from the factory. Fig. 5-5 shows the location of these filters. A few frequencies use untuned filters consisting of coils only. The output frequencies of the tone generators are numbered in order of increasing frequency. The lowest (No. 1) is about 32 cycles per second, and

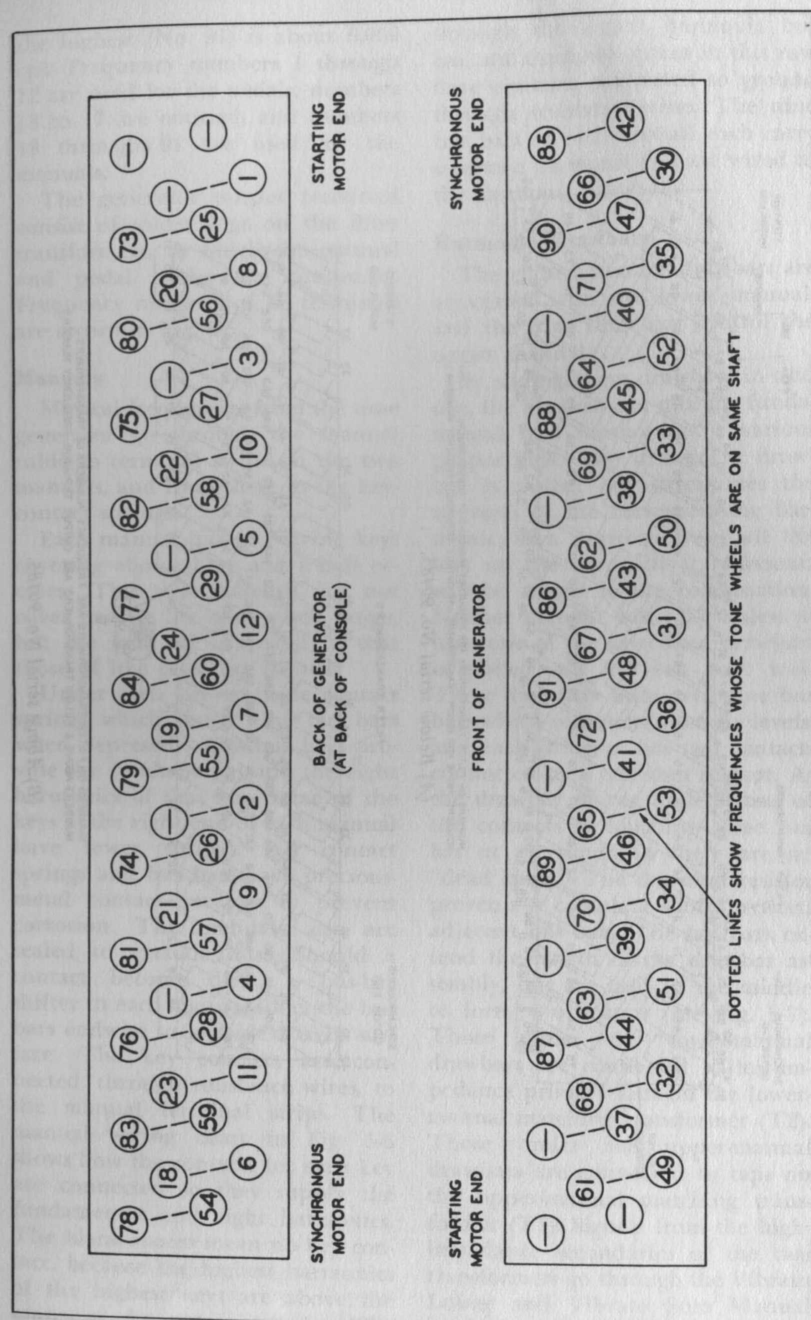


Fig. 5-4. Location of magnets on the tone generator.

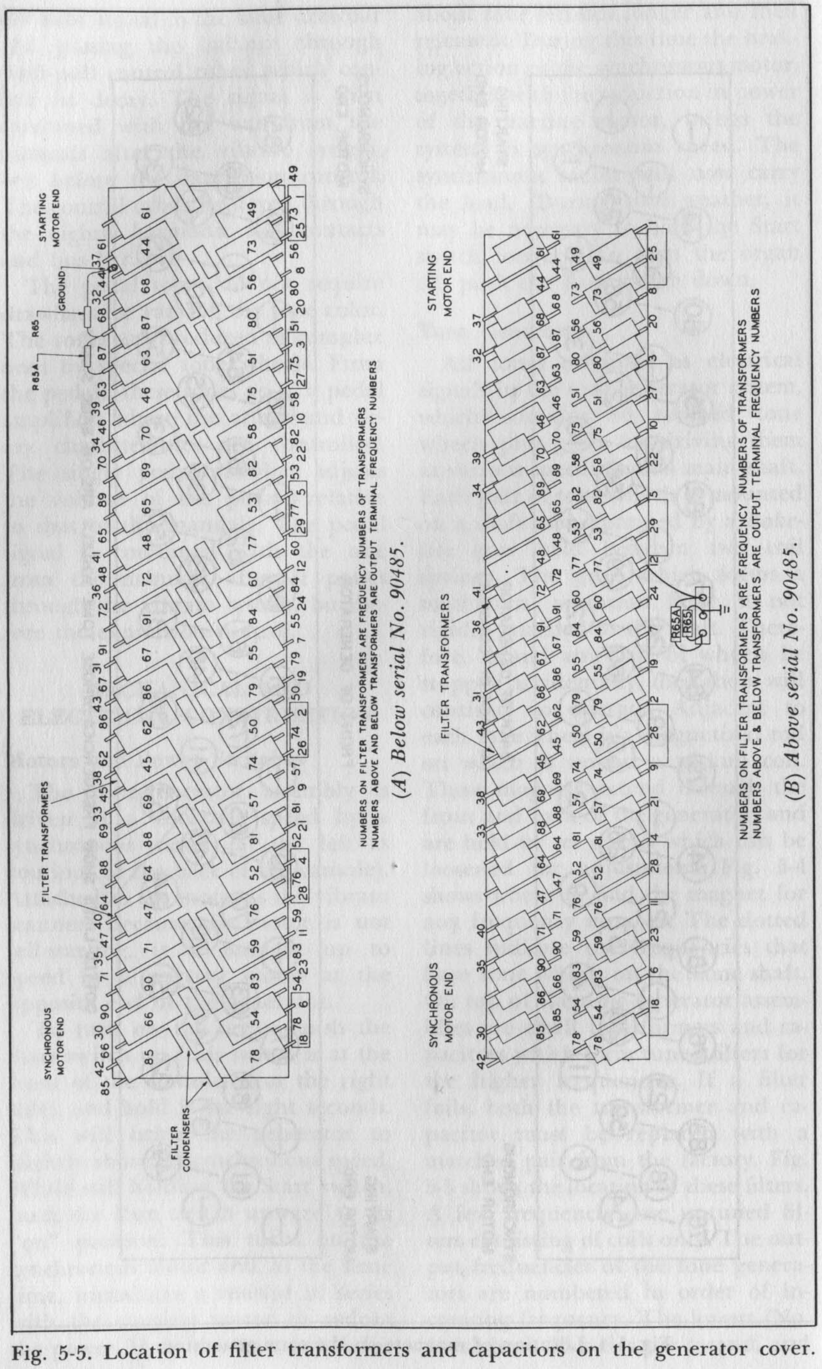


Fig. 5-5. Location of filter transformers and capacitors on the generator cover.

the highest (No. 91) is about 6,000 cps. Frequency numbers 1 through 12 are used for the pedals, numbers 13 to 17 are omitted, and numbers 18 through 91 are used for the manuals.

The generator output terminals consist of solder lugs on the filter transformers, to which the manual and pedal cables are connected. Frequency numbers of all terminals are shown in Fig. 5-5.

Manuals

Musical frequencies from the tone generator go through the manual cable to terminal strips on the two manuals, and from there to the key-contact springs.

Each manual has 44 playing keys covering about three and a half octaves. The two manuals do not cover exactly the same pitch range, but the keys are arranged so that those of like pitch are in line.

Under each key are nine contact springs which touch nine bus bars when depressed. The bus bars provide the fundamental and the eight harmonics of that key. Some of the keys at the right end of each manual have fewer springs. All contact springs and bus bars have precious-metal contact surfaces to prevent corrosion. The manuals also are sealed to exclude dust. Should a contact become dirty, a bus-bar shifter in each manual slides the bus bars endwise to provide a fresh surface. The key contacts are connected, through resistance wires, to the manual terminal strips. The manual wiring chart in Fig. 5-6 shows how the contacts for each key are connected so they supply the fundamental and eight harmonics. The blank spaces mean no key contact, because the highest harmonics of the highest keys are above the range of the tone generator. The percussion control tubes are keyed through the eighth harmonic bus bar, and the blank spaces in this row have contacts connected to ground through resistance wires. The nine bus bars of each manual each carry a certain harmonic and are wired to the harmonic drawbars.

Harmonic Drawbars

The eight harmonic drawbars are associated with the lower manual, and the nine drawbars control the upper manual.

By sliding these drawbars in and out, the organist can mix the fundamental and harmonics in various proportions. The distance a drawbar is pulled out determines the strength of the corresponding harmonic; if a drawbar is set all the way in, the harmonic it represents will be absent in the combination. Neither manual will play unless at least one of the associated drawbars is pulled out at least part way. These drawbars slide over nine bus bars which represent intensity levels, and each drawbar has two contacts connected by a one-ohm resistor. As the drawbar moves, at least one of the contacts is touching some bus bar at all times, so there are no "dead spots." The one-ohm resistor prevents a complete short between adjacent bus bars. The bus bars extend the length of the drawbar assembly, but are split in the middle to form two groups (see Fig. 5-7). Those under the lower-manual drawbars are connected to low-impedance primary taps on the lower-manual matching transformer (T2). Those under the upper-manual drawbars are connected to taps on the upper-manual matching transformer (T1). Signals from the high-impedance secondaries of the two transformers go through the Vibrato Lower and Vibrato Solo Manual control tablets to the amplifier input terminals.

	HARMONIC	BUSBAR LEAD COLOR													FREQUENCY NUMBERS																																											
UPPER MANUAL	SUB-FUND	BROWN													18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61
UPPER MANUAL	SUB-3RD	RED													37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
UPPER MANUAL	FUND	ORANGE													30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73
UPPER MANUAL	2ND	YELLOW													42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85
UPPER MANUAL	3RD	GREEN													49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	
UPPER MANUAL	4TH	BLUE													54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91						
UPPER MANUAL	5TH	VIOLET													58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91										
UPPER MANUAL	6TH	GREY													61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91													
UPPER MANUAL	8TH	WHITE													66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
NOTES			F	F#	G	G#	A	A#	B	C	C#	D	D#	E	F	F#	G	G#	A	A#	B	C	C#	D	D#	E	F	F#	G	G#	A	A#	B	C	C#	D	D#	E	F	F#	G	G#	A	A#	B	C	C#	D	D#	E	F	F#	G	G#	A	A#	B	C
KEY NUMBERS			6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61
	HARMONIC	BUSBAR LEAD COLOR	FREQUENCY NUMBERS																																																						
LOWER MANUAL	FUND	BROWN	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61												
LOWER MANUAL	2ND	RED	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73												
LOWER MANUAL	3RD	ORANGE	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80												
LOWER MANUAL	4TH	YELLOW	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85												
LOWER MANUAL	5TH	GREEN	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89												
LOWER MANUAL	6TH	BLUE	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91													
LOWER MANUAL	8TH	VIOLET	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91																		
LOWER MANUAL	10TH	GREY	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91																						
LOWER MANUAL	12TH	WHITE	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91																									

*Contacts Grounded Through 16 OHMS.

Fig. 5-6. Manual wiring chart.

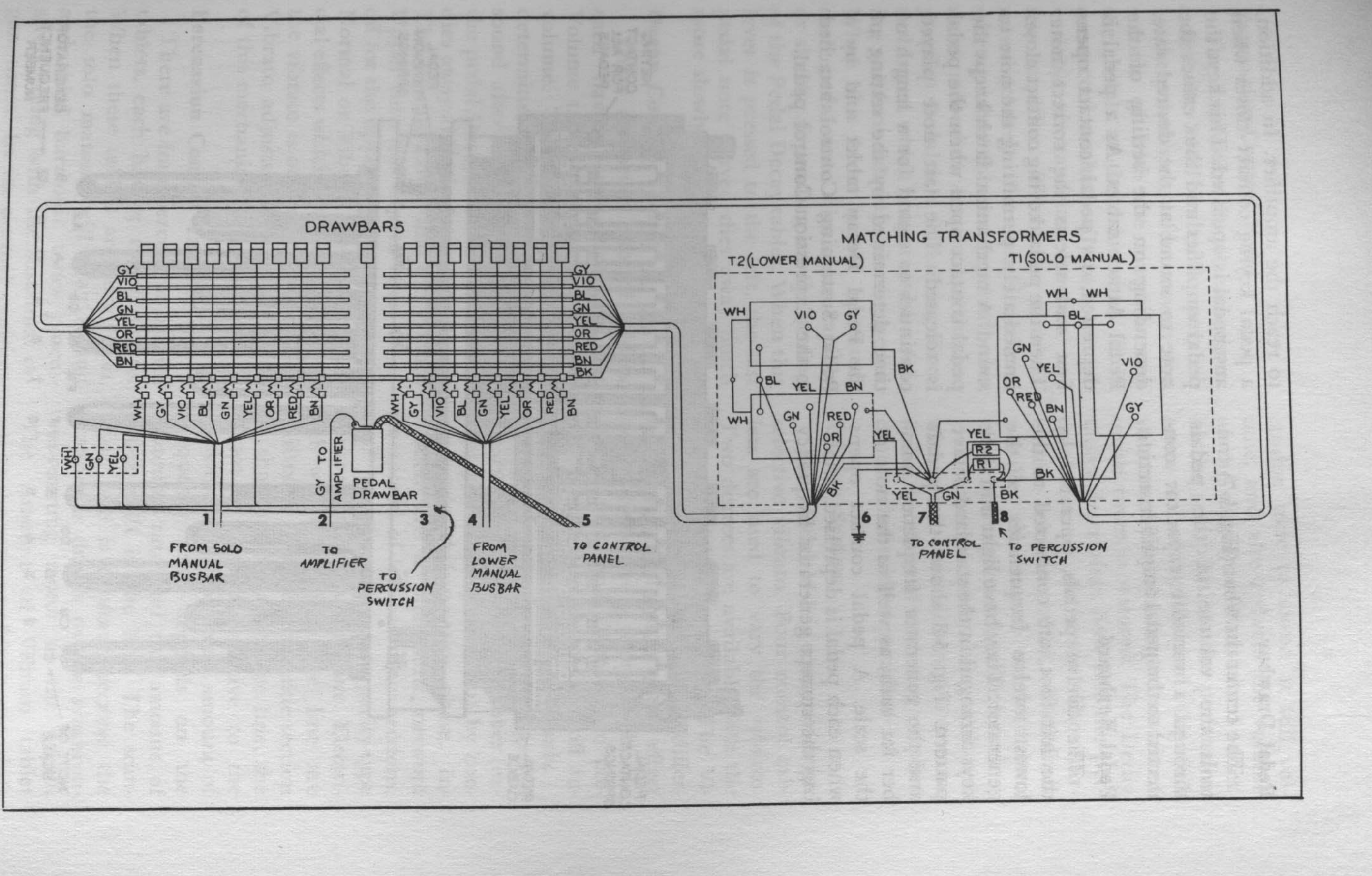


Fig. 5-7. Drawbars and matching transformers.

Pedal Drawbar

The center drawbar (Fig. 5-7) controls the volume of the pedals through a variable capacitor connected to the pedal amplifier section.

Pedal Keyboard

The twelve pedals, operated by the left foot, are connected to the lowest twelve frequencies of the generator. They have light and dark keys arranged in the standard octave pattern. Fig. 5-8 shows the pedals and the generator frequency number for each, as well as the note of the scale. A pedal contact opens when each pedal is depressed, allowing the correct generator frequency to reach the amplifier. In addition, a pedal keying contact closes when any pedal is operated. This keys the pedal amplifier and thus causes the note to sound at the desired rate, depending on the setting of the Pedal Attack tablet. As a pedal is depressed, its pedal contact opens first and selects the correct note. Then the pedal keying contact closes immediately, permitting the note to sound. A mechanical latch keeps the pedal contact open when the pedal is released. The last note played continues to sound for a length of time determined by the setting of the Pedal Decay tablet and by a Pedal Sustaining Control attached to the Expression-Control pedal.

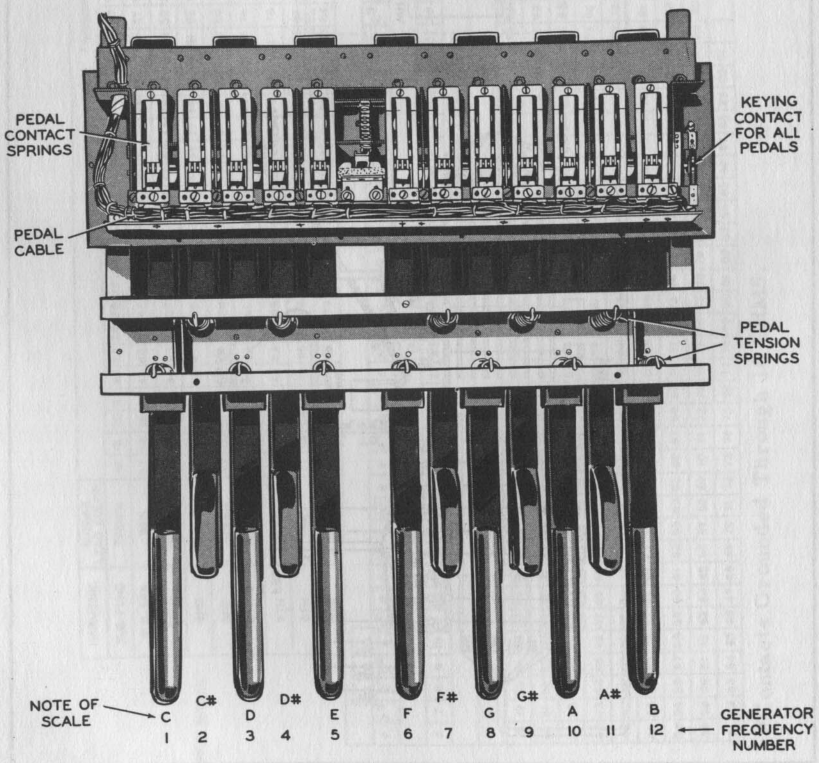


Fig. 5-8. Pedal keyboard.

Expression-Control Pedal

The Expression Pedal, sometimes called the Swell Pedal, is operated by the player's right foot to vary the volume of both the manuals and the pedals at the same time. It is connected mechanically to a special variable air capacitor mounted on the amplifier. When the pedal is raised (closed), the music is softest; when pushed forward (opened), the music is loudest. Attached to the Expression Pedal is a Sustaining Control Lever, which is operated by sliding the foot sideways on the pedal. When this lever is not operated, each pedal note dies away rapidly or slowly, depending on the setting of the Pedal Decay tablet. When this lever is pressed to the left, the last pedal note played dies away much more slowly.

Organ Control Tablets

There are seven control tablets, each having two positions. The Volume tablet changes the over-all volume. The Pedal Attack tablet determines how fast a note will sound after the pedal is depressed; the pedal Decay, how fast the sound dies away after the pedal is released. The Vibrato Lower and the Vibrato Upper turn the vibrato effect on or off for the upper and lower manuals. Normal or Vibrato Chorus are special effects which function only when the vibrato is on. Small, or Normal, Vibrato adjusts the pitch variation of this mechanism.

Percussion Control Tablets

There are four percussion control tablets, each having two positions. When these tablets are turned on, the solo manual will play second and third harmonic tones percussively, along with the sustained organ tones. In its normal position, the Volume tablet allows the percussion tone to sound at full volume, and also reduces the volume of the solo-manual sustained tones. In the soft position, the percussion tones sound softly and the full volume of the solo-manual sustained organ tones is restored. The Decay tablet determines how fast the percussion tones die away. The Harmonic Selector tablet determines whether the second or third harmonic percussion tones are heard.

All control tablets are equipped with precious-metal contacts to minimize the effect of corrosion or poor contact due to dust particles.

Vibrato System

The Model M-3 is equipped with selective vibrato. Four control tablets are used to vary the vibrato. Two degrees are available with the Amount of Vibrato tablet. The Vibrato Chorus tablet offers a different degree of chorus or celeste effect with each degree of vibrato. The Vibrato Lower and Vibrato Solo tablets turn the effect on and off independently for the two manuals.

The vibrato equipment (Fig. 5-9) varies the frequency of all tones (except pedal and percussion) by continuously shifting the phase. Included are a phase-shift network composed of low-pass filter sections, and a motor-driven capacity-type pickup that scans the line. Electrical waves fed into the line are shifted in phase by each line section so that, at any tap of the line, the phase is retarded relative to the previous tap. The exact amount of frequency shift depends on the scanning rate and the amount of phase shift in the line. The scanning rate is constant because the scanner is driven by the synchronous-running motor of the organ. The Amount of Vibrato tablet varies the amount of frequency shift by causing the whole line to be

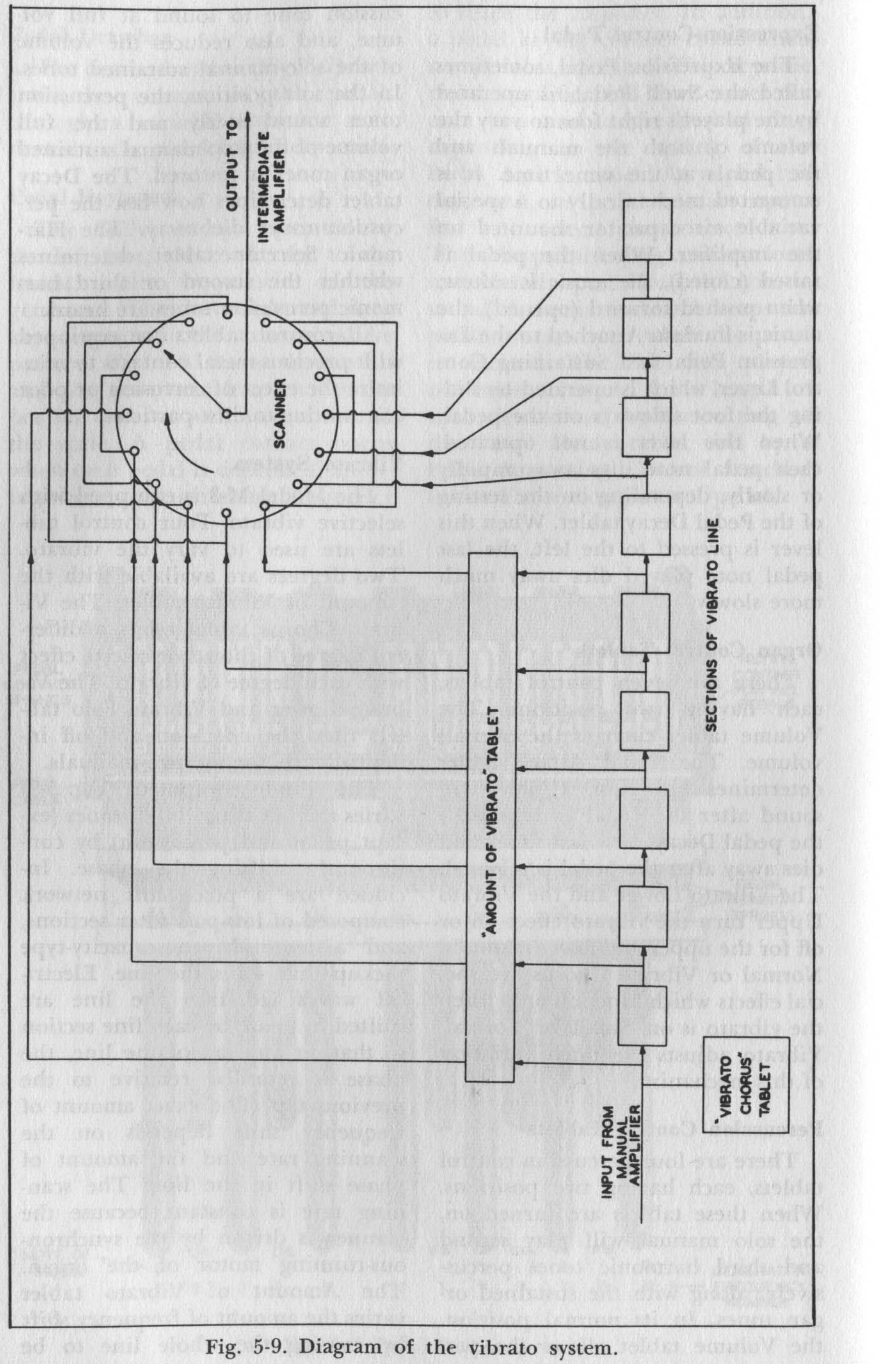
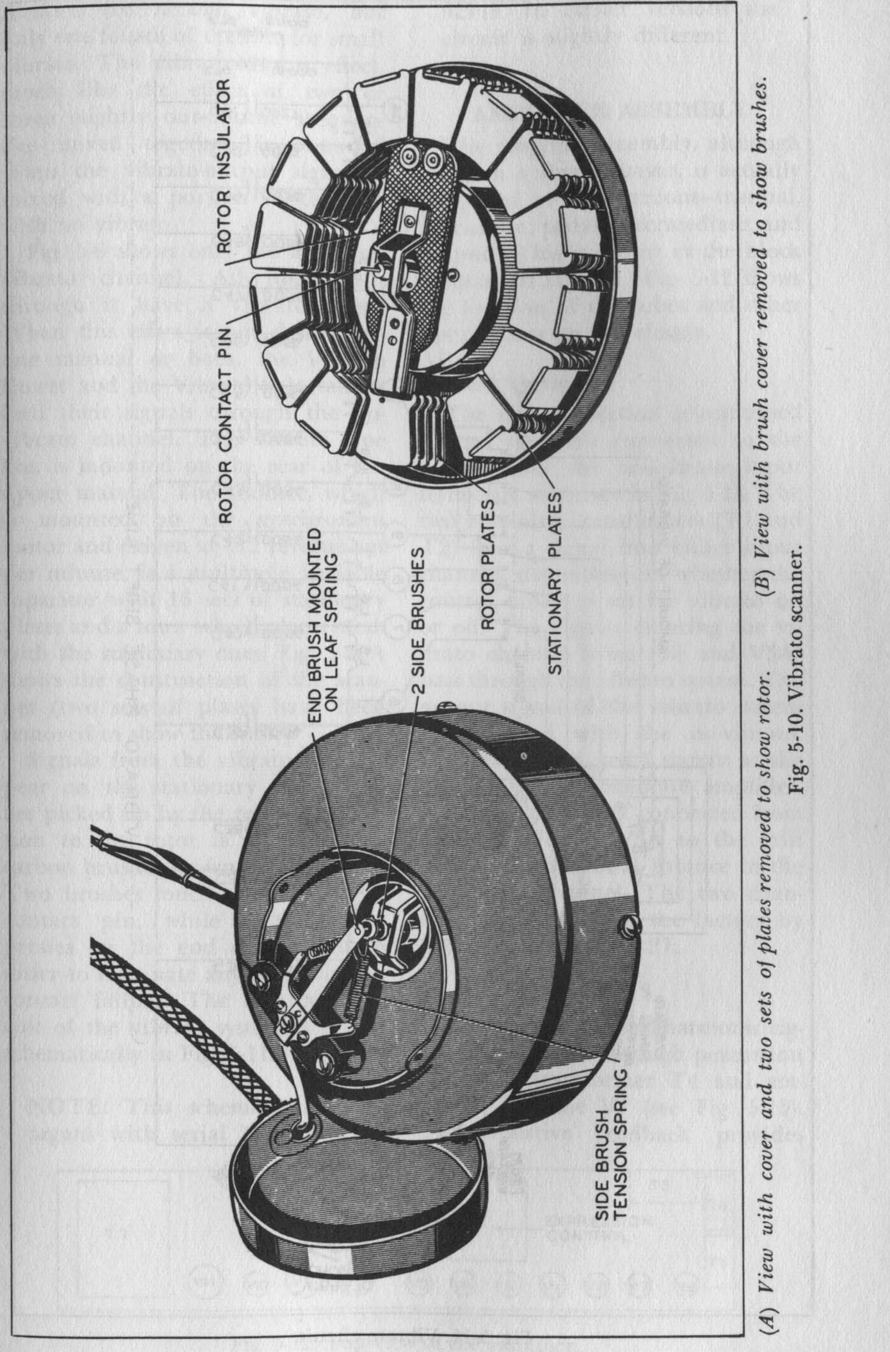


Fig. 5-9. Diagram of the vibrato system.



(A) *View with cover and two sets of plates removed to show rotor.* (B) *View with brush cover removed to show brushes.*

Fig. 5-10. Vibrato scanner.

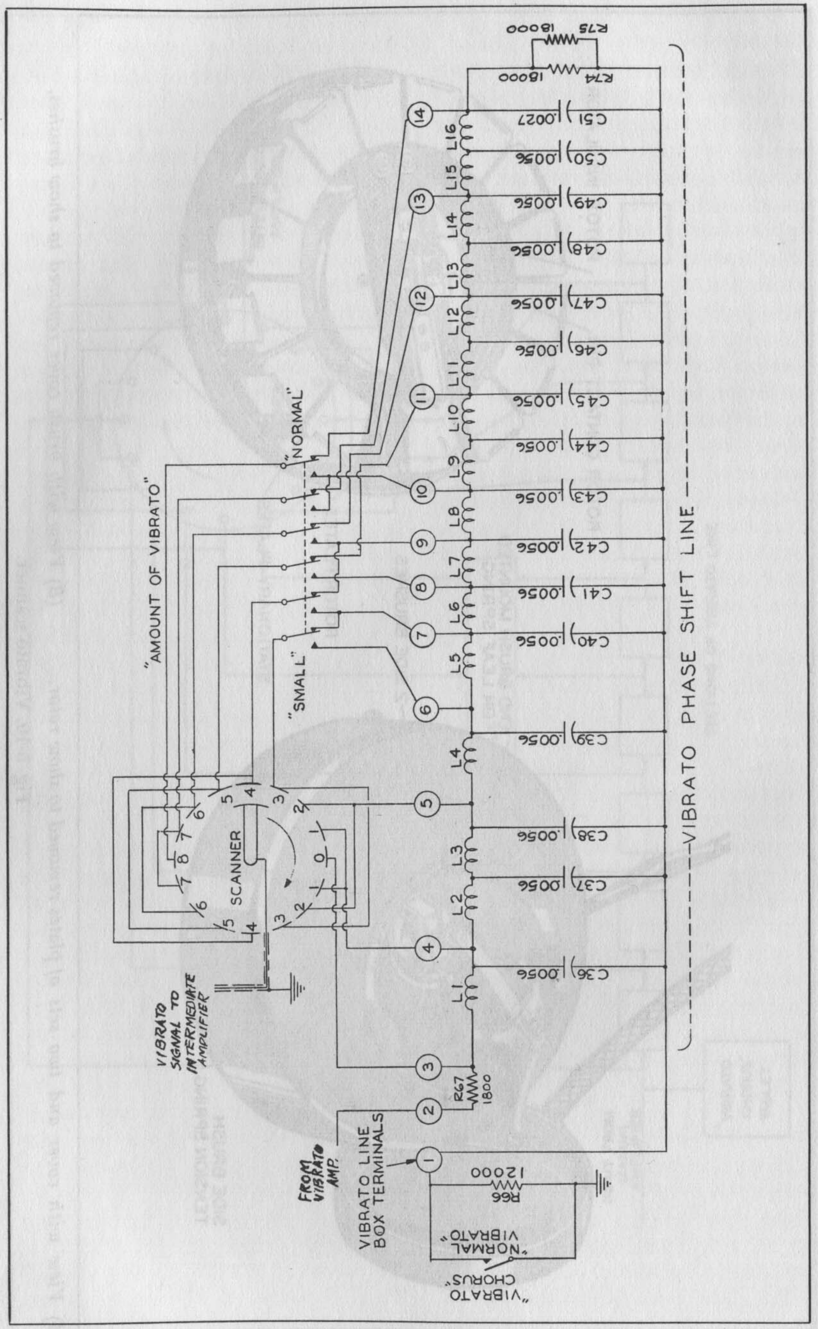


Fig. 5-11. Vibrato circuit.

scanned for normal vibrato, but only one fourth of the line for small vibrato. The vibrato chorus effect, much like the effect of two or three slightly out-of-tune frequencies mixed together, is obtained when the vibrato-output signal is mixed with a portion of the one with no vibrato.

Fig. 5-9 shows only the amplifier vibrato channel. All tones sent through it have a vibrato effect. When this effect is not desired on one manual or both, the Vibrato Lower and the Vibrato Solo tablets feed their signals through the no-vibrato channel. The vibrato line box is mounted on the rear of the upper manual. The scanner, which is mounted on the synchronous motor and driven at 412 revolutions per minute, is a multipole variable capacitor with 16 sets of stationary plates and a rotor whose plates mesh with the stationary ones. Fig. 5-10A shows the construction of the scanner (two sets of plates have been removed to show the rotor).

Signals from the vibrato line appear on the stationary plates and are picked up by the rotor. Connection to the rotor is made by the carbon brushes shown in Fig. 5-10B. Two brushes touch the side of the contact pin, while a third one presses on the end of the pin in order to eliminate any possibility of contact failure. The complete circuit of the vibrato system is shown schematically in Fig. 5-11.

NOTE: This schematic is for organs with serial Nos. above 92748. In earlier versions the circuit is slightly different.

AMPLIFIER ASSEMBLY

The amplifier assembly, although built on a single chassis, is actually composed of five sections—manual, percussion, pedal, intermediate, and output. (This is shown in the block diagram in Fig. 5-2.) Fig. 5-12 shows the location of the tubes and other components on the chassis.

Manual Section

The manual section is composed of two channels connected to the vibrato and the no-vibrato input terminals, as shown in Fig. 5-13. The two matching transformers (T1 and T2) feed a signal into either input channel, depending on whether the control tablet is set for vibrato on or off. The signals entering the vibrato channel tubes (V1 and V3A) pass through the vibrato system. The output signal of the vibrato system is combined with the no-vibrato, percussion, and pedal signals at the grid of the intermediate amplifier. A feedback network connected from cathode follower V3A to the grid of V1 provides tonal balance in the no-vibrato channel. The two channels are matched at the factory by proper selection of R27.

Percussion Section

The second- or third-harmonic signal is conducted through percussion matching transformer T4 and amplified by tube V7 (see Fig. 5-13). The resistive feedback provides

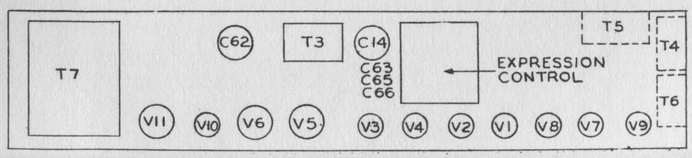


Fig. 5-12. Top view of the amplifier.

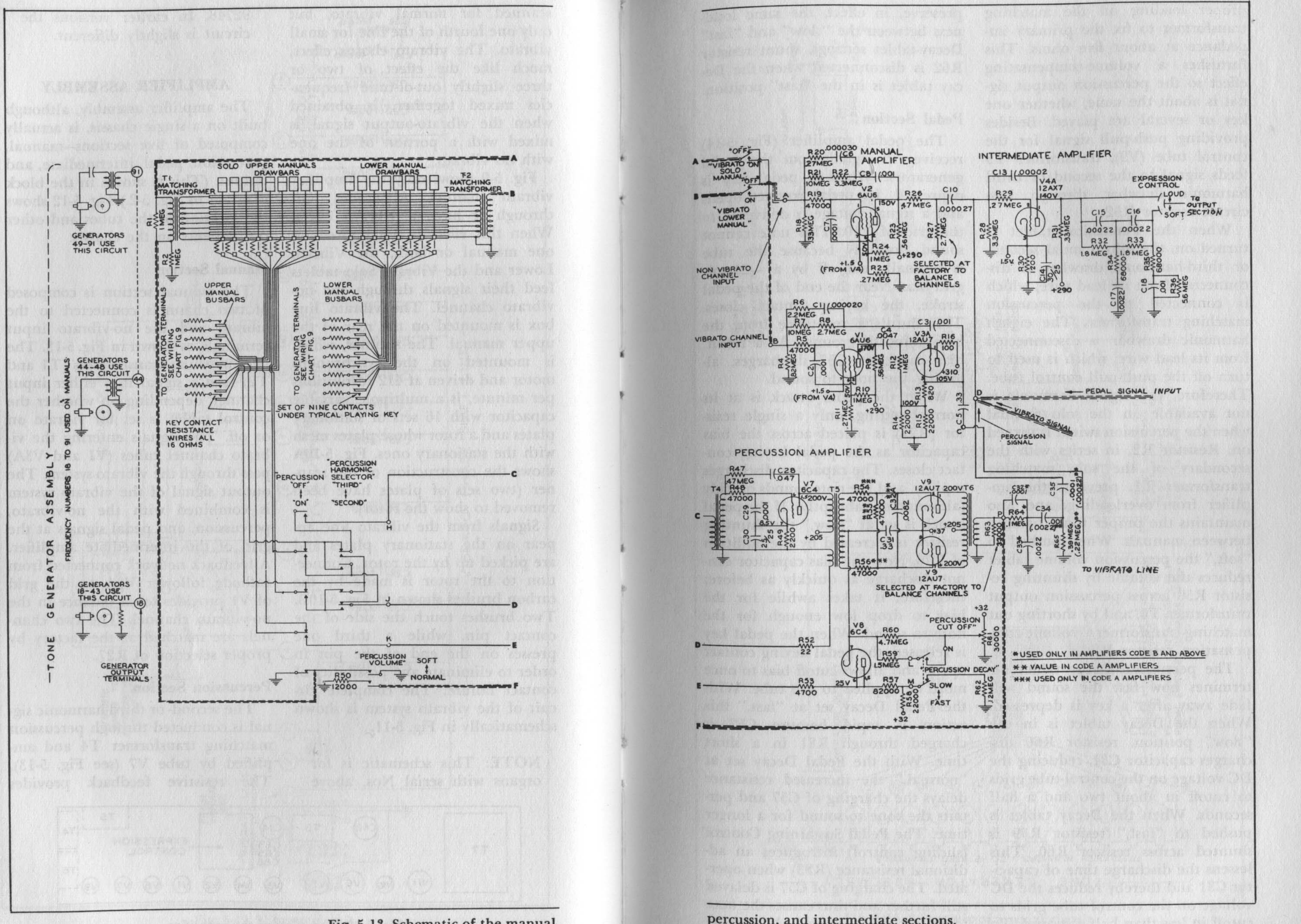


Fig. 5-13. Schematic of the manual, percussion, and intermediate sections.

proper loading on the matching transformer to fix the primary impedance at about five ohms. This furnishes a volume-compensating effect so the percussion output signal is about the same, whether one key or several are played. Besides providing push-pull signal for the control tube (V9), transformer T5 feeds signal to the second or third harmonic drawbar through key-circuit resistor R52.

When the Percussion tablet is turned on, the solo manual second- or third-harmonic drawbar is disconnected from its lead wire, which is connected to the percussion matching transformer. The eighth harmonic drawbar is disconnected from its lead wire, which is used to turn off the push-pull control tube. Therefore, the eighth harmonic is not available on the solo manual when the percussion switch is turned on. Resistor R2, in series with the secondary of the solo matching transformer T1, prevents the amplifier from overloading, and also maintains the proper tonal balance between manuals. When pushed to "soft," the percussion volume tablet reduces the volume by shunting resistor R50 across percussion output transformer T6, and by shorting out matching-transformer volume-compensation resistor R2.

The percussion Decay tablet determines how fast the sound will fade away after a key is depressed. When the Decay tablet is in the "slow" position, resistor R60 discharges capacitor C31, reducing the DC voltage on the control-tube grids to cutoff in about two and a half seconds. When the Decay tablet is pushed to "fast," resistor R59 is shunted across resistor R60. This lessens the discharge time of capacitor C31 and thereby reduces the DC voltage on the control tube grids to cutoff in less than half a second. To preserve, in effect, the same loudness between the "slow" and "fast" Decay-tablet settings, shunt resistor R62 is disconnected when the Decay tablet is in the "fast" position.

Pedal Section

The pedal amplifier (Fig. 5-14) receives its signal from the pedal generators. When a pedal key is depressed, its pedal contact opens and a signal voltage is delivered to the grid of V10. This note cannot sound instantly because the tube is normally cut off by a −21-volt grid bias. Near the end of the pedal stroke, the keying contact closes. This shunts a resistance from the bias point to ground. As a result, bias capacitor C57 discharges, allowing the note to sound.

When the pedal attack is at its normal setting, only a single resistor (R77) is placed across the bias capacitor as the pedal keying contact closes. The capacitor discharges rapidly, and the note sounds quickly (although not abruptly). If the pedal attack is set at "slow," the shunting resistor is increased by the addition of R76. Now the bias capacitor cannot discharge as quickly as before; therefore, it takes awhile for the bias to drop low enough for the note to sound. When the pedal key is released, the pedal keying contact opens and allows cutoff bias to once more be applied to the tube. With the Pedal Decay set at "fast," this action is rapid because C57 is charged through R81 in a short time. With the Pedal Decay set at "normal," the increased resistance delays the charging of C57 and permits the tone to sound for a longer time. The Pedal Sustaining Control (sliding control) introduces an additional resistance (R83) when operated. The charging of C57 is delayed still further and thus causes the note to sound much longer. A latching

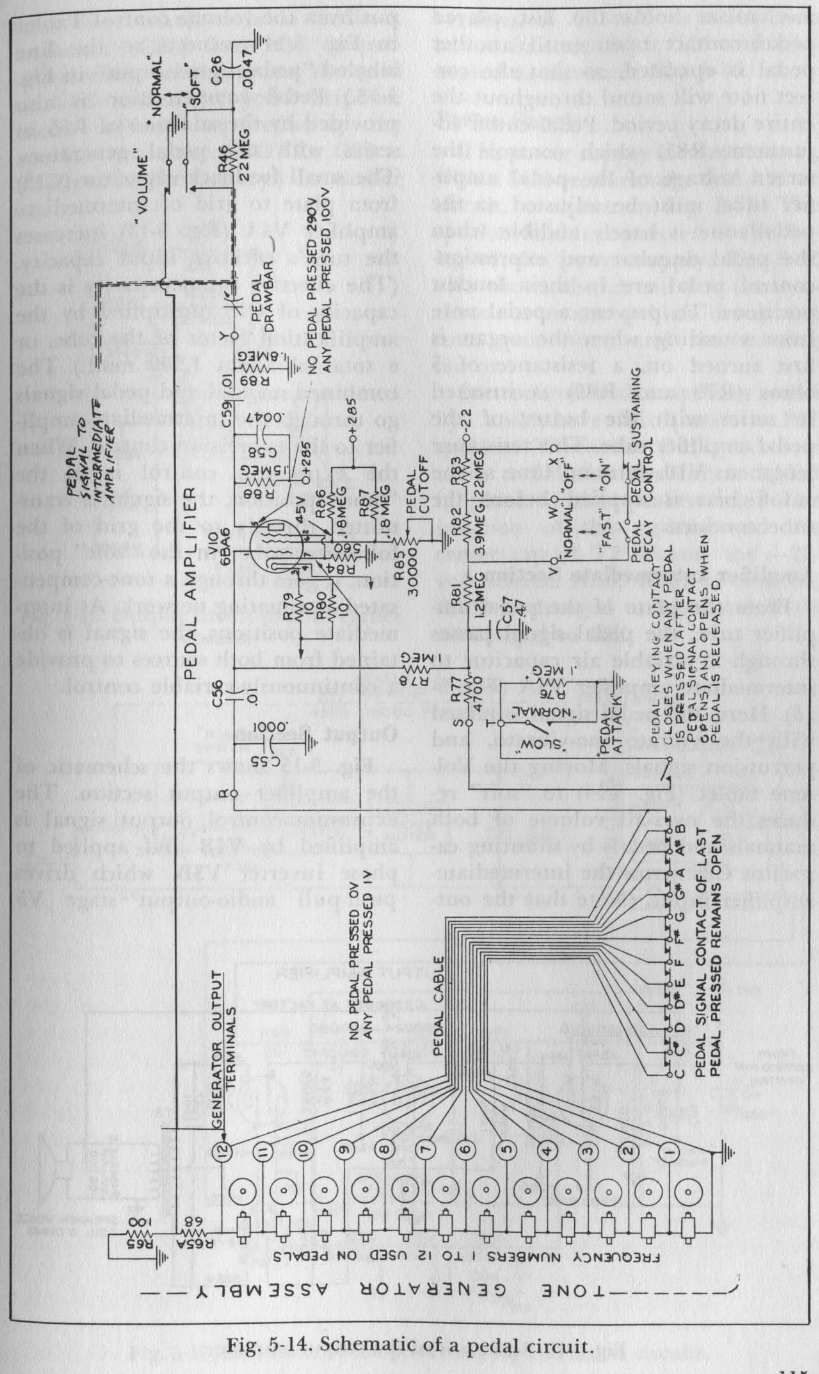


Fig. 5-14. Schematic of a pedal circuit.

mechanism holds the last played pedal contact open until another pedal is operated, so that the correct note will sound throughout the entire decay period. Pedal cutoff adjustment R85, which controls the screen voltage of the pedal amplifier tube, must be adjusted so the pedal tone is barely audible when the pedal drawbar and expression-control pedal are in their loudest positions. To prevent a pedal note from sounding when the organ is first turned on, a resistance of 5 ohms (R79 and R80) is inserted in series with the heater of the pedal amplifier tube. This resistance lengthens V10 warm-up time so the cutoff bias is applied before the tube conducts.

Amplifier Intermediate Section

From the plate of the pedal amplifier tube, the pedal signal passes through a variable air capacitor to intermediate amplifier V4A (Fig. 5-13). Here, the pedal signal is mixed with the vibrato, no-vibrato, and percussion signals. Moving the Volume tablet (Fig. 5-14) to "soft" reduces the over-all volume of both manuals and pedals by shunting capacitor C26 across the intermediate-amplifier input. (Note that the output from the volume control Tablet in Fig. 5-14 connects to the line labeled "pedal signal input" in Fig. 5-13.) Pedal compensation is also provided by the addition of R65 in series with the pedal generators. The small feedback capacitor (C13) from plate to grid of intermediate amplifier V4A (Fig. 5-13) increases the tube's effective input capacity. (The effective input capacity is the capacity of C13 multiplied by the amplification factor of the tube, or a total of about 1,500 mmf.) The combined manual and pedal signals go through the intermediate amplifier to the expression control. When the expression control is in the "loud" position, the signal is transmitted directly to the grid of the following tube; in the "soft" position, it goes through a tone-compensated attenuating network. At intermediate positions, the signal is obtained from both sources to provide a continuously-variable control.

Output Section

Fig. 5-15 shows the schematic of the amplifier output section. The expression-control output signal is amplified by V4B and applied to phase inverter V3B, which drives push-pull audio-output stage V5

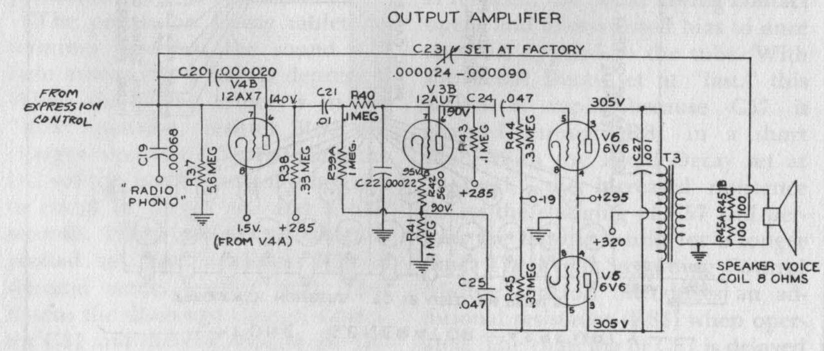


Fig. 5-15. Schematic of the output amplifier.

and V6. A small variable feedback capacitor (C23) from the output-transformer secondary to the grid of V4B makes the pedal response more uniform by reducing the speaker resonance. (NOTE: C23 is adjusted at the factory.) In earlier

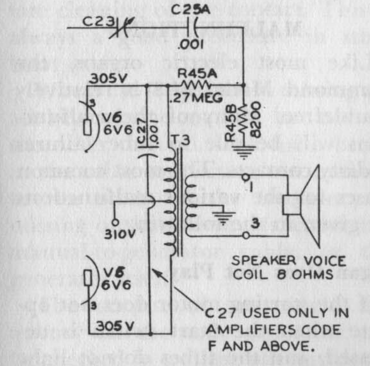


Fig. 5-16. Output circuit used in earlier versions.

versions, a .001-mfd capacitor was added in series with C23 and connected as shown in Fig. 5-16.

Power Supply

The power supply is conventional, with a 5U4 rectifier tube and a filter circuit, as shown in Fig. 5-17. The speaker field is connected in the B— leg of the power supply. Fig. 5-17 also shows the circuit for the synchronous motor (which drives the tone generators) and the starting motor.

Instruments with amplifiers coded "J" and above incorporate a PM speaker. When the PM speaker is used, a 180-ohm resistor is added in place of the speaker field. The junction of this resistor and the center tap of T7 become the —22-volt source. Also, R101 is omitted, R102 is changed to 10K, and R103 is changed to 56K.

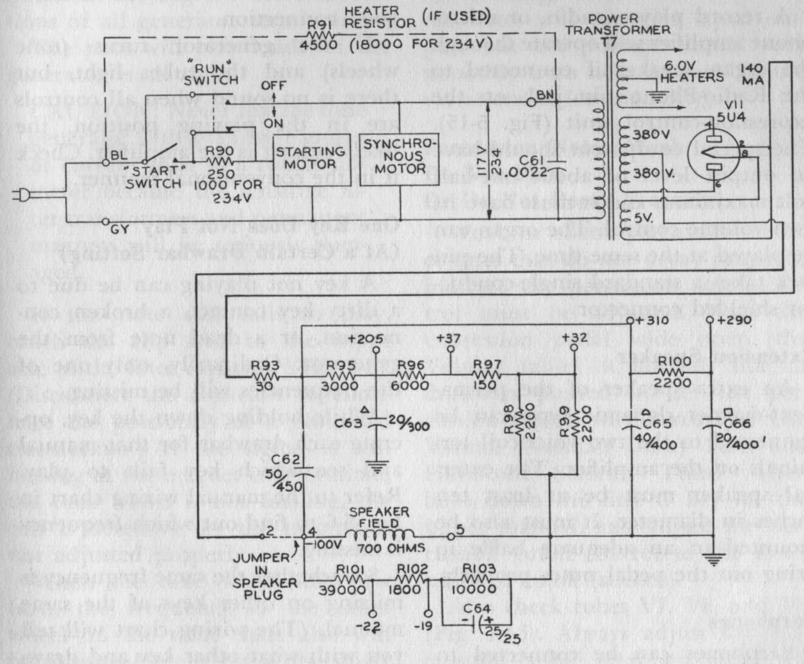


Fig. 5-17. Schematic of the power-supply and motor circuits.

Tube-Socket Voltages

The tube-socket voltages are shown on the schematics in Figs. 5-13 through 5-17. To make the tube sockets accessible, remove the lever from the expression-control shaft. Disconnect the two twisted wires from the "W" and "X" terminals on the amplifier (Fig. 5-14). (They can remain disconnected for the voltage tests.) Loosen the cable clamp on the lower shelf, remove the four amplifier chassis mounting screws, and turn the amplifier upside down. (Do not rest it on the expression-control lever.) The voltages shown on the schematic were taken with a 20,000-ohms-per-volt meter and all control tablets tilting toward the front of the console. No key should be depressed unless specified.

Special Equipment

A record player, radio, or microphone amplifier will operate through the organ speaker if connected to the Radio-Phono pin jack on the expression-control unit (Fig. 5-15). The special equipment should have an output level of about one-half volt maximum, and it must have its own volume control. The organ can be played at the same time. The pin jack takes a standard single-conductor shielded connector.

Extension Speaker

An extra speaker of the permanent-magnet dynamic type can be connected to the two voice-coil terminals on the amplifier. The external speaker must be at least ten inches in diameter. It must also be mounted in an adequate baffle to bring out the pedal notes properly.

Earphones

Earphones can be connected to the organ in the same manner as an external speaker. However, a 6- to 10-ohm resistor must be connected across the amplifier voice-coil terminals whenever the speaker is disconnceted. An open- and closed-circuit jack can be installed to provide these features.

MALFUNCTIONS

Like most electric organs, the Hammond Model M-3 is relatively troublefree. Many of the malfunctions will be due to tube failures or dirty contacts. The most common causes for the various malfunctions are given in the following.

Organ Does Not Play

If the starting motor does not operate when the Start switch is depressed, and the tubes do not light when the Run switch is on, check the power line input, fuses (if any), line cord, and the wall outlet for a good connection.

If the generator turns (tone wheels) and the tubes light, but there is no sound when all controls are in the playing position, the likely culprit is the amplifier. Check it in the conventional manner.

One Key Does Not Play (At a Certain Drawbar Setting)

A key not playing can be due to a dirty key contact, a broken connection, or a dead note from the generator. Ordinarily, only one of the frequencies will be missing.

While holding down the key, operate each drawbar for that manual and see which key fails to play. Refer to the manual wiring chart in Fig. 5-6 to find out which frequency is missing.

See whether the same frequency is missing on other keys of the same manual. (The wiring chart will tell you with what other key and drawbar you should get the same frequency.) If the frequency is missing on one key only, a key contact is probably dirty. Adjusting the busbar shifter should clear up the trouble. In extreme cases, it may be necessary to hold down the faulty key while turning the bus-bar shifter screw. The wiping action will facilitate cleaning of the contact. This is always a good procedure in stubborn cases.

When the frequency is missing on all keys of one manual but not on the other manual, look for a break in the cable connecting one manual to the other. If the frequency is missing on both manuals, check the manual-to-generator cable, or the generator itself.

The output of any single frequency on the tone generator can be checked by pulling out any drawbar and connecting a clip lead from its back to the generator terminal in question. See Fig. 5-5 for the locations of all generator terminals.

The note will play loudly if the generator is all right.

> CAUTION: Never test the tone generator with an outside source of current such as a continuity meter because the sensitive filter transformers and permanent magnets will be seriously damaged.

If the note still fails to play, touch the clip lead to the input side of the filter capacitor (Fig. 5-5). (Disconnect the capacitor to eliminate the possibility of a grounded transformer.) If the signal is still missing at the magnet coil terminal, the tone wheel is not turning, the coil is defective, or the magnet is not adjusted properly.

When the tone wheel does not turn, the frequency of the other wheel on the same shaft also will be missing (except for a few single wheels). To check, raise the generator slightly and feel the wheel with your finger to see if it is turning.

If the magnet coil is defective, the generator must be returned to the factory. Replacement of a coil requires dismantling of the entire generator.

A magnet may become loose and move far enough from the wheel to make the note inaudible. If so, it can be adjusted and locked in the proper position.

One Note Is Weak

One or more notes may be acoustically weak because of the room and its furnishings, although the measured signal level will be equal to that of its adjacent notes. This can be remedied by moving the organ slightly or by rearranging the room furnishings. Check all notes by attaching an output meter to the speaker terminals and taking voltage readings of the various notes. All notes will not give equal output, but the voltage should vary smoothly from note to note. Ignore variations of less than 30%.

Percussion Notes Weak, Do Not Play, Or Do Not Decay Properly

Weak or silent percussion notes, or ones that do not decay properly, indicate the percussion cutoff control must be adjusted. With the expression pedal wide open, the Volume tablet at normal, and all drawbars pushed in, set the percussion tablets for: Percussion On, Volume Normal, Decay Fast, and Harmonic Selector Third. Then hold down the first *C* key on the upper manual, and adjust the percussion cutoff control to the exact point of cutoff (silence).

Also check tubes V7, V8, and V9 (Fig. 5-13). Always adjust the percussion cutoff after replacing V9 (12AU7).

Pedal Note Sounds At Full Volume (Pedal Not Being Played)

Sometimes a pedal note sounds at full volume, even when not being played. This is caused by one of the pedals being forced downward and sideways, where it locks. Press the offending pedal down hard, and opposite the direction of tilt. It should come back up with no damage to the pedal assembly.

Pedal Note Sounds Softly Or Faintly (Pedal Not Being Played)

To remedy, set the expression pedal wide open, pull the pedal drawbar to its loudest position, and set the Volume Pedal Attack and Pedal Decay tablets to their normal positions. Play the highest pedal key, release it, and then wait 15 seconds for the note to die away. Slowly turn the pedal cutoff adjustment on the face of the amplifier (R85 in Fig. 5-14) clockwise until pedal note just disappears.

Always recheck this adjustment after replacing the 6BA6 tube (V10).

Hum

Do not mistake a loud 60-cycle or 120-cycle hum to mean the pedal cutoff needs adjusting. It may come from some nearby electrical appliance. Hum may be picked up by the matching transformer, the vibrato line, or the console wiring. It can be eliminated by moving either the console or the appliance.

Any other hum must originate in the amplifier circuit. It usually can be cured by replacing one or more electrolytic capacitors.

Do not forget to check all tubes in the amplifier circuit (see next paragraph).

Vacuum Tubes

All tubes are standard radio types that can be checked in the regular manner. Fig. 5-12 shows their locations in the amplifier.

When changing the 6BA6 (V10) or the 12AU7 (V9), always recheck the pedal cutoff adjustment.

PARTS REMOVAL

When it is necessary to remove a part for replacement or repair, the following procedures should be followed.

Removing A Key From The Upper Manual

To remove a key from the upper manual, take off the music rack and its base. Then remove the two screws holding the metal angle across the keyboards.

To remove a black key, loosen its key mounting screw, unhook the key from the screw, and lift out. To remove a white key, loosen its key mounting screw and those for the adjacent black keys. Unhook the black keys from the screws, push them back, and lift out the white key.

Removing A Key From The Lower Manual

To remove a key from the lower manual, take off the music rack and its base. Detach the pedal volume control by removing the two machine screws and loosening the wood screw which holds the friction clip to the top of the console. Unhook the control from the drawbar. Remove upper-manual mounting bolts A and B under the keyboard (Fig. 5-18). Place a ¾-inch block under each upper-manual chassis mounting block. The block holds the upper manual high enough so that the lower-manual key mounting screws can be reached.

To remove a black key, take out its key mounting screw, unhook the key from the screw, and lift out. To remove a white key, loosen its key mounting screw and those for the adjacent black keys. Unhook the black keys from the screws, push them back, lift out the white key.

Removing A Drawbar Contact Spring

The drawbar contact spring is removed by pushing the drawbar all the way in and removing the screw and nut at the back. Then pull out the contact spring while pressing with your thumb to release the pressure on the contact.

To completely disconnect the spring, unsolder the wire. Never pull the drawbar forward while the contact spring is *off*. The damper spring will catch in the slot and make it necessary for the entire drawbar assembly to be removed.

Removing A Drawbar Or Drawbar Knob

To remove a drawbar or knob, take off the music rack and its base. Take out the eight hex-head machine screws holding the drawbar assembly and the one screw fastening the angle across the upper-manual keys.

To remove the knob, pull the drawbar assembly toward the front of the console, prop it up, and remove the screw holding the knob.

To remove the drawbar and contact spring, pull them out at the back of the assembly while pressing with your thumb to release the pressure on the contact. The drawbar can be separated from the spring by taking out the screw and nut at the back of the drawbar.

Removing The Upper Manual

To remove the upper manual, take off the music rack and its base. Remove the dust cover over the generator by taking out the seven screws from the edge of the generator shelf and *loosening* the four screws in the cover (just below the upper-manual assembly). Detach the control panel by removing the six machine screws from the top. Lay the panel on the generator, being careful not to damage the generator wiring. (It is not necessary to disconnect the control-panel wires.)

Detach the pedal volume control by removing the two screws holding it. Loosen the wood screw which holds the friction clip to the top of the console. Unhook the control from the drawbar and lay it on top of the generator. Be careful not to damage the generator wiring. (The volume-control wires need not be disconnected.)

Remove the two screws fastening the matching transformer bracket to the upper manual. Take off the round cover held by two screws. Unsolder and pull loose the shielded wires and the black wire from the transformer.

Reattach the matching transformer to the upper manual. Unsolder the wires from the lower-manual drawbars. Remove upper-manual mounting bolts A and B under the keyboard. (See Fig. 5-18.) Remove the two upper-manual stop plates, held by two wood screws.

Prop up the front of the upper manual so the terminal strip is accessible. Be careful, when raising and lowering the manual, not to damage its terminal strip by rubbing it against the lower-manual keys. Unsolder the manual cable from the terminal strip. Lower the manual into its normal position. Detach the vibrato line box by removing the two screws (in the sides) fastening it to the underside of the console top. Lay the line box on top of the generator. (Do not damage the wiring.) The line-box wires do not have to be unsoldered (except in earlier Model M-3's).

If the line box is metal, unsolder the wires from the scanner, but leave it attached to the manual. Carefully lift the manual assembly (including the drawbars and matching transformer) out through the back of the console.

Remove the metal angle fastened across the keyboard by two screws. Take out the eight hex-head machine screws from the drawbar assembly. Lift off the drawbar and matching-transformer assemblies.

Removing The Lower Manual

To remove the lower manual, take off the music rack and its base. Remove the dust cover over the generator, as for the upper manual. Loosen the wood screw holding the friction clip of the pedal volume control to the top of the console. Remove upper-manual mounting bolts A and B under the keyboard. (See Fig. 5-18.)

Prop up the front of the upper manual as high as possible. Remove the two hex-head mounting bolts from the rear of the lower-manual chassis mounting blocks. Remove the three screws X, Y, and Z under the keyboard (see Fig. 5-18). Remove the lower-manual end blocks by taking out screws C, D, E, and F under the keyboard (see Fig. 5-18). Unsolder the manual cable wires from the terminal strip. Lift the manual out through the front of the console. Be extremely careful not to mar the woodwork.

Detaching And Opening The Control Panel

To detach and open the control panel, remove the dust cover over the generator, as explained before. Take out the six machine screws from the top of the panel. The control tablet box can now be lowered and pulled toward the rear of the console.

Lay the box upside down on the generator. Remove the bottom cover by taking out the four screws. (Be careful not to pull out the wires or cable. No wires need be disconnected.)

Detaching And Opening The Percussion-Control Switch

The percussion-control switch is detached and opened by taking out screws C and D under the keyboard (see Fig. 5-18) and the four fastenings holding the panel to the wood block.

Turn the tablet assembly upside down and remove the bottom cover. The wires need not be disconnected.

Removing Generator

To remove the generator, first take off its dust cover. Unsolder the five wires (at the line panel) going to the running and starting switches. (First, be sure to pull out the line plug.) Unsolder the three wires to the amplifier at the line panel, and the pedal and manual cables from the generator. Disconnect the scanner shielded wire from the amplifier terminal. Unsolder the cable of six green wires from the scanner terminals, and the scanner wires from terminals 12, 13, and 14, on the vibrato line box. Also unsolder the two black wires from the generator cover (connected to the same ground terminal as the carbon resistor), and the gray wire connected to the junction of the two carbon resistors on the generator cover. Remove the four generator hold-down screws, and unhook the four suspension springs from the generator. It can now be carefully lifted out.

Removing The Vibrato Scanner Or Synchronous Motor

Before removing the vibrato scanner or synchronous motor, remove the line plug, and take off the gen-

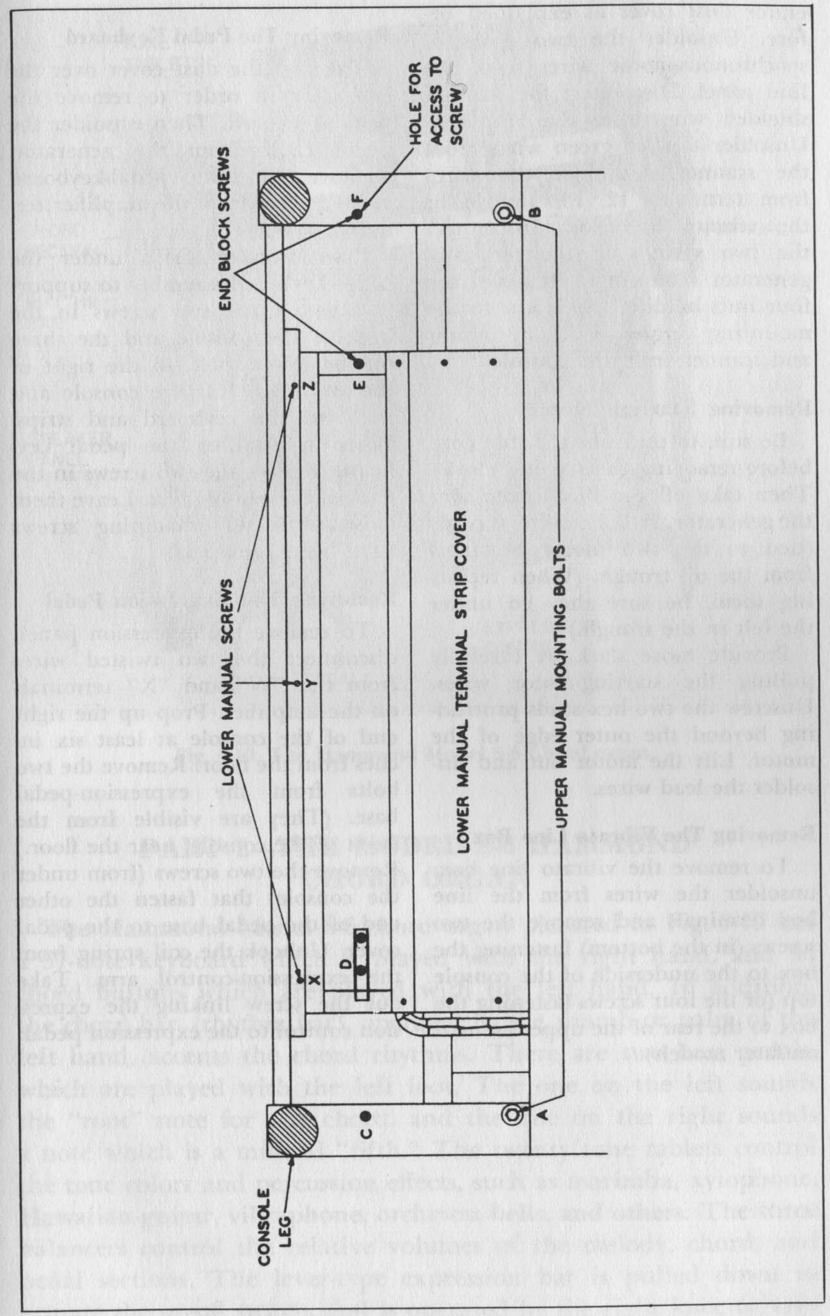


Fig. 5-18. Location of the screws holding the manuals (viewed from under the keyboard).

erator dust cover as explained before. Unsolder the two pairs of synchronous-motor wires from the line panel. Disconnect the scanner shielded wire from the amplifier. Unsolder the six green wires from the scanner. Unsolder the wires from terminals 12, 13, and 14 of the vibrato line box. Disconnect the two springs in the motor-to-generator coupling. Remove the four nuts holding the motor to the mounting angles. Lift the motor and scanner from the console.

Removing Starting Motor

Be sure to pull out the line cord before removing the starting motor. Then take off the dust cover over the generator. Pull the oiling threads (tied to the two motor bearings) from the oil trough. (When replacing them, be sure they go under the felt in the trough.)

Provide more slack by carefully pulling the starting-motor wires. Unscrew the two hex studs protruding beyond the outer edge of the motor. Lift the motor out and unsolder the lead wires.

Removing The Vibrato Line Box

To remove the vibrato line box, unsolder the wires from the line box terminals and remove the two screws (in the bottom) fastening the box to the underside of the console top (or the four screws fastening the box to the rear of the upper manual on later models).

Removing The Pedal Keyboard

Take off the dust cover over the generator in order to remove the pedal keyboard. Then unsolder the pedal cable from the generator. Remove the three pedal-keyboard twisted wires from the amplifier terminal panel.

Place wooden strips under the pedal keyboard assembly to support it. Remove the two screws in the back of the console and the three on the lower shelf, to the right of the amplifier. Lift the console and pull out the keyboard and strips. When reinstalling the pedal keyboard, replace the two screws in the *back* of the console *first*. Leave them loose until all remaining screws have been replaced.

Removing The Expression Pedal

To remove the expression panel, disconnect the two twisted wires from the "W" and "X" terminals on the amplifier. Prop up the right end of the console at least six inches from the floor. Remove the two bolts from the expression-pedal base. (They are visible from the front of the console, near the floor.) Remove the two screws (from under the console) that fasten the other end of the pedal base to the pedal cover. Unhook the coil spring from the expression-control arm. Take out the screw linking the expression control to the expression pedal.

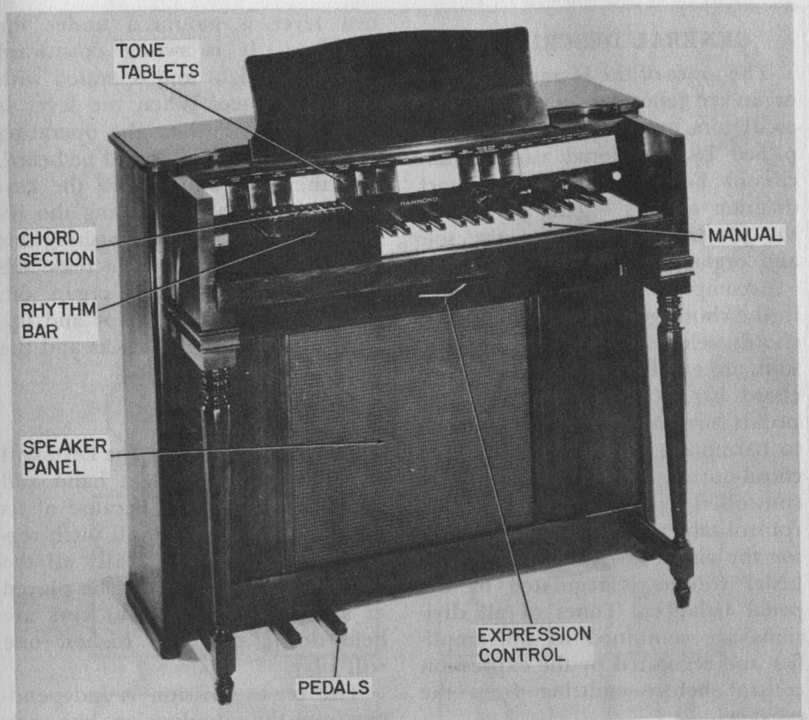


Fig. 5-19. The Hammond Model S-6 Chord organ.

PART 2—THE MODEL S-6 HAMMOND CHORD ORGAN

The Hammond Model S-6 chord organ pictured in Fig. 5-19 has a 37-note keyboard which is played with the right hand, and 96 chord buttons which are played with the left hand. In addition, the chord bar (rhythm bar), operated by the thumb or palm of the left hand, accents the chord rhythms. There are two bass pedals, which are played with the left foot. The one on the left sounds the "root" note for any chord, and the one on the right sounds a note which is a musical "fifth." The twenty tone tablets control the tone colors and percussion effects, such as marimba, xylophone, Hawaiian guitar, vibraphone, orchestra bells, and others. The three balancers control the relative volumes of the melody, chord, and pedal sections. The lever-type expression bar is pulled down to actuate the on-off switch, and is operated by the right knee to vary the over-all volume of the instrument.

GENERAL DESCRIPTION

The tones of the Hammond chord organ are generated by vacuum-tube oscillators, and then mixed and amplified by additional vacuum-tube circuits. Fig. 5-20, a simplified block diagram of this organ, shows how the playing keys control the solo and organ tone-generating systems.

Accompaniment tones originate in the chord generating system. The chords, selected with the chord buttons, are emphasized by pressing the chord bar. At the same time, the pedals furnish the correct bass notes to harmonize with the chords. The chord-button and pedal systems are controlled separately by the various control tablets. There is no balancer for the chord system; however, the pedal volume is regulated by the pedal balancer. Tones of all divisions are combined in the amplifier and regulated by the expression control before emitting from the speaker.

Tone Qualities

The tone qualities of the various divisions can be changed by the Mute, Strings, Flutes, Solo Woodwinds, and five Solo Timbre tablets.

Vibrato

The vibrato effect is available on all tonal divisions in the Hammond Model S-6. On the solo division, the extent of vibrato is adjustable. The terms "small" and "wide" refer to the extent of pitch variation. The rate of vibrato is created by a periodic raising and lowering of the pitch about six times a second.

Turning On and Off

The Hammond chord organ turns on quite differently from the larger models. The on-off control is incorporated on the volume (expression) control. The expression-control lever is mounted under the keyboard. It is swung downward and to the right and operated with the right knee. When the lever is moved downward to the operating position, a slight click will be heard, and the pilot light above the keyboard will light, indicating the instrument is on. Further pushing this pedal to the right will increase the volume. To turn the organ off, swing the lever to the left and upward until the switch clicks and the pilot light goes out.

Musical Divisions

The solo division on the keyboard is played with the right hand and supplies the melody. Because of its variety of tonalities in all pitch registers, it is used practically all the time. Only one note can be played at a time. When several keys are held down, only the highest one will play.

The organ division is independent from the solo division, although played by the same keys. The organ-division tones augment those from the solo division, making it possible for full chords to be played with the right hand. Both the solo and the organ divisions can be played at the same time. The melody note is usually the higher one and is played by the solo division. It can be emphasized by the use of a contrasting tone quality and a greater volume on the solo division.

The chord division, which has 96 buttons played by the left hand, furnishes the accompaniment to harmonize with the melody. (See Fig. 5-21.) Each button selects a full chord and an accompanying bass note. Only one button is played at a time. The chord division also includes a chord bar, which is played with the palm or thumb of the left hand. If the Sustain Cancel tablet is off, the chord will sound

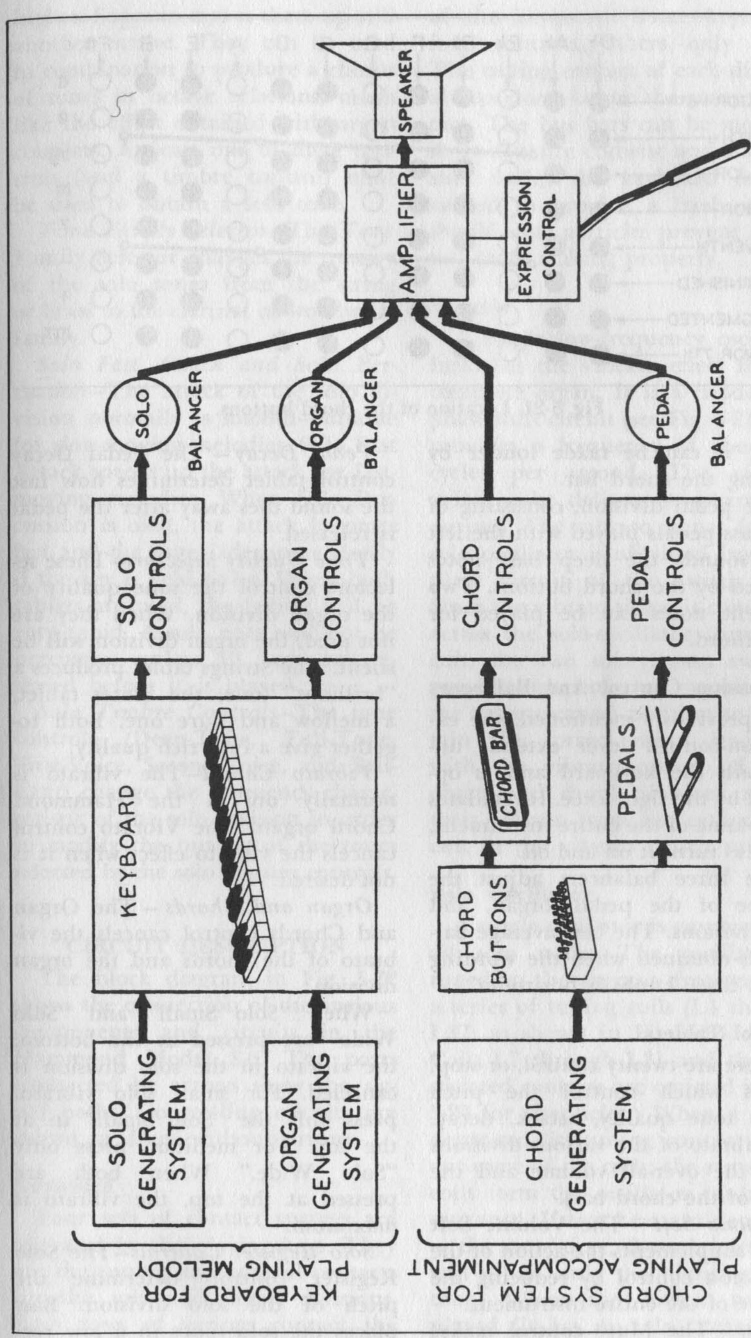


Fig. 5-20. Simplified block diagram of the Hammond Model S-6.

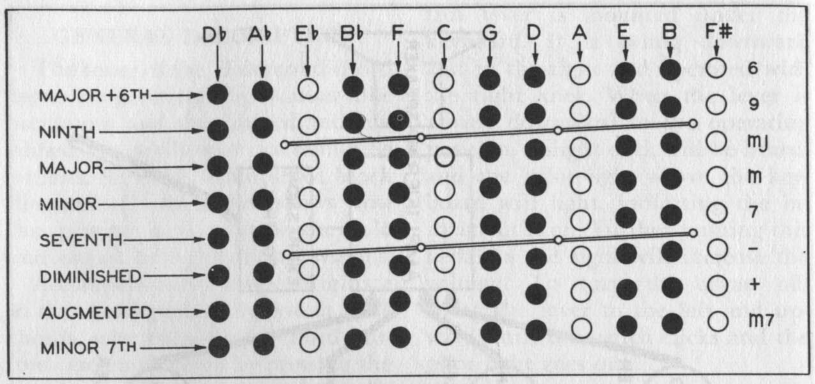


Fig. 5-21. Location of the chord buttons.

softly; it can be made louder by pressing the chord bar.

The pedal division, consisting of two bass pedals played with the left foot, sounds the deep bass notes selected by the chord buttons. Two different notes can be played for each chord.

Expression Control And Balancers

As previously mentioned, the expression-control lever extends underneath the keyboard and is operated by the right knee. It regulates the volume of the entire instrument, and also turns it on and off.

The three balancers adjust the volume of the pedal, organ, and solo divisions. The best average balance is obtained when the wording on all three knobs is horizontal.

Control Tablets

There are twenty control, or stop, tablets which control the pitch range, tone quality, attack, decay, and vibrato of the various divisions (also, the over-all volume and the effect of the chord bar).

Volume Soft—The Volume Soft tablet supplements the action of the expression control by reducing the volume of the entire instrument.

Mute—The Mute control makes the chord-button tones mellower.

Pedal Decay—The Pedal Decay control tablet determines how fast the sound dies away after the pedal is released.

Tone Quality Selectors—These selectors control the tone quality of the organ division. When they are not used, the organ division will be silent. The Strings tablet produces a "brilliant" tone; the Flutes tablet, a mellow and pure one. Both together give a full, rich quality.

Vibrato Cancel—The vibrato is normally on in the Hammond Chord organ. The Vibrato control cancels the vibrato effect when it is not desired.

Organ and Chords—The Organ and Chords control cancels the vibrato of the chords and the organ division.

When "Solo Small" and "Solo Wide" are pressed at the bottom, the vibrato in the solo division is canceled. For small solo vibrato, press only the "Solo Small" in at the top. For medium, press only "Solo Wide." When both are pressed at the top, the vibrato is maximum.

Solo Register Controls—The Solo Register controls determine the pitch of the solo division. Bass places the solo tones in a low register. Tenor moves them one octave

higher. Soprano moves them up still another octave. They can be used in combination to produce a chorus of tones in octave relations, much like the effect obtained with organ couplers. At least one of these controls (and a timbre control) must be used to obtain a solo tone.

Tone Family Selector—The Tone Family Selector changes the quality of the solo tones from the string or brass to the clarinet or woodwind family.

Solo Fast Attack and Solo Percussion—The attack of the solo division normally is smooth—suitable for slow-moving melodies. Solo Fast Attack speeds up the attack for fast-moving melodies. When Solo Percussion is used, the attack becomes fast and the note fades away slowly if the key is held down. When both tablets are used, the fading will be very rapid. A solo note will not be percussive unless all keys are released before it is played.

Solo Timbre Controls—The tone controls (Deep-Tone, Full-Tone, First-Voice, Second-Voice, and Brilliant) change the frequency characteristic of the solo division in order to modify the quality of the tones selected by the solo register controls.

CIRCUIT DESCRIPTION

The block diagram in Fig. 5-22 shows the connection of the various components and circuits in the Hammond Model S-6. The parts connected by arrows show the signal paths. Controlling circuits are shown by lines without arrows.

Keyboard

Four sets of contact springs are operated by the playing keys. They are the tuning and control contacts for the solo and organ divisions. Four rows of springs contact the four bus bars extending the length of the keyboard. Some keys have four contacts, others only three. The tuning contact of each division always closes before the control contact. The bus bars can be moved a short distance endwise and a slotted stud under the keyboard can be turned to provide a fresh surface should dust particles prevent a contact from making properly.

Vibrato

A single low-frequency oscillator furnishes the vibrato effect for the complete organ. It is a triode in a phase-shift circuit (see Fig. 5-23) that provides a frequency of about six cycles per second. The vibrato-switch tube delivers a square-wave output. The vibrato signal for the solo oscillator is obtained from the plate circuit of the switch tube. Since the vibrato signal is connected across the solo-oscillator tuned circuit, the two solo-vibrato switches provide compensating capacitors in the vibrato-cancel position to maintain the correct mean frequency with the vibrato on or off. The organ and chord divisions receive their vibrato from the cathode circuit of the vibrato switch tube.

Solo Oscillator

A single oscillator is employed for all solo notes. The oscillator is tuned to the soprano frequency by a series of tuning coils (L1 through L37) as shown in Fig. 5-24. (Note: Coils L7 through L31 and their associated contacts are omitted in Fig. 5-24 for simplicity.) When a key is depressed, its tuning contact shorts out some of the coils; the remaining coils form the oscillator tuning inductance. If two keys are depressed at the same time, the solo oscillator will sound only the higher-pitched tone. When the lowest note is played (it has no solo tuning contact), all 37 solo tuning coils are

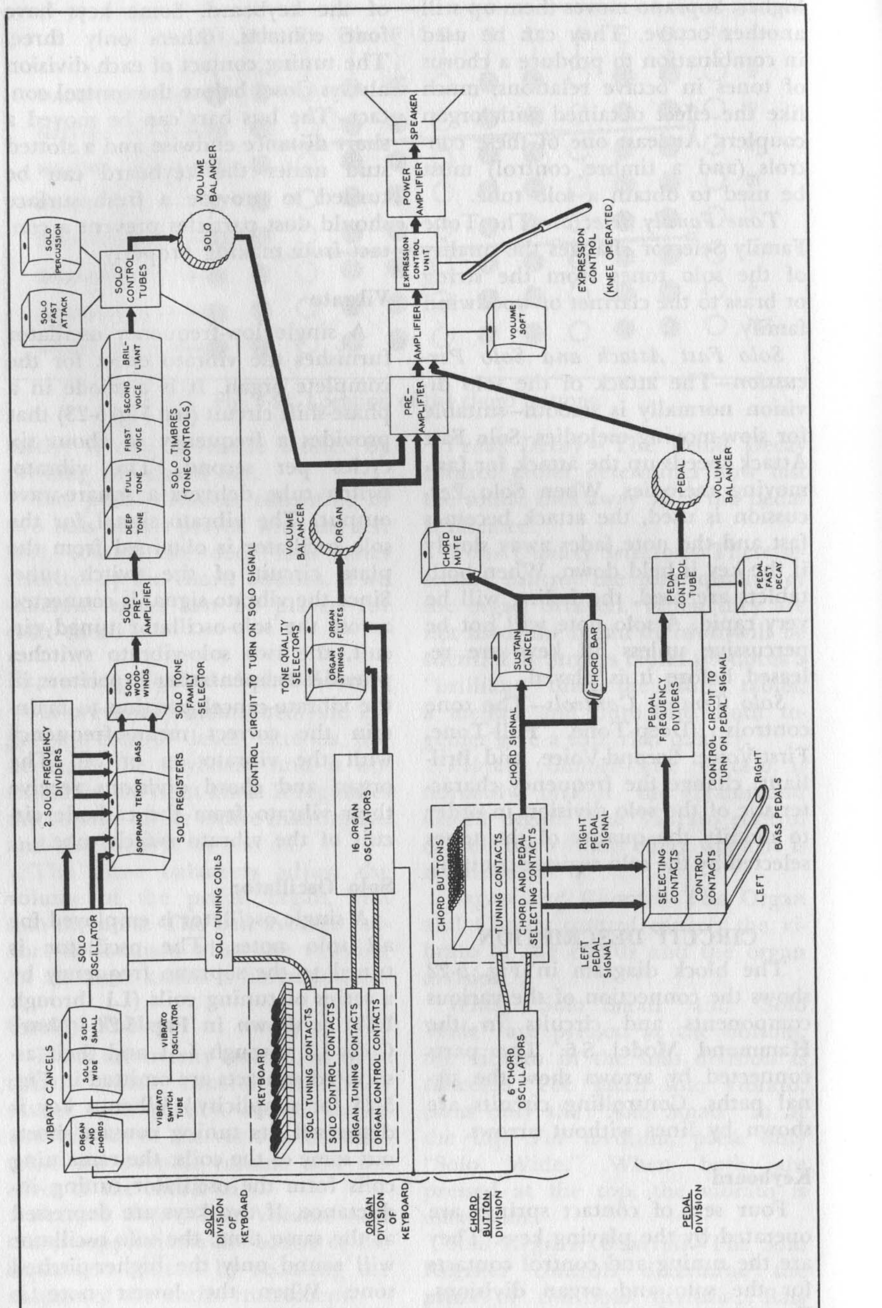


Fig. 5-22. Block diagram of the Model S-6.

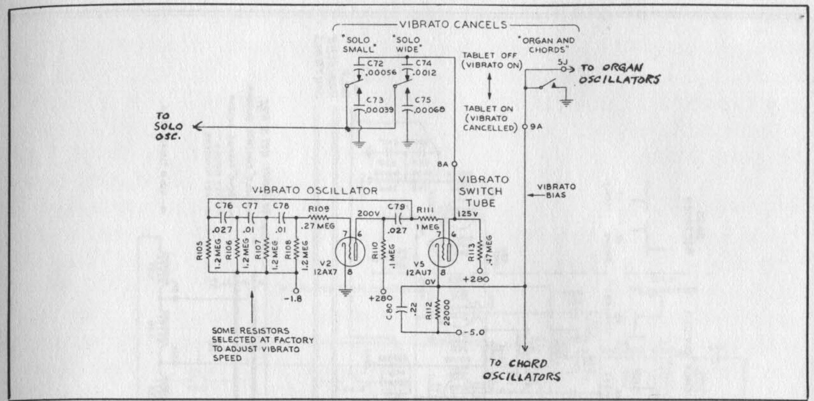


Fig. 5-23. Vibrato circuit.

connected in series to form the tuning inductance of the oscillator. The oscillator frequencies extend from 349 to 2,793 cycles per second.

The solo oscillator is a two-triode circuit and the tuned circuit is connected to the first grid. The Big Steps and Small Steps switches (see Fig. 5-24) tune the solo division as a unit by placing small capacitors across the tuned circuit. Several trimmer capacitors may also be wired in parallel with the main tuning capacitor (Fig. 5-24) to bring its capacitance to the required value. An oscillator rectifier tube (V3) furnishes a pulse waveform to operate the first frequency divider.

Solo Frequency Dividers

There are two frequency-divider stages, and each has three triodes as shown in Fig. 5-24. One acts as a driver and pulse rectifier to supply sharp and narrow negative pulses. Only one triode can conduct at a time because, as it draws plate current, it keeps the other cut off.

Solo Register Controls and Solo Woodwinds

Soprano tones are taken from the master oscillator (V1) and the oscillator rectifier (V3). The tenor tones are taken from the first frequency divider (V4) and the driver following it (V5), and the bass from the second frequency divider (V6) and a bass rectifier (V7). Thus, three sets of two signals each are supplied in the output of Fig. 5-24. The two signals in each set have the same frequency but different waveshapes.

The outputs from Fig. 5-24 connect to their respective inputs in Fig. 5-25. After passing through suitable tone-filter circuits, they furnish tones of the woodwinds family if the Solo Woodwinds tablet is on, or of the string family if it is off.

Solo Tone Controls

After first amplification by half of tube V8 (solo preamplifier), the solo signal reaches the five tone (timbre) controls, which are in series across the signal line. When Deep Tone is on (switch open), the signal is developed across a capacitor (C55) which emphasizes the low frequencies. Full Tone, which has only a resistor, R69, leaves the response rather flat. The First Voice and Second Voice peak near 750 and 1,000 cycles, respectively. For Brilliant, the signal appears across inductance L38, which emphasizes the higher frequencies. Each tone

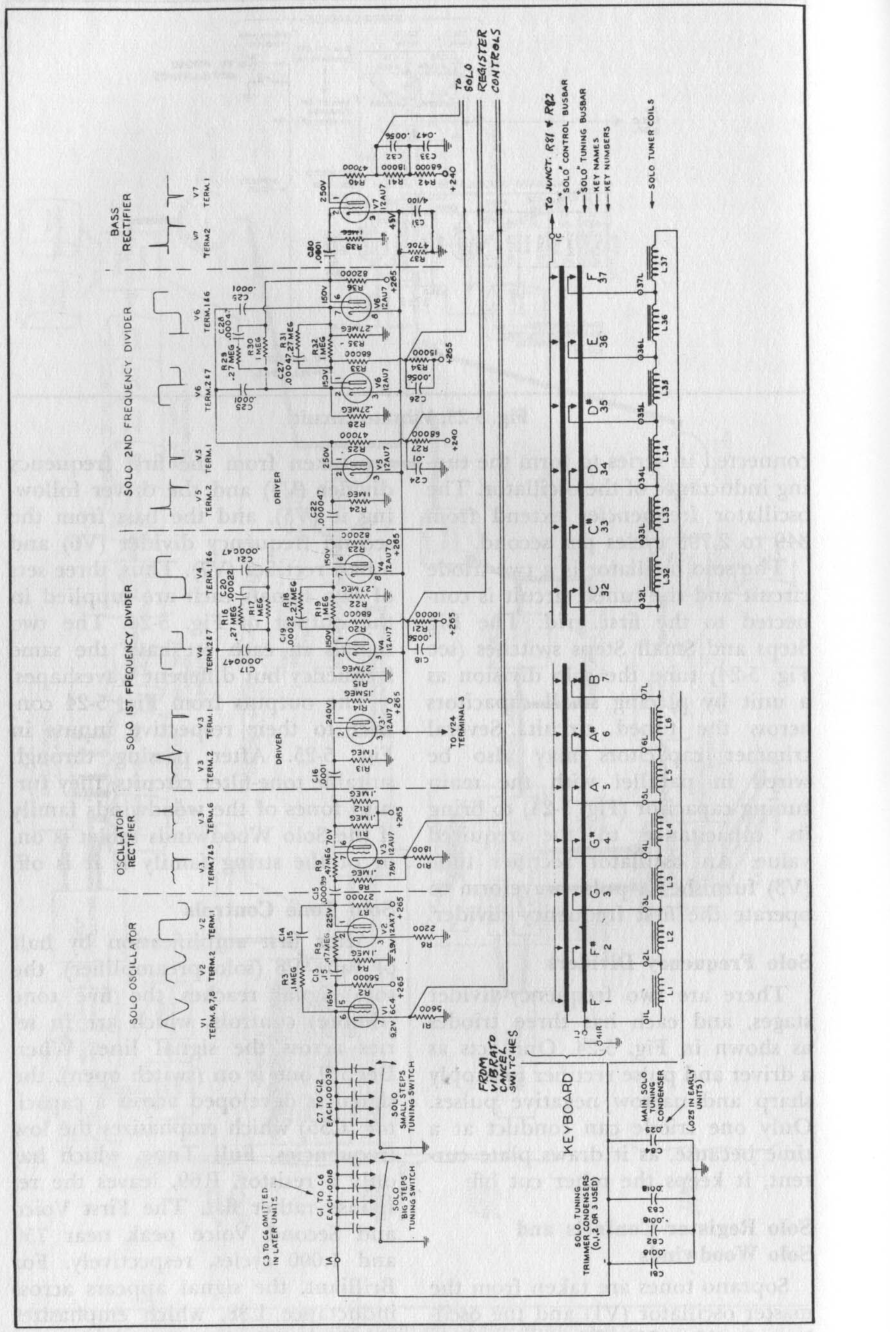


Fig. 5-24. Solo oscillator and frequency-divider circuits.

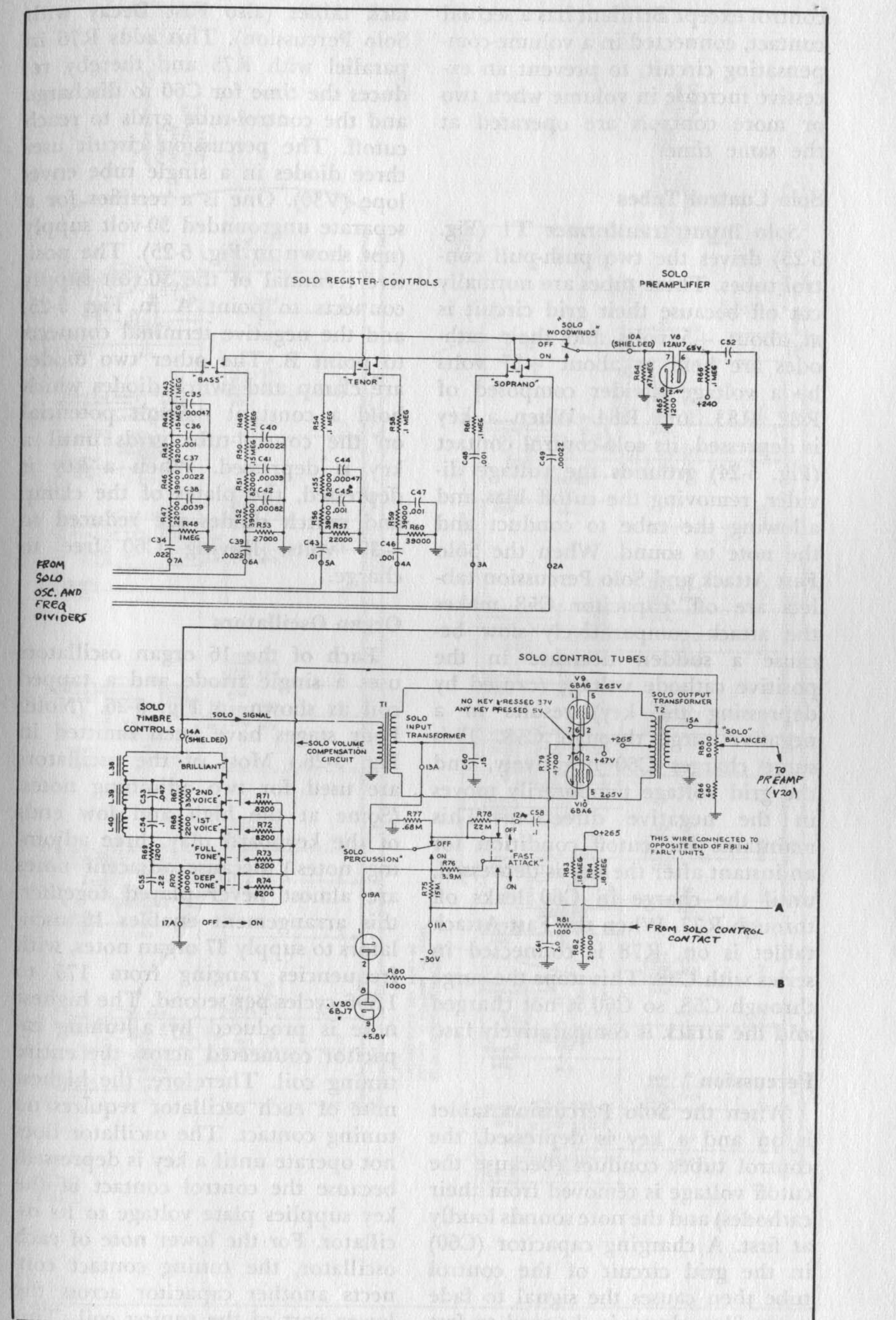


Fig. 5-25. Solo preamplifier in the solo control circuit.

control except Brilliant has a second contact, connected in a volume-compensating circuit, to prevent an excessive increase in volume when two or more controls are operated at the same time.

Solo Control Tubes

Solo input, transformer T1 (Fig. 5-25) drives the two push-pull control tubes. These tubes are normally cut off because their grid circuit is at about +5 volts and their cathodes are held at about +37 volts by a voltage divider composed of R82, R83, and R84. When a key is depressed, its solo-control contact (Fig. 5-24) grounds the voltage divider, removing the cutoff bias and allowing the tube to conduct and the note to sound. When the Solo Fast Attack and Solo Percussion tablets are off, capacitor C58 makes the attack comparatively slow because a sudden decrease in the positive cathode voltage (caused by depressing the key) results in a negative surge through C58. This surge charges C60 negatively, and the grid voltage temporarily moves in the negative direction. This maintains the cutoff condition for an instant after the key is depressed, until the charge in C60 leaks off through R77. When the Fast Attack tablet is on, R78 is connected in series with C58. This stops the surge through C58, so C60 is not charged and the attack is comparatively fast.

Percussion

When the Solo Percussion tablet is on and a key is depressed, the control tubes conduct (because the cutoff voltage is removed from their cathodes) and the note sounds loudly at first. A charging capacitor (C60) in the grid circuit of the control tube then causes the signal to fade away. Slow decay is changed to fast decay by pressing the Solo Fast Attack tablet (also Fast Decay with Solo Percussion). This adds R76 in parallel with R75 and thereby reduces the time for C60 to discharge and the control-tube grids to reach cutoff. The percussion circuit uses three diodes in a single tube envelope (V30). One is a rectifier for a separate ungrounded 30-volt supply (not shown in Fig. 5-25). The positive terminal of the 30-volt supply connects to point A in Fig. 5-25, and the negative terminal connects to point B. The other two diodes are clamp and switch diodes which hold a constant +5-volt potential on the control-tube grids until a key is depressed. When a key is depressed, the plates of the clamp and switch diodes are reduced to −30 volts, leaving C60 free to charge.

Organ Oscillators

Each of the 16 organ oscillators uses a single triode and a tapped coil as shown in Fig. 5-26. (Note: Four stages have been omitted in Fig. 5-26.) Most of the oscillators are used for two adjoining notes. (Some at the high and low ends of the keyboard play three adjoining notes.) Because adjacent notes are almost never played together, this arrangement enables 16 oscillators to supply 37 organ notes, with frequencies ranging from 175 to 1,396 cycles per second. The highest note is produced by a tuning capacitor connected across the entire tuning coil. Therefore, the highest note of each oscillator requires no tuning contact. The oscillator does not operate until a key is depressed, because the control contact of the key supplies plate voltage to its oscillator. For the lower note of each oscillator, the tuning contact connects another capacitor across the lower part of the tuning coil. This tap is located so the capacitor will

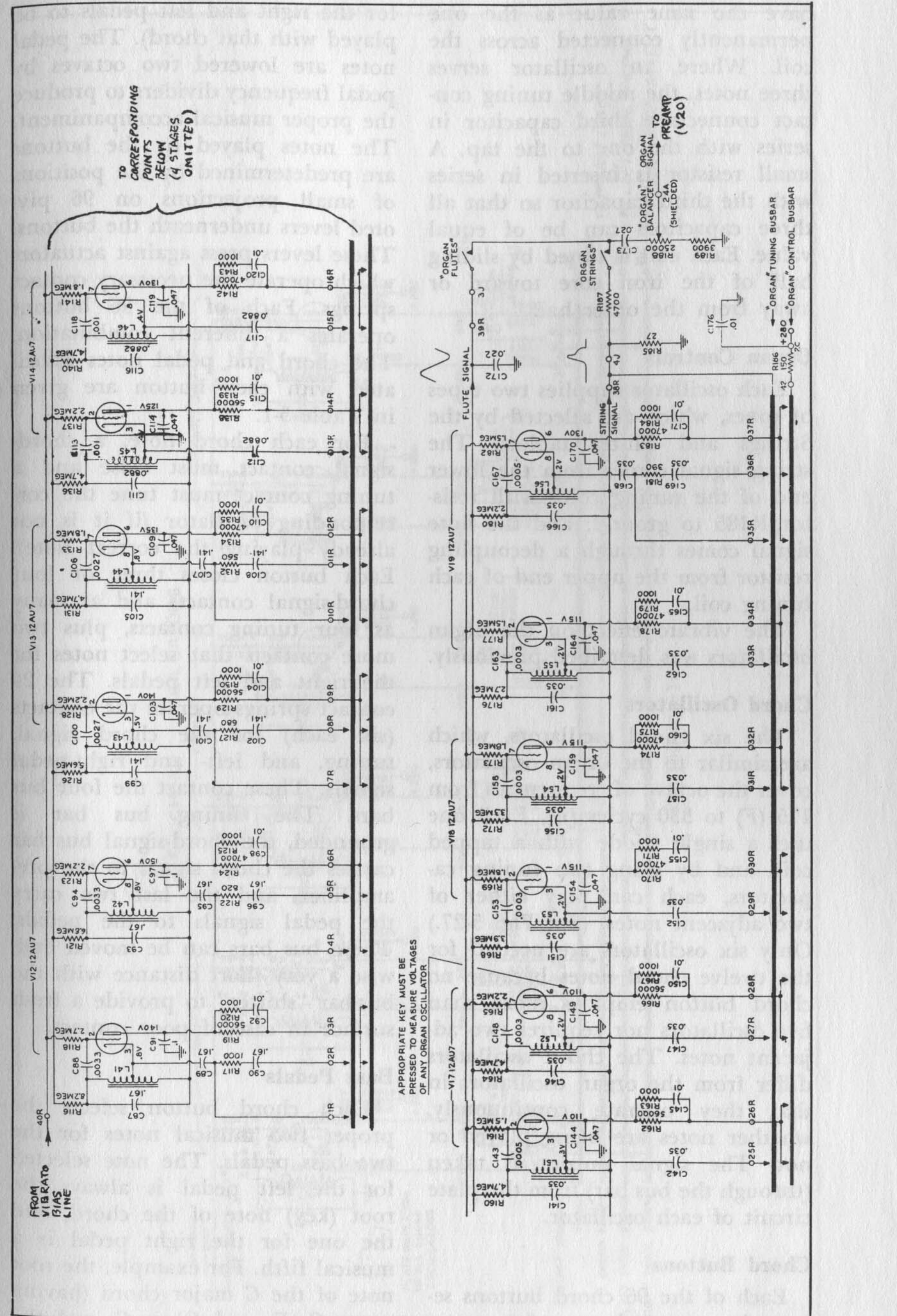


Fig. 5-26. Organ oscillators.

have the same value as the one permanently connected across the coil. Where an oscillator serves three notes, the middle tuning contact connects a third capacitor in series with the one to the tap. A small resistor is inserted in series with the third capacitor so that all three capacitors can be of equal value. Each coil is tuned by sliding half of the iron core toward or away from the other half.

Organ Controls

Each oscillator supplies two types of tones, which are selected by the Strings and Flutes tablets. The string signal comes from the lower end of the tuning coils, with resistor R185 to ground; and the flute signal comes through a decoupling resistor from the upper end of each tuning coil.

The vibrato effect on the organ oscillators was described previously.

Chord Oscillators

The six chord oscillators, which are similar to the organ oscillators, cover the octave of frequencies from 175 (*F*) to 330 cycles (*E*). Each one uses a single triode with a tapped coil, and by using two tuning capacitors, each can play either of two adjacent notes. (See Fig. 5-27.) Only six oscillators are needed for the twelve chord notes because no chord button employs more than five oscillators nor requires two adjacent notes. The chord oscillators differ from the organ oscillators in that they operate continuously, whether notes are being played or not. The signal output is taken (through the bus bar) 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 (also the correct notes for the right and left pedals to be played with that chord). The pedal notes are lowered two octaves by pedal frequency dividers to produce the proper musical accompaniment. The notes played by the buttons are predetermined by the positions of small projections on 96 pivoted levers underneath the buttons. These levers press against actuators which operate the necessary contact springs. Each of the 96 buttons operates a different combination. The chord and pedal notes associated with each button are given in Table 5-1.

For each chord note, a chord-signal contact must close and a tuning contact must tune the corresponding oscillator (if it is not already playing the correct note). Each button closes three or four chord-signal contacts and as many as four tuning contacts, plus two more contacts that select notes for the right and left pedals. The 24 contact springs operate the contacts (six each) for the chord signal, tuning, and left- and right-pedal signals. These contact the four bus bars. The tuning bus bar is grounded, the chord-signal bus bar carries the chord signal to the preamplifier, and the last two carry the pedal signals to the pedals. These bus bars can be moved endwise a very short distance with the bus-bar "shifter" to provide a fresh surface in case of poor contact.

Bass Pedals

Each chord button selects the proper two musical notes for the two bass pedals. The note selected for the left pedal is always the root (key) note of the chord, and the one for the right pedal is a musical fifth. For example, the root note of the *C* major chord (having notes *C*, *E*, and *G*) is *C*, and the fifth note is *G*. (See Table 5-1.)

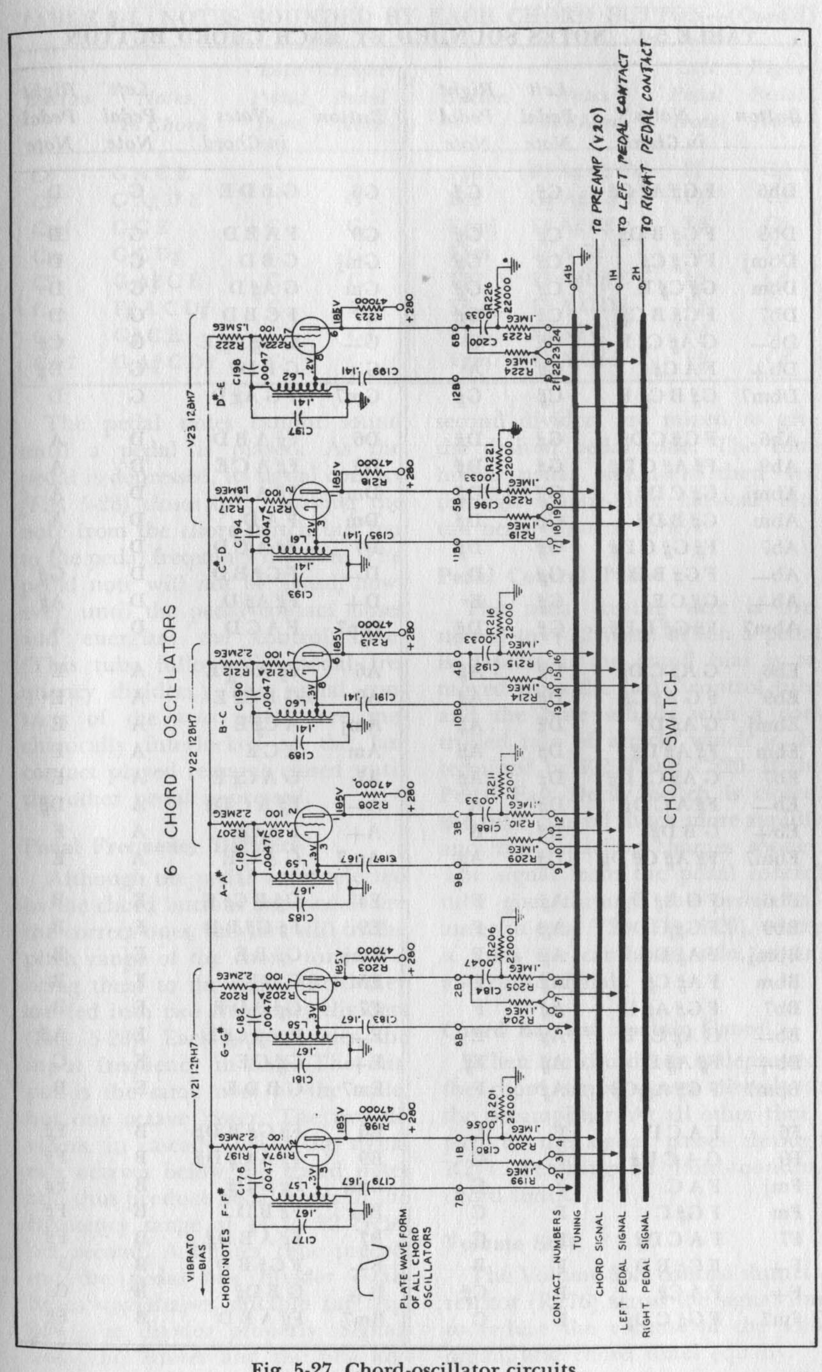


Fig. 5-27. Chord-oscillator circuits.

TABLE 5-1. NOTES SOUNDED BY EACH CHORD BUTTON

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#

TABLE 5-1. NOTES SOUNDED BY EACH CHORD BUTTON—(Cont'd)

Button	*Notes in Chord*	*Left Pedal Note*	*Right Pedal Note*	*Button*	*Notes in Chord*	*Left Pedal Note*	*Right Pedal Note*
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# C	F#	D
Cm7	G A# C D#	C	G	F#m7	F# A C# E	F#	C#

The pedal notes cannot sound until a pedal is played. As the pedal is depressed, its signal contact (Fig. 5-28) closes first, carrying the note from the chord-switch bus bar to the pedal frequency dividers. The pedal note will not be heard, however, until the pedal contact closes and energizes the control tube. (This tube follows the pedal frequency dividers.) The signal contacts of the two pedals are mechanically interlocked so the last contact played remains closed until the other pedal is pressed.

Pedal Frequency Dividers

Although the pedal notes selected by the chord buttons and pedals are the correct ones, they are still in the pitch range of the chord tones. To bring them to the right pitch, they are fed into two frequency dividers (Fig. 5-28). Each one divides the input frequency in half. The output is the same note of the scale, but one octave lower. The two dividers, in cascade, lower the signal two octaves below the chord notes and thus produce pedal notes in the frequency range of 44 to 82 cycles per second. A limiter tube preceding the pedal first divider establishes waveshapes suitable for tripping the divider properly. Signals from the limiter and the first and second dividers 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

The pedal keying wire is connected to +32 volts. When a pedal is depressed, the cutoff bias is removed from the pedal control tube and the note sounds with a controlled rate of attack, which is determined by R259 and C220. If the Pedal Fast Decay switch is closed, the tube cuts off much more rapidly and the capacitor charges sooner. The signal from the pedal control tube goes through the pedal balancer to tube V20 (Fig. 5-29), where it joins the combined solo, organ, and chord signals.

Chord Bar and Sustain Cancel

When the chord bar is depressed, the chord signal passes directly to the preamplifier. At all other times, part of the signal passes through R271, resulting in faint-sounding chord tones.

Volume Soft

The Volume Soft control shunts a resistor (R276) across the signal line to reduce the volume of the solo, organ, and chord tones equally.

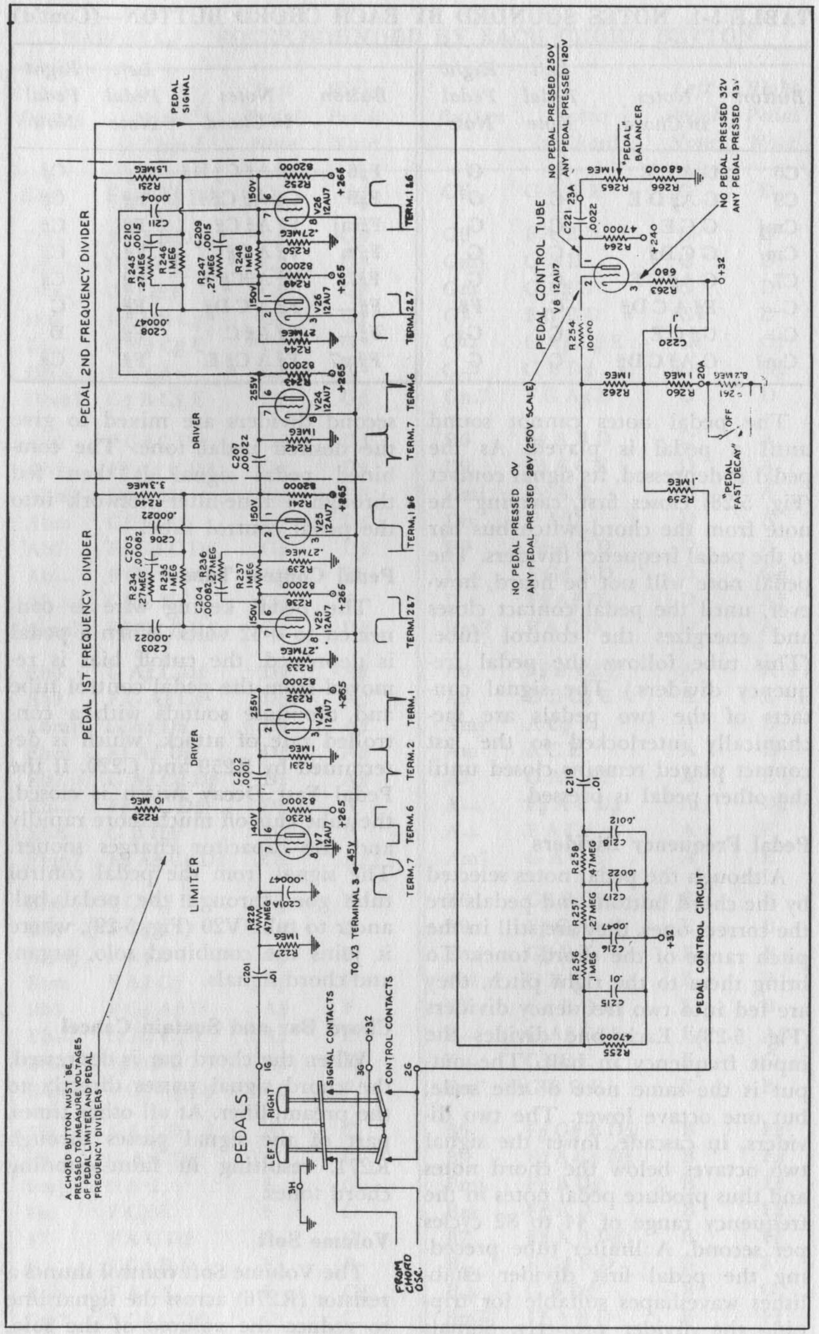


Fig. 5-28. Pedal circuits.

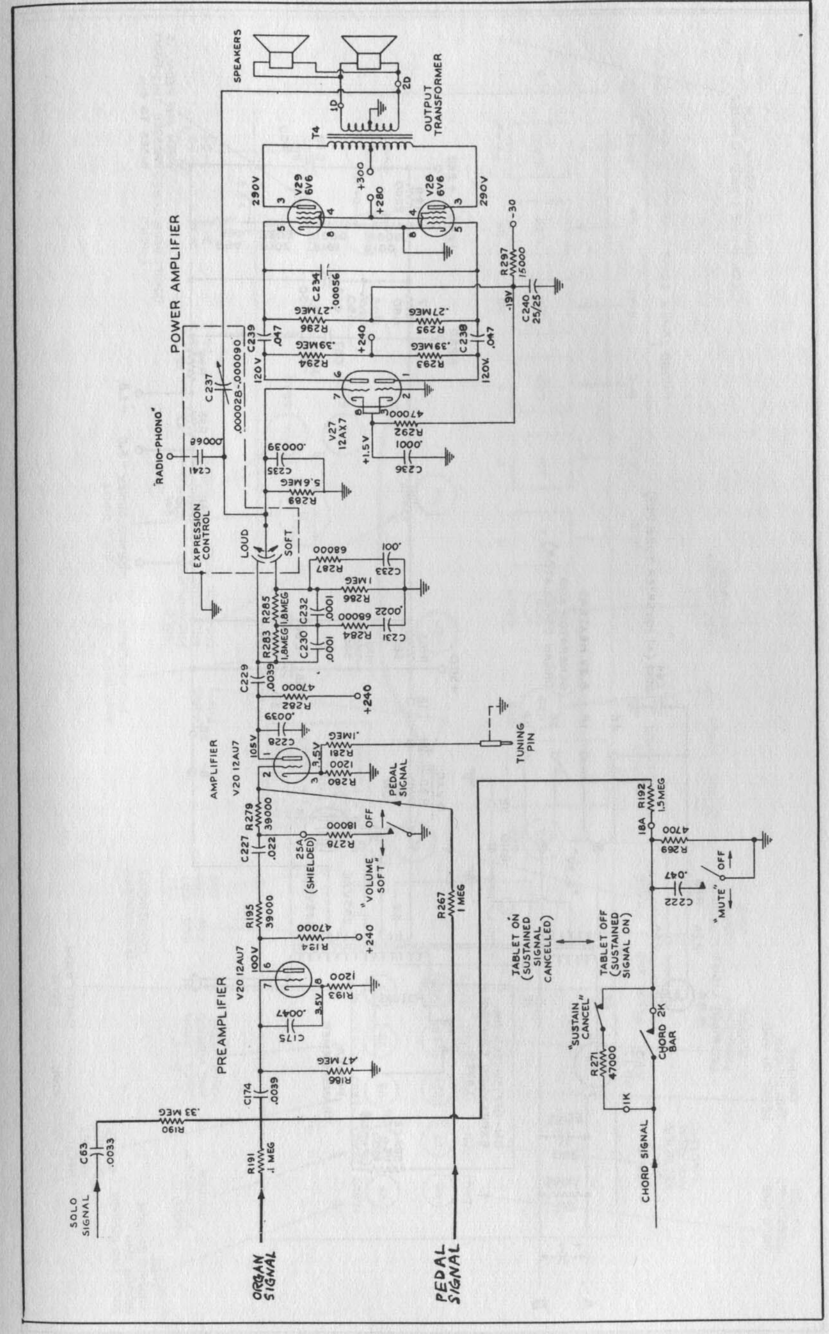


Fig. 5-29. Preamplifier and amplifier circuits.

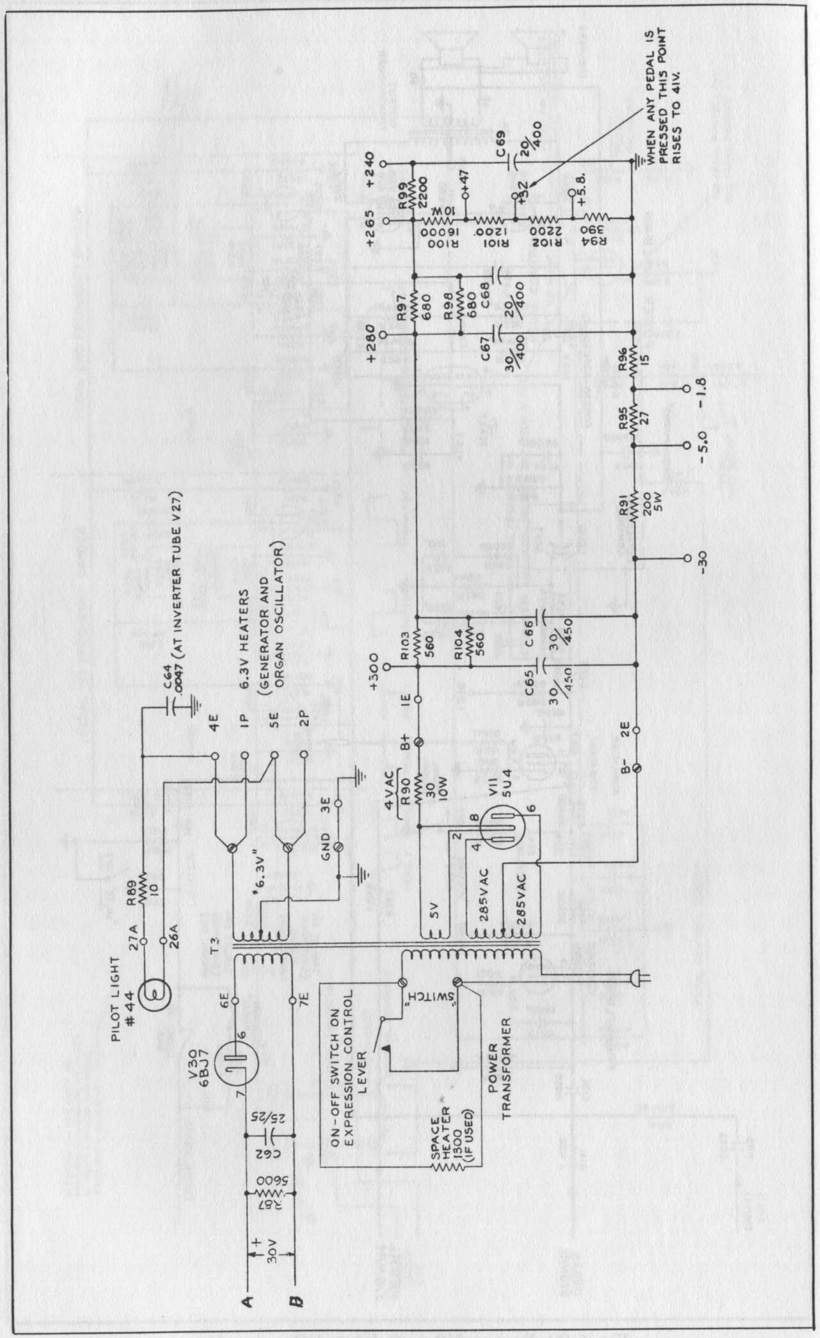


Fig. 5-30. Power-supply circuit.

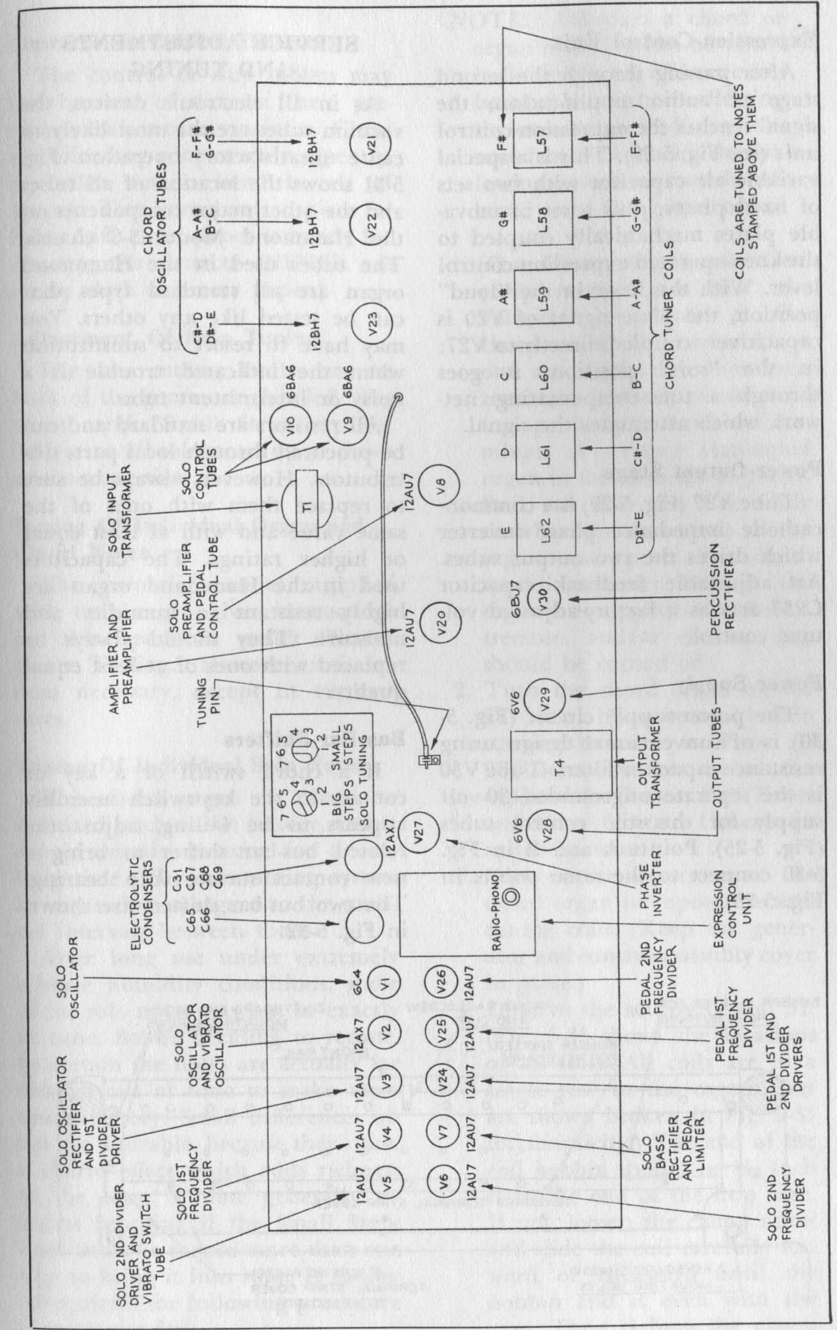


Fig. 5-31. Top view of a generator chassis.

Expression-Control Unit

After passing through the second stage of audio amplification, the signal reaches the expression-control unit (see Fig. 5-29). This is a special variable air capacitor with two sets of fixed plates, plus a set of movable plates mechanically coupled to the knee-operated expression-control lever. With the lever in the "loud" position, the plate signal of V20 is capacitively coupled directly to V27; in the "soft" position, it goes through a tone-compensating network which attenuates the signal.

Power-Output Stage

Tube V27 (Fig. 5-29) is a common-cathode impedance phase inverter which drives the two output tubes. An adjustable feedback capacitor C237 acts as a factory-adjusted volume control.

Power Supply

The power-supply circuit (Fig. 5-30) is of conventional design using resistance-capacitor filters. Tube V30 is the separate ungrounded 30-volt supply for the solo control tubes (Fig. 5-25). Points A and B in Fig. 5-30 connect to the same points in Fig. 5-25).

SERVICE ADJUSTMENTS AND TUNING

As in all electronic devices, the vacuum tubes are the most likely to cause unsatisfactory operation. Fig. 5-31 shows the location of all tubes and the other major components on the Hammond Model S-6 chassis. The tubes used in the Hammond organ are all standard types that can be tested like any others. You may have to resort to substitution when the indicated trouble is a noisy or intermittent tube.

All resistors are standard and can be procured through local parts distributors. However, always be sure to replace them with ones of the same value and with at least equal or higher ratings. The capacitors used in the Hammond organ are highly resistant to humidity and moisture. They should always be replaced with ones of at least equal quality.

Bus-Bar Shifters

If a chord switch or a key or contact in the key-switch assembly appears to be failing, adjust the related bus-bar shifter to bring a new contact surface into bearing. The two bus-bar shifters are shown in Fig. 5-32.

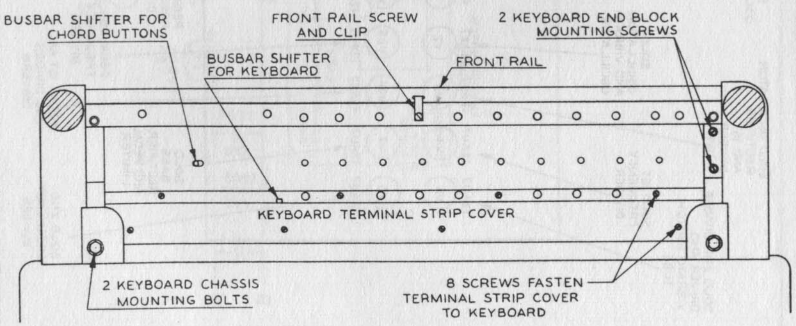


Fig. 5-32. Underside of the keyboard.

Contacts On Control Tablets

The control or stop tablets may fail because of dirt on their precious-metal contact surfaces. Clean the offending contact spring (gently, in order not to bend it out of shape). The corner of a piece of fairly stiff, clean paper is handy for cleaning the contacts. (NEVER use emery cloth or emery paper.)

Adjustment Of Solo Tuning

The two tuning knobs on the back of the generator (labeled "Big Steps" and "Small Steps" in Fig. 5-31) tune all solo notes up or down at the same time.

Tuning Of Individual Organ and Chord Notes

The owner's manual supplied with each organ gives instructions for this operation under "Screwdriver Tuning." However, it is seldom necessary, except in extreme cases.

Tuning Of Individual Solo Notes

The chord organ is tuned to standard pitch at the factory, and it should remain in tune for a very long time. The solo tuning system is very stable in regard to the musical intervals between tones.

After long use under extremely adverse humidity conditions, some of the solo notes may not be exactly in tune. Before deciding to retune, be certain the notes are actually far enough out of tune to make them unsatisfactory. Small differences often are desirable, because they cause a chorus effect which adds richness to the tone. A note generally requires retuning if the Small Steps knob must be turned more than one step to bring it into tune. If tuning is required, the following procedure is recommended:

NOTE: Although a chord or organ oscillator can be tuned individually, no solo note can be adjusted without affecting the ones below it. If any solo note has to be tuned, the following procedure must be adhered to in the proper order.

1. The Hammond Organ Company recommends that the voice-coil terminals of the chord organ be connected to one set of plates (either horizontal or vertical) of an oscilloscope, and the voice-coil terminals of another Hammond organ to the other set of 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, tremolo, and/or chorus, they should be turned off.
2. Turn the chord organ on for at least 15 minutes before starting to tune it. Press all 20 control tablets in at the top, and the Tenor, Full Tone, and three Vibrato Cancels in at the bottom.
3. Remove the top cover of the chord organ to expose the solo tuning coils. (Keep the generator and control assembly cover in place.)
4. Observe the setting of coil 37. (Fig. 5-33 shows the locations of all coils. All coils are in a single row in the organs, but are shown broken in Fig. 5-33 for simplicity.) The end of the coil bobbin should be 1/32 inch from the end of the iron core. If not, loosen the clamp screw and slide the coil carefully forward or backward until the bobbin end is even with the core. Then tighten the clamp screw.

5. Hold down the highest key (*F*) of the chord organ and *F* on the other organ. Adjust the volume levels so the horizontal and vertical deflections of the oscilloscope are almost equal.
6. Readjust the Big Steps and Small Steps solo tuning knobs to make the oscilloscope wave pattern move as slowly as possible.
7. Adjust coil 37, if necessary, to bring the chord organ in tune with the other Hammond organ. (The oscilloscope pattern will stand still, or move no farther than one cycle in two seconds.)

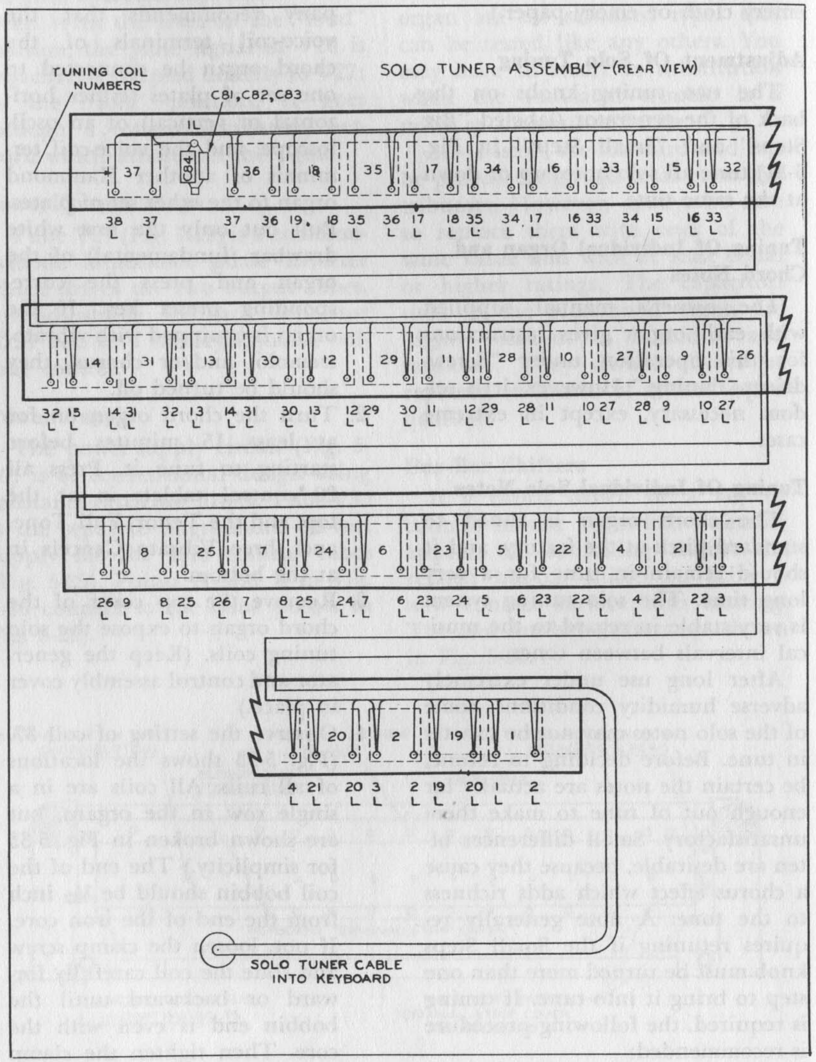


Fig. 5-33. Location of the solo tuning coils.

8. Release the *F* keys and hold down the next lower ones (*E*) on the two instruments. Adjust coil 36 the same way. Repeat for all other keys and coils in the proper descending chromatic order. It is extremely important to start with the highest note and progress downward one key at a time, because the tuning of the lower notes depends on the higher coils.
9. After completing the tuning, recheck all notes to make sure all coils are tuned accurately.

TROUBLESHOOTING

The chord organ may appear complicated, but a study of the circuit diagrams in Figs. 5-21 through 5-30 will show that troubles can be easily isolated by observing the operation of the various controls. In the following list of malfunctions, it is assumed the instrument plays correctly except as described.

After a trouble has been isolated to a section, it will be helpful to compare the voltages with those in the circuit diagram for that section. Make all measurements with a 20,000-ohms-per-volt meter. All readings are based on a supply-line voltage of 117 volts AC.

Waveshapes can be checked with an oscilloscope. In some parts of the circuitry, particularly in the oscillators and the frequency dividers, the waveform is very important. The patterns can then be compared with the ones on the circuit diagrams. (Some oscilloscopes may show inverted patterns, but it makes no difference as long as the shape is correct.)

Malfunctions

The schematic of the vibrato circuit was given in Fig. 5-23; the solo oscillator and frequency dividers in Fig. 5-24; the solo register controls, solo preamplifier, and solo control circuit in Fig. 5-25; the organ oscillators in Fig. 5-26; the chord oscillators in Fig. 5-27; the pedal frequency dividers and control circuit in Fig. 5-28; the amplifier in Fig. 5-29; and the power supply in Fig. 5-30. Fig. 5-31 shows the location of the tubes and principal components on the generator chassis, and Fig. 5-34 shows the location of the tubes and coils on the organ oscillator assembly. The rectifier tube is located on a separate power pack. Refer to these diagrams for tube location and component function in the following service hints.

Entire Instrument Fails To Play—Check the line voltage, the rectifier tube, amplifier tube V20, and phase-inverter and driver tube V27.

No Vibrato Effect—Check the vibrato-oscillator tube (V2) or the vibrato-switch tube (V5).

Radio-Frequency Oscillation — Check R254 (Fig. 5-28), which acts as a radio-frequency suppressor.

All Solo Notes Dead (Or Weak)—Check the solo oscillator tubes (V1 and V2) or the solo preamplifier tube (V8) and replace those found defective.

Solo, Organ, and Chord Divisions Dead (Or Weak)—The preamplifier tube (V20) is probably defective.

One Key Will Not Play A Solo Note On Any Register Control—Probably a dirty solo-control contact on one key. Adjust the solo-keyboard bus-bar shifter to provide a new contact surface.

One Key Plays the Lowest F Solo Note Instead of Its Correct Pitch (Adjacent Keys Play Correctly)—The solo tuning contact is probably dirty. A dirty contact can also cause a noisy (scratchy) note. Adjust the solo-keyboard bus-bar shifter.

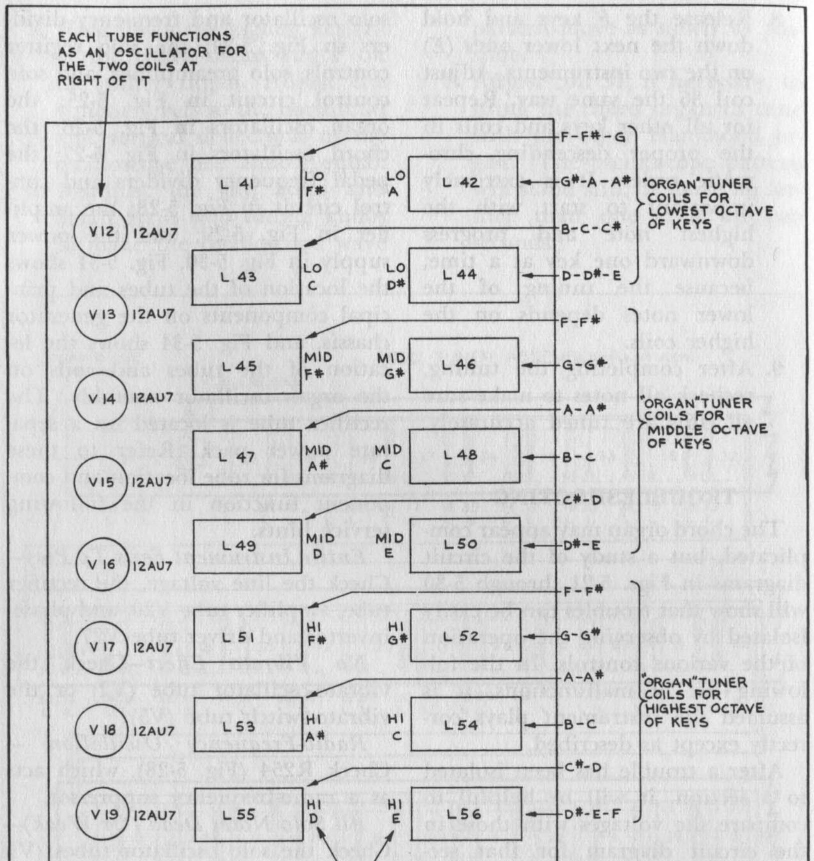


Fig. 5-34. Organ oscillator assembly.

One Solo Timbre Control Will Not Turn Off— Probably a dirty control contact, which should be cleaned.

All Solo Notes Fail To Play In One Position of Solo Woodwinds—Probably a dirty contact. Clean the tablet contacts.

Solo Key "Thumps" or "Clicks"—A "thump" each time a key is released indicates that the two solo control tubes (V9 and V10) are not properly matched. Install two new matched tubes.

One Solo Register Control Does Not Play For One Position Of The Solo Woodwinds Tablet—One contact of the register control tablet is probably dirty and should be cleaned. If the Bass tablet also fails while Solo Woodwinds is off, the bass-rectifier half of tube V7 may be defective.

Solo Bass Does Not Play (Solo Woodwinds Either On or Off)—Check tube V6. This tube may also make the tones very noisy or an octave too high.

Solo Bass Does Not Play At All, Tenor Does Not Play When The Solo Woodwinds Tablet is Off—The second-divider driver tube (V5) is probably defective. This tube may also cause the notes to be noisy (irregular) or an octave too high.

Solo Bass and Tenor Will Not Play At All, Soprano Will Not Play When The Solo Woodwinds Tablets Is Off—Check the oscillator rectifier tube (V3). NOTE: A common bias resistor (R37) and bypass capacitor (C31) is used for all solo and pedal dividers (see Fig. 5-24). A fault in either part may cause all solo and pedal dividers to fail. A fault in one divider can upset the common bias and also make all dividers fail. As a help, shunt another resistor across R37 of a value that will restore the bias to normal. All dividers except the faulty one should then work.

Solo Small or Solo Wide Vibrato Does Not Come On When The Vibrato Cancel Tablet Is Pushed In At The Top—The tablet contacts are dirty. Clean as recommended before.

Average Pitch Of A Solo Note Changes When Solo Small Or Solo Wide Is Manipulated—The compensating contact of the tablet is dirty, or the compensating capacitor is off value. Clean as recommended, or replace the capacitor.

One Key Will Not Play An Organ Note—Dirty organ-control contact on one key. Adjust the keyboard bus-bar shifter.

Two, Three, Four, Five, or Six Adjacent Keys Will Not Play Organ Notes—All organ oscillator tubes are dual triodes, and each half plays two or three adjacent notes. If one triode fails, two or three notes will also fail. If the whole tube is burned out, four, five, or six notes will not sound. The following is an aid in locating faulty tubes:

Low *F*, *F#*, and *G*; low *G#*, *A*, and *A#*; or all six V12
Low *B*, *C*, and *C#*; low *D*, *D#*, and *E*; or all six V13
Middle *F* and *F#*; middle *G* and *G#*; or all four V14
Middle *A* and *A#*; middle *B* and *C*; or all four V15
Middle *C#* and *D*; middle *D#* and *E*; or all four V16
High *F* and *F#*; high *G* and *G#*; or all four V17
High *A*, and *A#*; high *B* and *C*; or all four V18
High *C#* and *D*; high *D#*, *E*, and *F*; or all five V19

Organ Strings or Organ Flutes Will Not Play For Any Key—The corresponding tablet has a dirty contact. Clean the contacts carefully.

One Key Plays An Organ Note Having the Pitch of the Next Higher Note—The organ tuning contact is probably dirty. (This may also cause a noisy or irregular note.) Adjust the keyboard bus-bar shifter to provide a new contact surface.

Organ and Chord Vibrato Effect Will Not Turn Off—The Organ and Chords vibrato cancel tablets has a dirty contact. Clean as recommended.

NOTE: A single note in a chord is hard to detect because it will be masked by the other notes. Trouble in the chord section (which includes the chord button and pedal divisions) will probably affect both divisions; therefore, in the following, the pedals are used to determine failures in the chord section.

One Pedal Fails To Play With Any Chords—If the other pedal plays correctly, the oscillators, pedal control tube, and frequency dividers are working. Check for dirt in the signal and control contacts of the pedal switch. They can be cleaned in the same manner as the control tablets.

Both Pedals Fail To Play With Any Chords—Check the pedal control tube (V8) and the pedal frequency-divider system (V24, V25, and V26). Failure of the divider system may make the pedals electronically noisy or one or two octaves too high.

One Pedal Fails To Play With Certain Chords—If the other pedal plays correctly with all chords, all oscillators are working. Therefore, pedal-signal contact in the chord switch is probably poor. Adjust the chord-switch bus-bar shifter to obtain a new contact surface.

One Pedal Fails To Play With Some Chords, and the Other Pedal Fails to Play With Other Chords—Check for one or more dead oscillators. The left pedal plays the root note of the chord; the buttons with which the left pedal fails to play will indicate the defective oscillator.

If half a tube is faulty, both notes associated with it will be missing. If the entire tube is at fault, four notes will be absent. The following list will aid in locating faulty tubes in the pedal system:

Left Pedal Fails to Play	*Faulty Oscillator*	*Associated Tube*
All *F* and *F#* buttons	F, F#	V21
All *G* and A^b buttons	G, G#	V21
All *A* and B^b buttons	A, A#	V22
All *B* and *C* buttons	B, C	V22
All D^b and *D* buttons	C#, D	V23
All E^b and *E* buttons	D#, E	V23

If an oscillator is not operating, its two notes will be missing from the right as well as the left pedal. The chord-button chart in Table 5-1 shows the exact notes each pedal plays for each chord. The same notes will also be missing from the chords, but their absence will not be noticed except by a trained ear.

Pitch Of One Pedal Is One Note Too High On Some Chords—A tuning contact in the chord switch has failed to close. The note will have the wrong pitch, no matter where it occurs on either pedal or in the chords. To remedy, adjust the chord-switch bus-bar shifter for a new contact surface.

Pedal Fast Decay Tablet Does Not Affect the Decay Rate—Dirty contact in the tablet. Clean the contact as recommended.

Chord Bar Has No Effect (Chords Play If Sustain Cancel Is Pressed In At The Top)—Check for dirty chord bar contacts. They can be reached by removing the two screws holding the chord bar. Clean in the same manner as the control-tablet contacts.

One Note Missing From A Chord—It is difficult for anyone to identify a missing note by listening to the chord alone. For this reason, the chord can be checked against the corresponding organ notes. This is done by turning off all control tablets except Flutes, Strings, and Organ and Chords Vibrato Cancel. Always refer to the chord-button chart (Table 5-1) to see which notes are supposed to be present, and then play the same ones in the lowest keyboard octave. By alternately playing the keys and the chord button, you can easily tell

if the two chords sound alike and thus determine which note is missing. If a note is missing but the pedals play correctly on all buttons, most likely the chord-signal contact in the chord switch is probably dirty. This can be corrected by adjusting the chord-switch bus-bar shifter to bring a new contact surface into position.

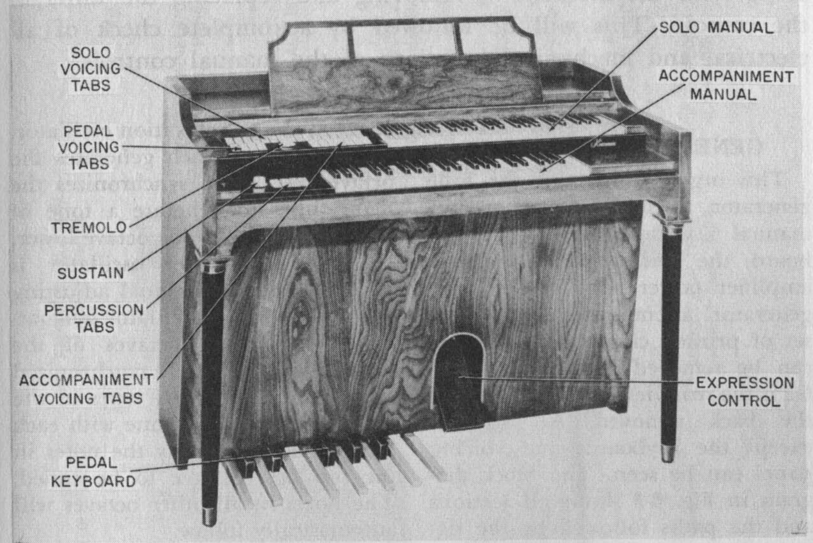


Fig. 6-1. The Kinsman Model CP electronic organ.

CHAPTER 6

THE KINSMAN ELECTRONIC ORGAN

The Kinsman organ (Fig. 6-1) is a *modular* console containing several modules, or electrical subassemblies. (Although the Kinsman Models A, B, C, and CP are discussed in this chapter, most of the information will apply to models which may be added to the line later.) Each subassembly is easily removable with simple tools, and any organ can be restored to normal operation by simply replacing the faulty section.

Therefore, the test procedures are of the utmost importance. Kinsman Manufacturing Company permits no repairs to be made on the various modules. Instead, they ask that the defective unit be returned to the factory and a new one put in its place.

For this reason, test procedures will be thoroughly explained, along with the methods of removing and replacing the units in the console. This will be followed by a complete check of all electrical and mechanical functions of the manual controls.

GENERAL DESCRIPTION

This organ consists of the tone generator assemblies, one or two manual keyboards, the pedal keyboard, the voicing panel, and the amplifier power supply. The tone generator assemblies consist of a set of printed circuit panels which can be removed individually. Fig. 6-2 is the rear view of the organ with the back removed. All sections except the keyboards and voicing panel can be seen. The block diagram in Fig. 6-3 shows all sections and the paths followed by the signals.

All tones on the keyboards originate in the twelve tone generators, one for each of the twelve notes of the chromatic scale. However, there are only six tone-generator printed-circuit panels because each panel carries the circuitry of *two* generators.

Each tone generator produces the basic organ tone for six octaves of any particular note. For example, the *D* generator produces six *D*'s, from the fourth *D* above to the second *D* below middle *C*. In each tone generator, the highest note is generated by a master oscillator using half of a vacuum tube. This master oscillator does not change pitch over long periods of time or with variations in the power-line voltage.

Each progressively lower octave is generated by an oscillator employing two small neon tubes, sometimes referred to as a relaxation oscillator. The oscillator which generates the octave just above synchronizes the neon tubes to generate a tone of the same note but one octave lower.

When the master oscillator is tuned with its individual adjusting screw, each neon oscillator generating lower-pitched octaves of the same tone is so closely synchronized that the pitches of all tones in the generator remain in tune with each other. Therefore, only the notes in the top octave have to be tuned. The notes in all other octaves will automatically follow.

The tone generators produce tones at *all* times while the organ is on. These tones are fed, through a wiring harness, to the switches under the manual keys. These switches are an integral part of each keyboard assembly. When a key is pressed, two or more tone-switch actions take place. For example, an 8′ tone is switched to the 8′ output of the keying system, and a 4′ tone, one octave higher, is switched to the 4′ output. In the Models B, C, and CP, a 16′ tone, one octave *lower*, is switched to the 16′ output, while a fourth set of contacts in the upper (manual) keyboard actuates the percussion circuits.

The outputs of the keying systems are fed to the *bus amplifier panel*, one of the units in the tone generator assembly (see Fig. 6-2). These tones are amplified and the separate outputs fed to the voicing panel.

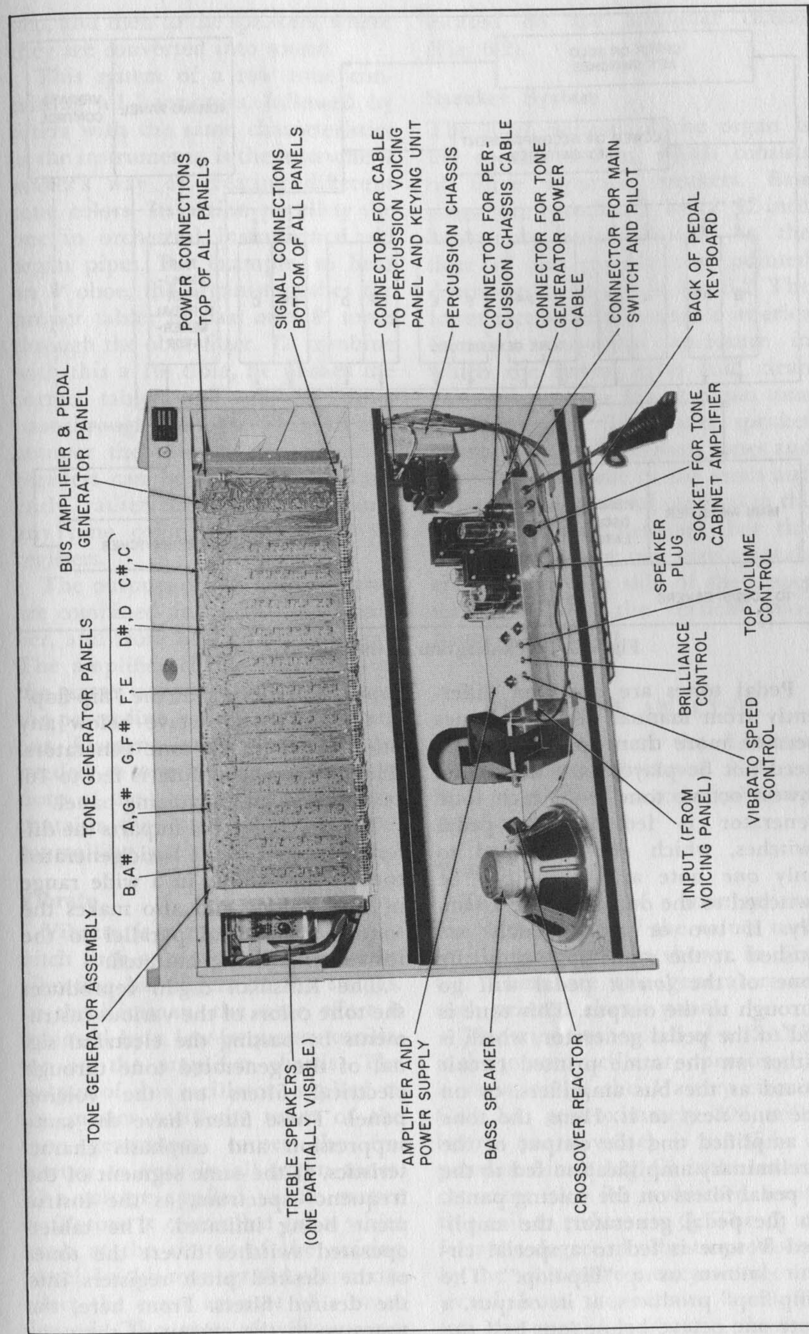


Fig. 6-2. The Kinsman Model CP organ with rear cover removed.

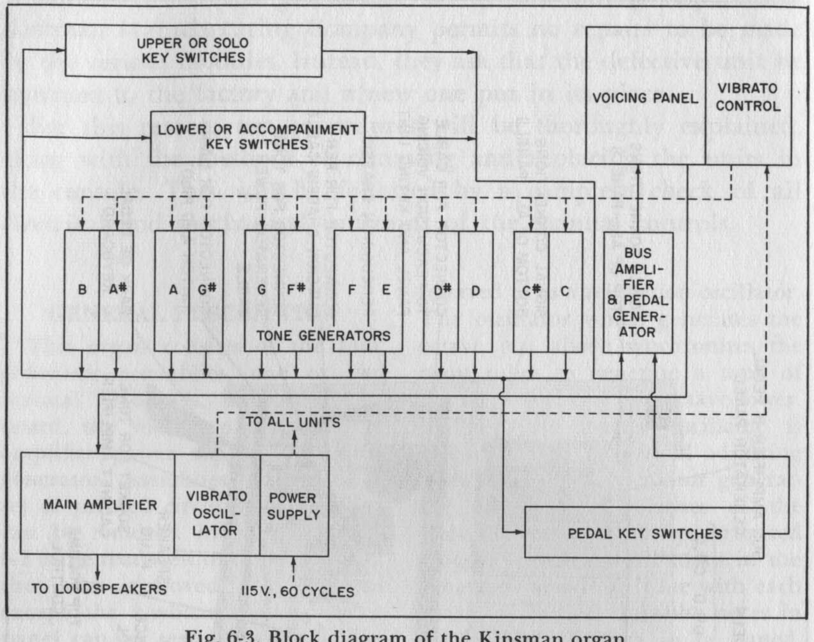


Fig. 6-3. Block diagram of the Kinsman organ.

Pedal tones are obtained differently from manual keyboard tones because more than one pedal note need not be played at a time. The lowest octave tone from each tone generator is fed to the pedal switches, which are connected so only *one* note at a time can be switched to the output of the assembly. If two or more pedals are pushed at the same time, only the tone of the *lowest* pedal will go through to the output. This tone is fed to the pedal generator, which is either on the same printed circuit board as the bus amplifiers, or on the one next to it. Here, the tone is amplified and the output of the preliminary amplification fed to the 8′ pedal filters on the voicing panel. In the pedal generator, the amplified 8′ tone is fed to a special circuit known as a "flip-flop." The "flip-flop" produces, at its output, a note one octave below (one-half the frequency) the note presented to its input. The output of the "flip-flop" is therefore one octave below any other notes in the tone generators. This lower-octave note is fed to 16′ pedal filters on the voicing panel.

The voicing panel imparts the different timbres to the basic generated tones. This results in a wide range of tone colors, and also makes the tones an electrical parallel to the instruments being imitated.

The Kinsman organ reproduces the tone colors of the various instruments by passing the electrical signal of the generated tone through electrical filters on the voicing panel. These filters have the same suppression and emphasis characteristics, at the same segment of the frequency spectrum, as the instrument being imitated. The tablet-operated switches divert the tones of the desired pitch registers into the desired filters. From here, the tones go to the output of the voicing panel, where they are ampli-

fied, and then to the speakers, where they are converted into sound.

This system of a raw tone containing all harmonics, followed by filters with the same characteristics as the instruments, is the instrument maker's way of creating different tone colors. Its action parallels the one in orchestral instruments and organ pipes. For example, to hear an 8′ oboe, the organist pushes the proper tablet to pass only 8′ tones through the oboe filter. To combine with this a 16′ tibia, he pushes the correct tablet, and only 16′ tones pass through the tibia filter. In this manner the tone colors and pitch registers can be selected independently, rather than having to sound any tone color through all pitch registers.

The outputs of the voicing panel are combined and fed to the amplifier, and from here to the speakers. The amplifier chassis also contains the power supply, which transforms the power-line voltage into the various filament and plate voltages needed to operate the various sections of the organ. The chassis also contains the "swell shoe" volume-controlling potentiometer.

Vibrato

Vibrato is a regular variation in pitch such as a violinist obtains by vibrating his fingers on the strings. In the Kinsman, the same effect is achieved by a low-frequency oscillator on the amplifier chassis. The output of this oscillator, applied to the master oscillator tubes of the tone generators, causes the frequency to vary in all organ tones. The voltage applied to the master oscillators is controlled by a white knob at the center of the voicing panel. In this manner the player can select the exact amount of vibrato desired. The rate of vibrato can also be controlled by an adjustment located on the amplifier chassis (Fig. 6-2).

Speaker System

The final portion of the organ is the speaker system, which consists of three separate speakers. Bass tones are produced by a 12-inch heavy-duty unit mounted on the floor of the console and pointed downward as shown in Fig. 6-2. The lower section of the console interior forms a bass-reflex enclosure in which the system gives full, clean bass, down to the lowest organ tone of 32.7 cycles. This large speaker cannot handle the highest tones and harmonics of some of the reeds and strings (which extend upward to the limit of human hearing). For this reason, there are two treble speakers—one on each side of the upper section, behind the vertical wood panel at the front.

TECHNICAL ANALYSIS

The operation of the Kinsman organ has been discussed. Now we shall proceed with a technical analysis of each portion.

Tone Generators

The schematic of a tone generator, with a table of the values used in all generators, is shown in Fig. 6-4. There are two generators on each printed circuit panel.

The triode tube, half of a 12AX7, is the master oscillator, operating in a variation of the Hartley circuit. Coil L1, approximately 300 millihenrys (mean value), is tuned by a powdered-iron slug. C1 is the tuning capacitor, and R1 is shunted across this coil to reduce its *Q*. The *Q* affects the degree of vibrato produced by the vibrato-frequency voltage injected from the vibrato oscillator (on the amplifier chassis) through R2. R1 produces a constant vibrato

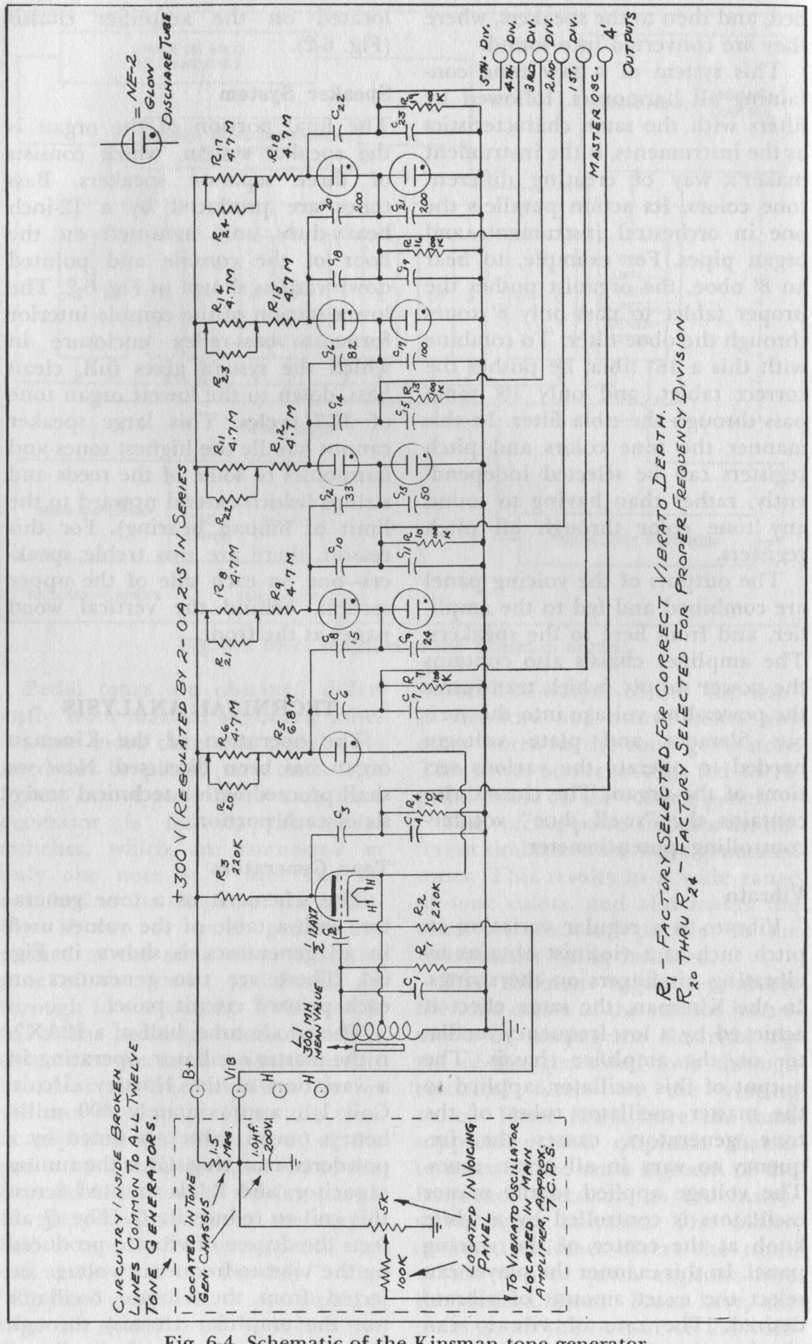


Fig. 6-4. Schematic of the Kinsman tone generator.

effect for all generators. The bottom of R2 (in common with the R2's of the other generators) goes to the top of a 5,000-ohm potentiometer, the bottom of which is grounded. The arm of this potentiometer receives the vibrato oscillator voltage. This arrangement keeps the resistance constant in all of the master-oscillator grid circuits, yet allows the organist to vary the vibrato voltage injection from zero to maximum.

The output from the oscillator is developed across the plate load resistor R3. The voltage there is a pulse; the net value of C3 and C4 is such that the pulse is integrated to produce an approximately sawtooth waveform (although rounded and lacking the harmonic development of a true sawtooth). The two capacitors are proportional to each other and to the AC voltage at the tube plate. As a result, the amplitude of the output from the junction is of the same value as the outputs from the frequency dividers. The output from the junction is used for the top 4′ octaves of the organ.

The frequency-divider stages employ small NE-2 neon lamps. The basic relaxation circuit consists of a resistor connected from the B+ supply to one electrode of a neon lamp. The other electrode of the neon lamp is grounded, and a capacitor is connected in parallel with the lamp. The output, a sawtooth oscillation, is taken from the ungrounded electrode of the neon lamps or from some point on the resistor. The frequency of oscillation depends on the value of the applied voltage, the type of neon lamp, and the value of the resistor and capacitor.

In the circuit in Fig. 6-4, the single neon lamp is replaced by two lamps which, except for the fact that almost twice as much B+ is required, makes no important difference in the circuit. We will consider only the single stage of the schematic in Fig. 6-4, composed of R11, R12, C14, C15, and the two neon lamps.

R11 and R12 in the series is the timing resistor. The timing capacitor is the net value (series) of C14 and C15. If the output is taken from the ungrounded electrode of the neon lamp, the impedance (and reactance), if any, of the load affects the oscillator. With C15 having a value ten times that of C14 in this circuit, its impedance is one-tenth that of C14. Ten-elevenths of the reactance which affects oscillator timing is therefore concentrated in C14. Hence, the effects of any load across C15 are negligible. Since the two units constitute a capacitive voltage divider, there is no frequency-sensitive effect. So the waveshape produced by the oscillator appears at the output intact, but reduced in amplitude.

Two major conditions are necessary in a relaxation frequency-divider arrangement:

1. The relaxation oscillator must have a free-running frequency somewhat lower than that at which synchronization is desired, but not so low that injection of a standard amount of synchronization signal cannot pull the frequency up to the desired point.
2. This sync signal must be injected in such a way that it is not reflected to the source of the synchronized signal, so no great amount of the sync-frequency signal is injected into the output of this signal.

By the correct selection of sync amplitude and timing values (resistors and capacitors), the two neon lamps can be made to fire only once for every two cycles of sync. When this occurs, we have a frequency divider. Since the relationship of the frequencies in two notes an octave apart is exactly 2:1, *all* octaves of a particular note can be produced by this method.

After initial adjustment in a factory jig, a master oscillator can be tuned over a range of three or four semitones on either side of a center frequency, without loss of synchronization of the lower-frequency dividers. In addition, normal changing of components with age does not cause any difficulties. The over-all stability of this system is comparable to synchronized vacuum-tube relaxation generators.

The neon lamps have an extremely long life (around 10,000 hours or more). They are artificially aged at the factory so they will be stabilized when the organ is shipped. Later, padding resistors (R20 through R24) may have to be readjusted because of component aging. Any qualified technician can make this adjustment with a potentiometer and an ohmmeter.

Key Switching

Each key operates two or more normally open contacts, which transmit tones through an isolating resistor to one of the output busses. The values of the resistors vary, becoming larger toward the lower end of each manual to give the treble tones a higher amplitude (volume) in the output busses. Most filters have some low-pass action which is offset for the fundamentals by the scaling of the keying resistor values. This is done so the ear can hear all notes at about the same volume (called *correct scaling*).

The keyboards consist of plastic molded keys plus a mechanical design of supporting the key-movement structure to prevent misalignment. The key switches employ precious-metal contacts which are an integral part of the keyboard.

Bus Amplifiers

The keying-bus outputs (4′, 8′, and in most models, 16′ tones from each manual) go to the bus amplifier panel in the tone generator assembly. Fig. 6-5 is the schematic for the bus amplifier in the Models C and CP. The circuits in the other models are similar to it. The bus amplifier provides isolation between the keying circuits and the formant filters. Otherwise, a tone would sound lower than normal if played more than once—for example, if played as an 8′ tone for one key and a 4′ tone an octave lower. Also, the outphased signals for the formant filters are derived in the bus amplifier. In addition, it provides a certain amount of amplification. Application of a large amount of negative feedback from the triode plate to the grid provides a low-impedance output. The feedback gives a low dynamic output impedance, and also reduces noise and distortion.

Pedal Generator

In the Models A, C, and CP, the pedal generator is on the same printed circuit board as the bus amplifiers (see Fig. 6-5). In the Model B, however, it shares with a special percussion circuit an *additional* printed circuit panel in the tone generator assembly. Nevertheless, the circuitry is the same.

The pedal-switch circuit is shown in the lower right-hand corner of the wiring diagram in Fig. 6-6. All switches are single-pole, double-throw types, and the normal position of each is shown in the diagram. The normally-open contact of each switch is fed its tone from the lowest divider of the proper generator (except that the upper *C* pedal

is fed its tone from the next-to-the-last *C* divider). The switch output line is connected to the pedal-generator input. When no pedals are being played, the pedal-generator input is grounded. When the *C* sharp pedal is depressed, the moving arm contacts the normally-open point and carries the *C* sharp tone through the closed *C* contacts to the pedal-generator input. If two pedals are pressed simultaneously, only the lower note will be sounded.

Note in Fig. 6-5 that the pedal-generator input from the switches goes through tube V2, which amplifies and shapes the signal to a sawtooth wave with a slow rise and a fast decline. The frequency is not changed. The output of V2 is fed to the 8′ pedal filters on the voicing panel. Amplification is sufficient for voicing the 8′ pedal tones and there is no intermodulation because only one tone is handled at a time.

Tube V1 is a simple "flip-flop" of the Eccles-Jordan type in which the second triode is cut off when the other one is conducting. This occurs each time a pulse is injected into the circuit through the 390-mmf capacitors C2 and C3 from amplifier and shaper tube V2.

The output from the "flip-flop" is taken from only one of the plates. As each incoming pulse causes the conducting triode to cut off and the cutoff triode to conduct, each triode makes a complete cycle from conduction to cutoff and back once for every two injected pulses. The output taken from one plate has a frequency only half that of the input pulses and is of 16′ pitch and a square wave. An RC network following the output plate alters the waveshape, after which the tone is fed from the 16′ output to the 16′ pedal filters.

The "flip-flop" is not an oscillator, since it cannot run free. It is stable in either of its two states, and a single pulse will change conduction from one tube to the other. After this, the condition will remain until the next pulse is injected, regardless of the length of time.

Voicing Panel

Bus-amplifier and pedal-generator outputs all go to the voicing panel. This is the control center of the organ; it contains the stop tablets, tone-color filters, and a vibrato control, as shown in Fig. 6-7. The three lower-keyboard inputs from the bus amplifiers go to normally-open tablet-operated switches—the 16′ input to one switch for the melodia; the 8′ tone to the trumpet, diapason, dulciana, and flute switches; and the 4′ tone to the string and flute tablets. In the voicing, the correct tone is passed from the proper keyboard, through a tab switch and an appropriate filter, to the common output leading to the main amplifier.

For example, to play the trumpet 8′ on the lower keyboard, push the lower trumpet 8′ tab to the On position. From Fig. 6-7 you will note that the lower keyboard 8′ signal from the bus amplifier goes through the lower-keyboard trumpet 8′ switch (now closed) through R57 and C23, to a series-resonant circuit consisting of L1 and C3. At the junction of L1 and C3, the output for the trumpet filter is across one element of the tuned circuit. Hence, there is a voltage rise at and around the resonant frequency. The filter output then goes through R6 to the main amplifier.

All voicing is done in the same way, and can be traced easily by passing the signal through a filter having the characteristic which will produce the desired timbre.

Note that only a single basic filter is needed for each voice. The tuned section of the trumpet filter is used

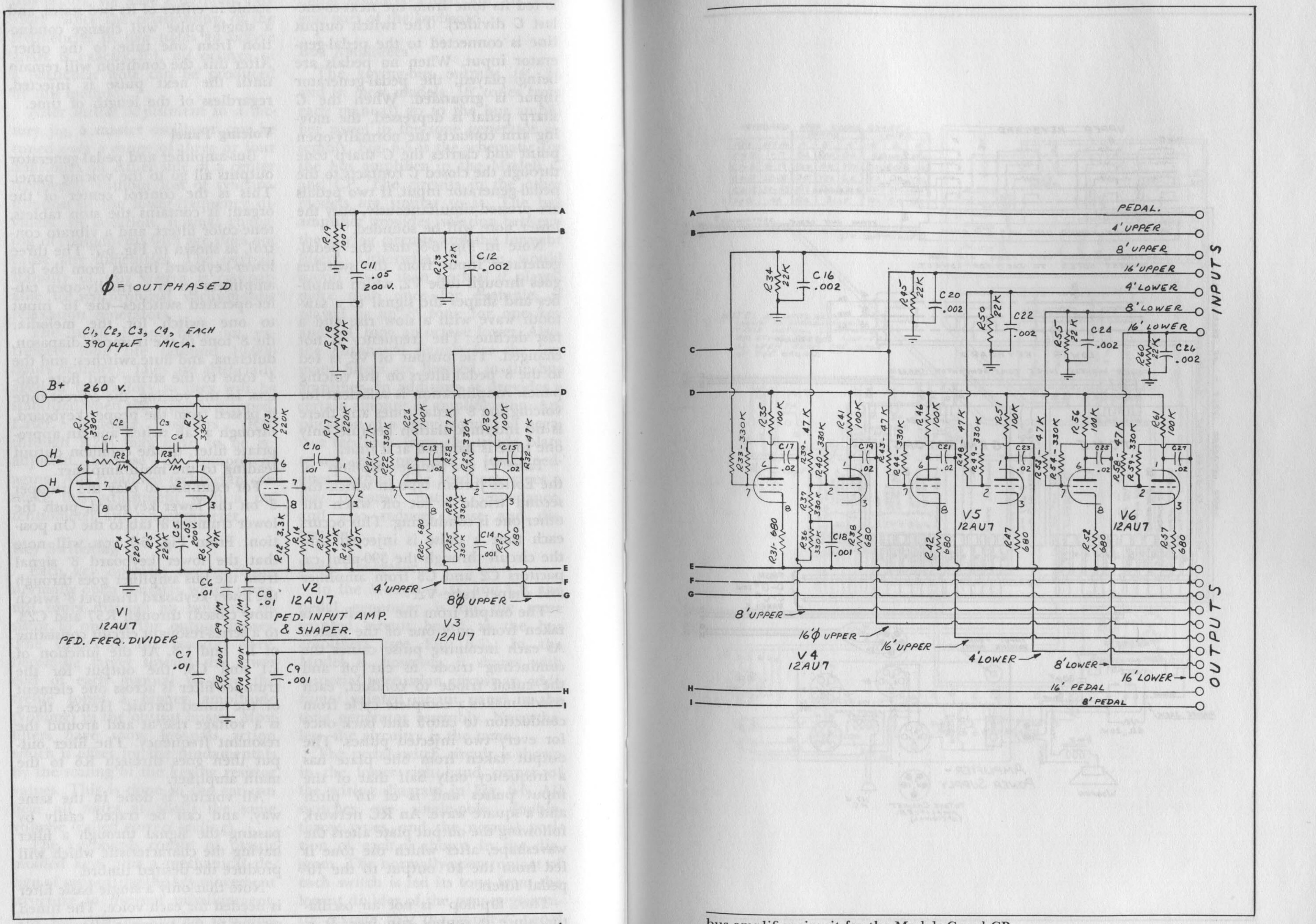


Fig. 6-5. Schematic of the pedal generator and bus amplifier circuit for the Models C and CP.

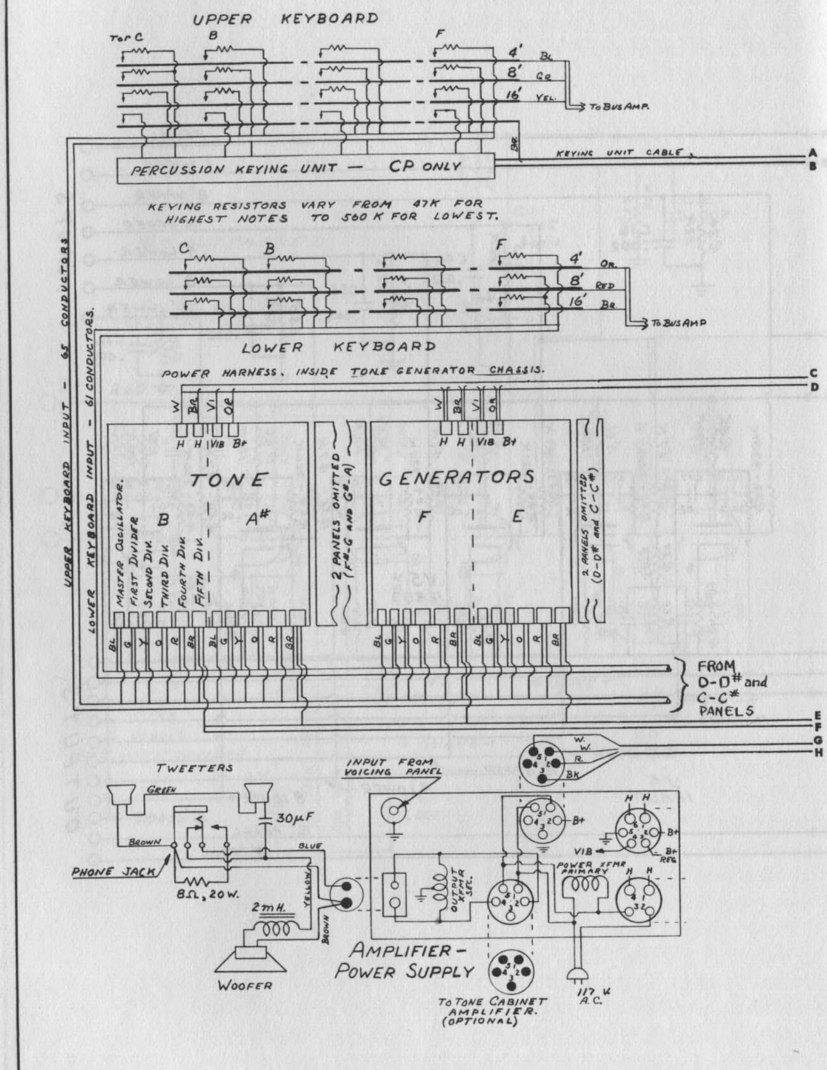
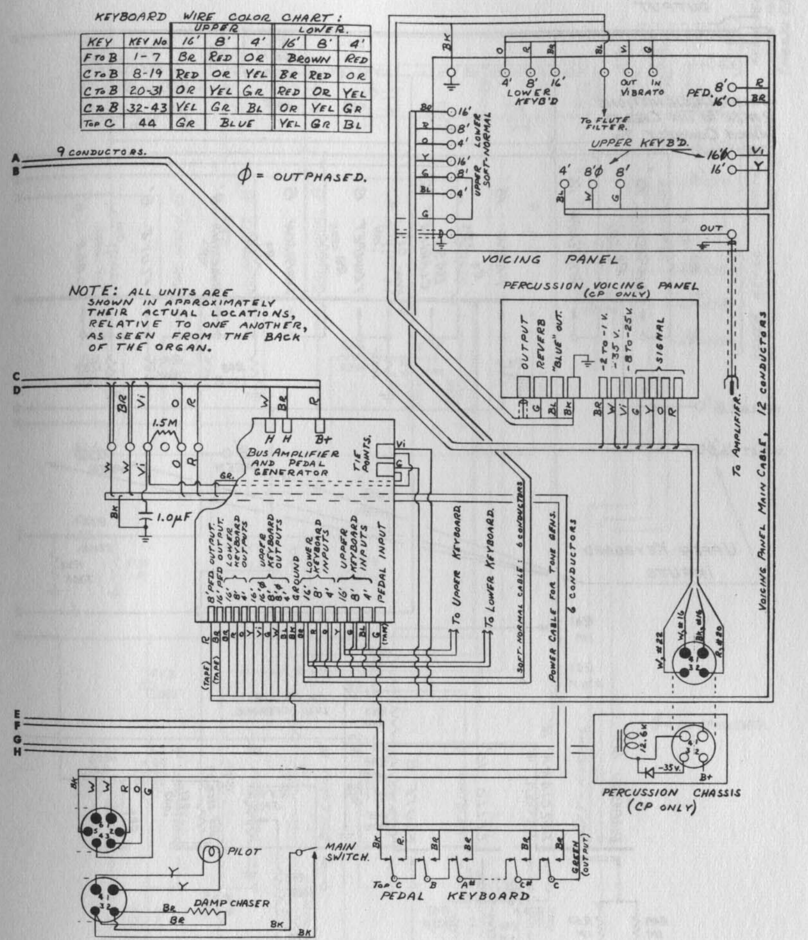


Fig. 6-6. Wiring diagram of the Models C and CP.



KEY	KEY No	UPPER 16'	UPPER 8'	UPPER 4'	LOWER 16'	LOWER 8'	LOWER 4'
F TO B	1-7	BR	RED	OR	BROWN		RED
C TO B	8-19	RED	OR	YEL	BR	RED	OR
C TO B	20-31	OR	YEL	GR	RED	OR	YEL
C TO B	32-43	YEL	GR	BL	OR	YEL	GR
TOP C	44	GR	BLUE		YEL	GR	BL

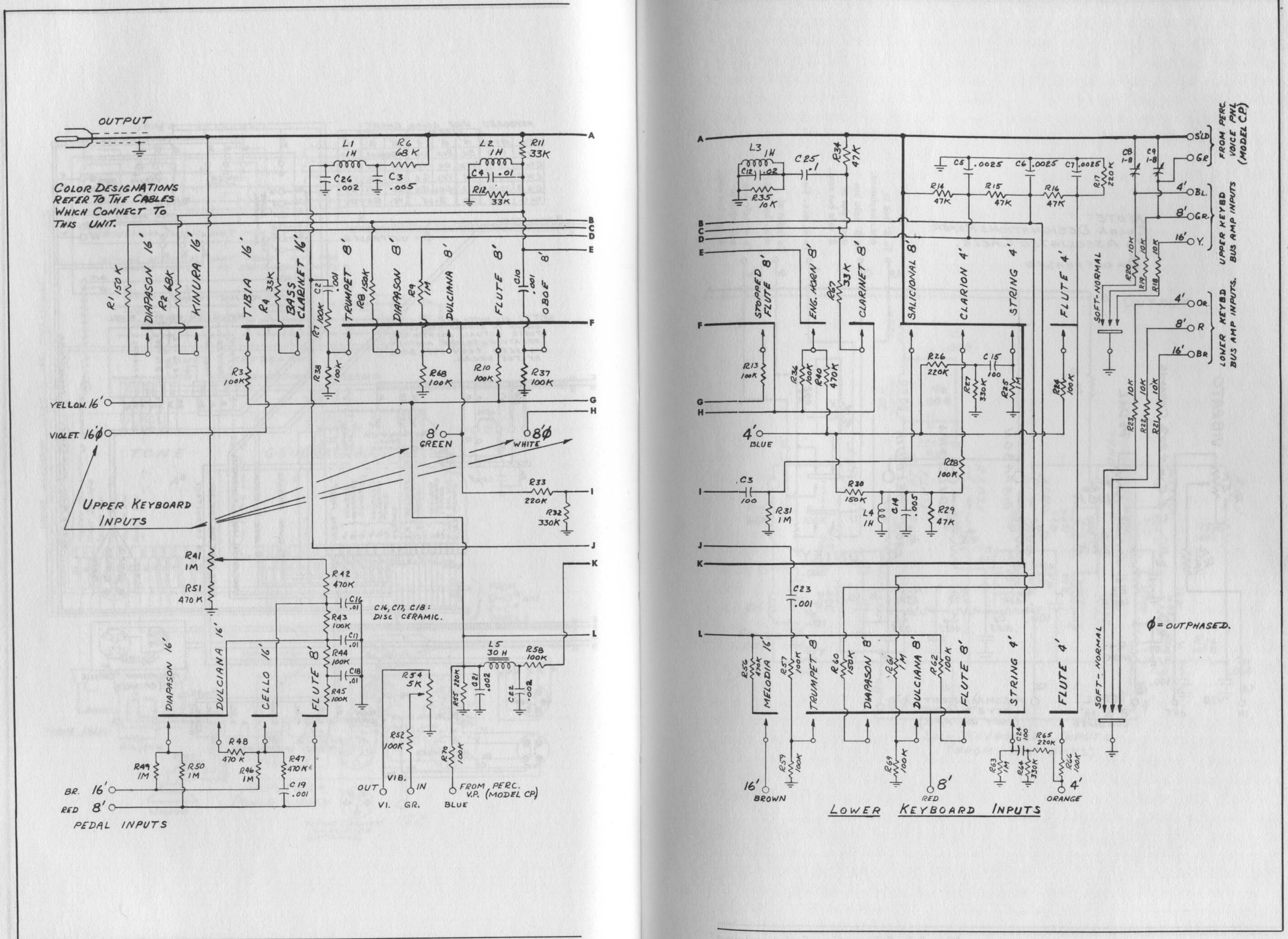


Fig. 6-7. Schematic of the voicing panel for the Models C and CP.

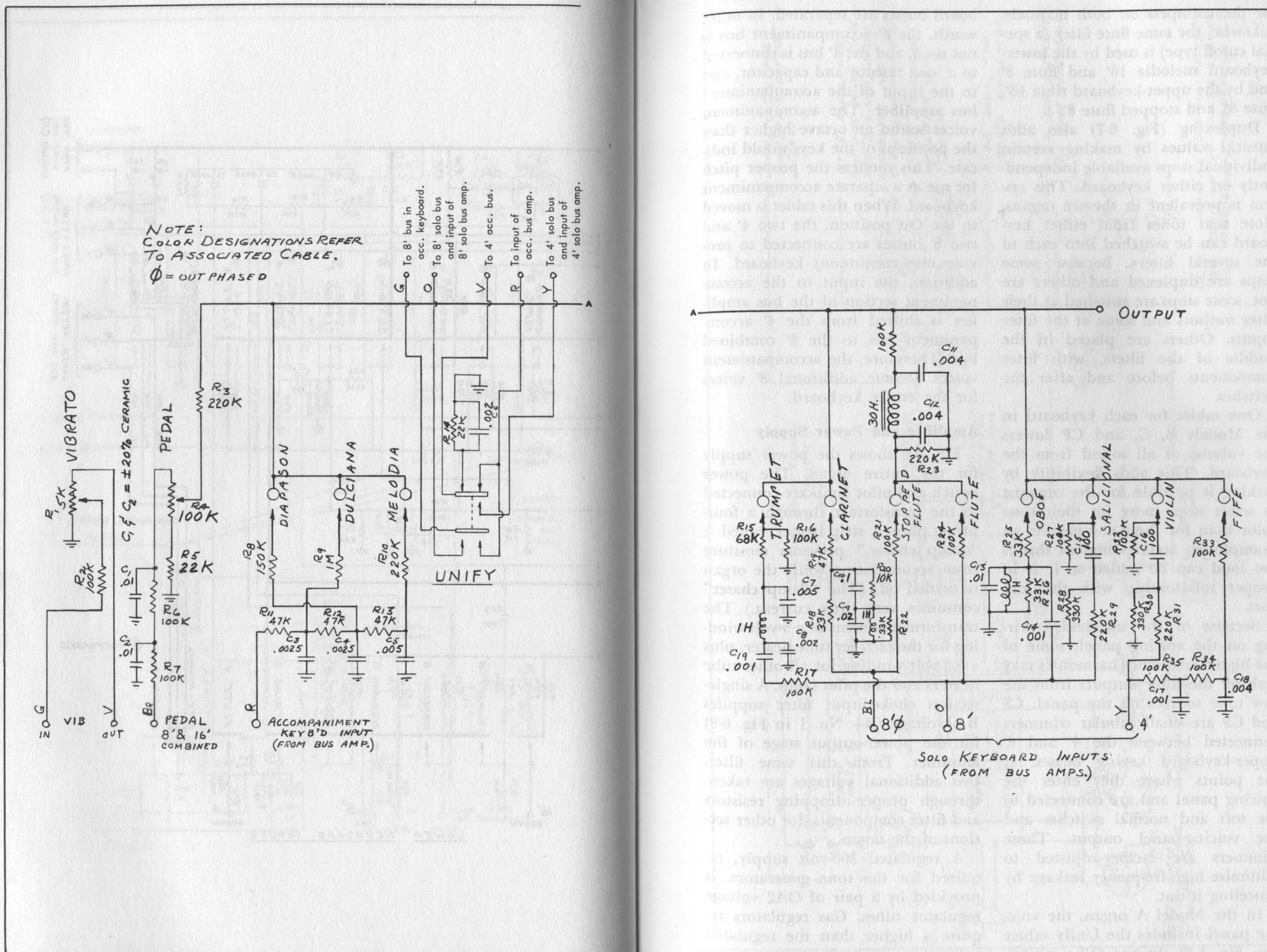


Fig. 6-8. Schematic of the voicing panel for the Model A.

for the trumpets on both manuals. Likewise, the same flute filter (a special cutoff type) is used by the lower-keyboard melodia 16′ and flute 8′ and by the upper-keyboard tibia 16′, flute 8′, and stopped flute 8′.

Duplexing (Fig. 6-7) also adds musical values by making certain individual stops available independently on either keyboard. This system is prevalent in theatre organs. Note that tones from either keyboard can be switched into each of the several filters. Because some stops are duplexed and others are not, some stops are switched at their filter outputs and some at the filter inputs. Others are placed in the middle of the filters, with filter components before and after the switches.

One tablet for each keyboard in the Models B, C, and CP lowers the volume of all sound from the keyboard. This adds flexibility by making it possible for the organist to select stops more for their tone color than for their volume. As an example, an accompaniment that is too loud can be muted so it is in proper relationship with the solo part.

Because of the unshielded wiring on the voicing panel, some of the higher-frequency harmonics may leak off the filter outputs from the raw tone sources on the panel. C8 and C9 are small tubular trimmers connected between the 4′ and 8′ upper-keyboard keying busses, at the points where they enter the voicing panel and are connected to the soft and normal switches and the voicing-panel output. These trimmers are factory-adjusted to minimize high-frequency leakage by canceling it out.

In the Model A organ, the voicing panel includes the Unify tablet (see Fig. 6-8). In the Off position, the solo and accompaniment keyboard busses are separated. In other words, the 8′ accompaniment bus is not used, and the 4′ bus is connected to a load resistor and capacitor, and to the input of the accompaniment bus amplifier. The accompaniment voices sound an octave higher than the positions of the keys would indicate. This renders the proper pitch for use as a separate accompaniment keyboard. When this tablet is moved to the On position, the two 4′ and two 8′ busses are connected to provide one continuous keyboard. In addition, the input to the accompaniment section of the bus amplifier is shifted from the 4′ accompaniment bus to the 8′ combined bus. Therefore, the accompaniment voices become additional 8′ voices for the entire keyboard.

Amplifier and Power Supply

Fig. 6-9 shows the power supply for the entire organ. The power switch and pilot lamp are connected to the transformer through a four-prong plug. A strip heater, called a "damp chaser," prevents moisture from accumulating while the organ is turned off. (The "damp chaser" consumes very little current.) The transformer consists of a 5-volt winding for the rectifier tube heater, plus a 6.3-volt winding for all other tube heaters and the pilot lamp. A single-section choke-input filter supplies B+ voltage (B+ No. 1 in Fig. 6-9) for the power-output stage of the amplifier. From this same filter, two additional voltages are taken, through proper dropping resistors and filter components, for other sections of the organ.

A regulated 300-volt supply, required for the tone generators, is provided by a pair of OA2 voltage regulator tubes. Gas regulators require a higher than the regulated voltage to start them. A unique method is used in the Kinsman or-

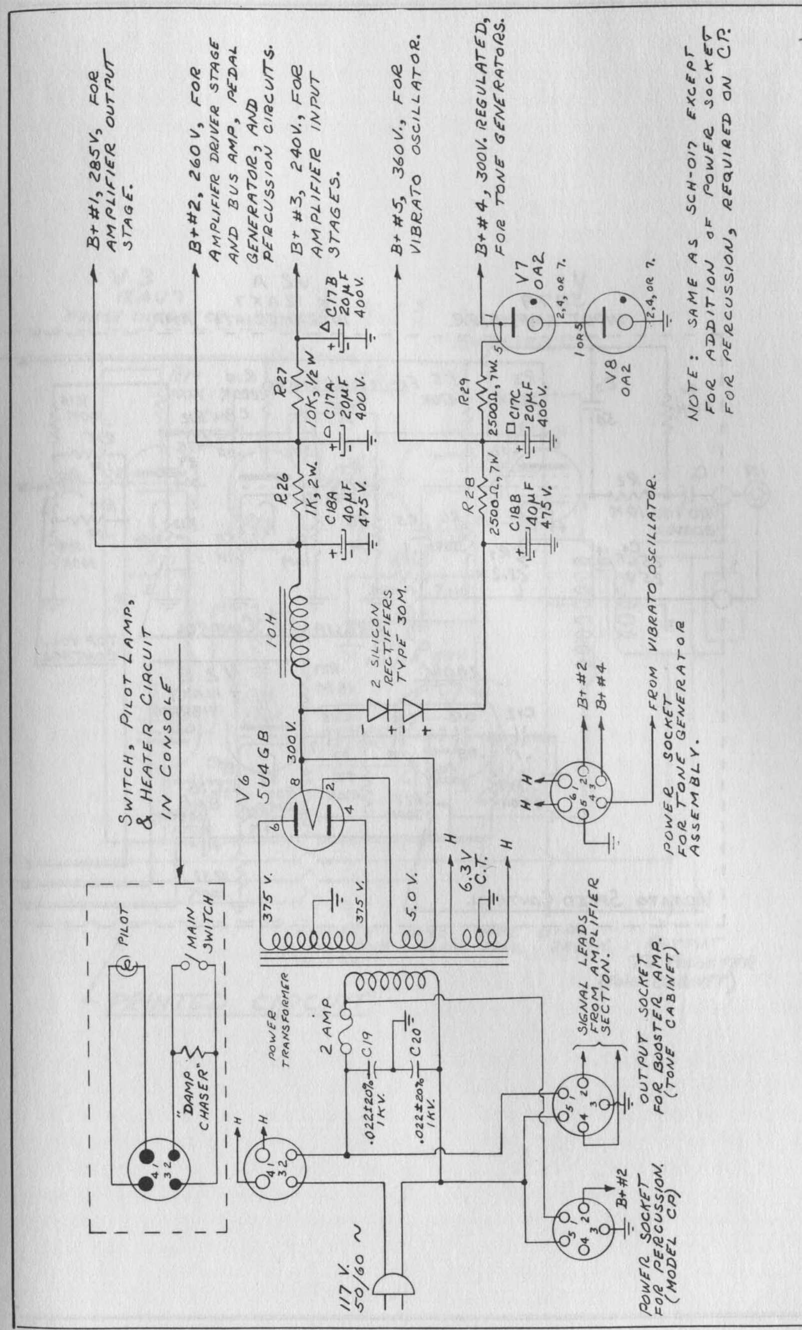


Fig. 6-9. Schematic of the power supply for Kinsman organs.

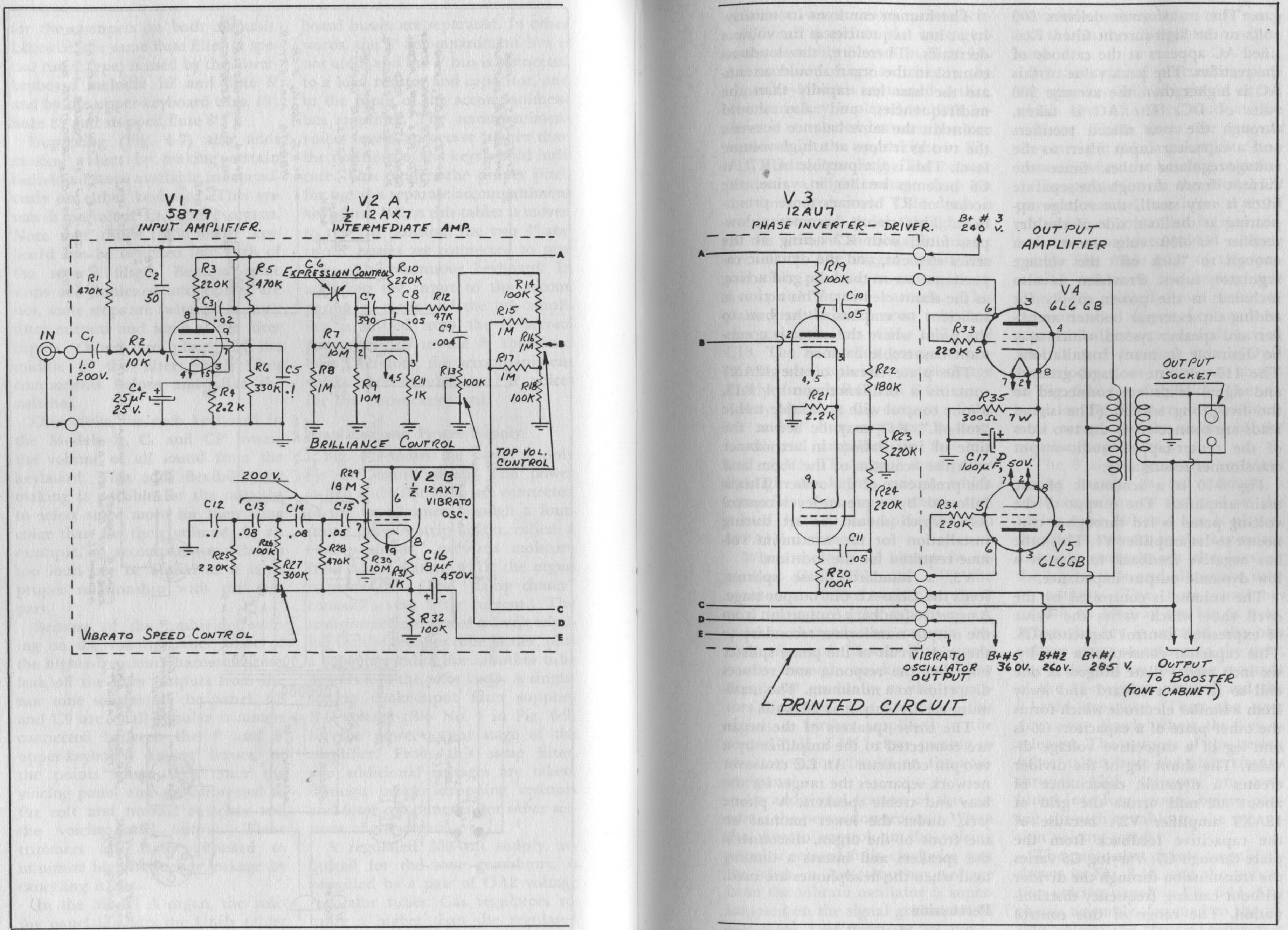


Fig. 6-10. Schematic of the amplifier and vibrato oscillator of Kinsman organs.

gan. The transformer delivers 300 volts to the high-current filter. Rectified AC appears at the cathode of the rectifier. The peak value of this AC is higher than the average 300 volts of DC. The AC is taken, through the two silicon rectifiers and a capacitor input filter, to the voltage-regulator tubes. Since the current drawn through the separate filter is very small, the voltage appearing at the load side of the dry rectifier is 430 volts—more than enough to "kick off" the voltage regulator tubes. Provision is also included in the power supply for adding an external booster amplifier and speaker system, which may be desirable in many installations. The 117-volt line voltage, ground, and signal leads are connected to the five-prong socket. (The signal leads are connected to the two sides of the center-tapped audio-output transformer secondary.)

Fig. 6-10 is a schematic of the main amplifier. The output of the voicing panel is fed through a connector to 1st amplifier V1. This tube has negative feedback to give it a low dynamic output impedance.

The volume is controlled by the swell shoe which varies the value of expression control capacitor C6. This capacitor consists of a two-by-six inch medal plate hinged at one end so it moves toward and away from a similar electrode which forms the other plate of a capacitor. C6 is one leg of a capacitive voltage divider. The shunt leg of the divider creates a dynamic capacitance of about .02 mfd across the grid of 12AX7 amplifier V2A because of the capacitive feedback from the plate through C7. Varying C6 varies the transmission through the divider without causing frequency discrimination. The range of this control is very wide, and no noise or hum is introduced by the system.

The human ear loses its sensitivity at low frequencies as the volume decreases. Therefore, the loudness control in the organ should attenuate the bass less rapidly than the midfrequencies, and also should maintain the same balance between the two as it does at a high-volume level. This is the purpose of R7. As C6 becomes smaller in value, the action of R7 becomes more prominent. This circuit becomes a low-pass filter, with R7 acting as the series element, and the dynamic capacitance across the tube grid acting as the shunt element. This action is sufficient to emphasize the bass to the point where the effect is a constant bass-treble balance.

The plate circuit of the 12AX7 contains a brilliance control R13, a tone control with a variable treble "roll-off." R13 may be set at the time of installation, in accordance with the acoustics of the room and the preference of the owner. This is followed by a preset level control R16, which should be set during installation for the maximum volume required for the location.

V3, a standard phase splitter, feeds the Class-AB 6L6 output stage. A negative-feedback connection from the output-transformer secondary to the grid circuit of the phase splitter improves the response and reduces distortion to a minimum. The maximum steady output is 20 watts.

The three speakers of the organ are connected to the amplifier by a two-pin connector. An LC crossover network separates the ranges for the bass and treble speakers. A phone jack, under the lower manual on the front of the organ, disconnects the speakers and inserts a dummy load when the headphones are used.

Percussion

In the Model B, the percussion circuitry is included, with the pedal

generator, on an extra printed-circuit board panel in the tone generator assembly (shown in Fig.6-11). An extra set of key switches in the upper keyboard is connected so that, when any key is played, a 100K resistor is connected between the two terminals (at the upper right in Fig. 6-11 labeled Perc. Key). The resistor produces a slight voltage drop on the lower terminal. This drop is transmitted as a pulse through C11 to the grid of monostable trigger circuit V3. The trigger circuit fires and thus produces a strong negative pulse on its cathode. This pulse fires the NE2 neon tube and charges capacitors C16, C17, and C18. The neon then goes out, permitting the capacitors to discharge slowly through R43 and R44.

Any signal at the outputs of the 16′ and 4′ bus amplifiers is combined and amplified in the first half of V4. This signal then passes through the keying circuit, which comprises two transformers connected back-to-back, plus the two 19PA1V *varistors.*

When there is no charge in capacitors C16, C17, and C18, the varistors are biased so that no signal gets through. As the capacitors are quickly charged, the varistors become forward biased. The signal comes through quickly, and then dies away gradually as the capacitors discharge. The output of this circuit is further amplified in the second half of V4 before passing to two tone-color circuits on the voicing panel.

An additional feature of this circuit is the percussion tremolo. When the vibrato control on the voicing panel is rotated fully clockwise past the click, a low-frequency voltage from the vibrato oscillator is superimposed on the signal grid of V4 in Fig. 6-11. This produces an amplitude modulation or tremolo on the

percussion voices only, very much like that in the vibraphone or vibraharp.

In this type of percussion, playing any key will trigger a circuit which keys all notes held at the moment. These notes die away as they are held (like a piano), but stop instantly when the keys are released.

The percussion in the Model CP provides manual sustain on a set of added voices, controlled by stop tablets on a separate added voicing panel. The main part of this percussion system is the keying unit (Fig. 6-12), printed-circuit panel underneath the upper keyboard. A separate half of a twin-triode keying unit is used for each note. [Only two triodes (four notes) are shown in Fig. 6-12 for simplicity. The circuits for the other triodes are identical except for the values of the coupling capacitors.]

The 8′ signal from the keyboard wiring harness is fed through a small capacitor to the grid of the keying tube. When a key is played, the fourth contact in the key-switch assembly grounds out the bias on the keying tube and allows the tube to amplify. The note continues steadily as long as the key is held. When the key is released, the bias voltage starts to return to the grid, but is delayed by the time constant of the 15-megohm resistor and the 0.1-mfd capacitor. Then the note dies away slowly when the key is released. The outputs of the keying tubes, taken from the plate circuits through 470K resistors, are combined into four groups before passing through a cable to the percussion voicing panel.

The percussion chassis assembly is shown in Fig. 6-13, and the percussion voicing panel, in Fig. 6-14. The chassis assembly, fastened to the inside wall of the console, contains a 12.6-volt filament transformer for

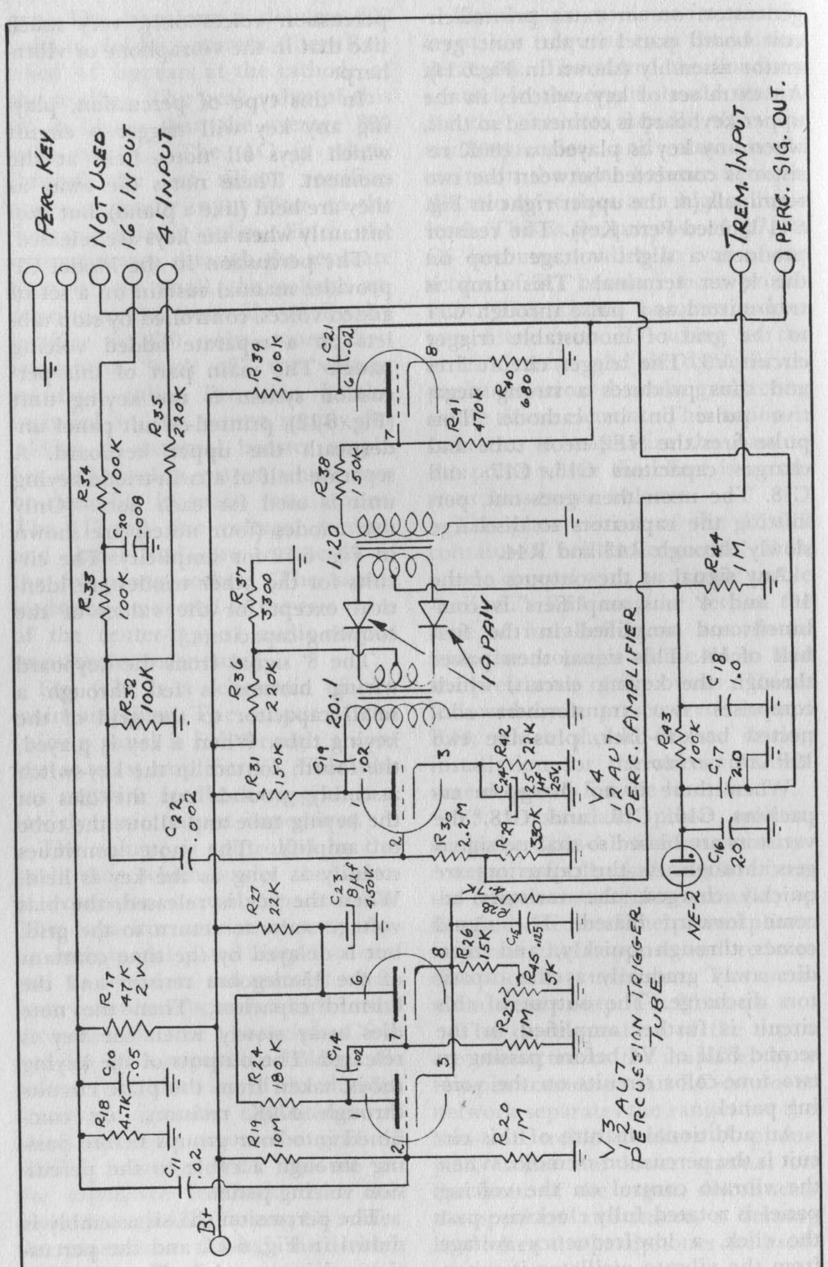


Fig. 6-11. Percussion circuit of the Model B.

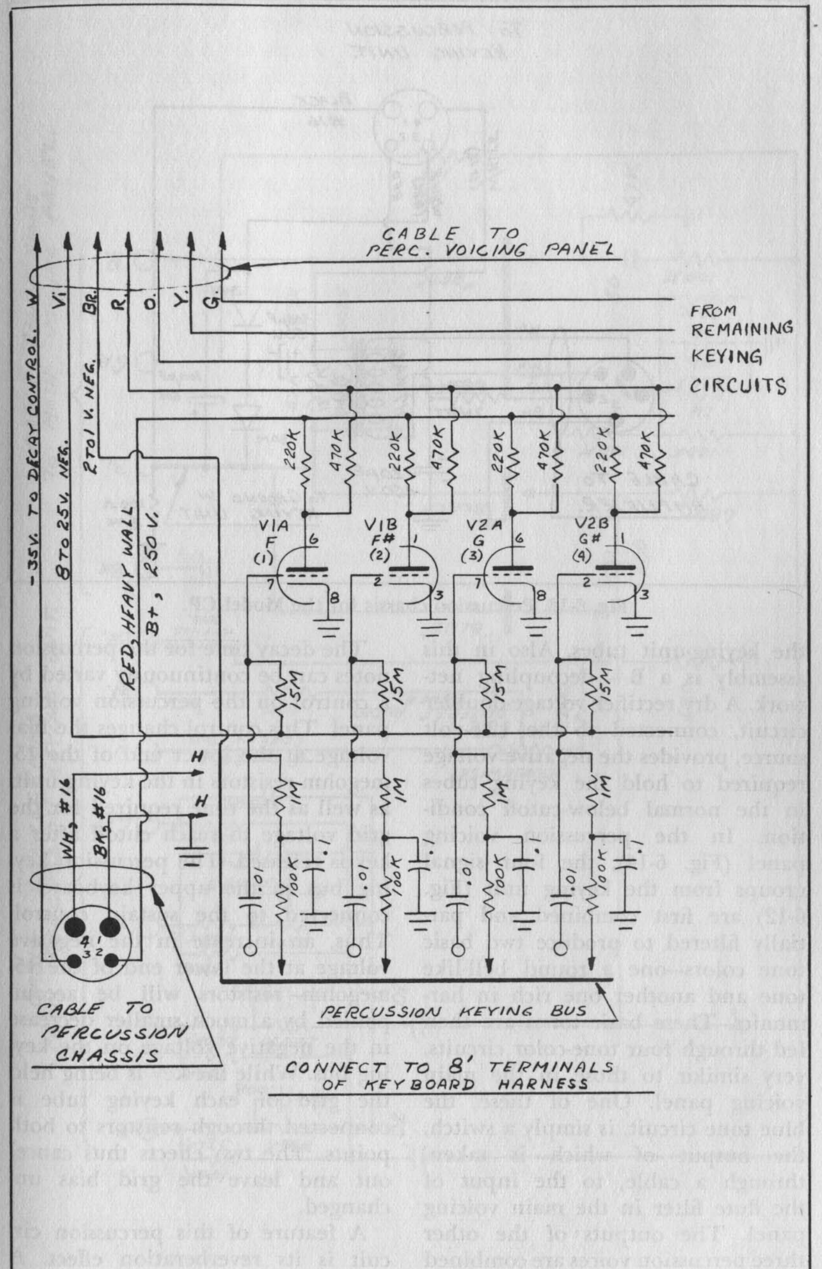


Fig. 6-12. Percussion keying circuit of the Model CP. (Note: For simplicity only four of the 44 individual keying circuits are shown.)

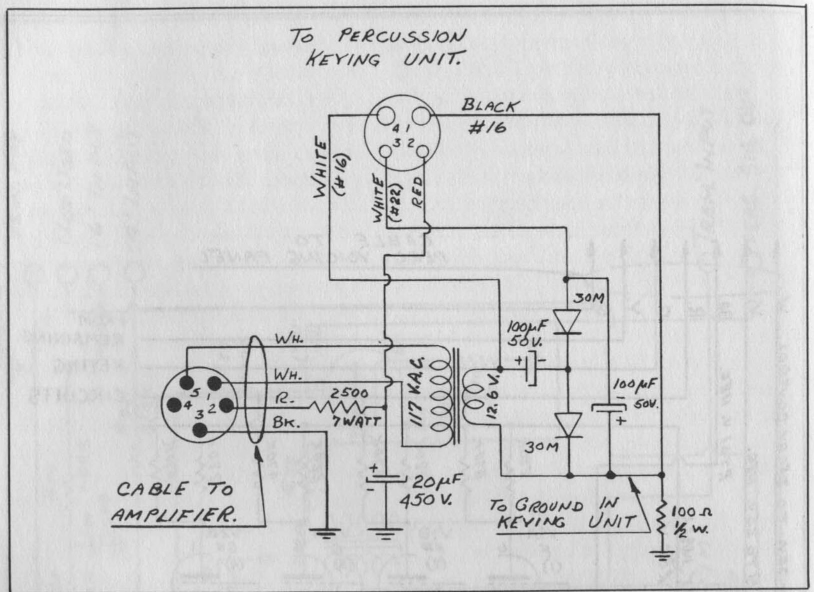


Fig. 6-13. Percussion chassis for the Model CP.

the keying-unit tubes. Also in this assembly is a B+ decoupling network. A dry rectifier voltage-doubler circuit, connected to the 12.6-volt source, provides the negative voltage required to hold the keying tubes in the normal below-cutoff condition. In the percussion voicing panel (Fig. 6-14), the four signal groups from the keying unit (Fig. 6-12) are first combined and partially filtered to produce two basic tone colors—one a round bell-like tone and another one rich in harmonics. These basic tones are then fed through four tone-color circuits, very similar to those in the main voicing panel. One of these, the blue tone circuit, is simply a switch, the output of which is taken, through a cable, to the input of the flute filter in the main voicing panel. The outputs of the other three percussion voices are combined and carried through a shielded lead to the output of the main voicing panel.

The decay time for the percussion notes can be continuously varied by a control on the percussion voicing panel. This control changes the bias voltage at the lower end of the 15-megohm resistors in the keying unit, as well as the time required for the grid voltage to reach cutoff after a key is released. The percussion keying bus in the upper keyboard is connected to the sustain control. Thus, an increase in the negative voltage at the lower end of the 15-megohm resistors will be accompanied by a much smaller decrease in the negative voltage on the keying bus. While the key is being held the grid of each keying tube is connected through resistors to both points. The two effects thus cancel out and leave the grid bias unchanged.

A feature of this percussion circuit is its reverberation effect. A small amount of the unfiltered signal from the percussion voicing panel is taken to the main voicing

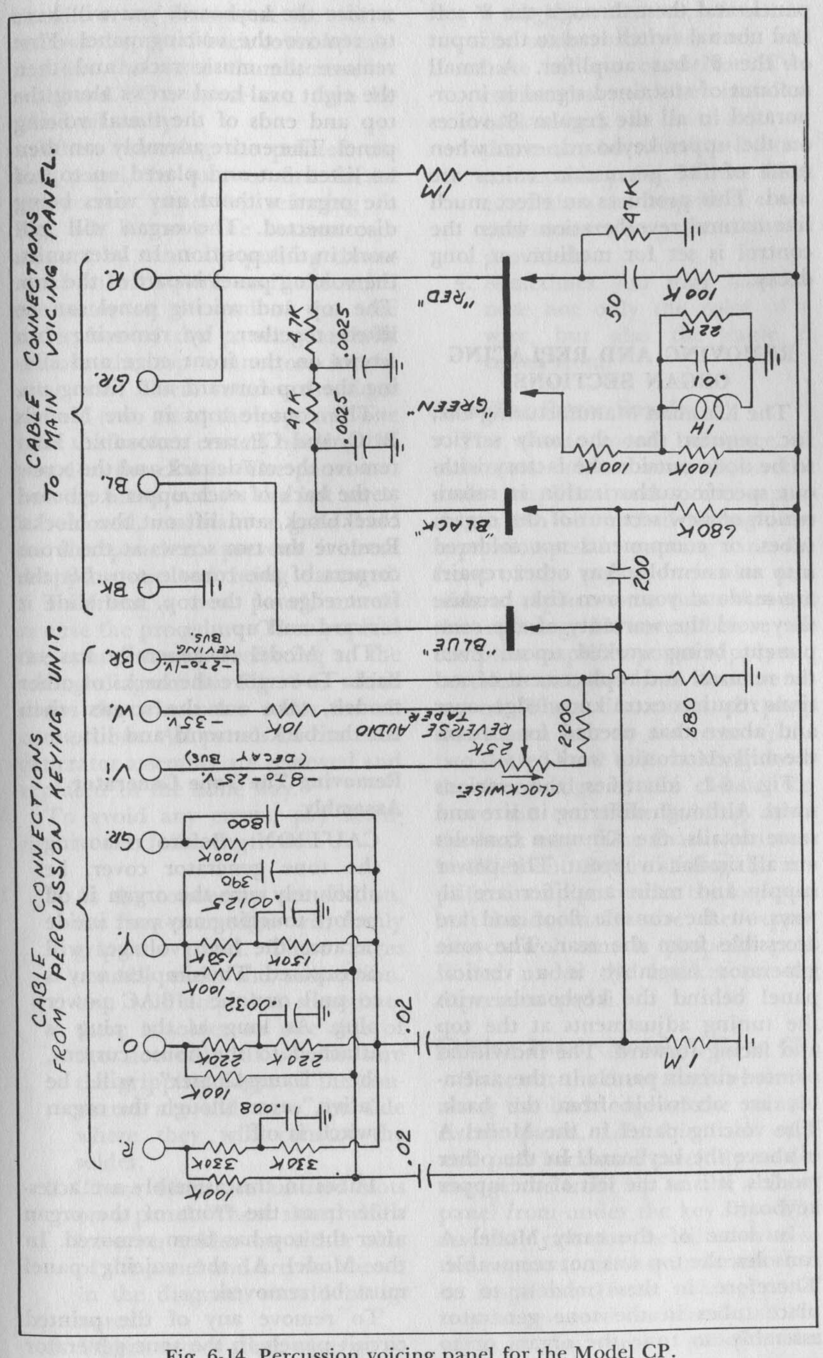


Fig. 6-14. Percussion voicing panel for the Model CP.

panel, and then through the 8′ soft and normal switch lead to the input of the 8′ bus amplifier. A small amount of sustained signal is incorporated in all the regular 8′ voices on the upper keyboard, even when none of the percussion voices are used. This produces an effect much like natural reverberation when the control is set for medium or long decay.

REMOVING AND REPLACING ORGAN SECTIONS

The Kinsman Manufacturing Co., Inc. request that the only service to be done outside the factory without specific authorization is substitution of new sections of the organ, tubes, or components not soldered into an assembly. Any other repairs are made at your own risk, because they void the warranty of the component being worked upon. Even the removal and replacement of sections requires extra knowledge, over and above that needed for run-of-the-mill electronics work.

Fig. 6-2 identifies the various units. Although differing in size and some details, the Kinsman consoles are all similar in layout. The power supply and main amplifier are always on the console floor and are accessible from the rear. The tone generator assembly is a vertical panel behind the keyboards, with the tuning adjustments at the top and facing forward. The individual printed-circuit panels in the assembly are accessible from the back. The voicing panel in the Model A is above the keyboard. In the other models, it is at the left of the upper keyboard.

In some of the early Model A consoles, the top was not removable. Therefore, in these models, to replace tubes in the tone generator assembly, to tune the organ, or to service the keyboard, you will have to remove the voicing panel. First remove the music rack, and then the eight oval-head screws along the top and ends of the metal voicing panel. The entire assembly can then be lifted out and placed on top of the organ without any wires being disconnected. The organ will still work in this position. In later units, the voicing panel is part of the top. The top and voicing panel can be lifted together, by removing two screws on the front edge and sliding the top forward and lifting up.

The console tops in the Models B, C, and CP, are removable. First remove the music rack and the screw at the back of each upper keyboard cheekblock, and lift out the blocks. Remove the two screws at the front corners of the console top, lift the front edge of the top, and slide it forward and up.

The Model A generally has no back. To remove the backs of other models, take out the screws; then tilt the back outward and lift.

Removing The Tone Generator Assembly

CAUTION: Before removing the tone generator cover, be absolutely sure the organ is off before touching any part inside because the high voltages will be exposed. The simplest way is to pull out the 110-AC power plug. As long as the plug is attached to the house current, the "Damp-Chaser" will be "alive," even though the organ switch is off.

Tubes in this assembly are accessible from the front of the organ after the top has been removed. In the Model A, the voicing panel must be removed.

To remove any of the printed circuit panels in the tone generator chassis, or to disconnect the wires, remove the metal back cover by taking out the three thumbscrews at each end. The cover can then be lifted off easily.

When removing the printed circuit panel, be sure to first locate the correct panel by referring to Fig. 6-2. Remove the bottom connectors by carefully pulling downward on each wire until the small connector on the end of the wire slides free of the panel. Carefully remove the top connectors in the same way. Then, remove the three screws, (two near the top and one near the bottom center) holding the panel to the chassis. The panel can now be lifted out. As the last screw is removed, maintain a good hold on the panel to prevent it from dropping out and being damaged.

To insert a new panel, merely reverse the procedure. Then replace the connections by referring to the wiring diagram in Fig. 6-6, which shows the wire color codes for all connections. All panels in the tone generator assembly are removed and replaced in the same way.

To avoid any errors, pay attention to the following notes:

1. As the connectors are slid on, the bent-over edges will firmly grip the panel. These *edges* actually make the connection. You will note that sometimes there is solder on one side of the slot only. If so, be sure the gripping edges of the connector are slid onto the side where they will contact the solder.
2. There often are unused slots on a panel. These slots, which have no solder on either side of the panel and are not shown in the diagram, should be ignored.
3. Where two or three wires go to a single connection, all will be the same color and each will have its own connector. Two connectors can be installed back-to-back in one slot, or there may be two slots for one connection point. Where three connectors are required, a second connection point is always provided.
4. Sometimes you may have to note not only the color of a wire, but also the cable it comes from.

Amplifier Power Supply

The vibrato speed, brilliance, or maximum volume controls on the main amplifier and power-supply chassis can be reached through the expression-pedal opening in the front of the organ. It is also possible to replace some tubes through this opening. However, before the complete amplifier-power supply can be taken out, the back must be removed. Then, disconnect all plugs and loosen (but do not remove) the two slotted-head bolts holding down the front edge of the chassis. Remove the two bolts holding down the back edge. The chassis can now be lifted out. Before sliding the amplifier into place under the loosened bolt heads, make sure the expression-control arm is properly positioned under the bracket on the expression pedal.

Voicing Panel (Model B, C, or CP)

Take out the three machine screws along the back edge of the printed circuit panel. Lift this back edge and pull backward carefully to disengage the front lip on the voicing panel from under the key slip. The assembly can now be lifted free so the contacts on the underside can be inspected. If the voicing panel is to be removed completely, all the wires in the voicing panel cables must be disconnected from the bus amplifier and pedal generator panels. The voicing-panel output cable will also have to be disconnected *from* the main amplifier.

Pedal Keyboard

The pedal keyboard will be easier to remove if the organ is stood on one end. (Use plenty of padding to avoid marring the console finish.) Take out the four bolts in the corners of the assembly. The assembly will now be free for inspection or contact adjustment. To remove the unit completely, the pedal-cable terminals will have to be disconnected from the tone-generator and pedal-generator panels. Also remove the cable clamps and carefully pull the cable out through the holes in the console shelf and floor.

Upper Keyboards (Models B, C, or CP)

Take out the bolt in the left rear corner, and the wire going to the lower keyboard fastened under this bolt. Then replace the bolt. Disconnect all upper-keyboard cable connectors from the tone-generator and bus-amplifier panels. Remove the clamps holding the cables in place, and cut any pieces of lacing cord or tape which may tie the keyboard cables to the others. The voicing panel cable must be disconnected so this panel can be removed with the keyboard, or else the voicing panel must be unfastened from the keyboard (as described earlier) in order that the keyboard can be removed without taking out the voicing panel. Remove the two hex-head bolts passing through the centers of the wooden mounting blocks at each end of the keyboard. The keyboard can now be lifted forward and out. Always be careful not to let the ends of the keyslip scratch the finish on the console.

Lower Keyboard

First, remove the upper keyboard as described. Then disconnect all lower-keyboard cable terminals. From underneath remove the three machine screws passing through an aluminum angle (part of the console) and into the front edge of the keyboard. Also from underneath, remove the two wood screws passing upward into each lower-keyboard cheekblock. Then lift out the cheekblocks. Remove the two hex-headed bolts (quite like the ones in the upper keyboard) passing through the end mounting blocks. This keyboard can now be lifted forward and out.

Percussion Panel (Model CP)

The percussion panel is removed by taking out the four flat-head screws passing upward from underneath.

TUNING THE KINSMAN ORGAN

Tuning a Kinsman organ is an elementary operation. Unlike a piano, the tones in an organ can be held for tuning. In the Kinsman organ there are only twelve tuning adjustments, one for each note of one octave. The *A* adjustment tunes all six *A's plus* the additional 16′ pedal *A*—or seven notes in all. Only twelve adjustments are necessary, all in proper relationship.

This relationship is characteristic of the equally-tempered scale on all keyboard instruments. The scale involves a compromise required by the limitation to twelve fixed notes to the octave. The musical fourth and fifth intervals are tuned to a frequency ratio slightly different from an exact zero beat (in other words, no audible roll). If a musical fifth interval were tuned to an exact frequency ratio of 1.5 to 1, there would be no beat. However, the tempered-scale ratio is 1.498 to 1. The second harmonic of one note and the third harmonic of the other, although not exactly alike, are close enough to produce an audible beat because their frequency ratio is 2.996 to 3.

To tune the organ, it is only necessary to go through a sequence of musical intervals and tune each one to the correct frequency ratio, which is determined by listening to the beats.

The tuning table shows this method of tuning by counting beats. If carefully done, precise results can be achieved. However, the tempered scale itself is a compromise, with every musical interval differing slightly from the ideal pitch relationship. Otherwise, there would be no beats. Extreme accuracy in tuning therefore is unnecessary, since any slight errors will only result in a slightly different compromise which is probably as good as the tempered scale itself. However, the beat for each interval must be as correct as possible, and on the correct side of the zero beat (that is, a note which should be tuned flat with respect to zero beat must not be tuned sharp, even though the same beat count may result). If the procedure is carried out accurately, the final check between F3 and C4 will show the correct beat. But if errors are made anywhere, the beat for this check interval will not be correct. The entire procedure will then have to be repeated.

Tuning Chart

Table 6-1 gives the proper procedure for tuning the Kinsman organ. Before doing so, make sure the vibrato is turned off. Then select an 8′ stop. (The 8′ diapason is good.) First tune *C* to some standard, such as a C523.3 tuning fork, until you hear no beat. Then hold down middle *C* (C3) and G3 (the fifth interval above middle *C*). Tune *G* to an exact fifth, or no beat, and then flat (counterclockwise) until you can count approximately ten beats in ten seconds, as shown in Table 6-1. Then, in turn, tune each of the other notes by holding down the two keys shown in the first two columns. Tune for zero beat, and then flat, until you can count the approximate number of beats in the third column.

To insure against tuning drift or jumping because of loose tube elements after the tuning is completed, tap the tube associated with each adjustment and listen to the beat. If the pitch shifts, change the tube.

If the final check interval between F3 and C4 does not sound the correct beat, the procedure must be repeated.

MALFUNCTIONS

The following descriptions show which sections of the organ may be at fault. Do not be fooled into thinking a defect exists where the condition is part of the organ design. A typical example is an owner who complains the lowest half-octave of the lower manual repeats the same notes as the above on the 16′ melodia stop. This is part of the organ design.

Diagnosis

The various stops and controls of the Kinsman organ (including those not readily accessible to the organist) can be used, along with the block diagram in Fig. 6-3, to pinpoint a source of trouble. The block diagram traces the flow of normal operations from each unit, or major assembly, to the next unit—from the tone generators to the speakers. This enables the troubleshooter to find

TABLE 6-1. TUNING CHART

Hold This Note (or Standard)	*Tune This Note*	*Practical Number of Beats Flat in 10 Seconds to Use for Tuning*	*Theoretical Number of Beats in 10 Seconds (for Equal Temperament)*
C fork 523.3 cps or *C* above middle *A* on a piano	C4, one octave above middle *C*	Unison, no beat	0.0
C3 (middle *C*)	G3 (5th interval up)	10	8.8
G3	D3 (4th interval down)	14	13.3
D3	A3 (5th interval up)	10	9.9
A3	E3 (4th interval down)	14	14.9
E3	B3 (5th interval up)	10	11.2
B3	F3 (4th interval down)	14	16.7
F#3[1]	C#3 (4th interval down)	14	12.5
C#3	G#3 (5th interval up)	10	9.4
G#3	D#3 (4th interval down)	14	14.0
D#3	A#3 (5th interval up)	10	10.5
A#3	F3 (4th interval down)	14	15.8
F3	C4 (5th interval up)[2]	10	11.8

[1] To stay within the octave, tune a 4th interval down twice in succession. Since a 4th interval is the inversion of the 5th, tuning F#3 down to C#3 is the same as tuning a 5th interval up to C#4.

[2] Check only, do not tune. The beat should be 10 to 11.8.

the trouble by the process of elimination.

By using the various stops and controls, or the plugs and the various connectors between units, and by working backward from the amplifier output stage to the tone generators, you can isolate the fault to a specific stage. This order is usually modified by a check of the easier-to-reach controls first.

Suppose the organ hums loudly when turned on. First operate the expression-control pedal. If the hum becomes louder and softer, it must be coming through the expression control, not in the output stage of the amplifier. Now check the top volume control on the amplifier, and then the amplifier input (by disconnecting the gray plastic cable at the end of the amplifier nearest the expression pedal). If each check affects the hums, we have eliminated first the intermediate and then the input stages to the amplifier.

Turn off all the stop tablets. Assume the hum stops. The entire amplifier and part of the voicing panel circuitry can now be eliminated. Turn the stops back on, one at a time. If the hum is heard only when one or more of the 8′ lower keyboard stops are on, some part of the organ common to these stops and no others is defective. The most likely place is the 8′ lower-keyboard section of the bus amplifier, and the most likely defective component is the 12AU7 tube. You can locate this tube on the bus amplifier panel by referring to the schematic, or you can replace the 12AU7 tubes on the bus amplifier panel, one at a time, until the trouble clears up.

Remember that although there are stops of only three different footages on each keyboard of the Models B, C, and CP, there are a total of not six, but eight, bus amplifier sections. This is due to the outphasing circuits. Thus, in testing for faulty outphased stops, 16′ tibia (and on the Model C and the CP, bass clarinet) and 8′ stopped flute, English horn, and clarinet must be considered separately from the other 16′ and 8′ stops.

Suppose we have a bad note, such as a sputtering or warbling sound, or one that is badly off pitch. The trouble is almost certain to be in the tone generator for that note. To verify our suspicions, listen with one stop on at a time. Each generator note occurs at several places on the keyboards. When similar stops on both keyboards are at fault, the defect, if in the generator, will be heard on both. By changing from an 8′ to a 4′ stop and simultaneously moving down one octave on the keyboard, we will hear the same generated tone.

It is important to remember the frequency-divider principle used in the Kinsman organs. Each note is derived, in the tone generator, from the next higher octave of the same note. Failure of any frequency-divider stage will show up as a faulty note, not only at the particular pitch, but also at all lower octaves of the same note. Therefore, you must determine whether the fault is originating in the master oscillator at the head of the chain—or whether it is in a later stage, meaning the entire generator panel for that note must be replaced. First, turn on the upper-keyboard 4′ flute stop only (octave Fife in the Model A). Listen to the bad note in the top octave of the keyboard. If dead or off pitch, the trouble is in the master oscillator and can probably be corrected by replacing the 12AX7 tube. If the top octave is functioning properly or if replacing the 12AX7 does not help, the printed circuit panel will have to be replaced.

When a pedal note is bad or completely dead, check the pedals above it. A bad back contact on one note will affect all notes above. Make sure a loop of the power cord isn't caught under the back of the pedal keyboard. If the fault is in a single pedal note, listen to the lowest octave of the same note on a manual keyboard. Be sure it is the lowest generated octave. The lowest generated octave from *C* to *E* can be heard with only the 16′ melodia stop on the lower keyboard. If the fault is here also, it is originating from the tone generator for that note. The generator must then be replaced. If not, there may be a loose connector at the bottom of the tone generator panel.

Again be careful not to be misled by secondary symptoms. Suppose the 4′ upper-keyboard output from the bus amplifier should become disconnected. The main symptoms would be dead 4′ stops. By trying the stops one at a time, you would quickly discover the trouble. However, if you did not, you might notice another confusing symptom.

With no stops on, you would hear a weak 4′ signal, stringlike in tone color. With 8′ or 16′ full bodied stops (flute, tibia, etc.), this stringlike 4′ tone would alter the 8′ or 16′ tone color. By reading the technical description of the voicing panel, you will see how the trimmer capacitors—provided to cancel out leakage signals—could cause this. For this reason, if you are confronted with a confusing symptom, first, look for another, more straightforward one.

Typical Symptoms

Some of the more common troubles, their causes, and the remedies for each are given in the following.

Dead Notes—When dead notes are encountered, check to see if they are dead on all stops of the same footage. If so, the cause is probably a faulty bus amplifier tube or a defect in the circuit. Check the connectors to make sure all are in place; if so, replace the tube. If this doesn't correct the defect, replace the bus amplifier panel.

If one stop is dead and the other stops of the same footage are all right, the defect is probably in the voicing panel, switch, or connecting eyelet. Lift and inspect the voicing panel. If the trouble cannot be found, replace the panel.

One dead note in all positions of one keyboard (the other octaves of the same note are all right) indicates the output connector at the tone generator is probably pulled off. Replacing the connector should correct the trouble. A dead or intermittent note in one position of one keyboard when the other positions are all right indicates a defect in the keyboard, broken connections, or a bent switch blade. Inspect the keyboard; if the fault is not easily corrected, consult the factory for instructions or a replacement keyboard.

Hum—A loud hum when stops of one footage are on usually indicates a heater-to-cathode short in the 12AU7 tube in the bus amplifier. If replacing the tube does not correct the trouble, replace the bus amplifier panel.

Bad Notes—A defective frequency-divider stage in a tone generator will produce a rough or choppy note, or a note away off pitch. Lower octaves of the same note will also be bad, but the top octave will be all right. The effect may be worse with full or almost full vibrato. To correct this condition, replace the tone-generator panel. If the top octave is also bad or dead, the master oscillator in the tone generator is probably defective. Replace the 12AU7 tube. If tube replacement does not correct the fault, replace the tone-generator panel. When a note appears scratchy as a key is depressed, the key-switch assembly is probably dirty. It can usually be cleaned by operating the key rapidly. If not, the bus should be cleaned (by qualified persons only).

Console Rattles—This fault is usually more noticeable when notes of a certain pitch are played; it will

tend to clear up when the volume is depressed. A console rattle is usually caused by a loose part in the console, or loose screws in the treble speakers. Locate the rattle and tighten the offender.

Defective Pedal Notes—If all pedal notes from a certain one to the top of the pedal keyboard are dead, look for a defective contact on the highest operating key switch. Also check to see that the power cord or carpet is not interfering with the pedal operation. Should all 16′ pedal notes sound at 8′ pitch, the pedal-frequency divider is out or the 16′ pedal-generator output is disconnected. Change the 12AU7 pedal tube. If necessary, replace the panel.

No Vibrato—No vibrato usually indicates a defective 12AX7 tube in the amplifier. If replacing the tube does not correct the defect, replace the amplifier panel.

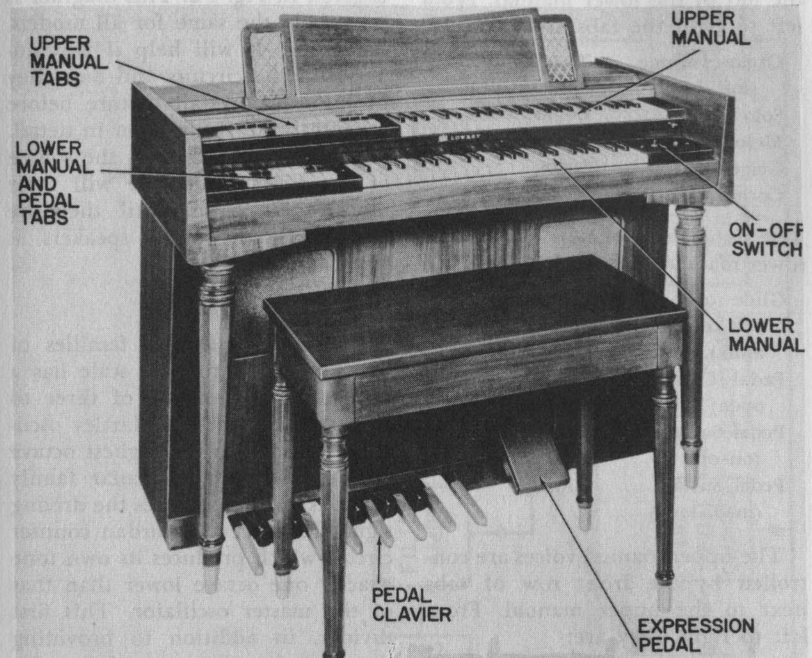


Fig. 7-1. A typical Lowrey electronic organ.

CHAPTER 7

THE LOWREY ELECTRONIC ORGAN

A typical Lowrey electronic organ with the principal components labeled is shown in Fig. 7-1. Each manual has 44 keys, and the pedal clavier contains 13 pedals. Models S, SS, and DS are covered in this chapter. All are very similar; where differences do exist, they will be pointed out in our discussion.

TAB SWITCHES

The lower manual voices are controlled by the front row of tabs to the left of the lower manual. From left to right the tabs are:

Organ volume (soft–full)	Trombone
	French Horn
Solo	English Horn
Melodia	Vox Humana
Geigen	String
Cornet	

The second row of tabs next to the lower manual is (from left to right).

Glide (on–off)	Pedal (soft)
Glide (cont.–auto.)	Pedal (med.)
	Pedal (full)
Pedal 16′ (mute–open)	8′–4′ upper to lower (off–on)
Pedal Sustain (on–off)	8′–4′ upper to lower (soft–loud)
Pedal Sustain (med.–long)	

The upper manual voices are controlled by the front row of tabs next to the upper manual. From left to right, they are:

Trombone 16′	Trumpet 8′
Flute 16′	Oboe 8′
Gedekt 16′	Saxophone 8′
Cello 16′	String 8′
Solo 8′	Flute 4′
Flute 8′	String 4′
Clarinet 8′	Quint 5⅓′
Principal 8′	

The rear group of tabs next to the upper manual controls the various percussion effects. From left to right they are:

Staccato (on–off)	Vibraharp
Manual attack (fast–slow)	Guitar
	Music Box
Sustain (on–off)	Vibrato (slow–fast)
Sustain (med.–long)	
	Vibrato (light–heavy)
Chimes	
Accordian	Vibrato (on–off)
Harpsichord	

BLOCK DIAGRAM

The block diagram of the organ is given in Fig. 7-2. This diagram is essentially the same for all models. Therefore, it will help if you understand the circuits and how they fit into the over-all picture before attempting to study them in detail. A good starting point is the source of the tones, which we will trace along their paths until they are emitted by the organ speakers as musical tones.

Tone Generators

Each of the twelve families of tones in the chromatic scale has a tone chassis consisting of three to five vacuum tubes. A Hartley oscillator is tuned to the highest octave required for the particular family of tones. It also provides the driving signal for an Eccles-Jordan counter circuit which produces its own tone exactly one octave lower than that of the master oscillator. This first divider, in addition to providing the tone for its proper keys, also drives another Eccles-Jordan counter circuit that provides a next-octave-lower tone. Depending upon the model, two, three, or four counter circuits—all controlled by the master-oscillator frequency—are coupled together.

Key Switches

The tones generated (AC at this point) are passed to the key switches, which are activated by the organ keys. These switches ground the tones when the keys are in the rest position. When the keys are depressed, the switches pass the tones on along a path that will eventually lead to the speaker. Sustained tones are not passed directly to the key switches, but are keyed by a voltage applied to the key switches.

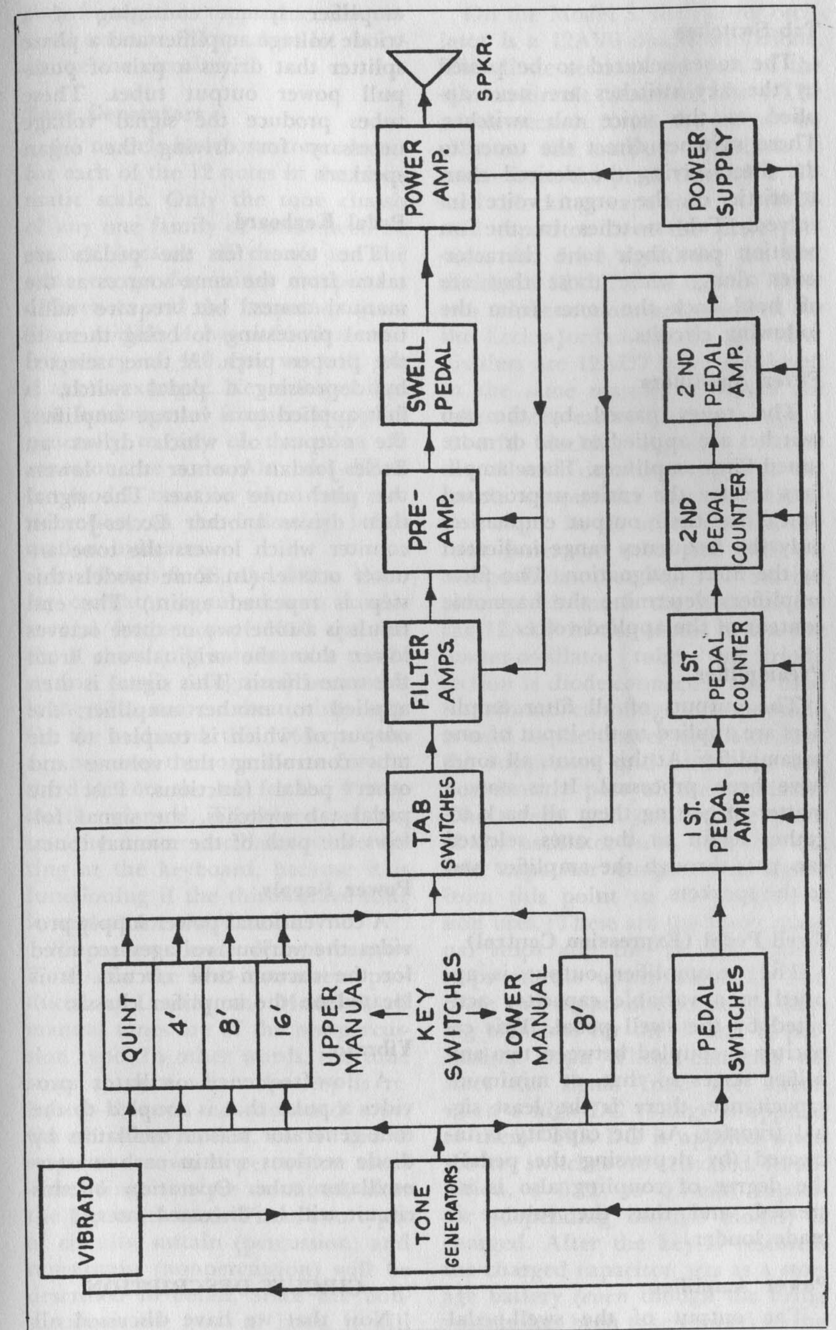


Fig. 7-2. Block diagram of the Model S organ.

Tab Switches

The tones selected to be passed by the key switches are next applied to the voice tab switches. These switches direct the tones to the filters giving the desired characteristic of the organ voice involved. Tab switches in the on position pass their tone characteristics along, while those that are off hold back the tones from the following circuits.

Filter Amplifiers

The tones passed by the tab switches are applied to one or more tuned filter amplifiers. These amplifiers receive the entire unprocessed tones, but their output emphasizes only the frequency range indicated by the filter designation. The filter amplifiers determine the harmonic content of the applied voice.

Preamplifier

The outputs of all filter amplifiers are applied to the input of one preamplifier. At this point, all tones have been processed. It is now a matter of getting them all back together again so the ones selected can pass through the amplifier and to the speakers.

Swell Pedal (Expression Control)

The preamplifier output is applied to a variable capacitor activated by the swell pedal. This capacitor is coupled between two amplifier stages so that, at minimum capacitance, there is the least signal transfer. As the capacity is increased (by depressing the pedal), the degree of coupling also is increased, and thus the volume is made louder.

Power Amplifier

The output of the swell-pedal capacitor is applied to an audio-amplifier system consisting of a triode voltage amplifier and a phase splitter that drives a pair of push-pull power output tubes. These tubes produce the signal voltage necessary for driving the organ speakers.

Pedal Keyboard

The tones for the pedals are taken from the same sources as the manual tones, but require additional processing to bring them to the proper pitch. A tone, selected by depressing a pedal switch, is first applied to a voltage amplifier, the output of which drives an Eccles-Jordan counter that lowers the pitch one octave. The signal then drives another Eccles-Jordan counter which lowers the tone another octave. (In some models this step is repeated again.) The end result is a tone two or three octaves lower than the original one from the tone chassis. This signal is then applied to another amplifier, the output of which is coupled to the tabs controlling the volume and other pedal functions. Past the pedal tab switches, the signal follows the path of the manual tones.

Power Supply

A conventional power supply provides the various voltages required for the vacuum-tube circuits. It is located on the amplifier chassis.

Vibrato

A low-frequency oscillator provides a pulse that is coupled to the tone-generator master oscillators by diode sections within each master-oscillator tube. Operation of this circuit will be discussed later.

CIRCUIT DESCRIPTION

Now that we have discussed all of the blocks, and determined how

they fit together to produce the desired tones at the speaker, let us examine the circuitry.

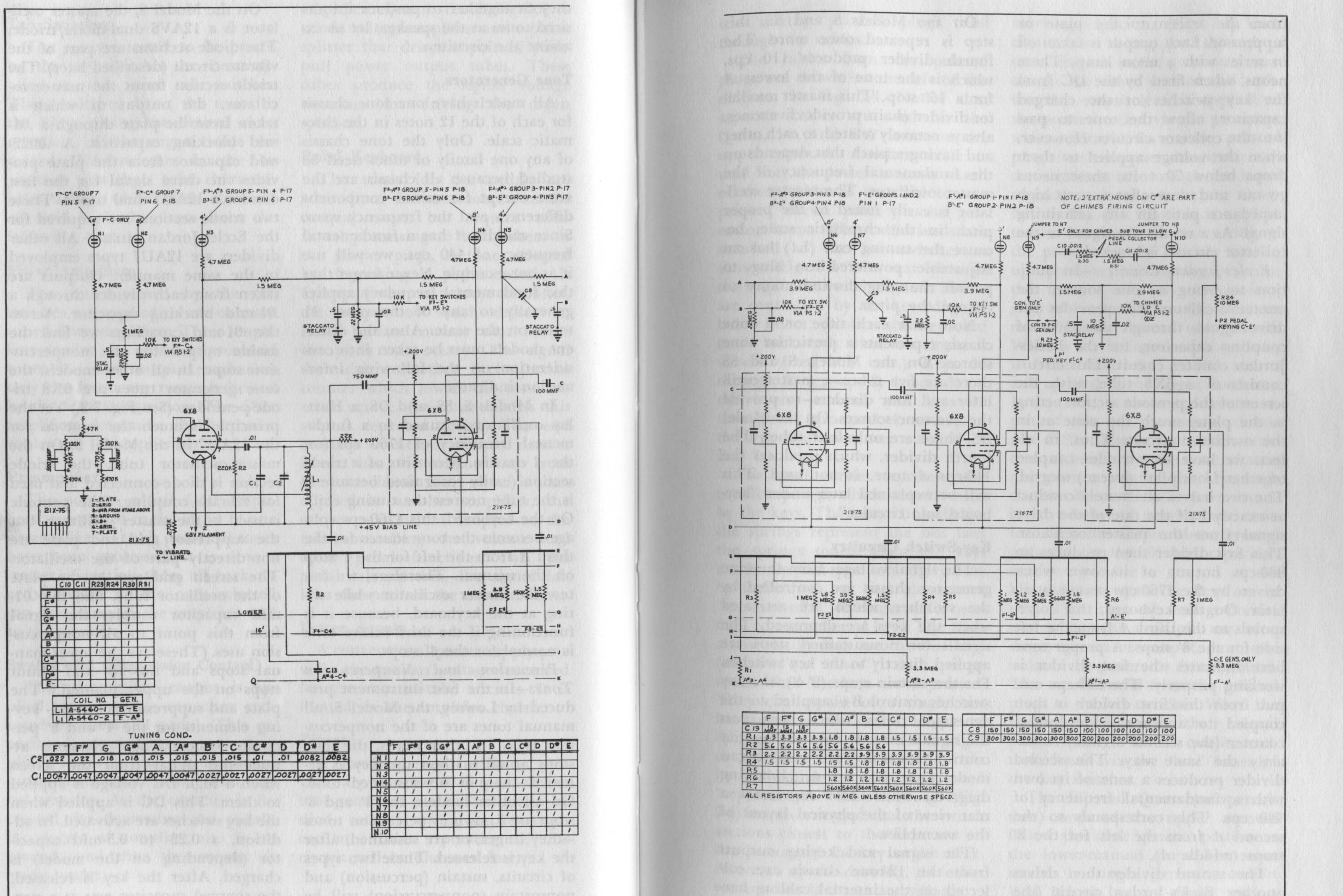
Tone Generators

All models have one tone chassis for each of the 12 notes in the chromatic scale. Only the tone chassis of any one family of tones need be studied because all chassis are the same except for minor component differences and the frequency span. Since middle *A* has a fundamental frequency of 440 cps, we will use it as our example. Never forget that this fundamental frequency applies generally to any of the other 11 tones on the scale. Also, the different models must be taken into consideration, as the following information indicates.

In Models S, SS, and DS, a Hartley oscillator is tuned to a fundamental frequency of 1760 cps (on the *A* chassis). It consists of a triode section (easily recognized because it is the tube nearest the tuning coil). On the keyboard, this 1760-cps voltage becomes the tone source for the third *A* from the left for the 4′ stop on the manual. Therefore, we can test the master oscillator while sitting at the keyboard, because it is functioning if the third-octave tone is normal for the 4′ stops.

Percussion and Nonpercussion Tones—In the first instrument produced by Lowrey, the Model S, all manual tones are of the nonpercussion type. In other words, the tone stops at once when the key is released—there is no sustained tone. On all other models, the 4′ and 8′ stops are known as percussion tones—they linger, or are sustained, after the key is released. These two types of circuits, sustain (percussion) and nonsustain (nonpercussion) will be described in detail. Since the nonsustain is the basis of both, it will be described first.

On the Model S, the master oscillator is a 12AV6 dual-diode/triode. The diode sections are part of the vibrato circuit (described later). The triode section forms the master oscillator, the output of which is taken from the plate through a .01-mfd blocking capacitor. A .0022-mfd capacitor from the plate provides the drive signal for the first divider, a 12AU7 dual triode. These two triode sections are required for the Eccles-Jordan circuit. All other dividers are 12AU7 types employed in the same manner. Outputs are taken from each divider through a .01-mfd blocking capacitor. Across the .01-mfd capacitors we find the usable output for the nonpercussion stops. In all other models, the tone generator tubes are 6X8 triode-pentodes. (See Fig. 7-3.) Yet the principle is much the same as for the 12AU7 in the Model S. On the master-oscillator tube, the triode section is diode-connected and used for vibrato coupling. The pentode is used as the master oscillator, but the suppressor grid and plate are not directly part of the oscillator. The screen grid acts as the plate of the oscillator tube, and the .01-mfd capacitor couples the signal from this point to all nonpercussion uses. (These are the lower manual stops and the 16′ and Quint stops on the upper manual.) The plate and suppressor act as B+ keying elements for the 4′ and 8′ percussion stops. These elements attract the signal from the screen when a high DC voltage is applied to them. This DC is applied when the key switches are activated. In addition, a 0.22- to 0.5-mfd capacitor (depending on the model) is charged. After the key is released, the charged capacitor acts as a storage battery (*even* though the firing voltage has been taken away) so the signal can continue to be drawn



	C10	C11	R23	R24	R30	R31
F	/		/		/	
F#	/		/		/	
G	/		/		/	
G#	/		/		/	
A	/		/		/	
A#	/		/		/	
B	/		/		/	
C	/	/	/	/	/	/
C#		/		/		/
D		/		/		/
D#		/		/		/
E-		/		/		/

	COIL NO.	GEN.
L1	A-5460-1	B-E
L1	A-5460-2	F-A#

TUNING COND.

	F	F#	G	G#	A	A#	B	C	C#	D	D#	E
C2	.022	.022	.018	.018	.015	.015	.015	.015	.01	.01	.0082	.0082
C1	.0047	.0047	.0047	.0047	.0047	.0047	.0027	.0027	.0027	.0027	.0027	.0027

	F	F#	G	G#	A	A#	B	C	C#	D	D#	E
N1	/	/	/	/	/	/	/	/				
N2	/	/	/	/	/	/	/	/				
N3	/	/	/	/	/	/	/	/	/	/	/	/
N4	/	/	/	/	/	/	/	/	/	/	/	/
N5	/	/	/	/	/	/	/	/	/	/	/	/
N6	/	/	/	/	/	/	/	/	/	/	/	/
N7	/	/	/	/	/	/	/	/	/	/	/	/
N8	/	/	/	/	/	/	/	/	/	/	/	/
N9												/
N10												/

	F	F#	G	G#	A	A#	B	C	C#	D	D#	E
C13	15 MMF	15 MMF	15 MMF									
R1	3.3	3.3	3.3	3.3	1.8	1.8	1.8	1.8	1.5	1.5	1.5	1.5
R2	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6				
R3	2.2	2.2	2.2	2.2	2.2	2.2	3.9	3.9	3.9	3.9	3.9	3.9
R4	1.5	1.5	1.5	1.5	1.5	1.5	1.8	1.8	1.8	1.8	1.8	1.8
R5					1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
R6					1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
R7					560K	560K	560K	560K	560K	560K	560K	560K

ALL RESISTORS ABOVE IN MEG UNLESS OTHERWISE SPECD.

	F	F#	G	G#	A	A#	B	C	C#	D	D#	E
C8	150	150	150	150	150	150	100	100	100	100	100	100
C9	300	300	300	300	300	300	200	200	200	200	200	200

Fig. 7-3. Model SS tone generator schematic.

from the screen to the plate or suppressor. Each output is taken off in series with a neon lamp. These neons, when fired by the DC from the key switches or the charged capacitor, allow the tone to pass into the collector circuits. However, when the voltage applied to them drops below 70 volts, these neons go out and thus offer a very high impedance path for any remaining signal. As a result, the signal to the collector circuits is blocked.

Eccles-Jordan Counters—In addition to being a tone source, the master oscillator also provides the drive signal, through the 750-mmf coupling capacitor, for the Eccles-Jordan counter circuit. This circuit consists of a 6X8 tube, with the screen of the pentode section acting as the plate, much the same as in the oscillator circuit. Thus, in effect, we have two triodes coupled together from plate (screen) to grid. The two halves alternately conduct at exactly half the rate of the drive signal from the master oscillator. This first divider then produces an 880-cps output of its own when driven by the 1760-cps master oscillator. On the keyboard, this corresponds to the third *A* from the left side for the 8′ stops. A proper tone here indicates the first divider is working properly. The 880-cps output from this first divider is then coupled to another Eccles-Jordan counter (the second divider) in exactly the same way. The second divider produces a tone of its own with a fundamental frequency of 440 cps. This corresponds to the second *A* from the left for the 8′ stops (middle *A*).

The second divider then drives another Eccles-Jordan circuit (the third divider) which produces a 220-cps output of its own. This is the lowest *A* on the keyboard for the 8′ stops.

On the Models S and SS, this step is repeated once more. The fourth divider produces 110 cps, which is the tone of the lowest *A* for a 16′ stop. This master oscillator-divider chain provides five tones, always octavely related to each other and having a pitch that depends on the fundamental frequency of the master oscillator. The master oscillator is easily tuned to the proper pitch in the chromatic scale, because the tuning coil (L1) has an adjustable powdered-iron slug to permit changing the inductance to change the pitch.

Note that each tube on a tone chassis represents a particular tone source. On the Models S and SS there are five tubes—a master oscillator and four dividers—to provide the five tone sources. On the Model DS, there are only four tubes. The fourth divider, which produces the 110-cps *A* tone, is not used. This will be explained later under "keyboard solo circuits."

Key-Switch Circuitry

The signal voltages from the tone generator chassis are controlled by the switches, which are activated when the keys are depressed. The signals for nonsustained stops are applied directly to the key switches. For the sustain stops (8′-4′), the key switches control B+ applied to the generator tubes, which then pass the signals directly into the quality control chassis. For each organ model there is a key-switch wiring diagram, which also represents a rear view of the physical layout of the assemblies.

The signal and keying outputs from the 12-tone chassis are collected on the internal cabling harness and applied to a group of printed sockets on the generator frame. The path toward the key switches then continues on through

the mating printed plugs, and through the cables.

The cables from the printed plugs are shown on the left of the diagram in Fig. 7-4. Notice that separate cables are used for the Quint, 16′, and 8′-4′ tones on the upper manual. Another cable is used for the lower manual. Each of these cables is attached to two printed circuit plugs on the generator frame. The cable leads are attached to the key switches as shown. Fig. 7-4 is a rear view of the organ; the switch sections shown are controlled by the keys directly below them. (Notice the keyboard reads backwards when the organ is viewed from the rear.) Keys 15 through 32 (groups 3, 4, and 5) on the lower manual, and keys 13 through 30 (groups 3, 4, and 5) on the upper manual, are omitted in Fig. 7-4.

The small circles represent the contact springs, which are activated by the keys. The heavy lines below the springs represent the bus bars the springs touch when the keys are in the rest position. They may be individual bus bars, designated "separate offs," or longer units common to a number of keys. The lines above the springs are the bus bars (called "on buses") the springs touch when the keys are depressed. They can consist of a single bus bar running the entire length of the keys, or groups of six or eight or multiples thereof. Or they can be individual bus bars, designated "separate ons." The drawings (Fig. 7-4) are so arranged that the switch sections closest to the keys are on the bottom of the key switch deck. As we go up the drawing, the other sections are laid out accordingly.

Let us first consider the lower-manual, nonsustain, key-switch circuits. The tone-generator outputs are taken through the .01-mfd blocking capacitors (Fig. 7-3), each output first being put through a series resistor in the generator chassis. At the other end of this resistor, the output lead is applied to the printed socket via the generator wiring harness. Its mating printed plug then continues the circuit and the signal enters through the lower manual cable shown at the lower left in Fig. 7-4. Here it is applied to the key-switch contact spring of the proper key. In the key rest, or up, position, this spring rests on the lower "off" bus, which is a *ground return*. Thus, the tone remains silent when not played. When a key is depressed, the spring is lifted from the ground return and applied to the upper "on" bus. It, in turn, is connected to the input of the quality control chassis (via P-20). The output series resistors, although on the tone chassis, are more a part of the key-switch circuit. Because each tone source has a number of usages, these resistors keep the output above ground potential at the .01-mfd capacitor, and yet provide a ground at the key switches when the keys are at rest. This type of voltage-divider system permits multiple use of a single generator output, and also isolates the generator from ground. The tonal flow is from the printed plugs to the key switches. When the keys are depressed, their signal passes through to the quality control chassis via the "on" buses of the key switches.

The 16′ and Quint (nonpercussion) stops of the upper manual follow the same general pattern as the lower-manual stops. On some models a single generator-output lead brings both a Quint and a 16′ tone to the key switches. The tone is first brought to the associated 16′ switch spring with which there is a "separate off," which is

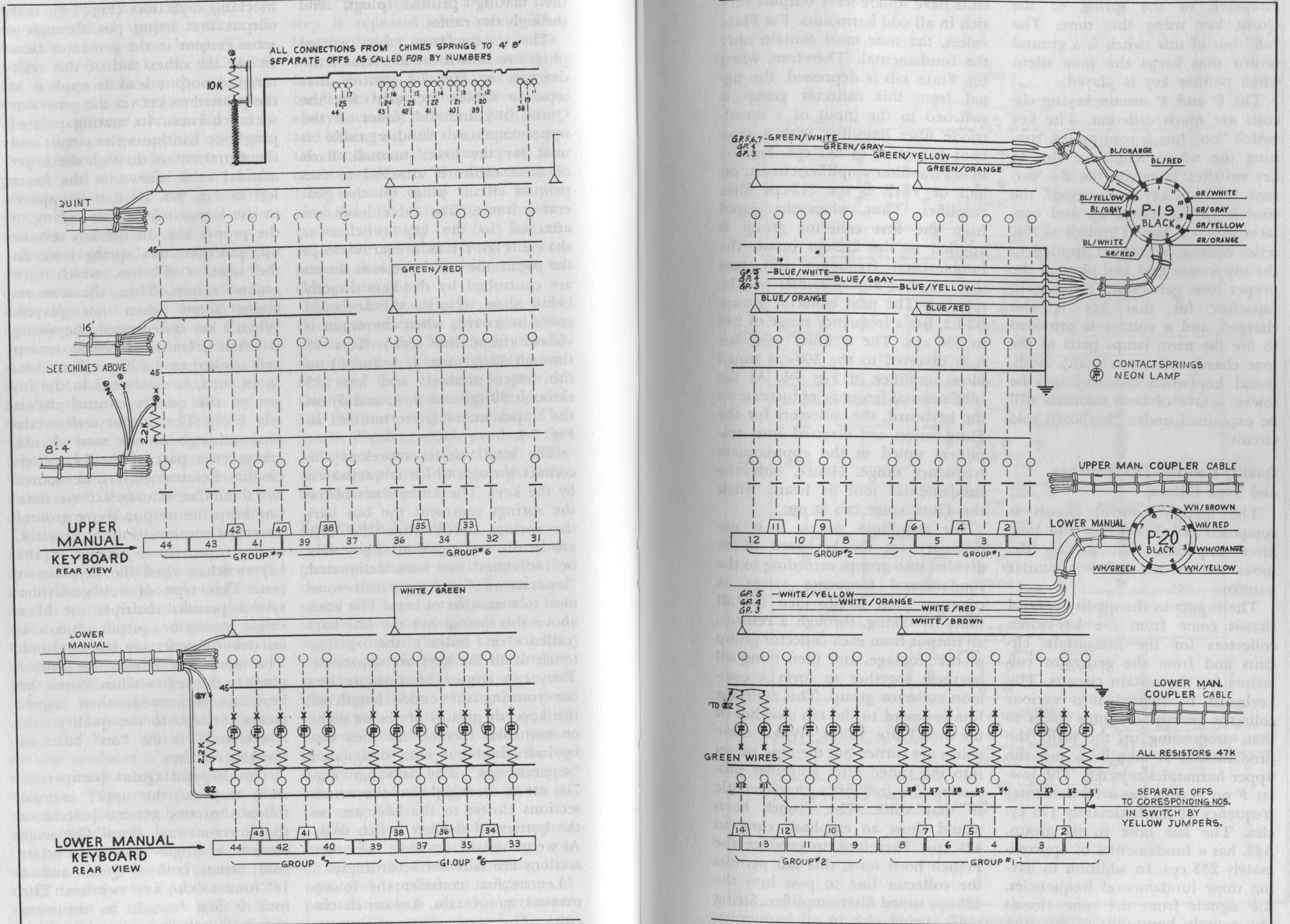


Fig. 7-4. The key-switching circuits.

jumpered to the spring of the Quint key using this tone. The "off" bus of this switch is a ground return that keeps the tone silent when neither key is played.

The 8′ and 4′ sustain keying circuits are much different. The key switch "on" bus is continuous, running the whole length of the 44 key switches. It carries the B+ current. When a key is depressed, the contact spring moves up and contacts this bus bar. Through a 10K series resistor, voltage is applied to the suppressor grid and plate of the proper tone generator. The sustain capacitor for that key is also charged, and a voltage is provided to fire the neon lamps (part of the tone chassis collector circuit). Additional key-switch circuitry for the lowest octave of both manuals will be explained under "keyboard solo circuit."

Quality-Control–Tab Switches and Tone Filters

The quality control chassis is composed of tab switches and tone filter amplifiers that process the tones. All models follow a similar pattern.

The inputs to the quality control chassis come from the key-switch collectors for the nonsustain circuits and from the generator collectors for the sustain circuits. The keyboard is divided into various collector groups for Flute voices so that, progressing up the scale, the fundamental is amplified and the upper harmonics rejected. The lowest *F* on 8′ stop has a fundamental frequency of approximately 175 cycles. The last note in its group, A#2, has a fundamental of approximately 233 cps. In addition to having these fundamental frequencies, the signals from the tone chassis also contain harmonics of this fundamental. Eccles-Jordan counter circuits have square-wave outputs very rich in all odd harmonics. For Flute voices, the tone must contain only the fundamental. Therefore, when the Flute tab is depressed, the signal from this collector group is switched to the input of a tuned-triode filter amplifier with a resonant frequency of 212 cps. Fig. 7-5 shows the filter amplifier circuit; on half of V61B is the 212-cps filter amplifier. Thus, when the signal from the first collector group is applied to the 212-cps input, the fundamental frequency will pass through, but all harmonics will be rejected. The next collector group, B2-E2, has a frequency range of 246 to 330 cps. The 8′ Flute voice for it is diverted to the 300-cps tuned filter amplifier in Fig. 7-5. As the fundamental frequencies increase on the keyboard, the collectors for the Flute voices are directed into amplifiers tuned to the approximate frequency range. Hence, only the fundamental tone is heard when the Flute voice tab is on.

For non-Flute voices, it is unnecessary for the keyboard to be divided into groups according to the fundamental frequency range. A common path is provided for all tones by taking, through a resistor, an output from each collector group of that footage, and then tying all of them together to form a common collector group. This collector line is passed to the tab switches of the non-Flute voices. When these voices are turned on, the tone passes into the tuned filter amplifier producing the frequency characteristic to that voice. The French horn would show an emphasis close to 425 cps. Therefore, to produce the French horn tone, this tab permits the collector line to pass into the 425-cps tuned filter amplifier. String tones, being rich in all harmonics, go to a high-pass triode section

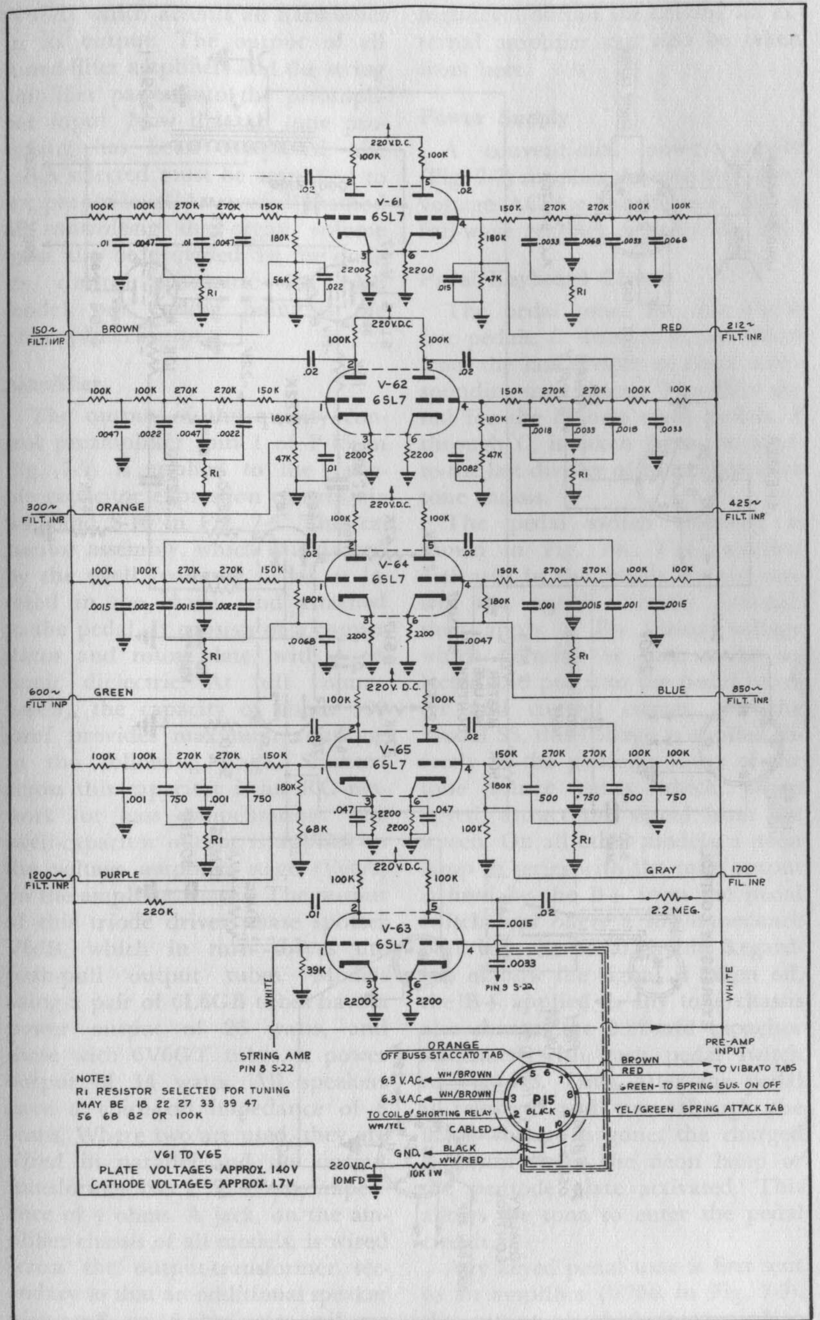


Fig. 7-5. The filter amplifier circuit.

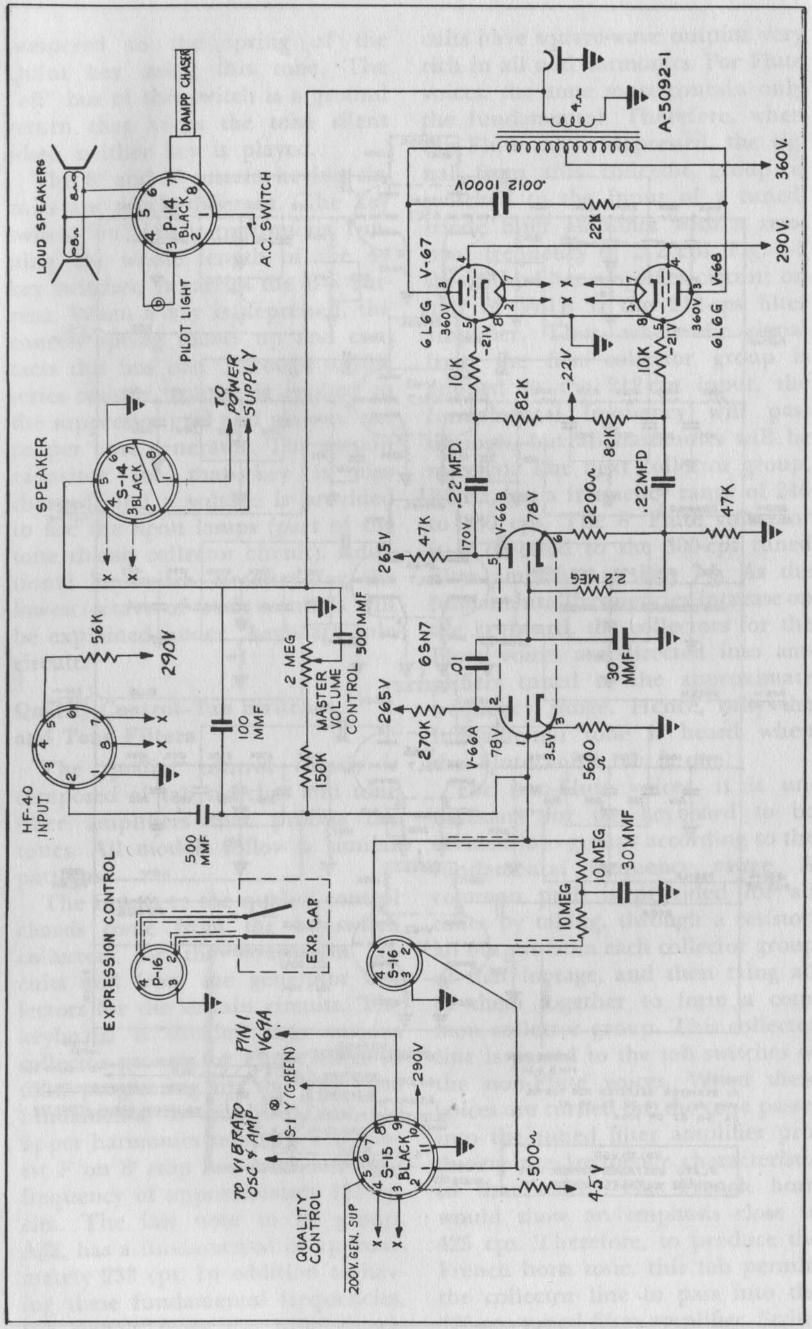


Fig. 7-6. Model SS power output circuit.

(V63A) which accents all harmonics in its output. The output of all tuned-filter amplifiers and the string amplifier passes into the preamplifier input. Now that all tone processing has been completed, the tones selected must be amplified to the proper level. An over-all method of controlling the organ volume must also be provided. In the quality control schematic for each model, our ending point is the preamplifier output.

Amplifier

The output of the quality control preamplifier (pin 1 of P-15 in Fig. 7-5) is applied to the variable capacitor expression control via S-15 and S-16 in Fig. 7-6. This capacitor assembly, which is activated by the swell (volume) pedal, is located in the chassis and attached to the pedal. It consists of a copper stator and rotor plate, with a ceramic dielectric. At full volume (swell), the capacity of about 500 mmf provides maximum coupling to the following stage. Shunted across this capacitor is an RC network for bass compensation. The swell-capacitor output is applied to the voltage amplifier stage (V66A) on the amplifier chassis. The output of this triode drives phase splitter V66B, which in turn drives the push-pull output tubes. Models using a pair of 6L6GB tubes have a power output of 26 watts, and those with 6V6GT tubes, a power output of 14 watts. All speakers have a voice-coil impedance of 8 ohms. Where two are used, they are wired in parallel and the output transformer has a matching impedance of 4 ohms. A jack, on the amplifier chassis of all models, is wired across the output-transformer secondary so that an additional speaker with an 8- or 16-ohm voice coil can be plugged in. A low-impedance, high-level output for driving an external amplifier can also be taken from here.

Power Supply

A conventional power supply (Fig. 7-7) supplies the necessary low-voltage AC for the heaters, and a full-wave rectifier supplies the B+.

Pedal Keyboard Circuit

The pedal tones for the lowest five pedals, *C* through *E*, are taken from the last divider of their corresponding tone chassis. The drive signal for the highest eight pedals, *F* through *C*, is taken from the next-to-the-last divider of their respective tone chassis.

The pedal switch assembly is shown in Fig. 7-8. The switches, activated by the pedals, do not control the signals directly. Instead, they apply a B+ firing voltage which permits the tone to be selected and put into the pedal counter and control circuit. On the Model SS, this voltage is applied directly to the pentode plates of the tone source tubes which,. when keyed, attract the signal from the screen. On all other models, a neon lamp in series with the tone output is fired by the B+ from the pedal switch and offers a low-impedance path into the pedal circuit. Regardless of how the signal is taken off, the B+ applied to any tone chassis also charges the 0.22-mfd capacitor associated with each pedal switch in Fig. 7-8. Thus, after the pedal is released, and even though the firing voltage is gone, the charged capacitor keeps the neon lamp or the pentode plate activated. This allows the tone to enter the pedal circuit.

Any keyed pedal tone is first sent to an amplifier (V70B in Fig. 7-9), the output of which is coupled to an Eccles-Jordan counter circuit

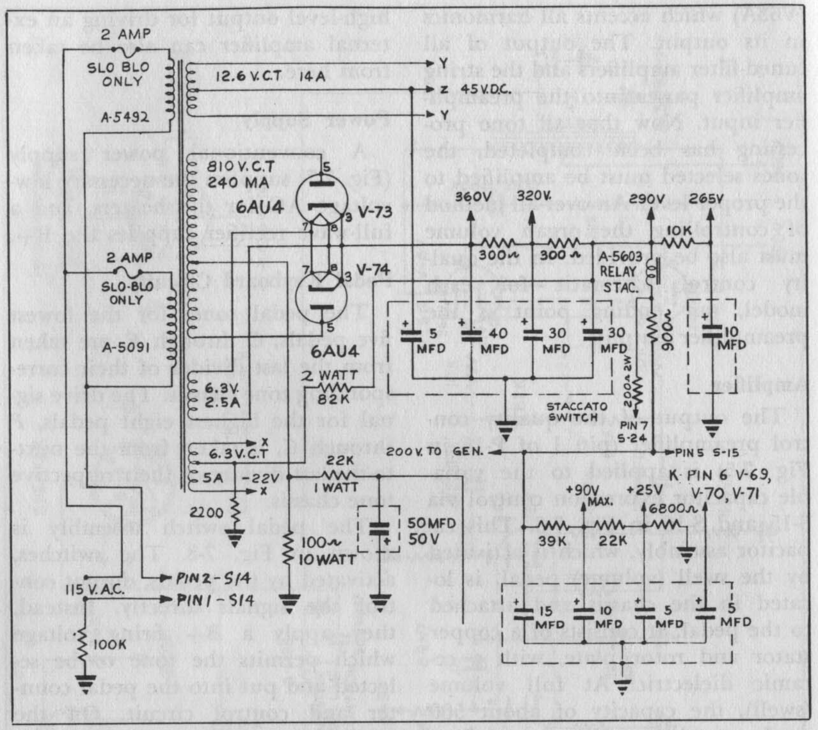


Fig. 7-7. Power supply used in Model SS.

(V69B-V70A) that lowers the tone one octave. This output is then applied to another Eccles-Jordan circuit (V71) where it is lowered still another octave. In models where the tone chassis use a solo counter for the bottom octave on the manual keyboard (instead of a divider for each chassis), the pitch requirements are such that a third counter is necessary to reach down to the 16′ level on the pedals.

At the proper pitch level, the counted-down tone is then applied to the last pedal tube circuit, or the control tube. V71B (Fig. 7-19) functions as the control tube. Thus, when a pedal is depressed, a B+ path is provided, through the *E* pedal switch in Fig. 7-8 and the 22K resistor, to the orange lead. From here the path is through the pedal relay to the green lead, and then through the 22K resistor to the light gray lead. The light gray lead is connected to pin 5 of P-13. Pin 5 of S-13 (Fig. 7-9) is connected, through the 100K resistor, to pin 6 of S-11. From here, the 1- and 1.2-meg resistors lead to the plate of V71B. When the plate is keyed (by depressing any pedal), a signal is taken off through the .0047-mfd blocking capacitor to pin 3 of S-11. Here it is applied to the tab switches regulating the pedal volume. These switches and their associated resistors determine the signal level applied to one of the low-frequency tuned filter amplifiers (Fig. 7-5) or (in some models) the string amplifier. In this manner, the pedal tones find their way into the main-amplifier line.

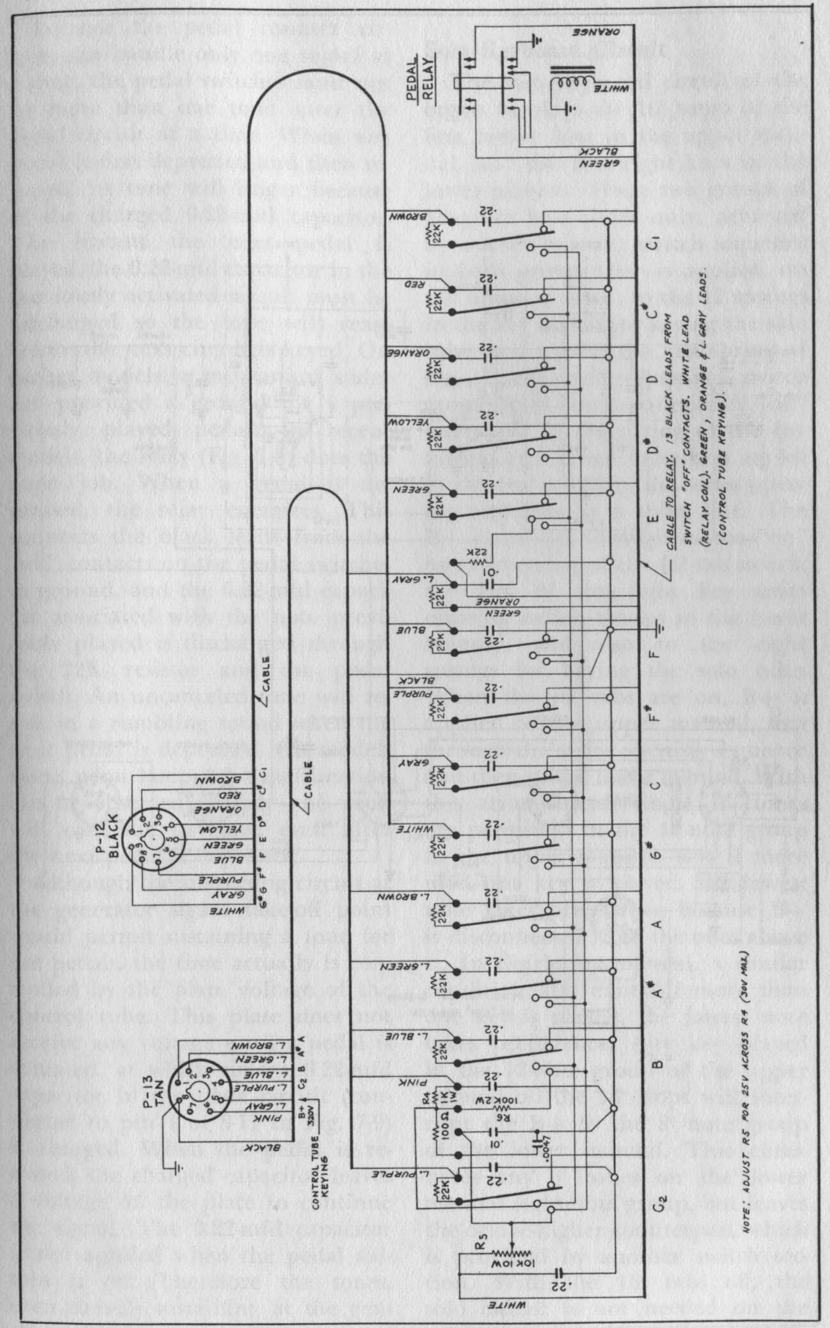


Fig. 7-8. The pedal switch assembly.

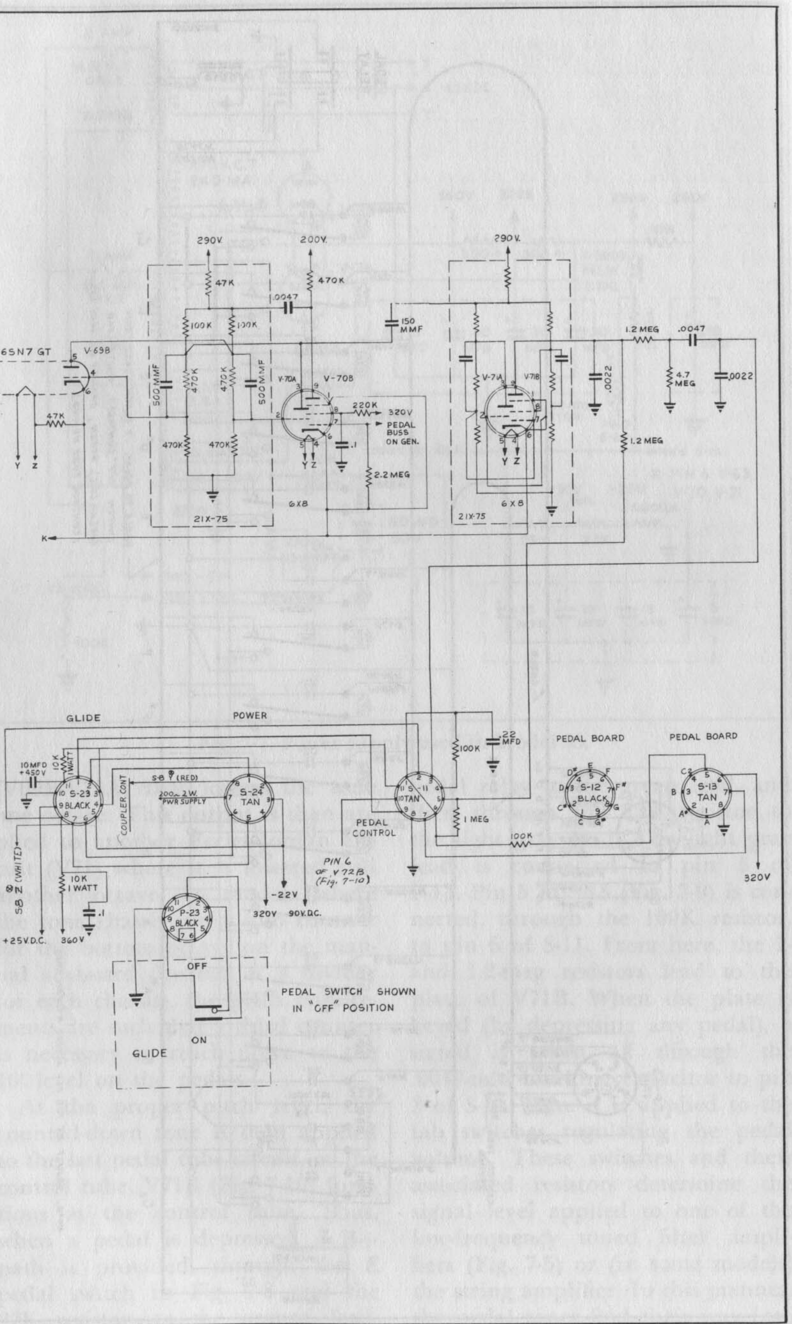


Fig. 7-9. The pedal amplifier and counter circuits.

Because the pedal counter circuits can handle only one signal at a time, the pedal switches must not let more than one tone enter the pedal circuit at a time. When any pedal is first depressed and then released, its tone will linger because of the charged 0.22-mfd capacitor. The instant the next pedal is played, the 0.22-mfd capacitor in the previously activated circuit must be discharged so the tone will cease before the next circuit is keyed. On earlier models, a mechanical slider bar provided a ground for a previously played pedal. In recent models, the relay (Fig. 7-8) does the same job. When a pedal is depressed, the relay energizes. This connects the black leads from the "off" contacts on the pedal switches to ground, and the 0.22-mfd capacitor associated with the note previously played is discharged through the 22K resistor and the pedal switch. An uncanceled tone will result in a rumbling sound when the next pedal is depressed. On models using neon lamps, the malfunction can be observed visually—the neon will continue to glow, even after the next pedal is depressed.

Although the sustaining circuit at the generator signal take-off point would permit sustaining a tone for the pedals, the time actually is controlled by the plate voltage of the control tube. This plate does not receive any voltage until a pedal is actuated, at which time a 0.22-mfd capacitor in the plate circuit (connected to pin 1 of S-11 in Fig. 7-9) is charged. When the pedal is released, the charged capacitor leaves a voltage on the plate to continue the signal. The 0.22-mfd capacitor is not applied when the pedal sustain is off. Therefore the tones, even though sustaining at the generator level, are cut off at the control tube.

Solo Keyboard Circuit

The solo keyboard circuit of the organ involves the 16′ tones of the first twelve keys in the upper manual, and the first eight keys in the lower manual. These two groups of keys are solo tones only, achieved by a series-opening switch sequence in both groups. B+ is applied, on the upper manual, to the 12 springs in the key switch for keying the solo tube, and also to the first spring of the 12-key series-opening switch group. Each key has a separate "off" bus wired to the spring of the following key. When these keys are all in the rest position, the series opening sequence is a solid line. The B+ continues through to the "on" bus and spring of the 16′ tab switch, the first of the eight key series opening switch groups in the lower manual, and also to the eight springs for keying the solo tube. When the 16′ tabs are on, B+ is applied to the upper manual, first through the series opening sequence and then to the lower manual. With this arrangement, single 16′ tones are permitted in the 12-note group in the upper manual. But if more than one key is played, the lowest note takes precedence because B+ is disconnected from the ones above it. In the lower manual, a similar condition also exists—if more than one key is played, the lowest note takes precedence. Any key played in the 12-note group of the upper manual on the 16′ stops will interrupt the B+ to the 8′ note group of the lower manual. This eliminates any 8′ tones on the lower manual eight-note group, but leaves the octave-higher counterpart, which is provided by another switch section. With the 16′ tabs off, the solo circuit is not needed on the upper manual. Therefore, B+ is sent directly to the lower manual.

The "separate on" buses of these solo sections are connected to 470K plate resistors of the last divider of their respective generators. When the plate is keyed, the tone passes through a capacitor to the solo collector line, where it is applied to the solo-tube input and counted down one octave.

In addition to keying the generator, another section of the key switch also applies B+ to the solo-tube plate or suppressor. The upper manual keys the plate, and the lower manual, the suppressor. The tone, counted down one octave, is drawn to its respective element and applied to the collectors. Thus, when a key is played in the first 12-key group of the upper manual, its respective generator is fired. The tone is then applied to the solo tube and counted down one octave. From here it is drawn to the plate (which is also keyed) before being applied to the collector. In the lower manual, the procedure is the same except the solo-tube suppressor is keyed.

Vibrato

The vibrato circuit is given in Fig. 7-10. A triode section (V72A) employed as a low-frequency phase-shift oscillator provides the vibrato signal pulse. The slow speed is 5.7 cps and the fast speed is 7.1 cps. These speeds are regulated by the values of the resistors in the phase-shift network between the plate and grid.

The output of the phase-shift oscillator is coupled to another triode (V72B) which functions as a cathode follower. The output of this cathode follower provides a low-impedance driving source that is connected to the diode sections of all twelve master-oscillator diodes in the tone generator (Fig. 7-3). These diodes, alternately conducting and not conducting, vary the effectiveness of

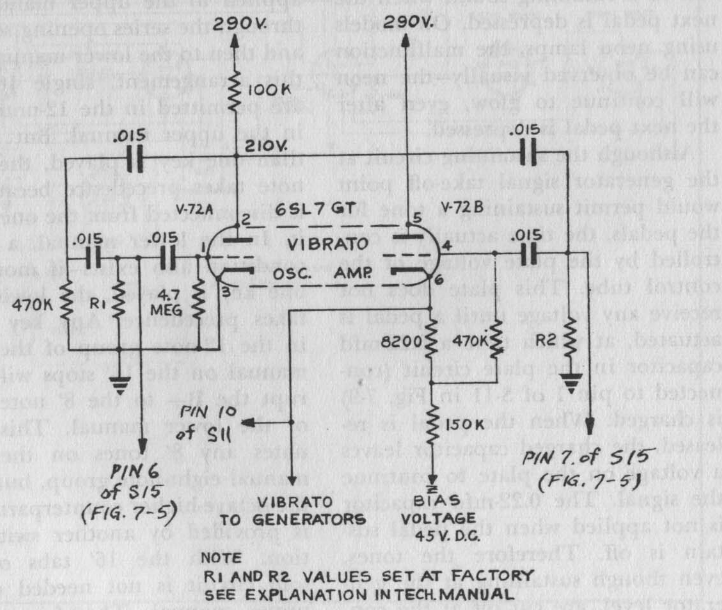


Fig. 7-10. The vibrato oscillator and amplifier.

the capacitor (C1) coupled between their plates and the oscillator tank circuit.

The output of the phase-shift oscillator is controlled by the vibrato tab switches. With the vibrato off, the output is grounded through the off-on switch. The "heavy" depth is determined by the value of the output resistor at the phase-shift oscillator. When the tab is turned to the "light" position, an additional resistor is shunted across to lower the output level of the oscillator. The "slow" speed is determined by the value of a resistor in the phase-shift network. In the "fast" position, this resistor is shunted by another to lower the effective resistance and thus increase the speed. In the "slow-heavy" position, another resistance, shunted across the output, decreases the heaviness to prevent a "wah-wah" effect.

Glide

The glide pedal (Fig. 7-9), when activated, closes a switch circuit that applies B+ to the vibrato diodes of the master oscillators. (When the glide tab is depressed, pins 9 and 10 of S-11 are connected.) Then, when these diodes conduct heavily, the variation from the vibrato oscillator is canceled out and the vibrato thus eliminated. The capacitor to the tank circuit (C1 in Fig. 7-3) now becomes more of a factor, and flattens the output from the master oscillator.

TUNING AND ADJUSTMENTS

Tone Generators

There is only one adjustment for each tone chassis. The brass screw in the tuning coil (L1) adjusts the powdered-iron slug which tunes the master oscillators. There are 12 master oscillators, one for each tone in the chromatic scale. The proper adjustment of these 12 slugs assures proper tuning of the entire instrument, including both the manuals and the pedals. Any technician familiar with tuning by intervals will tune one chassis to unison with a standard tuning fork, and then set the other eleven, using intervals (but being sure not to use any vibrato). The lesser experienced tuner may prefer a set of 12 tuning bars, so he can set all 12 by unison.

Key Switches

The key switches are underneath and to the rear of the keys. The adjustment for each switch is at the back of the key. A threaded stud is attached to the key, and held to it is a hairpin-like wire clip. This clip is carefully adjusted at the factory and, under normal circumstances, should not require any attention.

Quality Control Chassis

Some models have potentiometer adjustments for the vibrato speed and depth on the quality control chassis. These adjustments are set at the factory and should not be changed unless absolutely necessary.

Amplifier and Power Supply

The only amplifier and power-supply adjustment is a potentiometer control. It regulates the over-all volume on the Models S and SS to suit the room conditions.

Pedal Switch Assembly

At the top rear of each pedal channel is an adjustable "ear," the height of which determines the amount of pedal motion required to activate a pedal switch. This "ear" is factory-set and hence requires no adjustment. If the "ear" is forced down too far, however, the pedal will not sound unless depressed very hard (and in extreme cases, will not sound at all). On the other hand, if the "ear" is bent up too high, the switch may not return to its "off-position" bus. A burbling sound will then be heard when any pedal immediately following the poorly adjusted one is depressed.

The relay-type pedal switch has an adjustment for the relay current. This requires setting of the 7.5K (in earlier models) or 10K control R5 in Fig. 7-8 near the high *C* pedal switch. To check this adjustment, connect a DC voltmeter across the 1,000-ohm, 1-watt resistor (R4) on terminals 5 and 6 at the top of the switchboard (counting from the high *C* end). When any pedal is keyed, the reading across this resistor should be 25 volts. If not, readjust R5 to read 25 volts.

CAUTION: Never set this control for more than 30 volts across R4.

SERVICING THE LOWREY ORGANS

As with the servicing of all organs, first make sure the complaint is not actually a defect in some other circuit. Check all controls and keys first to determine just what sections are not functioning properly; then proceed with the servicing of that section.

Tone Generators

If only one family of tones is affected (for instance all *C*'s), and the defect occurs on both manuals and pedals, a defective tone generator is indicated.

Since each circuit depends on the one above it to provide the drive signal, the highest circuit which no longer functions is probably at fault. Progressively test each key, starting with the master oscillator, to determine the defective circuit.

Self-bias is applied to all Eccles-Jordan divider circuits through a common supply produced across a resistor on the amplifier chassis. Should all generator divider circuits fail, this voltage should be checked.

The most probable causes of trouble in the tone generator circuits are:

1. Defective generator tube. Try exchanging a tube from one of the other operative generators. If the tube is to blame, the trouble will "move" to the other generator.
2. Broken wire; shorts caused by wires dressed too close together or by a piece of wire scrap or solder. Place a weight on the key with the defective tone, and probe the parts with an insulated probe. Defects of this kind will usually be touch-sensitive, and probing will localize the fault.
3. Electrical component failure. If the failure is in a divider circuit, suspect the printed circuit under the corresponding socket. All Eccles-Jordan circuit components are enclosed within it. If the master oscillator is inoperative, check the individual components, and particularly the tuning coil, which should be checked for an open circuit. NOTE: There are two types of printed circuits, 21X75 and P-6021. Always replace with the same type—except the Model SS first divider should always be replaced with a P-6012.

As an alternate generator test, use the meter probe only (no continuity test) and place the VOM close to the 6SN7 voltage amplifier stage on the amplifier chassis. Touch the end of the probe to the side of the .01-mfd blocking capacitor farthest from the master oscillator. If the oscillator is working, the tone will be capacity-coupled directly from the generator into the amplifier, and this will indicate that the master oscillator is operating. Repeat at each .01-mfd capacitor of each succeeding divider. The highest circuit that does not provide a tone is the defective one.

Key Switches

An open circuit anywhere—starting at the generator output, the printed socket or plug, and the contact spring of a particular key—will cause a dead key on that footage.

The keying switches do nothing more than control the tonal flow from the tone generators to the tone-filter inputs. Continuity tests will reveal opens or shorts in this section.

A grounded output anywhere on a nonsustain circuit will kill not only its own, but also all other tones to its collector group. If two outputs become shorted together, the ground from the one not played will be transferred to the other and cause a grounded collector group. If a contact spring touches its "off" bus and the "on" bus at the same time, the group will be dead because the ground from the "off" bus will be transferred to the collector. When a spring touches both buses at the same time, bend away one of the bus bars to attain the necessary gap, or else change the contact spring. In the latter case, the contacts may also need re-forming.

Quality Control

Quality control failure will be found only on certain tabs, or in groups of successive keys when the Flute tabs are used. If in the preamplifier, the problem will be common to all keys and stops on both the manuals and the pedals.

Check each voice tab on all keys. Note which non-Flute voices are defective on the entire keyboard, and the exact keys which are defective on Flute voices. If a filter amplifier trouble, all problem areas will lead to the particular circuit involved. When the pattern does not point to one filter amplifier, then inspect the individual switching circuits on the tab switches. Watch for improperly seated contact springs, resin solder joints, and springs which have fallen out through the bottom. These springs can be easily replaced. Merely put them through the tube pin from the bottom, and toggle the tab halfway until it goes straight into the actuator.

Amplifier and Power Supply

All keys and all stops will be affected when the amplifier or power supply fails. The circuit is quite simple, so the usual troubleshooting methods can be employed.

Pedal Circuit Failure

Check all keys and stops on the manuals. If everything is normal here, the amplifier circuits common to both the pedal and the manual are functioning properly.

There are two basic types of failures. The pedals may be dead, or there may be a burbling sound caused by two drive signals entering the pedal circuit at the same time.

If all pedals are dead, determine if the tone generators are providing the signal. The neon lamp will go on when its corresponding pedal is pressed, indicating a signal is present. Now determine if voltage is being supplied to the control tube when a pedal is depressed. If this voltage is normal, be sure the signal from the blocking capacitor is passing through the tab switch circuits and into the amplifier. All pedals will be dead if there is circuit failure anywhere—from the generator collector line, through the pedal amplifier, counter circuits, and the tab switches, to the amplifier.

In Model S organs below serial No. 25000, the original switch did not provide enough "wipe" on return of the firing spring. These switches should be replaced with the improved switches. If pedal burble is encountered on one or more notes in the Model S, but the neon tube action is O.K. (only one glows at a time), check for a 100-mfd capacitor between the pedal neon and ground. If one is present, remove it because this capacitor will sometimes cause oscillations with the resultant burble. Also in the Model S, the pedal neons (particularly low *C* through *E*) may glow faintly, even without a keying signal. This is caused by too high a drive signal. To remedy, change the 470-ohm series resistor feeding the neon bulb to 680K on generators *C* through *E*.

Pedal burble in Model SS is probably caused by a defective (cathode to filament leakage) 6 X 8 tube in the tone chassis of a good pedal. Replace the tube.

Vibrato Failure

When the phase-shift oscillator fails, the vibrato will be dead on all tones. If there is no vibrato on one family only, check the diode sections of the master oscillator for that family. If trying several tubes does not bring the phase-shift oscillator to life and the cathode-follower triode is all right, suspect the .015-mfd capacitors in the oscillator circuit.

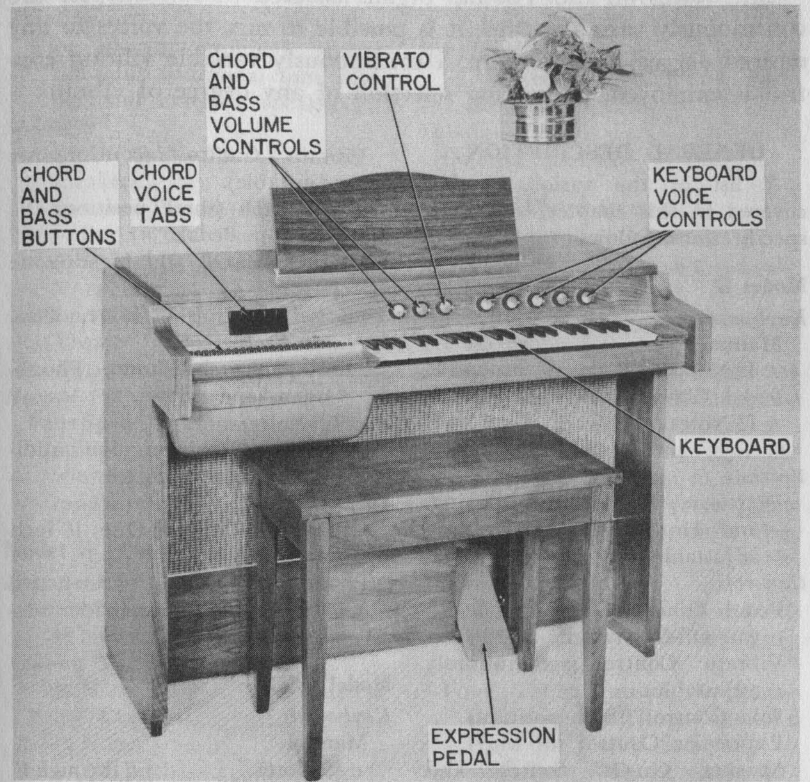


Fig. 8-1. The Thomas Model J chord organ.

CHAPTER 8

THE THOMAS ELECTRONIC ORGAN

Thomas Models G, GP, GS-1, H, J, and K organs are very similar, differing only in the controls, number of keys, amplifiers, and speakers. Some models also incorporate a record changer which may be played separately or along with the organ. The Model J pictured in Fig. 8-1 is a chord organ. Thomas also produces transistor models; however, they will not be covered in this chapter.

The voices on the Thomas organs covered in this chapter are continuously variable; thus, it is possible to mix the voices to any desired degree. Furthermore, a continuously variable vibrato control is employed, permitting selection of any degree of vibrato.

GENERAL DESCRIPTION

A list of the various models covered in this chapter, and their specifications, follows:

Model G

Keyboards
Manual
49 Notes F through F
Pedal Clavier
13 Notes
(16′ pitch) C through C
Voices
Diapason, Reed, Flute, String, and Horn. (All continuously adjustable.)
Controls
Pedal Volume Control and Organ Off-On Switch.
Vibrato Control (continuously adjustable).
Solo Control (three position).
Expression Control.
Speaker On-Off Switch and Headphone Jack.
Amplifier
10-Watt. (Provision for additional tone cabinet.)
Speaker
10-inch PM.

Model GP

Keyboards
Manual
49 Notes F through F
Pedal Clavier
13 Notes
(16′ pitch) C through C
Voices
Diapason, Reed, Flute, String, and Horn. (All continuously adjustable.)
Controls
Pedal Volume and On-Off Switch.
Vibrato Control (continuously adjustable).
Solo Switch (three position).
Expression Pedal.
Speaker On-Off and Headphone Jack.
Phono Controls—Volume, Bass, and Treble.
Selector Switch—Phono, Phono-Organ, and Organ.
Amplifier
10-Watt. (Provision for additional tone cabinet.)
Speakers
Organ and Phono—One 10-inch unit.
Phono Only—One 5″ tweeter, two 6″ mid-range, plus divider network.

Model GS-1

Keyboards
Manual
49 Notes F through F
Pedal Clavier
13 Notes
(16′ pitch) C through C
Voices
Diapason, Reed, Flute, String, and Horn. (All continuously adjustable.)
Controls
Pedal Volume Control and Organ On-Off Switch.
Vibrato Control (continuously adjustable).
Solo Switch (three position).
Expression Pedal.
Speaker On-Off Switch and Headphone Jack.
Phono Controls—Volume, Bass, and Treble.
Selector Switch—Phono, Phono-Organ, Organ.
External Input Balance Control.

Phono-Tuner Selector Switch.
Amplifiers
Two 10-watt amplifiers. (Provisions for additional tone cabinet and external speakers.)
Speakers
Organ Only—Two 10-inch speakers.
Organ and Phono (dual position) —One 10″ speaker on the organ, one 10″, one 6″, and one 5″ tweeter on the phono.
Phono Only—Two 10″ speakers. Two 6″ mid-range speakers. Two 5″ tweeters.
Record Player
Four-Speed Automatic. (Plays monaural or stereo records, automatic shut-off after last record.)

Model H (The Concerto)

Keyboards
Swell Manual
44 Notes F through C
Great Manual
44 Notes F through C
Pedal Clavier
13 Notes
(16′ pitch) C through C
Voices
Swell Manual—Diapason, Reed, Trumpet, Flute, String, Oboe, and Vox Humana.
Great Manual—Diapson, Clarion, Flute, String, and French Horn.
Pedal Clavier—Reed, Diapason, and Bourdon.
Controls
All voice controls have tablet (on-off) stops and variable intensity controls.
Percussion Attack and Decay tablet stops with adjustable controls.
Preset (on-off) tablet and seven variable intensity controls, duplicating the Swell manual voices.
Individual Expression pedals for each manual.
Speaker on-off switch and headphone jack.
Amplifier
25 Watts. (Provision for additional tone cabinet.)
Speakers
One 12″ and one 8″ PM.

Model J (Chord Organ)

Keyboard
44 Notes F through C
Chord Section
120 Buttons arranged in standard accordion pattern.
80 Buttons produce Major, Minor, Seventh, and Dimished Chords in all keys.
40 Remaining Buttons play the Tonic or 3rd note of the respective key, and at the same time sound a 16′ pitch Base Note.
Controls
Five variable keyboard controls —Diapason, Reed, Flute, String, and Horn.
Four Tablet (on-off) Switches—Vox Humana, Flute, Cello, and Horn for Chord Section.
Chord Note Volume Control.
Bass Note Volume Control and On-Off Switch.
Variable Vibrato Control for the keyboard, and a tablet switch that permits cancellation of the Vibrato for the chord section only.
Expression Control.
Speaker On-Off Switch and Headphone Jack.
Amplifier
10-Watt. (Provision for additional tone cabinets.)
Speaker
One 10″, (plus one 8″ in later models).

Model K (The Intermezzo)

Keyboard
Swell Manual
37 Notes F through F

Great Manual
37 Notes F through F
Pedal Clavier
13 Notes
(16′ pitch) C through C

Voices

Swell Manual—Diapason, Reed, Flute, String, Horn, and Oboe.
Great Manual—Diapason, Reed, Flute, and String.
Pedal Clavier—Diapson.

Controls

Pedal Volume Control and Organ (off-on) Switch.
Variable intensity control for for each voice.
Expression control.
Speaker on-off switch and headphone jack.
Individual (variable) Vibrato controls for each manual.

Amplifier

10-Watt. (Provision for additional tone cabinet.)

Speakers

One 10-inch and one 8-inch PM.

THEORY OF OPERATION

Tone Generator Oscillators

Tones of the Thomas organs covered in this chapter are created by vacuum-tube Hartley oscillators in which one stage provides two, three, or four consecutive notes.

When more than one key associated with the same oscillator is depressed, only the highest note will sound. Operating any key selects a tuning circuit and applies a keying voltage to the grid of the respective tube. This action offsets a fixed cutoff bias and thereby causes the circuit to oscillate.

When the highest note of a group is played, a single-pole, double-throw switch disconnects the lower notes through a series contact, completing the circuit between the keying bus and the oscillator tube grid (see Fig. 8-2). When the middle note of a group is played, a keying voltage is applied to the tube, and tuning capacitor C206, connected across the tuned circuit, reduces the pitch by approximately one semitone. The key contact for the lowest note (a single-pole, single-throw switch), applies the keying voltage and connects tuning capacitor C207 across the tuned circuit.

A variable inductor (L201) in the oscillator circuit provides coarse tuning of a shared group of notes. A spring-loaded screw changes the inductance by varying the air gap.

The fine tuning of each note (thoroughly covered in the tuning section) is furnished by variable resistors R212, R213, and R214 in series with each keying-voltage circuit. Each group of notes shares half of a 12AU7 tube on the same component panel with variable inductor L201 and main tuning capacitor C201.

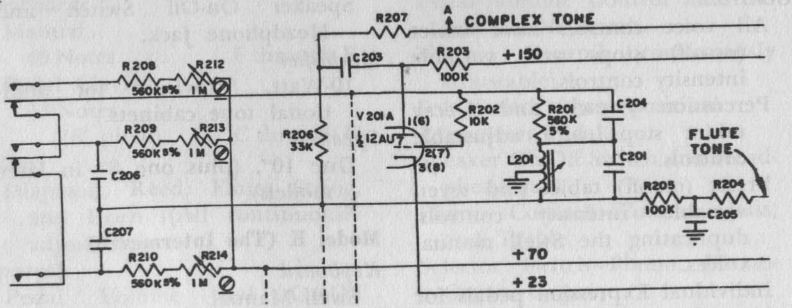


Fig. 8-2. A typical Thomas oscillator circuit.

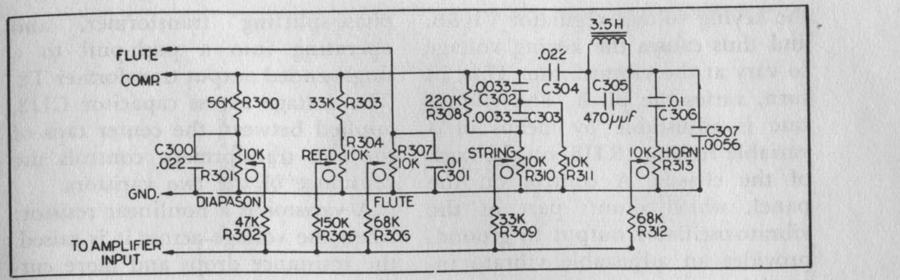


Fig. 8-3. Typical Thomas voicing circuits.

Control Panel

The oscillators generate two signals, a Flute tone (almost a pure sine wave) and a complex tone (very rich in harmonics). Both tones are fed into the control panel, which is made up of formant circuits consisting of high- and low-pass and resonant-frequency sections. These circuits, either singly or in combination, shape the signal waveform.

The complex signal is fed into the control panel and formant circuitry, where it is formed into the harmonic combinations that create the Diapason, Reed, String, and Horn-type voices. (See Fig. 8-3.)

The flute signal is fed into the control panel, but bypasses the formant circuitry. The Flute and complex signals are then combined and fed into the amplifier input. Potentiometer-type voice controls are incorporated in the models covered in this chapter. Thus, the voices can be blended in an infinite variety.

Amplifier and Power Supply

A conventional audio amplifier amplifies the signal sufficiently to operate the speakers or auxiliary tone cabinets. The expression (volume) control, a variable resistor, controls the shunting of the input signal to ground.

The power-supply circuits provide the necessary voltages for the amplifier and tone generators. An 0A2 gas voltage-regulator tube provides a constant cathode bias for the oscillators, regardless of the number of notes played. This bias voltage must be constant, or the tuning will be seriously affected. Fig. 8-4 shows how this is accomplished. Half of a 12AU7 (V102A) maintains a constant current through common oscillator cathode resistor R127. Keying voltage to the generator is also regulated to stabilize oscillator operation. This circuit uses half of the 12AX7 (V105B).

A phase-shift oscillator (V105A) applies a low-frequency voltage to

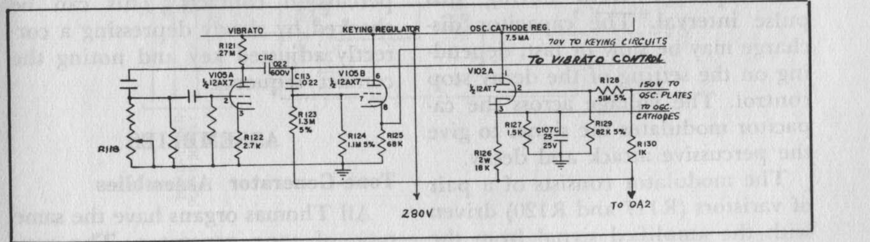


Fig. 8-4. The vibrato, keying regulator, and oscillator cathode-regulator circuits.

the keying voltage regulator V105B, and thus causes the keying voltage to vary at the vibrato rate. This, in turn, varies the pitch. The vibrato rate is adjustable by means of a variable resistor (R118) on the back of the chassis. A control on the panel, which shunts part of the vibrato-oscillator output to ground, provides an adjustable vibrato *intensity*.

Percussion System

The percussion in the Thomas organ permits a large variety of tonal effects. It also provides an adjustable explosive attack and decay to any associated note. The percussion is repetitive. When one key is held down, the note sounds with a sharp attack and then slowly dies away. Then, while that key is still held down and a second note is depressed, both keys will sound with a sharp attack and a long decay.

On top of each key with which the percussion unit is associated, there is a single-pole, double-throw switch that charges or discharges a .001-mfd capacitor (C114 in Fig. 8-5). It acts as a pulser for the one-shot multivibrator V101 (12AU7) which, when triggered, puts out a pulse lasting approximately one-fiftieth of a second. The pulse is then fed to a 6AQ5 cathode-follower keyer stage V102. One of the sets of contacts on the attack stop tablet controls this keyer stage. The cathode-follower output charges 4-mfd capacitor C113 during this pulse interval. The capacitor discharge may be slow or fast, depending on the setting of the decay stop control. The voltage across the capacitor modulates the signal to give the percussive attack and decay.

The modulator consists of a pair of varistors (R117 and R120) driven with the amplified signal from the control-panel output, through a phase-splitting transformer, and operating into a push-pull to a single-ended output transformer T2. The voltage across capacitor C113, applied between the center taps of the two transformers, controls the resistance of the two varistors.

A varistor is a nonlinear resistor; when the voltage across it is raised, the resistance drops and more current flows. These units are installed in matched pairs; so both will have to be replaced if either is defective. The 4-mfd percussion capacitor is very critical; it should be replaced only with a factory-tested unit.

The signal is applied through the percussion attack control to the grid of the preamp stage into the modulator circuit. After leaving the modulator, it goes through the post amplifier stage and then back through the attack stop to the amplifier input. In order for the percussive effect to be properly formed, the associated tone generators must operate before the multivibrator and modulator are triggered. The key switches and the percussion whiskers are adjusted so that, before the percussion whisker touches the upper bus bar, the oscillator is turned on slightly.

If a note does not have the proper percussive attack, check its percussion key switch. Readjust the contacts and whisker for proper sequence. The timing is not too critical, as long as the oscillator has been slightly keyed before the percussion contacts. This can be checked by slowly depressing a correctly adjusted key and noting the contact sequence.

ASSEMBLIES

Tone-Generator Assemblies

All Thomas organs have the same type of tone generator. The generators differ only in the number

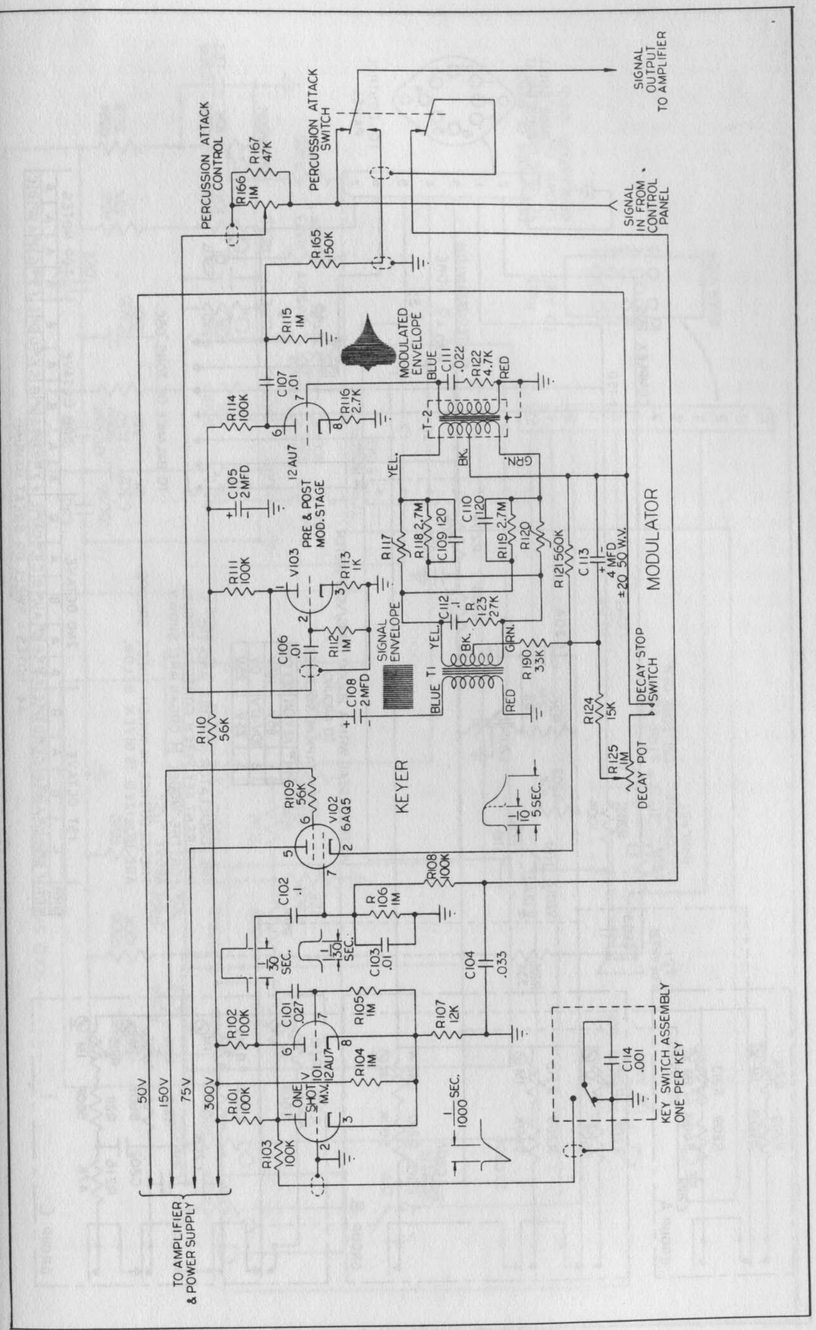


Fig. 8-5. The Thomas percussion circuit.

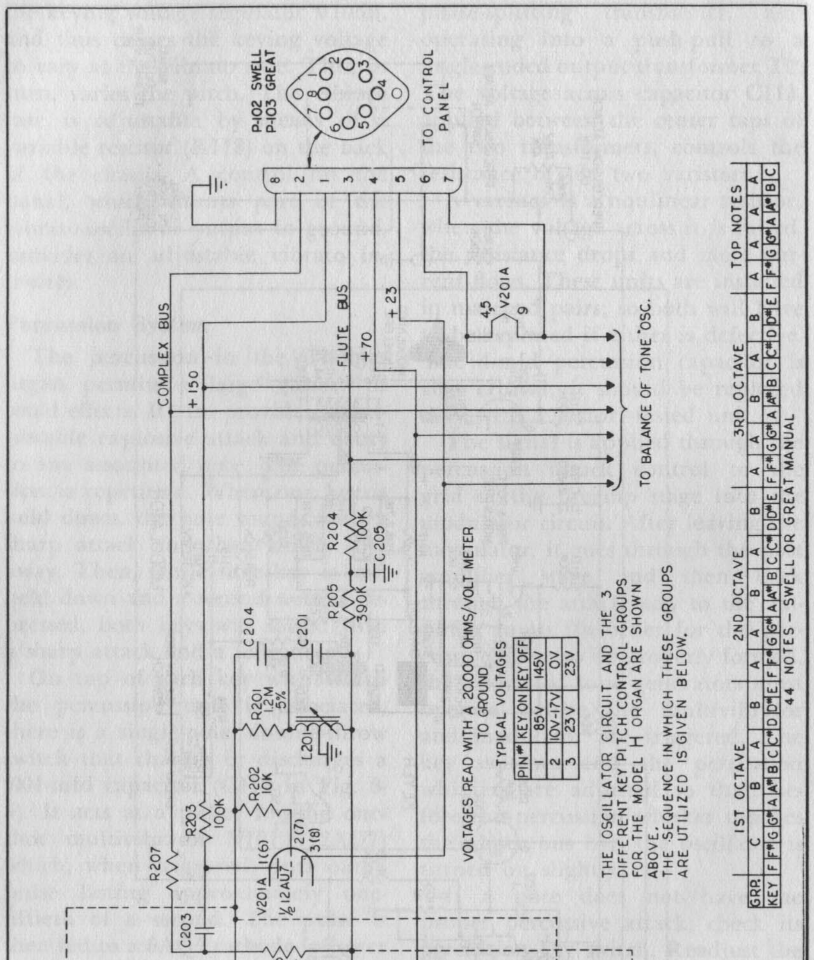


Fig. 8-6. Tone generator used in the Model H2 organ.

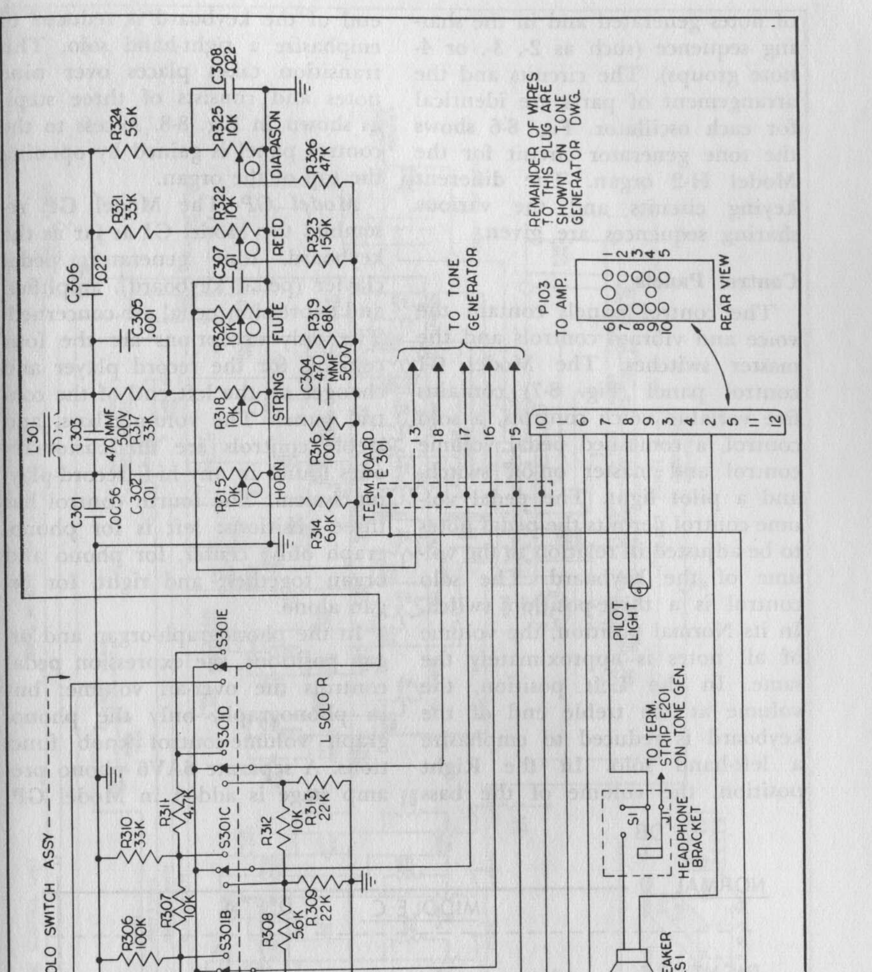


Fig. 8-7. Control panel for the Model GI organ.

of notes generated and in the sharing sequence (such as 2-, 3-, or 4-note groups). The circuits and the arrangement of parts are identical for each oscillator. Fig. 8-6 shows the tone generator circuit for the Model H-2 organ. The different keying circuits and the various sharing sequences are given.

Control Panels

The control panels contain the voice and vibrato controls and the master switches. The Model GI control panel (Fig. 8-7) contains five variable voice controls, a solo control, a combined pedal volume control and master on-off switch, and a pilot light. The pedal volume control permits the pedal notes to be adjusted in relation to the volume of the keyboard. The solo control is a three-position switch. In its Normal position, the volume of all notes is approximately the same. In the Left position, the volume at the treble end of the keyboard is reduced to emphasize a left-hand solo. In the Right position, the volume of the bass end of the keyboard is reduced to emphasize a right-hand solo. This transition takes places over nine notes and consists of three steps, as shown in Fig. 8-8. Access to the control panel is gained by opening the top of the organ.

Model GP—The Model GP resembles the Model GI as far as the keyboard, tone generator, pedal clavier (pedal keyboard), amplifier, and expression pedal are concerned. The only exceptions are the four controls for the record player and changer on the left end of the control panel. The volume, bass, and treble controls are the customary ones found in any hi-fi record-playing system. The fourth control has three positions: left is for phonograph only; center, for phono and organ together; and right, for organ alone.

In the phonograph-organ and organ positions, the expression pedal controls the over-all volume; but in phonograph, only the phonograph volume-control knob functions. A separate 6AV6 phono preamp stage is added in Model GP.

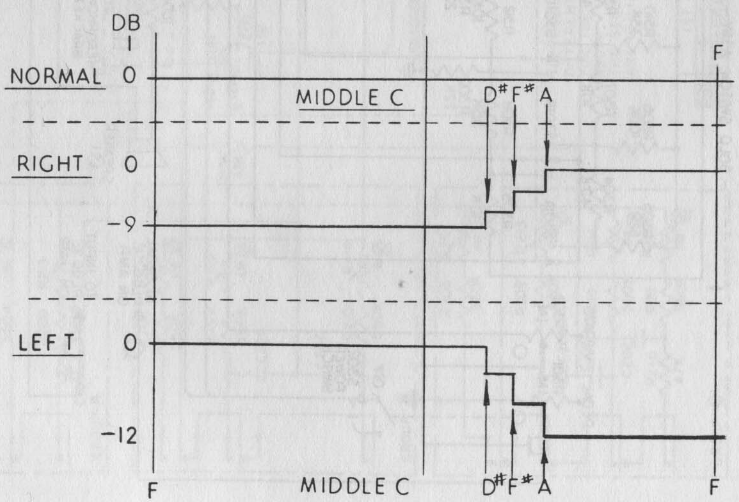


Fig. 8-8. Solo-control characteristics.

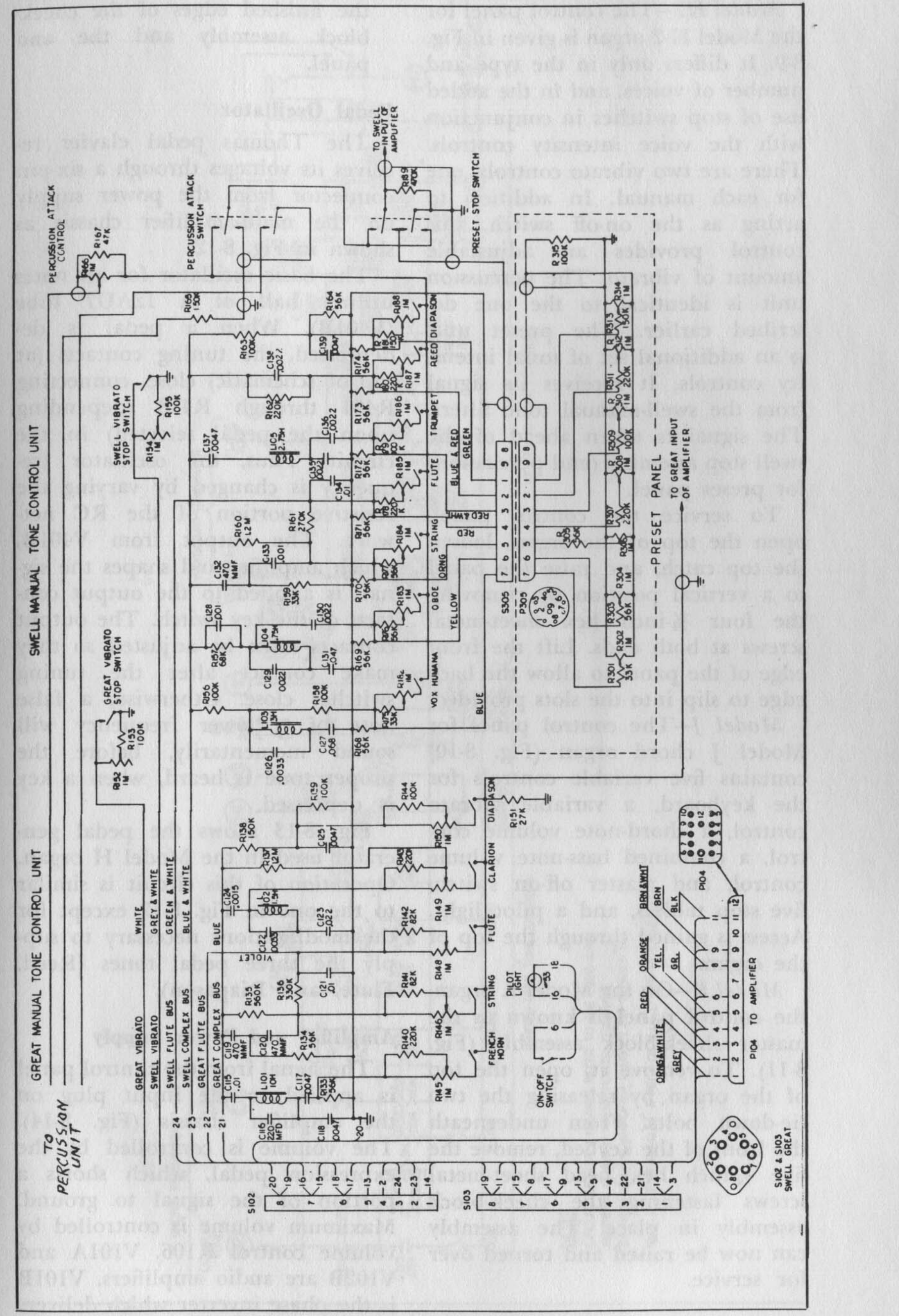


Fig. 8-9. Control panel for the Model H2 organ.

Model H2—The control panel for the Model H-2 organ is given in Fig. 8-9. It differs only in the type and number of voices, and in the added use of stop switches in conjunction with the voice intensity controls. There are two vibrato controls, one for each manual. In addition to acting as the on-off switch, this control provides an adjustable amount of vibrato. The percussion unit is identical to the one described earlier. The preset unit is an additional set of tonal intensity controls. It receives its signal from the swell-manual tone filters. The signal is taken ahead of the swell stop assembly (and percussion) for preset panel.

To service the control panel, open the top of the organ, loosen the top catch, and raise the panel to a vertical position by removing the four ¼-inch hex sheet-metal screws at both ends. Lift the front edge of the panel to allow the back edge to slip into the slots provided.

Model J—The control panel for Model J chord organ (Fig. 8-10) contains five variable controls for the keyboard, a variable vibrato control, a chord-note volume control, a combined bass-note volume control, and master off-on switch, five stop tablets, and a pilot light. Access is gained through the top of the organ.

Model K—On the Model K organ, the control panel is known as the master cheek-block assembly (Fig. 8-11). To remove it, open the top of the organ by releasing the two tie-down bolts. From underneath the front of the keybed, remove the five ¼-inch hex head sheet-metal screws fastening the cheek-block assembly in place. The assembly can now be raised and turned over for service.

NOTE: Be careful not to mar the finished edges of the cheek-block assembly and the end panel.

Pedal Oscillator

The Thomas pedal clavier receives its voltages through a six-pin connector from the power supply on the main-amplifier chassis as shown in Fig. 8-12.

The basic oscillator for all notes utilizes half of a 12AU7 tube (V401B). When a pedal is depressed, the tuning contacts (at top of schematic) close, connecting R401 through R413 (depending upon the pedal selected) in the circuit. Thus, the oscillator frequency is changed by varying the resistive portion of the RC network. The output from V401B, which amplifies and shapes the signal, is applied to the output contacts of the key switch. The output contacts must be adjusted so they make contact after the tuning switches close. Otherwise, a false note of a lower frequency will sound momentarily, before the proper tone is heard, when a key is depressed.

Fig. 8-13 shows the pedal generator used in the Model H organ. Operation of this circuit is similar to the one in Fig. 8-12 except for the modifications necessary to supply the three pedal tones (Reed, Flute, and Diapason).

Amplifier and Power Supply

The signal from the control panel is applied to the input plug on the amplifier chassis (Fig. 8-14). The volume is controlled by the expression pedal, which shorts a portion of the signal to ground. Maximum volume is controlled by volume control R106. V101A and V102B are audio amplifiers. V101B is the phase inverter which delivers the two signals, 180° out of phase,

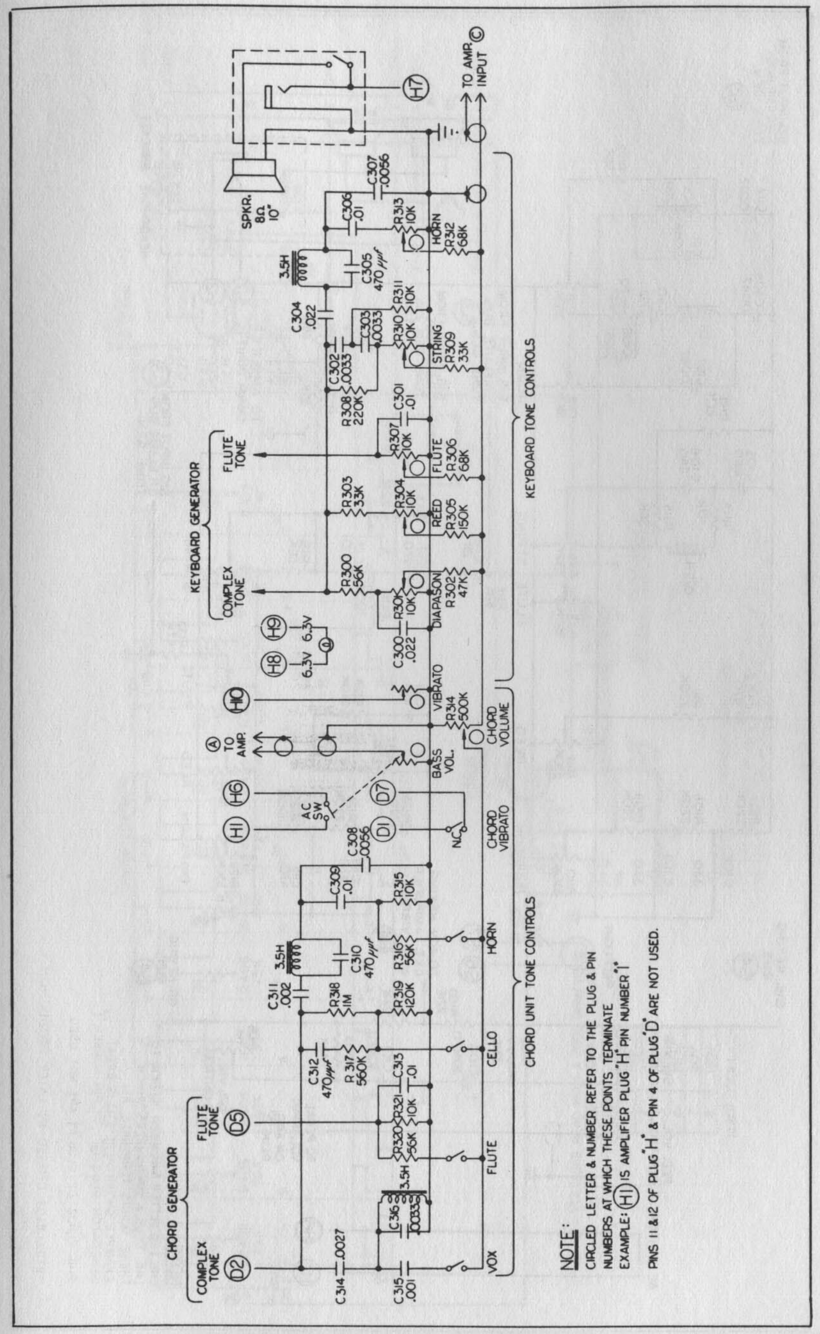


Fig. 8-10. Control panel for the Model J organ.

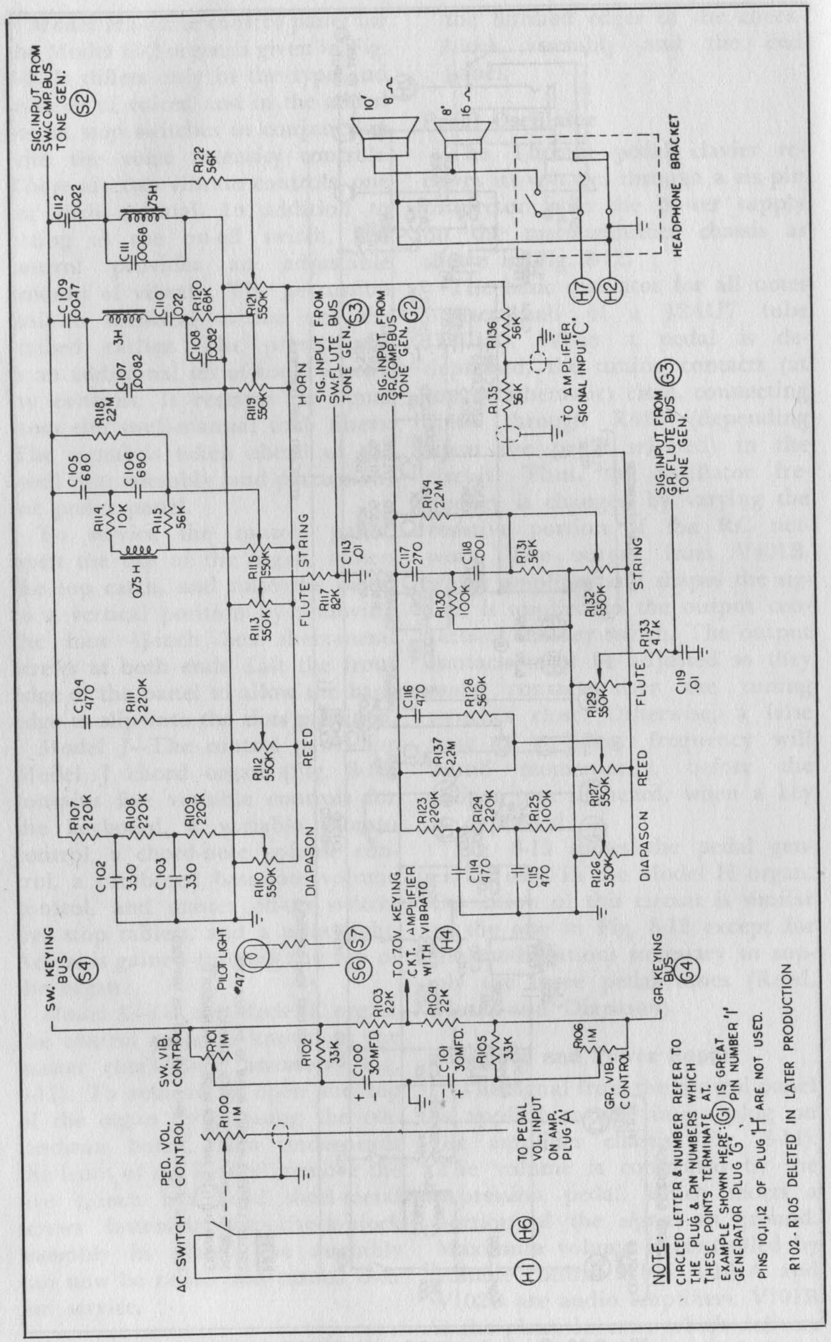


Fig. 8-11. Cheek-block assembly for the Model K organ.

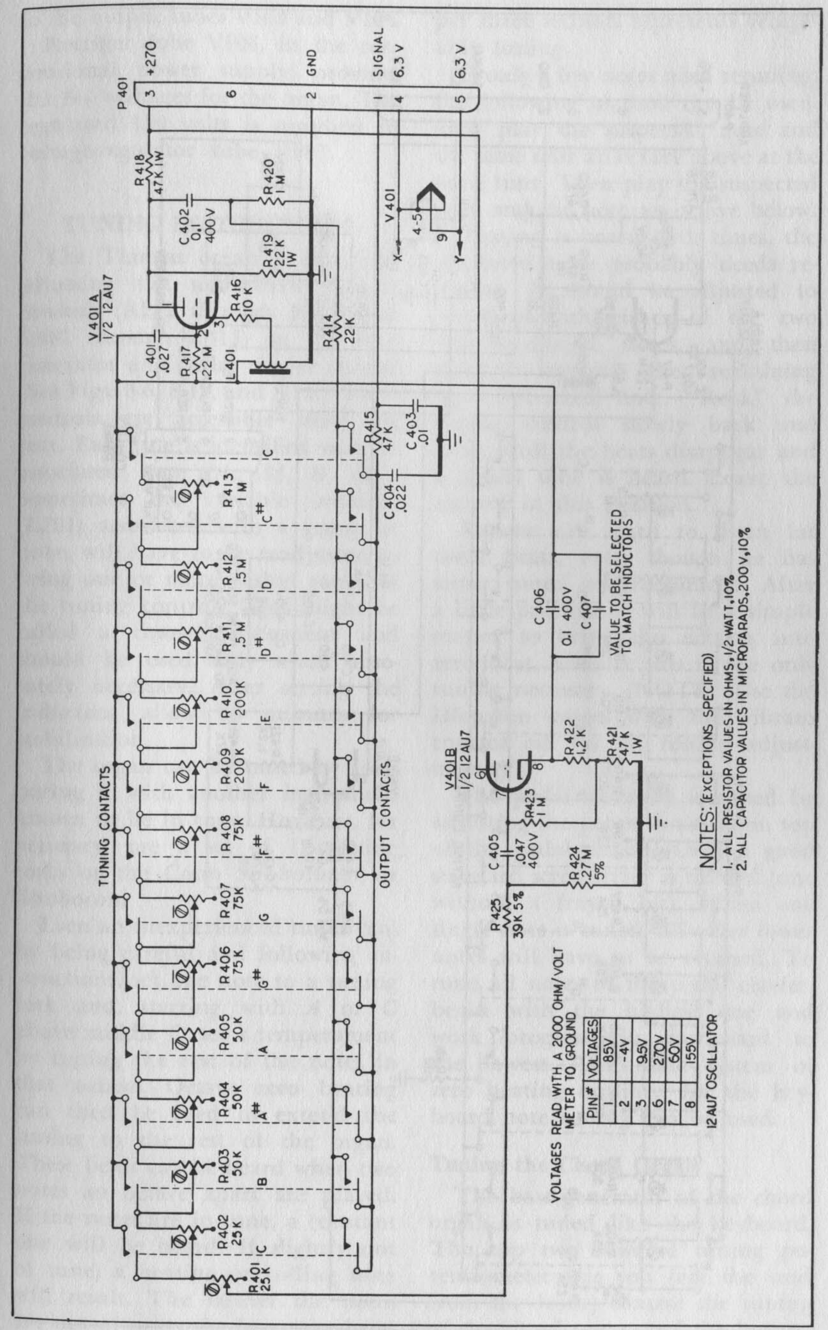


Fig. 8-12. Pedal generator in Models G and K.

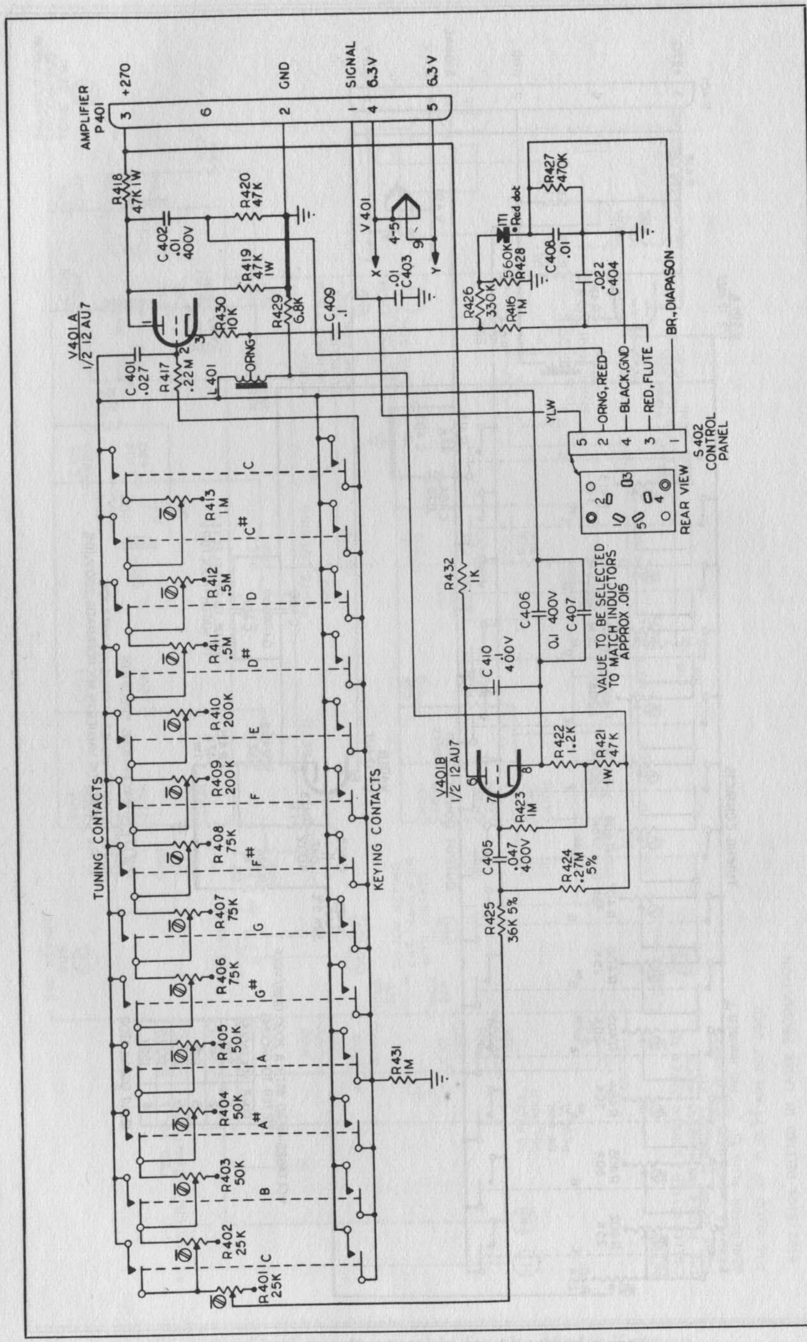


Fig. 8-13. Pedal generator used in Model H2.

to the output tubes V103 and V104.

Rectifier tube V106, in the conventional power supply, provides the B+ voltages for the organ. The regulated 150 volts is supplied by voltage-regulator tube V107.

TUNING INSTRUCTIONS

The Thomas organ is tuned by adjusting the screwdriver slotted controls (R212 through R215, and R401 through R413) on the tone generator and pedal clavier chassis. (See Figs. 8-6, 8-12, and 8-13.) These controls are accessible from the rear. Each one is identified with its associated note (*A*, *A#*, *B*, etc.). Sometimes the variable inductor (L201) associated with a group of notes will have to be readjusted to bring one or more within range of the tuning controls. This might be called a coarse adjustment and should be used only when absolutely necessary. After setting the inductors, allow 30 minutes for stabilization.

The organ can be tuned by comparing it with another instrument known to be in tune. However, for accuracy, use a set of 12 tuning forks or the Conn *Strobotuner* or *Strobocon.*

Even an inexperienced tuner can, by being careful and following instructions, set one note to a tuning fork and, starting with *A* or *C* above middle *C*, set a temperament by tuning the rest of the notes in that octave. Octave zero beating can then be used to extend the tuning to the rest of the organ. These beats can be heard when two notes an octave apart are played. If the notes are in tune, a constant one will be heard. If slightly out of tune, a beating or rolling note will result. The farther the notes are out of tune, the faster the beating will be. A beat of less than one per three seconds represents acceptable tuning.

If only a few notes need retuning, the following method can be used. First play the suspected note and the same note an octave above at the same time. Then play the suspected note and the note an octave below. If beating is heard both times, the suspected note probably needs retuning. It should be adjusted to zero-beat with either of the two octavely-related notes, and then checked against the remaining octavely-related note. "Rock" the tuning control slowly back and forth until the beats disappear and a steady tone is heard. Leave the control in this position.

Anyone can learn to listen for these beats, even though he has never tuned an instrument. After a little practice, it will be a simple matter to bring the octaves into zero beat. Usually this is the only tuning necessary. (NOTE: Use the Diapason voice, with the vibrato control off, for all tuning adjustments.)

The pedal assembly is tuned by adjusting the potentiometers on top of the pedal chassis. Only a good standard screwdriver is needed (one without a frayed bit). When any single note is tuned, all other lower notes will have to be retuned. To tune all notes of the pedal clavier, begin with the highest one and work progressively downward to the lowest. The same system of zero beating outlined for the keyboard note tuning can be used.

Tuning the Chord Organ

The bass generator of the chord organ is tuned like the keyboard. The top two rows of tuning potentiometers (as you face the unit from the front) control the tuning of the chord notes, and the bottom two rows control the bass notes.

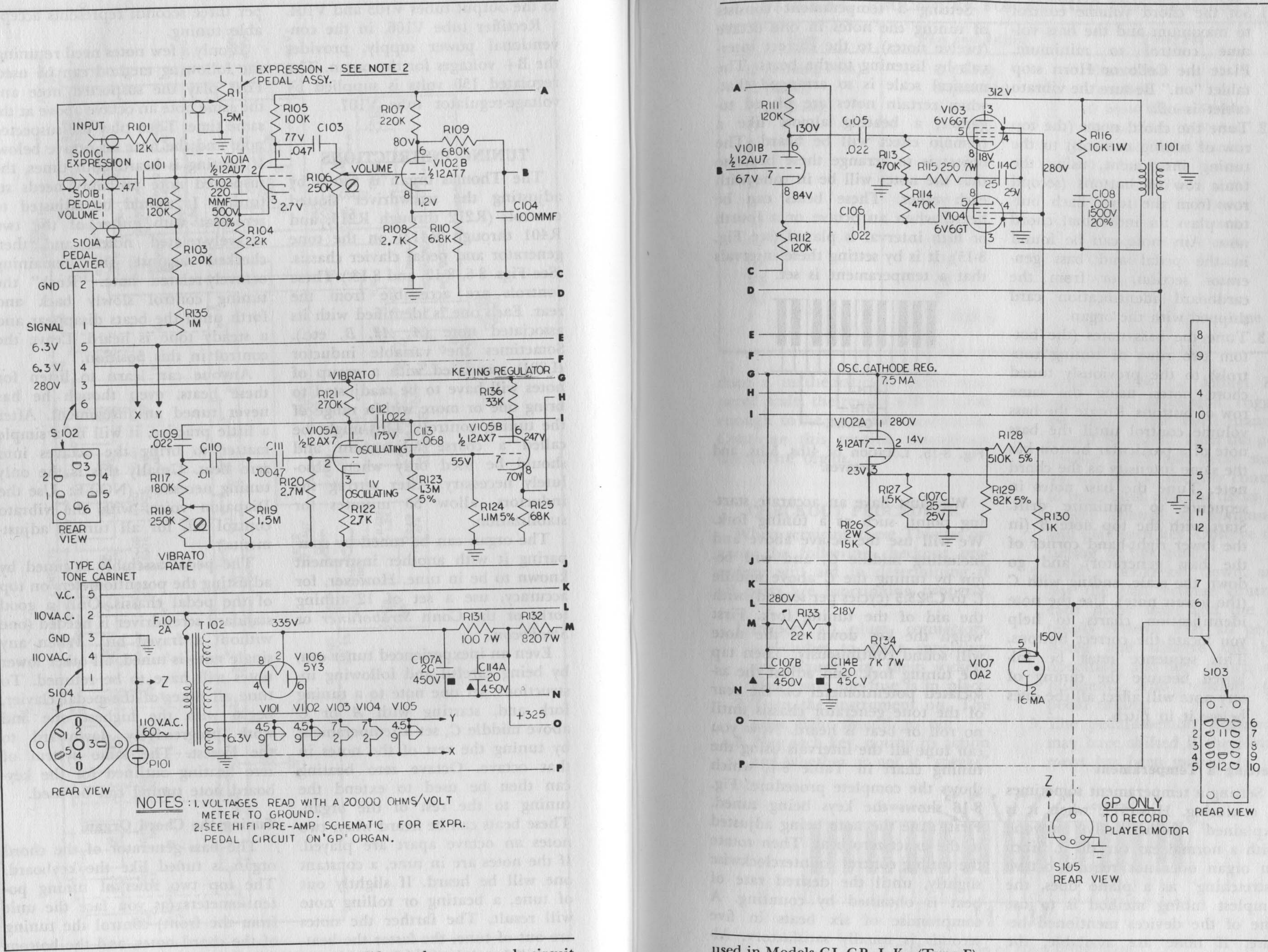


Fig. 8-14. Amplifier and power-supply circuit used in Models GI, GP, J, K, (Type E).

1. Set the chord volume control to maximum and the bass volume control to minimum. Place the Cello or Horn stop tablet "on." Be sure the vibrato tablet is off.
2. Tune the chord notes (the top row of tuning controls) to the tuning instrument, using the tonic row of buttons (second row from the top). Each button plays an individual chord note. Any note can be found in the pedal and bass generator section, or from the cardboard identification card shipped with the organ.
3. Tune the bass notes (the bottom two rows of tuning controls) to the previously tuned chord notes, using the same row of buttons. Rotate the bass volume control until the bass note of a particular button has the same intensity as the chord note. Tune the bass notes in sequence to minimize drift. Start with the top note *B* (in the lower right-hand corner of the bass generator) and go down the scale, ending with *C* (the lowest note). Use the note identification charts to help you locate the correct buttons. This sequence must be followed because the tuning of any note will affect all the ones below it in pitch.

Setting a Temperament

Setting a temperament sometimes is confusing. However, when it is explained methodically, anyone with a normal ear can do it. Since an organ does not require octave "stretching" as a piano does, the simplest tuning method is to use one of the devices mentioned before. If none are available, the following method will be valuable.

Setting a temperament consists of tuning the notes in one octave (twelve notes) to the correct intervals by listening to the beats. The musical scale is so arranged that, when certain notes are played together, a beating almost like a tremolo effect will be heard. The object is to arrange these beats so that the notes will be in tune with each other. These beats can be heard when an octave or a fourth or fifth interval is played (see Fig. 8-15). It is by setting these intervals that a temperament is set.

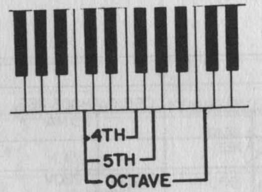


Fig. 8-15. Location of 4ths, 5ths, and octaves.

We must have an accurate starting point, such as a tuning fork. We will use the octave above and including middle *C*, and will begin by tuning the *C* above middle *C* to C523.3 (cycles per second) with the aid of the tuning fork. First weigh the key down so the note will sound continuously. Then tap the tuning fork, and adjust the associated potentiometer on the rear of the tone generator chassis until no roll or beat is heard. Now you can tune all the intervals using the tuning chart in Table 8-1, which shows the complete procedure. Fig. 8-16 shows the keys being tuned. First, tune the note being adjusted to the exact zero beat. Then rotate the tuning control counterclockwise slightly, until the desired rate of beat is obtained by counting. A compromise of six beats in five seconds is usually satisfactory. Although this method will not pro-

TABLE 8-1. PROCEDURE FOR SETTING TEMPERAMENT

Play	*Play and Adjust*	*Tune For*
C (Tuning Fork)	C (523.3)	Exact Pitch
C (523.3)	C (Middle)	Zero Beat
C (Middle)	G	5 beats flat in 5 secs.
G	D	7 beats flat in 5 secs.
D	A	5 beats flat in 5 secs.
A	E	7 beats flat in 5 secs.
E	B	5 beats flat in 5 secs.
B	F#	7 beats flat in 5 secs.
F#	C#	5 beats flat in 5 secs.
C#	G#	5 beats flat in 5 secs.
G#	D#	7 beats flat in 5 secs.
D#	A#	5 beats flat in 5 secs.
A#	F	7 beats flat in 5 secs.
F	C (523.3)	Check Only—Do not tune (5 beats in 5 secs.)

duce a mathematically exact tempered scale, the results will be close enough to be musically acceptable. Continue this routine throughout the entire organ.

CHECKOUT PROCEDURE

When servicing these Thomas organs, the following checkout procedure will aid in determining if all parts are functioning properly.

1. Inspect all plugs, connectors, and tubes to make sure they are securely in their sockets. Make sure the fuse is in place.
2. Turn the instrument on. The pilot light should go on.
3. Play each key, noting its action and whether or not it "speaks" properly. (In the Model H2 organ, the percussion trigger switches on the swell manual should be tested. Turn the percussion attack and decay stops on, the attack intensity control to maximum, and the decay intensity control to minimum, and play each key. Observe the tuning at this time.)
4. Hold a pedal key down, and test the bass volume control, each pedal stop, and the intensity control. Play all pedal notes, and observe the key operation and key switch adjustment. Also observe the pedal tuning.
5. The pedal-assembly alignment may have shifted if the instrument has been moved. If so,

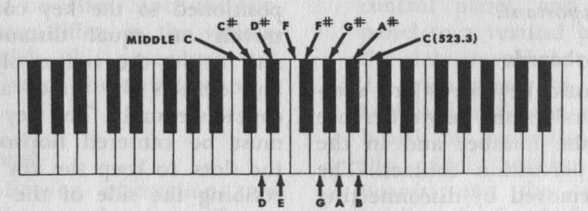


Fig. 8-16. Location of notes being tuned.

some of the white keys will strike the floor when played. Realign if necessary.

6. Operate the expression control. Does the volume become louder or softer? Also listen for squeaks or binds.
7. Play the instrument at a high volume level. Tighten any loose assemblies, screws, etc., if you hear rattles and vibration.
8. After completing steps 1 through 7, tune and service the organ as necessary. (Be sure to support the top after opening it, so the hinges will not be strained.)

SERVICING THE THOMAS ORGANS

Leaf Key Switches and Their Adjustment

The key switches consist of an SPST for the lowest note and an SPDT for the remainder. When they are properly adjusted, the note will not sound before the key has been depressed one-sixteenth of an inch, and should sound before the key is an eighth of an inch from the bottom. In the upper notes of any group, the lower contact must break before the upper one makes. This adjustment is best checked by ear. Hold down the lowest note in each group, one at a time. As an upper note is pressed, the lower one must stop sounding immediately. *This adjustment is extremely important.*

Plastic Keyboards

The plastic keyboards are similar in all models, the only difference being in the number and in the use of a percussion contact. The keys are removed by disconnecting the key return spring and pulling the key forward. This disengages the key pivot spring from the key rack. It should take a pull-out force of about six to eight pounds to remove a key. If a key is loose, bend the key pivot spring by hand to provide more tension. When replacing a key, be sure the felt on the key guide bracket finger is in place and the bracket upstop is properly located between the upstop and downstop felts before engaging the pivot spring in the key rack. Also make sure the key contact pin is centered between the key contacts, and the key return spring is properly attached.

The side play of a key can be adjusted by twisting the top of the individual bracket key guide finger, and the spacing on the sides, by bending the finger sideways. To adjust the key height, bend the foot of the bracket upstop under the front of the keys. The complete key assembly, or any of the individual parts, can be purchased for replacement.

Printed-Circuit Key Contact Switches

The printed-circuit key contacts must be properly adjusted. Otherwise, the organ will play erratically. With the keys at rest, the key pins should deflect the bottom contacts. The upper contact should be adjusted so the note does not sound until the key is depressed at least an eighth of an inch, but not later than a fourth of an inch. The printed circuit boards should be positioned so the key contact pin travels an equal distance above and below the center of the slot and deflects the upper and lower contacts equally. The key pins also must be centered horizontally in the slots, to keep the key pin from rubbing the side of the slot. The bottom contact wire of all single-pole, double-throw contacts must

break with the key pin before the upper contact makes. This can be checked audibly by holding down the lowest note (the single-pole, single-throw key contact) of a given sharing group. When the higher notes are slowly depressed, the lowest note will cease to sound before the upper note sounds. Single whiskers can be bent with a soldering aid or needle-nose pliers. All bending should be close to the whisker mounting point or at the 45-degree bend only. The whiskers should be as nearly vertical as possible when not deflected by the key pins; they must not rub the phenolic board. Some switchboards may have to be removed for inspection or replacement. If so, they should be repositioned as described here.

Handle the key springs carefully! They can be slipped off the end of the key pin. However, do not touch the body of the spring. Either insert a pointed instrument through the end loop, or grab the loop with a pair of needle-nose pliers. Be just as careful, when replacing the springs, to not handle its body. For any rewiring, use a small soldering iron. Make all solder joints rapidly and with a minimum of heat to avoid overheating the phenolic board. Be sure the solder does not creep up and coat the spring wire.

Whenever removing wires connected to the switchboard, always draw a diagram showing the colors of the wires removed and which eyelets had no wires. Since the wiring sequence differs in the various organ models, this procedure will save time when the switchboard is replaced.

Key Removal

The following instructions are for removing wooden keys. To remove plastic ones, follow Steps 1, 2, and 3 only. Any plastic key can be removed by releasing the return spring at the back of the key and pulling the key forward to disengage the pivot spring from the rack.

Single-Manual Organs

1. Loosen the console top bolts (under the rear corners of the front keybed overhang).
2. Lift the console top. Loosen (but do not remove) the two screws holding the control panel locating brackets (at the ends of the control panel). Remove the control panel.
3. Take off the keyboard trim-strip extrusion by unscrewing the screws at each end.
4. Remove the upstop channel assembly by unscrewing the two upstop nuts at each end of the channel. *Do not* remove the adjustment screw in the center of the channel.
5. Now any key can be removed by releasing its return spring (at the rear of the key) and raising the key off its balance pin (also known as the center guide pin). Be careful not to damage the key contact switches.

Model H Organ

1. Raise the top of the organ by releasing the catch under the center and disengaging the front edge from the tension fasteners.
2. Remove the four ¼-inch hex head screws at the ends of the control panel, and raise the panel to a vertical position in the slots provided.
3. To gain access to the lower keyboard, raise the upper keyboard by removing the key-slip panel (between the keyboards) and the two screws holding the front of the upper keyboard in place. (Be careful,

when removing a key from the swell manual, not to damage the percussion contact whiskers.)

The upper keyboard on the Model K organ is reached by opening the top of the organ and releasing the tie-down bolts. (The Model K uses the same type of tie-down bolts as the single-manual organ.) The lower keyboard on the Model K organ is exposed for service in the same manner as for the Model H organ.

Pedal Claviers

The pedal claviers can be serviced by removing the back cover (held in place by ¼-inch hex head sheet-metal screws) and removing the assembly from the organ as follows:

1. Lay the organ on its side on a pad.
2. Remove the ¼-inch hex head sheet-metal screws holding the unit to the front baffle board.
3. From underneath, remove the three 5/16-inch machine screws in the back edge.
4. Disconnect the cable to the amplifier, and remove the unit.

The pedal assembly must be removed before an individual pedal key can be replaced. The keys are removed by unscrewing the Phillips head screw in the bottom center of the key and the sheet-metal screw at the back of the pedal assembly.

When replacing the Phillips head screw, you may have to remove the cover from the assembly in order to hold the pedal leaf switch actuating assembly.

Expression Pedal—Models G, J, and K

The expression-pedal control is a variable resistor which shunts the amplifier input signal to ground. A capacitor in series with the control provides frequency compensation to produce more expression at medium and high frequencies. The pedal action can be adjusted to the individual's needs by turning the set screws in the fiber bearing blocks. The pedal shaft sometimes must be lubricated to prevent squeaking. A tiny dab of *Vaseline* or *Lubriplate,* or a good grade of grease, can be applied with a toothpick. Never use oil; it may enter the control.

Malfunctions

Some of the more common malfunctions, their cause and cures are listed in the following.

Single Dead Note—A possible cause of a dead note is a bad key switch. If the bottom contact of either two higher notes in a group of three is not making, the lower notes of the group will be dead. A dirty contact will usually clean itself if the key is played rapidly for a few seconds. Another possibility is an open or shorted tuning potentiometer—check it with an ohmmeter. The trouble may be a sliver of metal which is grounding a terminal to the potentiometer case. Sometimes a terminal becomes slightly bent and is grounded to the cover.

Three Dead Notes in the Same Group—This is probably caused by a defective 12AU7 tube. Also check for an open circuit in oscillator coil L201.

Six Dead Notes in Two Adjacent Groups—The most common cause is both sections of a 12AU7 tube defective.

All Notes Dead (Tubes Light and Gas Regulator Glows)—Check the speaker on-off switch (directly under the left cheek block of the console). If O.K., check for a defective 12AX7 keying voltage regulator tube or a shorted or defective amplifier tube.

One Note Sounds Continuously—Check for a jammed or defective key switch.

Several Notes Sound Continuously (or at Random)—Look for a defective 12AT7 regulator or circuit component. This circuit provides cathode bias to the tone oscillators. If there is no bias, the circuits will oscillate at random.

Note Stops (or Goes Off and On) When Vibrato Is Turned on Fully—The tuning control for the note has probably been turned too far clockwise. Readjust the associated inductor.

Tuning Controls Do Not Bring Notes Into Tune—If a tuning control will not bring a note into tune, change the gap of tuning inductor L201. For example, if the pitch of middle *C* is still low, even with the control at the full clockwise limit, it can be raised by increasing the gap in the tuning inductor. Because this inductor also serves middle *C#* and *D,* their pitches will also be raised, and their tuning controls will have to be readjusted. Set the gap so no control must be set at its full limit, either upper or lower. Also be careful not to set a control too near the clockwise stop because the vibrato will be exaggerated. (The tone may even be interrupted.) If it is impossible to arrive at a gap that permits all three notes to be tuned with the controls in a satisfactory position, install new tuning capacitors.

Vibrato Rate Choppy on Bottom F Note—Readjust the potentiometer on the *F* note until the vibrato returns to normal. Then reset the coil and other three potentiometers. Retune by zero-beating the octaves.

Distortion—Check the amplifier gain-control setting at the rear of the amplifier chassis in this manner:

1. Connect a voltmeter across the speaker voice coil.
2. Set the vibrato control to off, the solo control in the center, and the five voices to maximum.
3. Depress the expression control all the way (loudest volume).
4. Hold down the middle *C* note, and adjust the gain-control setting to read 2.0 volts on the voltmeter.

If distortion still exists, replace the amplifier power tubes, the rectifier tube, or do both. (Sometimes other tubes in the amplifier may cause distortion and should also be replaced.)

Pedal Clavier—If a single note fails, check for a defective pedal switch. The most common cause is the bottom SPST switch not making contact when the pedal is depressed. A false note sounding before the correct tone indicates the top SPST switch is closing before bottom one. Readjust for proper operation. Should all notes become inoperative, check for a defective tube, pedal generator or an open or shorted circuit component. (A small particle of metal may have fallen in the pedal clavier. It can be blown out with compressed air.) If one tuning potentiometer will not tune and all the others do, it should be replaced. All pedals (or a group of pedals) sounding the same note indicate a short in the top contacts of the highest correctly operating switch. A short in the bottom contacts of the switch will cause a false note to sound continuously.

Fig. 9-1. The Wurlitzer Model 4000 chord generator.

CHAPTER 9

THE WURLITZER MODEL 4000 CHORD ORGAN

The Wurlitzer Model 4000 chord organ pictured in Fig. 9-1 has a 41-note solo manual with conventionally arranged keys. The chord section has 45 chord buttons for playing the accompaniment. Nine bass buttons, instead of the more conventional pedals, are used to play the bass notes.

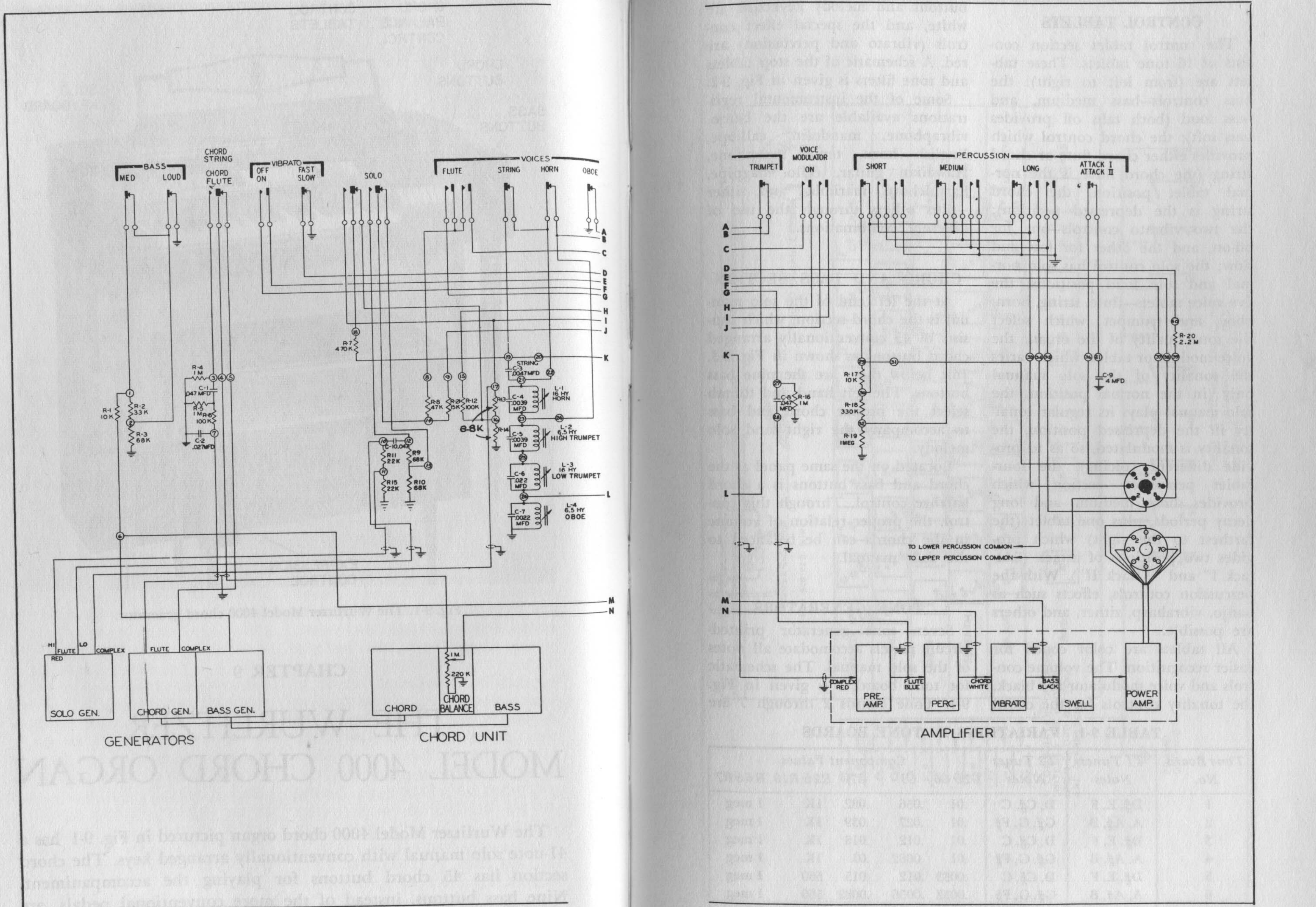


Fig. 9-2. Stop tablets and tone filters.

CONTROL TABLETS

The control tablet section consists of 16 tone tablets. These tablets are (from left to right): the bass controls—bass medium, and bass loud (both tabs off provides bass soft); the chord control which provides either chord flute or chord string (the chord flute is the normal tablet position, the chord string is the depressed position); the two vibrato controls—one for off-on, and the other for fast and slow; the solo control has solo normal and solo loud positions; the five voice tablets—flute, string, horn, oboe, and trumpet, which select the tone quality of the organ; the voice modulator tablet, which varies the tonality of the solo manual only (in the normal position, the solo manual plays its regular tonality in the depressed position, the tonality is modulated, so as to provide different voicing); the four-tablet percussion section which provides short, medium, and long decay periods, plus one tablet (the farthest to the right) which provides two positions of attack ("Attack I" and "Attack II"). With the percussion controls, effects such as banjo, vibraharp, zither, and others are possible.

All tablets are color coded for easier recognition. The volume controls and voice modulator are black, the tonality controls for the chord buttons and melody keyboard are white, and the special effect controls (vibrato and percussion) are red. A schematic of the stop tablets and tone filters is given in Fig. 9-2.

Some of the instrumental registrations available are the banjo, vibraphone, mandolin, calliope, English horn, tenor saxaphone, Hawaiian guitar, cello, bagpipe, harpsichord, marimba, and zither —plus others through the use of different combinations.

CHORD AND BASS SECTION

At the left end of the solo manual is the chord section, which consists of 45 conventionally arranged chord buttons as shown in Fig. 9-3. Just below them are the nine bass buttons. The left hand and thumb select the proper chord and bass to accompany the right-hand solo melody.

Located on the same panel as the chord and bass buttons is a chord balance control. Through this control, the proper relation of volume in the chords can be balanced to the solo manual.

TONE GENERATORS

Seven tone generator printed-circuit panels accomodate all notes of the solo manual. The schematic for tone board 1 is given in Fig. 9-4. Tone boards 2 through 7 are

TABLE 9-1. VARIATIONS IN TONE BOARDS

Tone Board No.	*T1 Tunes Notes*	*T2 Tunes Notes*	*Component Values*				
			C2&C6	*C3*	*C7*	*R2&R10*	*R6&R7*
1	D#, E, F	D, C#, C	.01	.056	.082	1K	1 meg
2	A, A#, B	G#, G, F#	.01	.027	.039	1K	1 meg
3	D#, E, F	D, C#, C	.01	.012	.018	1K	1 meg
4	A, A#, B	G#, G, F#	.01	.0082	.01	1K	1 meg
5	D#, E, F	D, C#, C	.0033	.012	.015	560	1 meg
6	A, A#, B	G#, G, F#	.0033	.0056	.0082	560	1 meg
7	D#, E	D, C#, C	.0033	.0033	.0039	560	1.5 meg

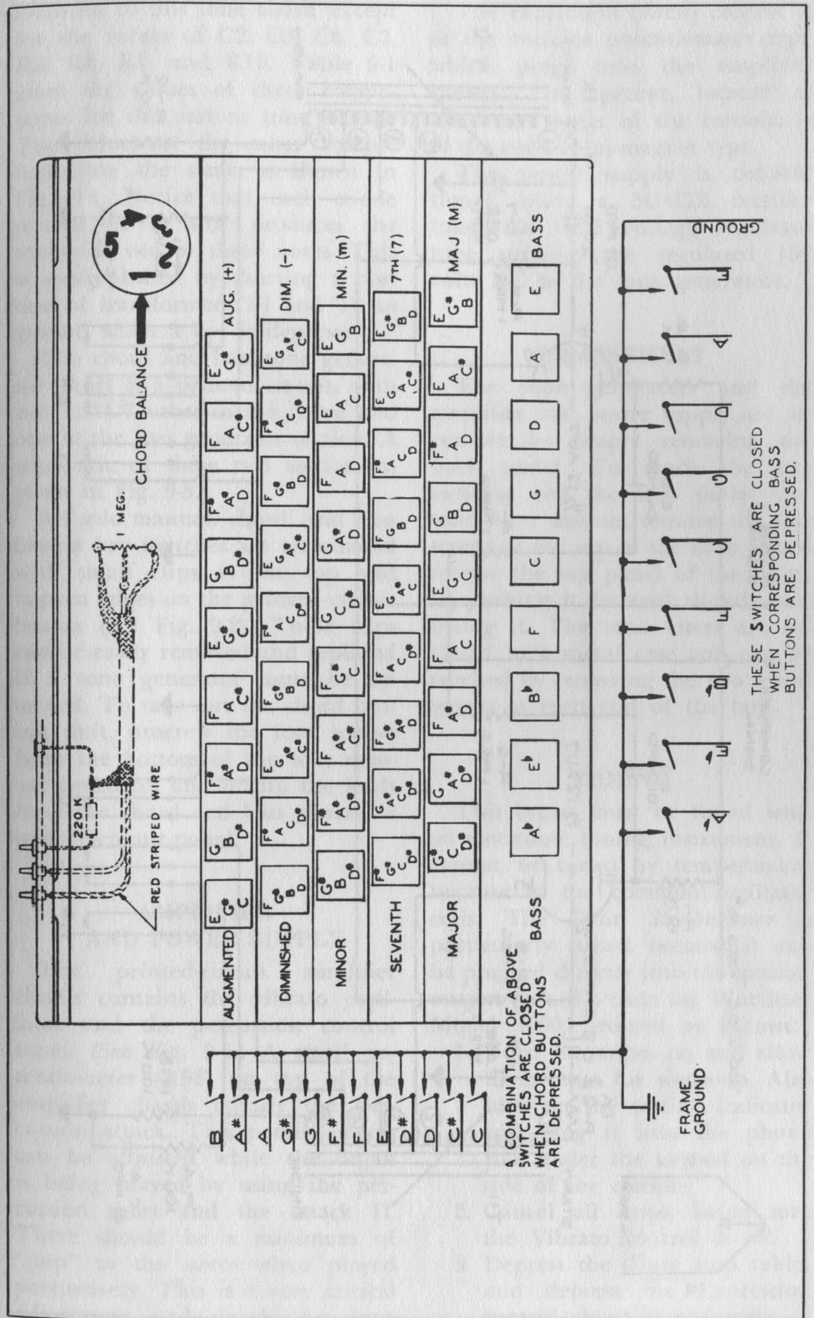


Fig. 9-3. The chord unit.

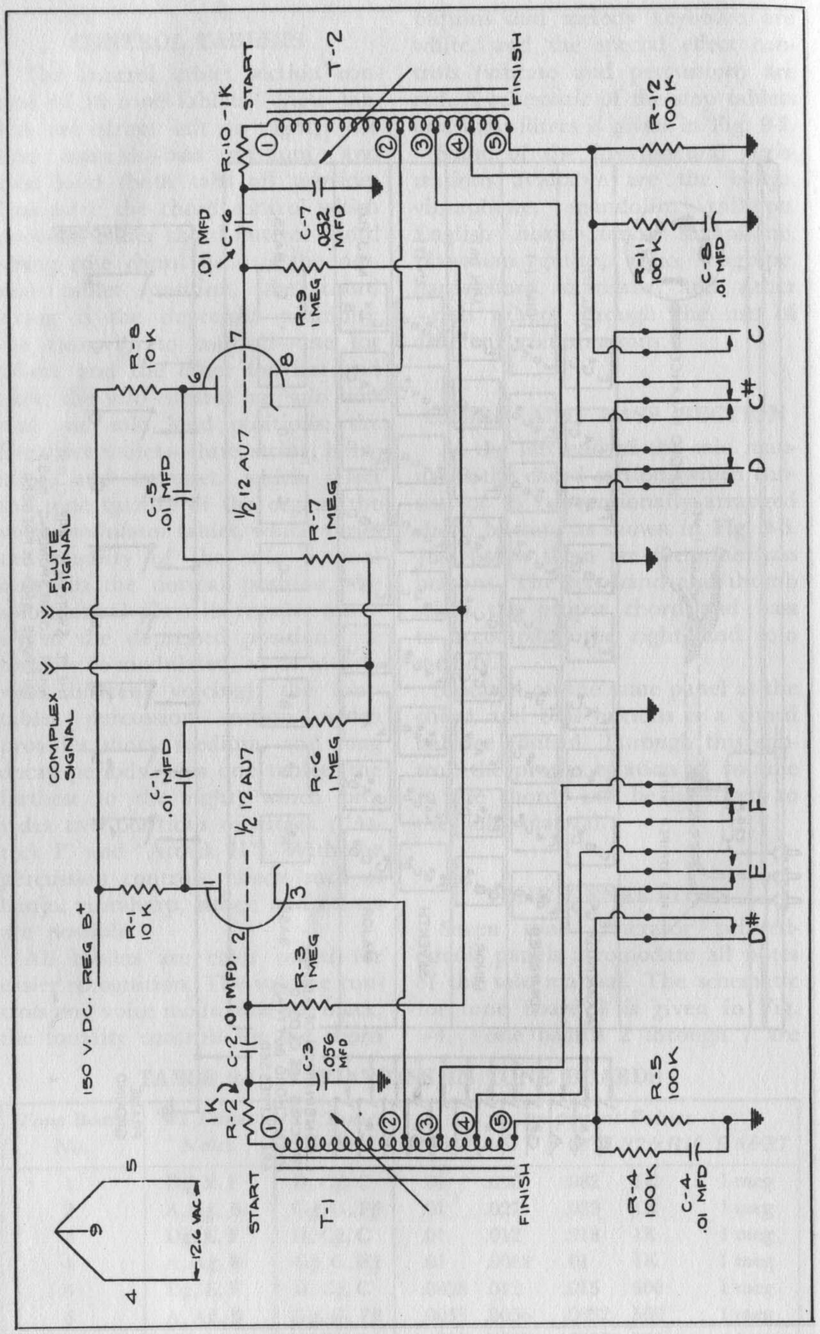


Fig. 9-4. Tone generator—tone board No. 1.

identical to this tone board except for the values of C2, C3, C6, C7, R2, R6, R7, and R10. Table 9-1 gives the values of these components for the various tone boards. The values of the other components are the same as shown in Fig. 9-4. Notice that each triode section of a tube produces the tones for two or three notes. This is accomplished by shorting a portion of transformers T1 and T2 to ground when a key is depressed.

The chord and bass tone generator panel is a printed circuit, with two 12AU7 tubes in the chord and one in the bass generator section. A schematic of these two sections is given in Fig. 9-5.

All solo manual, chord, and bass button key switches are terminated with small clips at the top and bottom edges on the printed circuit boards (see Fig. 9-2). These clips can be easily removed and replaced if a tone generator must be removed. To take out the chord button unit, unscrew the four screws from the bottom of the solo manual keyboard, and unclip the leads from the chord and bass generator printed-circuit panel.

AMPLIFIER AND POWER SUPPLY

The printed-circuit amplifier chassis contains the vibrato oscillator and the percussion control tubes. (See Fig. 9-6.) A small potentiometer (R98) on top of the amplifier chassis adjusts the percussion attack. This potentiometer can be adjusted while the organ is being played by using the percussion short and the attack II. There should be a minimum of "pop" to the notes when played percussively. This is a very critical adjustment and should be done quite carefully.

The expression (swell) control is of the variable potentiometer type which plugs into the amplifier chassis. The speaker, located at the front center of the console, is of the permanent-magnet type.

The power supply is conventional, using a 5U4GB rectifier tube. An OD3 voltage regulator tube supplies the regulated 150 volts DC to the tone generators.

DISASSEMBLY

The tone generators and the amplifier and power supply are accessible by simply removing the back panel. To reach the key switches and the stop tablet and tone filter section, remove the two screws at the top of the back. Then release the top panel of the organ by pushing it forward slightly and lifting it. The tone filters are enclosed in a metal case and can be reached by removing the two metal screws at each end of the box.

TUNING

This organ must be tuned with an electronic tuning instrument. It cannot be tuned by temperament because of the common oscillator coils. The Conn *Strobotuner* is particularly suited because it can be plugged directly into the speaker output jack. To tune the Wurlitzer Model 4000, proceed as follows:

1. Turn the organ on and allow 15 minutes for warm-up. Also turn on the tuning indicator and plug it into the phone jack under the keybed on the side of the console.
2. Cancel all stops, being sure the Vibrato control is off.
3. Depress the Flute stop tablet and depress the Expression control about three-fourths of the way.

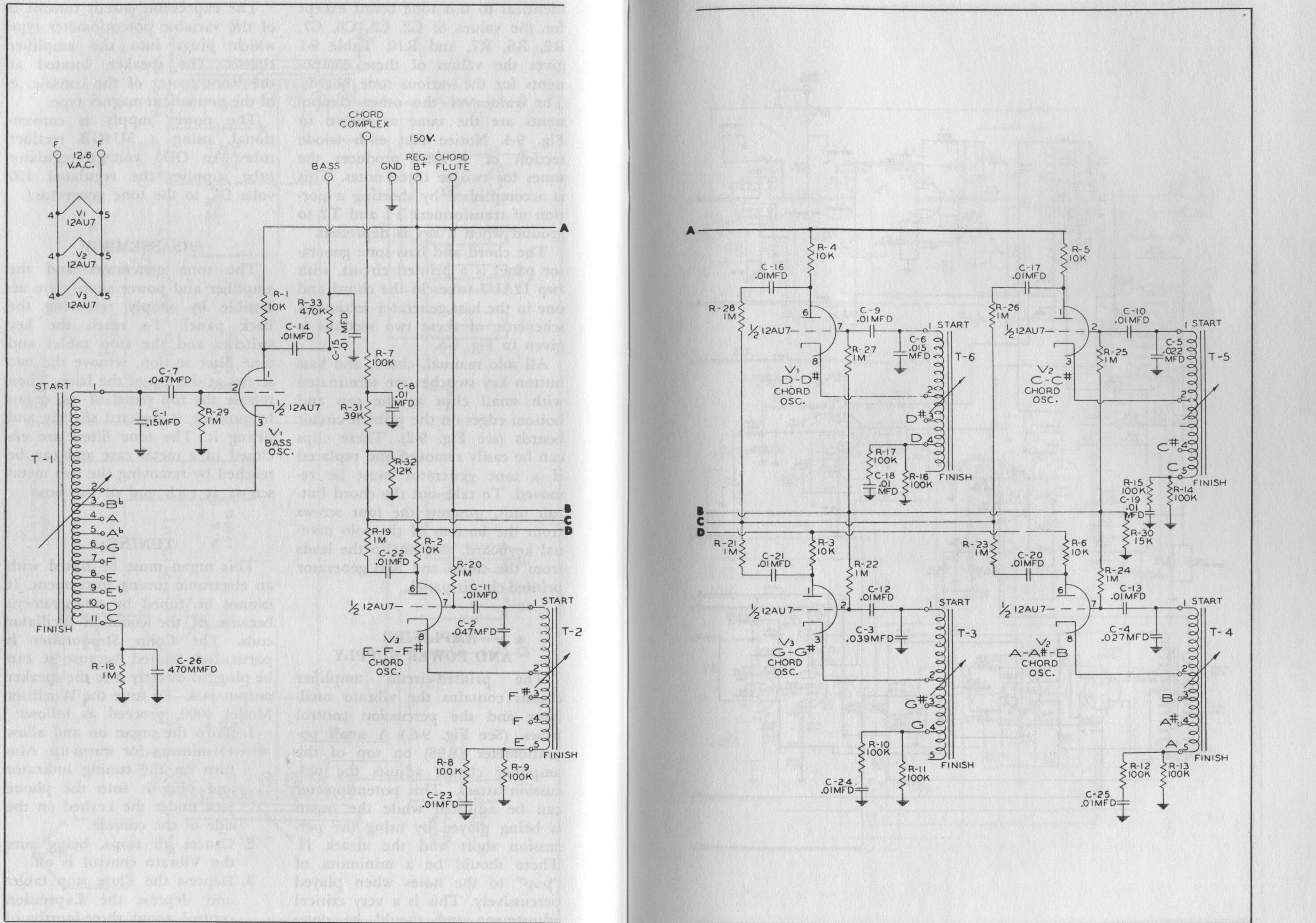


Fig. 9-5. Schematic of the chord and bass generators.

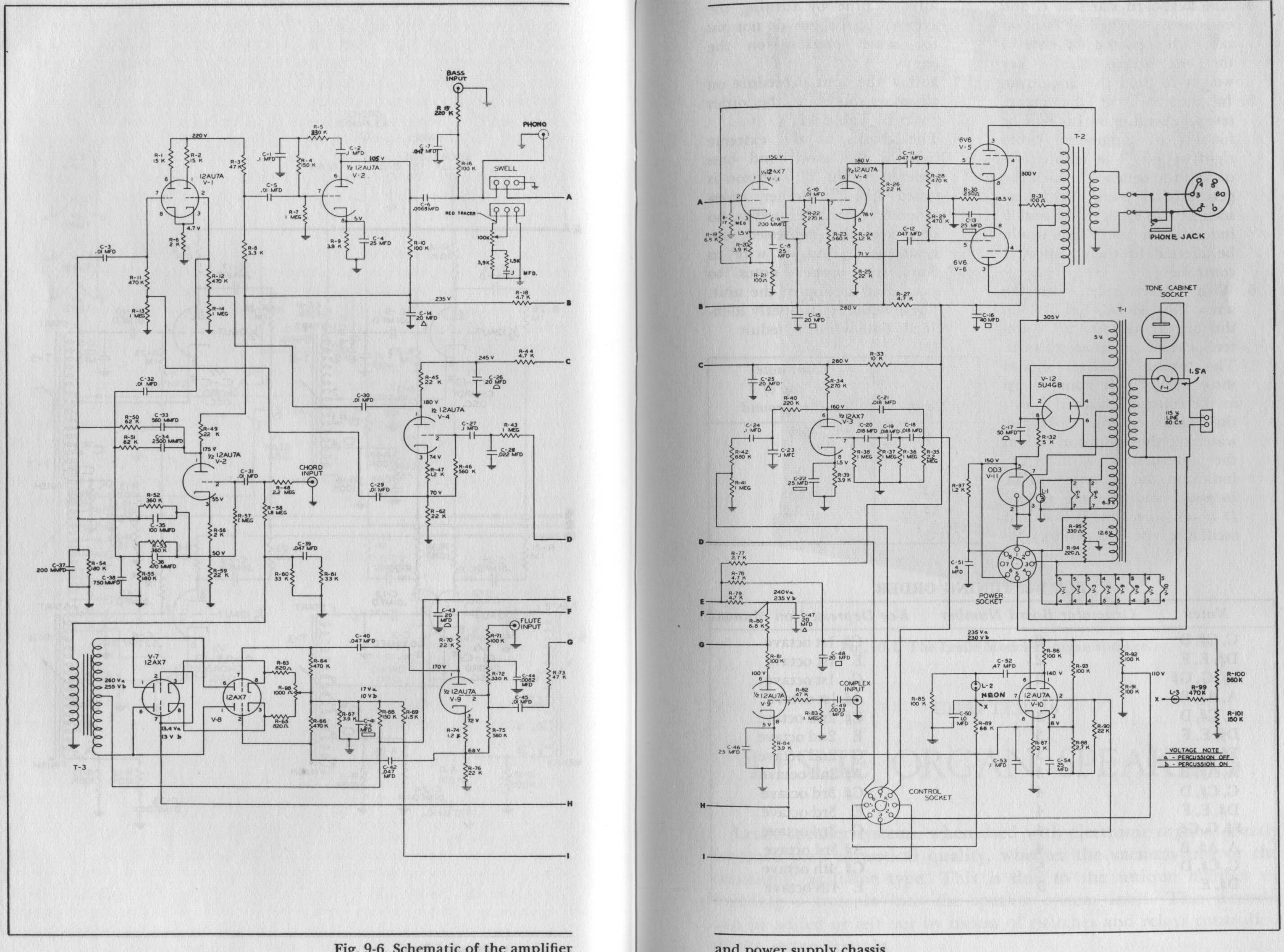


Fig. 9-6. Schematic of the amplifier and power supply chassis.

4. The keyboard starts at *C* and ends at *E*, a range of four octaves. Depress the *C#* note of the first octave. Use a key weight to hold the key down.
5. In the back of the organ, seven generator boards will be found, all numbered from right to left. The number indicates the octave in which the generator is used; the letters such as *C, C#, D, A, A#* and *B* indicates the notes that would be affected by their respective controls.
6. With a screwdriver, turn the screw labeled "C, C#, D," on the board marked "2," counterclockwise a quarter turn. The tuning indicator should show the *C#* note going sharp as the control is turned. Turn this same control clockwise, watching the indicator. When the pattern stands still on the indicator, the *C#* note will be in tune (and also the *C* and *D* notes, since this is a shared oscillator type of generator). Be sure to tune by turning the screw clockwise, and do not put too much pressure on the screw.
7. Follow the same procedure on all other notes in the order given in Table 9-2.
8. The chassis at the extreme right is the chord and bass generator unit. This section is tuned like the other seven generator boards. However, no keys need be depressed; instead, use a jumper wire to short the proper notes to ground at the top of the unit. These notes are properly identified. Follow this schedule:

Notes	*Short note at top of unit to ground*
C-C#	C
D-D#	D
E-F-F#	F
G-G#	G
A-A#-B	A#
Bass F	F

TABLE 9-2. TUNING ORDER

Notes	*Generator Board Number*	*Key Depressed on Manual*
C, C#, D	2	C# 1st octave
D#, E, F	2	E 1st octave
F#, G, G#	2	G 1st octave
A, A#, B	2	A# 1st octave
C, C#, D	3	C# 2nd octave
D#, E, F	3	E 2nd octave
F#, G, G#	3	G 2nd octave
A, A#, B	3	A# 2nd octave
C, C#, D	4	C# 3rd octave
D#, E, F	4	E 3rd octave
F#, G, G#	4	G 3rd octave
A, A#, B	4	A# 3rd octave
C, C#, D	5	C# 4th octave
D#, E	5	E 4th octave

Fig. 10-1. The Leslie Model 47 organ speaker.

CHAPTER 10

LESLIE ORGAN SPEAKERS

Leslie speaker systems, when used with electronic organs, greatly improve their acoustical quality, whether the vacuum-tube or the transistor oscillator type. This is due to the unique manner of building a tremolo into the speaker system itself. This tremolo can be added or left out by means of switches and relays controlled at the organ console.

The Leslie Model 47 speaker, shown in Fig. 10-1, contains a 35-watt amplifier. It is equipped with a 30-foot cable and the necessary switches and controls to permit operation of the organ console alone, the Leslie cabinet alone, or the two combined.

Leslie speakers are protected by United States Patents R.E-23, 323, and others. They were invented by Donald J. Leslie of Electro Music, Pasadena, California. The manufacturer supplies complete information about installing them for the different makes of organs. Therefore, only those few items making up the servicing of these units need be considered.

PREVENTIVE MAINTENANCE

Every Six Months— Place 20 or 30 drops of high-grade sewing-machine oil in each of the two tremulant-motor oil tubes at the back of the cabinet. Make sure all amplifier tubes are lit. (The unit will still work if only one of the matched pair of audio-output tubes is working, but results will be greatly *impaired*). Also, inspect the tremulant-motor belts to see if they are fraying.

Every Year—Oil the upper tremulant rotor. This oil hole is at the center of the *Bakelite* tremulant assembly and is clearly marked. Allow about five drops of oil to flow down this tube, but not to overflow at the opening. Do not let any oil get on the belts or in the pulley grooves.

NOTE: Instruments in steady use should be oiled every three months, and the upper rotor every six months.

Amplifier Tubes—A complete, new set of tubes should be installed after about a thousand hours of use. The weakening of these tubes is so drawn out that you may not be aware of the substandard results. Always test new tubes before putting them into service.

SERVICING

Amplifier and Electrical

To remove the amplifier, take out the screw holding the front of the amplifier chassis to the bottom of the cabinet. Remove the two motor and two speaker plugs and pull out the chassis. In replacing, align the back of the chassis so the amplifier guide and hold-down clamp will engage the amplifier.

Fuse

The fuse is a *Slo-Blo* unit (2 amp in Model 47 and 3 amp in Model 51C). Before replacing, determine why it has blown.

Power-Tube, Screen-Voltage Regulation

A simple regulating circuit holds the output-tube screens at the best operating voltage, regardless of variations in the signal level.

Gas regulator tubes maintain a constant voltage drop regardless of current variations (within rated limitations). An OC3-VR105 regulator tube provides a constant voltage reduction in a series circuit to the output-tube screens. A resistor of approximately 4700 ohms, ½ watt, (not critical in value) connected to pin 2 of the regulator tube suppresses possible gas-tube oscillations caused by screen-current

variations. It also acts like a fuse in case of an accidental screen-circuit short.

Distortion

Distorted sound most often is caused by too high a setting of the speaker volume control. The amplifier gain is purposely higher than necessary so low-power consoles will provide the full sound output from the speaker. Setting this volume control to maximum will result in distortion when the organ swell (expression) control is wide open. Therefore, use the following procedure to prevent this:

1. Set the speaker volume control to minimum.
2. Set the console swell (expression) control fully on (loudest).
3. Place all except the 16′ lower manual tablets on.
4. Play full chords and one pedal note, and turn the speaker amplifier volume control from low to high until distortion can be heard. Then slowly back off the volume control just far enough to remove the distortion. This adjustment does not have to be made again.

CAUTION: Do not set the volume control to produce continual distortion because the speakers will be damaged.

Voltage Readings

If the amplifier develops trouble, measure the various voltages and compare them with the ones on the circuit diagrams (Figs. 10-2 and 10-3). These voltages should be measured with a 20,000-ohms-per-volt VOM. (Keep the meter resistance, line voltage, and parts tolerances in mind.)

Electrolytic Capacitors

The electrolytic capacitors are 30-30-30-10 mfd, 475-volt units. Because electrolytic capacitors eventually wear out, they are contained in a plug-in can that is as easy as a tube to replace.

Automatic Electric Braking on Tremulant Motors

When the tremolo control switch is turned off, the control relay applies a direct current to the tremulant motors, braking them. While the switch is off, the direct current flows through the motors continuously. No harm is done because the current is far below the normal running ratings.

This DC braking voltage is obtained by rectifying and filtering a 25-volt tap on the power-transformer primary. The circuit contains a silicon diode rectifier; a 200-mfd, 50-volt filter capacitor; a filter choke coil to eliminate switching clicks; and a 3-ohm, 10-watt current-limiting resistor to protect the silicon rectifier from current surges.

Horn-Reflector Replacement

When a reflector is damaged, cut the standoff pins so they can be pulled out with a pair of slip-joint "gas" pliers.

Make sure, when putting on the new reflector that the cut edge is at the top of the horn in the operating position. Use the special cement furnished by the manufacturer.

Speakers and the Dividing (Crossover) Network

Leslie uses a full two-way system with two separate speakers. Pedal and midrange tones are generated by a heavy-duty, 15-inch speaker with an alnico permanent magnet.

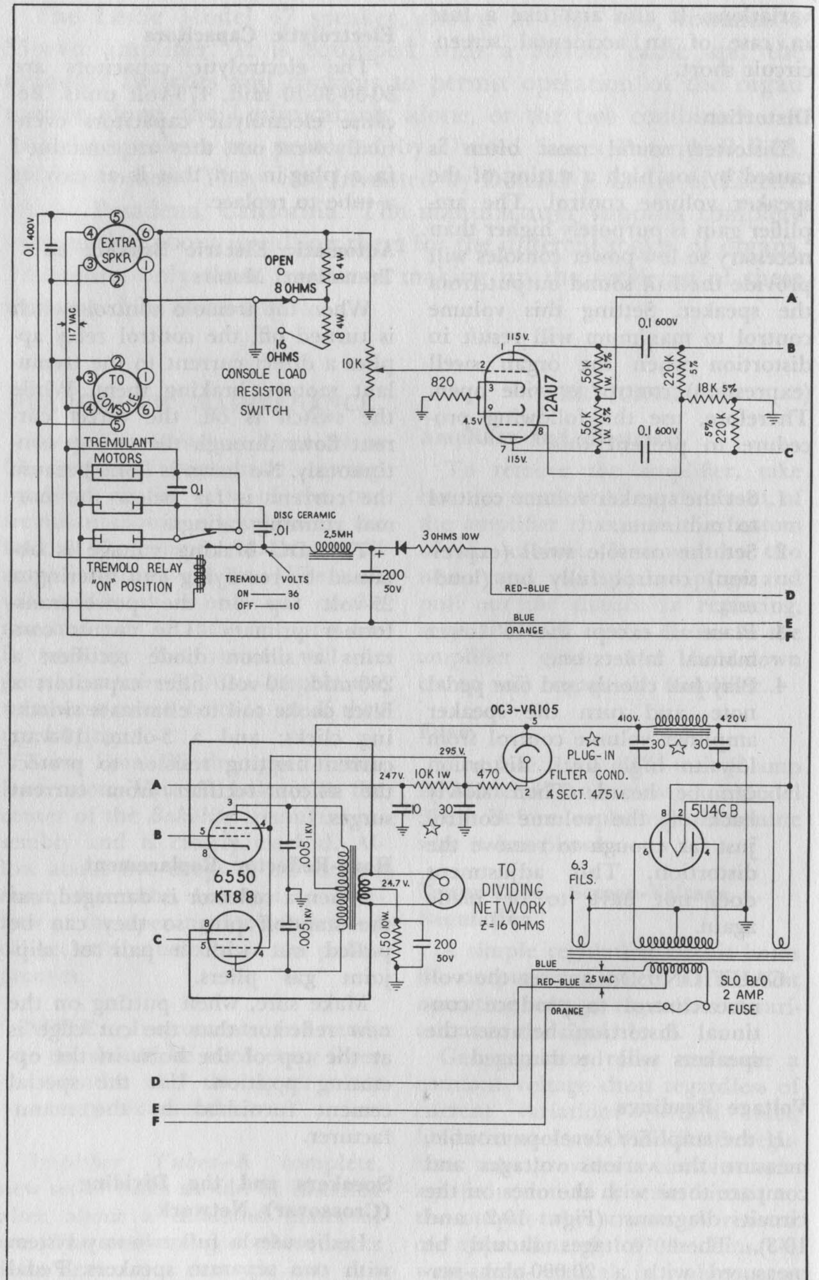


Fig. 10-2. Schematic of the Leslie Model 47 power amplifier.

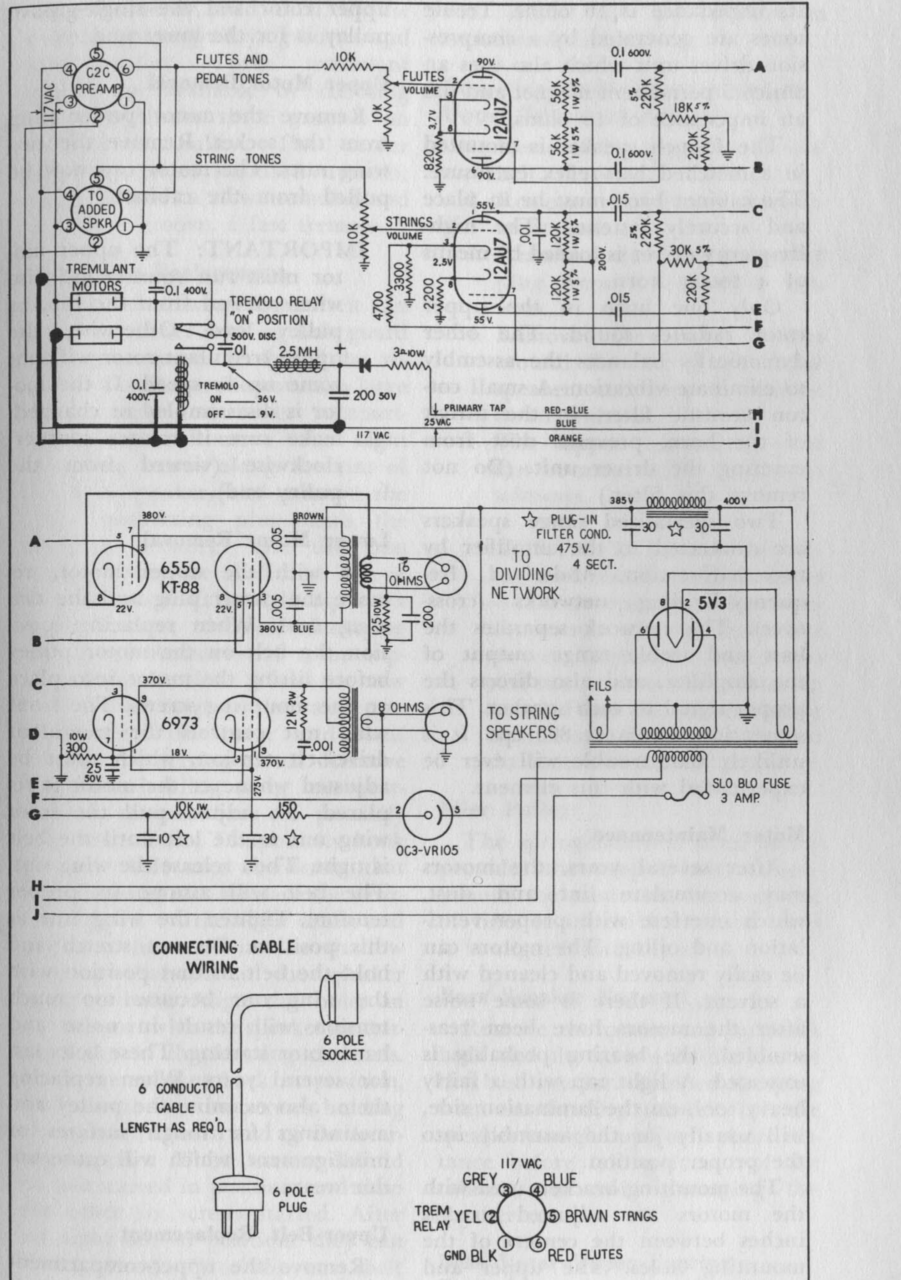


Fig. 10-3. Schematic of the Leslie Model 51C two-channel power amplifier.

Its impedance is 16 ohms. Treble tones are generated by a compression driver unit which also uses an alnico 5 permanent magnet and has an impedance of 16 ohms.

The 15-inch speaker is mounted in a matched bass-reflex enclosure. The cabinet back must be in place and securely fastened. The high-frequency driver is loaded by means of a rotary horn.

Only one horn in the upper rotor radiates sound. The other dynamically balances the assembly to eliminate vibration. A small cotton acoustic filter, in the throat of the horn, prevents dust from entering the driver unit. (Do not remove this filter.)

Two specialized range speakers are connected to the amplifier by two half-section, *M*-derived, frequency-dividing networks (crossover). The network separates the bass and treble range output of the amplifier, and also directs the proper signal to each speaker. This separation occurs at 800 cps. It is unlikely that trouble will ever be experienced with this element.

Motor Maintenance

After several years, the motors may accumulate lint and dust, which interfere with proper ventilation and oiling. The motors can be easily removed and cleaned with a solvent. If there is some noise after the motors have been reassembled, the bearing probably is unseated. A light tap with a fairly heavy tool, on the lamination side, will usually jar the assembly into the proper position.

The mounting brackets used with the motors are adjusted to 5⅞ inches between the centers of the mounting holes. The upper and lower motors are interchangeable when the proper pulley is used. The three-groove pulley is for the upper rotor and the single-groove pulley is for the lower one.

Upper Motor Removal

Remove the motor power plug from the socket. Remove the two wing nuts. The motor can now be pulled from the cabinet.

IMPORTANT: The upper motor must run counterclockwise when viewed from the top, or pulley, end. Otherwise, the upper tremulant rotor will not come up to speed. If the motor is disassembled or changed, make sure it rotates counterclockwise (viewed from the pulley end).

Lower Motor Removal

As with the upper motor, remove the power plug and the two wing nuts. When replacing, position the belt on the motor pulley before lifting the motor into place on the mounting screws. The front wing nut controls the tremulant drive-belt tension, which must be adjusted whenever the motor is replaced. To adjust, pull the front wing nut to the left until the belt is tight. Then release the wing nut. The belt will assume its proper tension. Tighten the wing nut at this position. Do not stretch and hold the belt in that position with the wing nut because too much tension will result in noise and hard rotor starting. These belts last for several years. When replacing them, also examine the pulley and mountings for rough surfaces or misalignment, which will cause undue wear.

Upper-Belt Replacement

Remove the upper-compartment cover and restretch the new belt by pulling it to its full length. Place it first over one horn and

then the other, and then in the desired motor-pulley groove and idler pulley. Three tremulant speeds are available by choosing any one of the three grooves on the motor pulley. The center groove provides standard tremolo; upper groove, a slow tremolo; and the lower groove, a fast tremolo.

Lower-Belt Replacement

A frayed or worn lower belt can strike the lower shelf or belt guard and cause noise. It should be replaced as follows: Remove the large center back and lower compartment cover. Remove the eight mounting screws along the rim of the bass speaker, and remove the cable connecting plug from the dividing network. Lift the bass speaker from the shelf and out of the cabinet. (Lift straight up for a short distance to avoid damaging the cone.) Remove the rotor support from the shaft. Place the new belt on the large pulley, and pass it between the rotor and shelf towards the driving motor. Remove the motor-holding wing nut nearest the cabinet back to partially drop the motor. Temporarily hook the new belt over the screw that had the wing nut. Replace the bearing support on the rotor shaft, and position the ends in the shallow locating channels at the speaker opening hole. Align the holes in the support with the speaker mounting holes in the locating channels. Place the speaker back in position, and install the two screws holding the speaker at each end of the bearing support. These screws should be just started in position, and then the other six screws started. After all eight are in position, they can be tightened. Place the new belt on the driving-motor pulley and place the motor back in position, using the original holding wing nut. Adjust the belt tension as mentioned earlier.

Removing Treble Speaker and/or Upper Tremulant Rotor

1. Remove the upper cover and belt.
2. Remove the center-compartment back.
3. Remove the treble-speaker plug from the dividing network.
4. Remove the three screws around the rim of the treble speaker, and drop it straight down and out.
5. The upper tremulant rotor can be removed by turning it sideways.

IMPORTANT: Be sure the rubber and metal thrust washers are on the spindle so the tremulant rotor will operate at the correct height and bass tones will not produce thrust-bearing noises. Place the rubber washer on the spindle first, and then the metal washer on top of it.

Idler Pulley

The spring-mounted idler pulley provides the proper belt tension. Should the mounting be bent out of line, it should be rebent until it is aligned with the belt.

Bass Speaker Removal

Remove the center compartment back and the screws in the rim of the bass speaker. Remove the plug from the dividing network. Lift the speaker straight up for a short distance before taking it out of the cabinet, to avoid damaging the speaker cone.

Bass Rotor Upper Bearing Replacement

1. Remove the bass speaker. (See preceding paragraph.)

2. Remove the top half of the bearing clamp. The bearing can now be lifted out and a new one installed.

If the new bearing is slightly loose, remove the bearing support assembly from the cabinet and disassemble it. Bend the lower half of the bearing clamp so it will apply more pressure to the ball bearing.

Bass Rotor Lower Bearing Replacement

1. Lay the cabinet on the floor so the bottom is accessible.
2. Remove the two screws fastening the bearing mounting plate to the cabinet. The entire bearing assembly can now be pulled from the shaft. Do not lose the flat metal washer between the rotor and the lower bearing grommets.
3. To replace the ball-bearing assembly, remove the top half of the bearing clamp.
4. When reassembling the bearing holder to the rotor shaft, don't forget the flat washer between the rotor and bearing grommets.

Lower Tremulant Rotor Removal

1. Remove the bass speaker.
2. Remove the upper bearing support and belt.
3. Using the large pulley as a handle, remove the tremulant rotor shaft by twisting and pulling up at the same time. The tremulant rotor will then come out from the back of the cabinet. Save the metal flat washer between the bearing and rotor grommets.
4. When replacing the tremulant rotor, be sure the sound-deflector surface curves downward and the flat metal washer is in place between the bearing and the rotor bottom grommets. Use a little oil or *Vaseline* as a lubricant when putting the rotor shaft back on the rotor. Neither lubricant will harm the neoprene grommets.

NOTE: When inserting the lower shaft, hold the rotor in a position that will allow the end of the shaft to enter the bearing grommet without displacing the flat metal washer between the bearing and rotor grommets. The shaft will be easier to align if the cabinet is placed on the floor and the lower bearing assembly removed, just as for replacing a lower bearing assembly. In this way, you can determine if the washer between the ball-bearing grommet and the tremulant rotor grommet is properly in place.

CHAPTER 11

ELECTRONIC ORGAN TUNING DEVICES

Before we discuss electronic organ tuning devices, a word about tuning—what it means, why it is done, and how—would be apropos.

It would be ideal if all musical instruments did not change their pitch during their useful life. Unfortunately, they do. Moisture, temperature, and other conditions take their toll. For this reason, the instruments must be tuned from time to time. A good example of an untuned instrument is the "tinny" piano which is the trademark of saloons in movie and TV westerns.

The predominant tuning device is the fork—a high-grade **U**-shaped object with a handle on the bottom. Vibration of its two prongs gives out a single pure note of constant pitch, the pitch depending on the length and thickness of the prongs. The standard, adopted by the French in 1859, is *A* above middle *C*. The fork moves back and forth 870.9 times a second at 15°C. (59°F.). The tone remains the same; it is not subject to the effects of moisture, temperature, and other conditions which plague musical instruments.

The tuning fork may be mounted on a hollow box to increase its volume by resonance. It is momentarily vibrated by a light tap, or kept in constant vibration by an intermittently energized electromagnet on one of the prongs.

A variation, the tuning bar, is a steel bar set on a resonance box. Because of its greater volume, the tuning bar is used by bands and orchestras. Nevertheless, it works on the same principle as the tuning fork—that is, it vibrates at the standard pitch.

Tuning forks can be obtained in complete sets of thirteen. They are accurate within .001 vibration per second at 70 to 72 degrees Fahrenheit, in a full chromatic octave from middle *C* (C261.63 through C523.25, which is the standard for A440 scale temperament). These tuning devices are accepted as standard by the U. S. Bureau of Standards and the American Federation of Musicians.

To go back to the beginning of the standardization of organ tuning, and to the recognized standards of pitch as we in the United States know them today, we must go away back to 1880. This was the year the A440 pitch was adopted as the standard, first in this country, and later throughout the world.

The advent of the electronic organ, coupled with the fact that it would be serviced by men trained in electronics instead of music, soon led to the development of electronic tuning devices. By using them, service technicians (even though they may have a "tin" ear) can tune the organ just as accurately as the organ tuner.

THE CONN *STROBOTUNER*

The *Strobotuner* (Fig. 11-1) provides organ service technicians with a portable device for rapidly and accurately tuning electronic organs (or any other musical instrument). By stroboscopically comparing a sound frequency with a standard frequency, it determines whether a

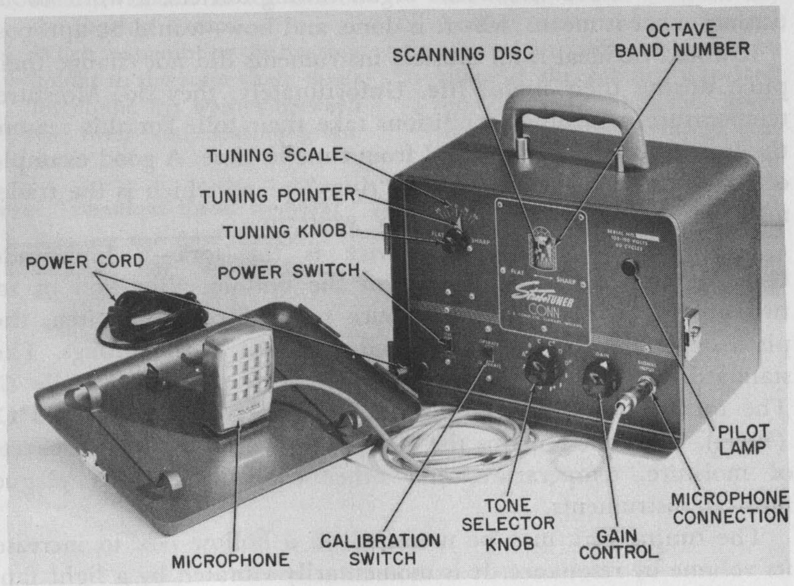


Fig. 11-1. The Conn *Strobotuner*.

musical tone is sharp, flat, or in tune with the equally tempered scale, based on the standard A440 cycles per second. Its range covers 84 semitones (half tones)—from one-fifth of a semitone below C1 (first octave *C* at the lower end of a keyboard) to one-fifth above B7 (seventh octave *B* at the upper end of a keyboard). This is the full range of a piano, and is well within the range of any electric or electronic organ. The *Strobotuner* is equipped with a high-impedance microphone for audio tone pickup, plus a five-foot cable and plug. It is 10⅛ inches long, 7½ inches deep, 7¾ inches high, and weighs 13 pounds.

There is a single viewing window in the center of the face panel, and

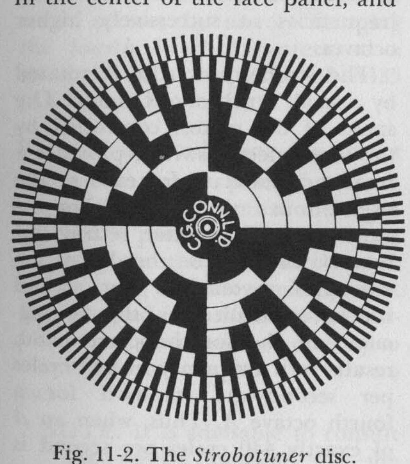


Fig. 11-2. The *Strobotuner* disc.

behind the window, a stroboscopic scanning disc. On the disc are printed seven circular bands consisting of alternate light and dark segments, as shown in Fig. 11-2. Each band represents one octave. The smallest band, near the hub, represents the first octave; the outermost band, the seventh octave. The number on each band indicates the octave.

The tone selector switch has a position for each of the twelve chromatic notes of the musical scale. It, together with the multiple-band stroboscopic disc, provides the full seven-octave range. In the upper left corner of the face panel are a tuning knob, pointer, and scale. The scale is graduated in five-cent intervals, from zero in the center to 20 cents left for flat and 20 cents right for sharp. (One cent equals 1/100th of a semitone.) The pointer and scale indicate the amount a note is either sharp or flat. Across the bottom of the panel are power, calibration, and note selector switches, plus a gain-control knob and microphone or patch-cord input jack.

Setting Up The *Strobotuner*

Remove the cover, and plug the power cord into any 110-volt, 60-cycle outlet. The pilot lamp will light when the power switch is turned on, indicating that current is getting to the instrument. Allow ten minutes for the instrument to warm up.

> IMPORTANT: Do not obstruct the ventilating grilles behind the *Strobotuner*. Be sure there is good air circulation around them. Otherwise, the instrument may become overheated and be damaged.

Calibration Before Tuning

After the *Strobotuner* has warmed up, hold the calibration switch down as far as it will go, and adjust the tuning knob until the pattern appearing on the smallest octave band in the strobodisc window seems to stand still. (A slip pointer arrangement allows the tuning knob to be rotated as far as necessary to produce a stationary pattern, while permitting the pointer to be set anywhere on the scale.) Next, move the pointer to the zero (center) position, but leave the tuning knob in place. (Normally the pointer can be slipped independently from the tuning knob. However, you may have to hold the knob to prevent it from turning with the pointer.) The calibrate switch can be released after the pattern comes to a standstill, so both hands will be free to reset the pointer. After setting the pointer to zero, recheck the calibration to be certain the tuning knob has not been moved and the instrument is still in calibration. To do this, simply depress the calibration switch and note if the pattern in the first (inside) octave band is still stationary. You are now ready for operation.

Check the calibration frequently, particularly when using the tuning knob for measurements or tuning standards other than A440 cps. Each time you use the tuning knob to deviate from the standard pitch, check the calibration before making the next measurement.

Standards other than line frequency may be used for calibrating the *Strobotuner*—for example, the 440-cps signal from radio station WWV. If using other sources, just feed the signal to the *Strobotuner* through its microphone. The calibrate switch is not used at this time. Only the tuning knob and pointer need be adjusted.

NOTE: When calibrating with the power-line frequency, be absolutely sure it is a *true* 60-cycle current. The instrument can be operated on, but not calibrated to, as low as 50-cycle current. When true 60-cycle power is not available, a standard other than the power-line frequency is mandatory for accurate calibration.

Principle of Operation

The *Strobotuner* employs the stroboscopic principle, whereby the frequency of the sound introduced by the musical instrument is compared with a standard frequency from the *Strobotuner*. Two neon bulbs, flashing in step with the frequency of the sound reaching the microphone, illuminate a rotating disc. The disc is imprinted with a pattern consisting of seven rings with alternate light and dark segments that correspond roughly to the spokes of a wheel. Starting with the one at the center, each ring has exactly twice as many segments as the preceding one. This corresponds to musical tones, which double their frequencies at successively higher octaves.

The stroboscopic disc is rotated by a small synchronous motor. The speed of the motor, controlled by the tone selector switch, provides a frequency standard for each of the twelve tones of the scale. For example, a tone selector setting for tone *A* would cause the disc to rotate 27.5 revolutions per second which, multiplied by the 16 segments of the fourth octave band, results in a frequency of 440 cycles per second—the standard for a fourth octave *A*. Thus, when an *A* of exactly 440 cycles per second is sounded in the microphone or through the patch cord, the corresponding illuminated band of spokes will appear stationary because the rate of flashes (tone frequency) equals the exact number of disc spokes passing a given point.

Therefore, if the sound has a frequency of 438 cycles per second, the 16-segment "A" pattern band would appear to rotate slowly to the left; but if slightly higher in pitch than 440 cps, the pattern would appear to rotate slowly to the right. This is how the *Strobotuner* instantly shows whether a tone is flat or sharp.

Turning the tuning knob will vary the speed of the disc slightly, within the normal intervals of one semitone provided by the tone selector switch. When adjusted to produce a stationary pattern for an off-pitch tone, the tuning pointer then shows by approximately how many cents (1/100ths of a semitone) the tone is sharp or flat.

The tuning knob also provides for measurements, in correct intervals, of the equally tempered scale for standards other than A440. If a scale based on A435 is desired, for example, correct intervals can be obtained for all other tones in the seven octaves by merely bringing the *fourth band A* pattern to a standstill at a frequency of A435 (A4 minus 20 cents).

Suggestions for Tuning the Organ

For best pickup, place the microphone directly in front of the organ speaker. A patch cord, offered as an accessory to the *Strobotuner*, enables tuning without a microphone. It is plugged into the built-in headphone jack, or connected directly to the audio output when there is no jack.

NOTE: It is advisable to consult the service manual for the make of organ being tuned, in order to learn the recommended procedure.

Allow ten to fifteen minutes for both the *Strobotuner* and the organ to warm up. Then calibrate the tuner, as described in the section on calibration.

Adjust the gain control to produce the best pattern contrast. Then adjust the tuning control on the organ until the pattern on the strobe disc is stationary. The tone selector knob must be reset for each tone measured.

While tuning an organ, check the *Strobotuner* calibration from time to time, by depressing the calibration switch while the scale pointer is set at zero. If power-line variations have altered the instrument from A440, the initial calibration will have to be repeated.

Instead of tuning successive notes in each octave, some organ tuners prefer this alternate method: First, set the selector switch at *C* and tune all the *C*'s in all octaves. Then proceed with all the *C* sharps, etc. This method will reduce the number of tone-selector switch settings and thereby speed up the tuning operation. Complete instructions for using the *Strobotuner* to tune an organ were given in Chapter 3.

It is not a good idea to "stretch" any octaves in organ tuning, as is done in tuning a piano, because of the octave couplers used in so many registrations. Remember that an instrument held to within *one-quarter* to *one-half* of one per cent receives better listener acceptance than one with perfect pitch.

From time to time it is advisable to check the vacuum tubes in the *Strobotuner*, as insurance against any errors from this source.

SUMMARY

The service technician has quite a choice of devices designed to tune an electronic organ. Some of them are much more expensive than others. Fortunately, it is not necessary for the technician to spend a lot of money. If he has a good musical ear, he will find the tuning fork is the most economical device —yet its accuracy cannot be surpassed.

GLOSSARY

A

Accompaniment Manual. The keyboard used for playing the accompaniment to the melody. Also called the lower manual or great manual. (See Manual.)

Amplifier. The portion of the organ used to increase the signal strength from the tone generators sufficiently to operate the speaker system.

Attack. The length of time it takes for a tone to reach full intensity after a key is depressed. On most organs this effect is adjustable by either a switch or potentiometer.

B

Baffle. A partition or enclosure used with a speaker to increase the length of the air path from the front to the rear of the speaker diaphragm. This reduces the interaction between sound waves produced simultaneously by the front and rear surfaces of the diaphragm, and thus improves the fidelity of the reproduction and directs the sound in the desired direction.

Bass. The lower tones of the organ. The pedal tones.

Bass-Reflex Enclosure. A speaker enclosure in which a portion of the radiation from the rear of the speaker is used to reinforce the bass tones.

Beat. The phenomenon that takes place when two tones slightly different in frequency are sounded simultaneously. The tones will alternately cancel and reinforce one another, resulting in a rise and fall of the intensity of the combined sound—termed *beat*. The more closely the two tones are brought into tune, the slower the *beat*.

Bus Bar. An uninsulated electrical conductor (wire or rod) which distributes voltages to various points or collects tones from several sources.

C

Chord. A combination of harmonious tones that are sounded together through the use of one or more fingers on either or both hands. On chord organs, depressing a single chord button selects the full chord.

Cipher. A tone produced when no key is being depressed.

Clavier. Any keyboard, either hand- or foot-operated. In electronic organs, this may consist of one, or more hand-operated keyboards and the foot-operated pedals.

Console. The complete organ cabinet.

Coupler. A stop tablet which permits the playing of tones on one manual with the keys of another manual, or the simultaneous sounding of octavely-related tones on the same manual.

Crossover Network. The frequency-selective circuit that divides the high and low tones for application to their respective speakers.

D

Decay. The length of time it takes for a tone to fade away after the playing key is released. On many organs this effect is adjustable by either a switch or potentiometer.

Decibel. The unit of measurement used for expressing a change in magnitude of the signal or sound level (abbreviated db).

Diapason. The fundamental tone color of all organ music. It is not imitative of any orchestral instrument, and is thus in a class by itself.

Diode. An electrical component with the property of conducting current in one direction and blocking it in the opposite direction.

Doppler Effect. The change of pitch in a tone, caused by movement of the sound source relative to the listener.

E

Expression Control. The control which regulates the over-all volume of the organ. Usually operated with the right foot.

Extended Octaves. Tones above or below the notes on the regular keyboard which can be sounded only when certain couplers are on. For example, if the highest manual key is 73 and the 4′ coupler is on, note 85 will sound.

F

Flat. A note one-half tone below its related white key. (See Sharp.)

Flute. One of the four basic tone colors which resemble the orchestral flute. A flute tone is void of many upper harmonics, and therefore, is a pure (sine-wave) tone.

Formant Filters. A waveshaping network used to modify the signal from the tone generator so it will assume the waveshape of the desired tone.

Frequency. The number of complete cycles or vibrations per unit of time, usually per second.

Frequency Response. The range in frequency over which a given amplifier and speaker will reproduce the various pitches.

Fundamental. The normal pitch of a musical tone. The lowest frequency component of a complex waveform.

G

Great Manual. The keyboard normally used for playing the accompaniment to the melody. Also called the accompaniment manual or lower manual. (See Manual.)

H

Half Tones. (See Semitone.)

Harmonic. The component of a complex note, the frequency of which is a multiple of the fundamental frequency. Also called an overtone.

I

Interval. The difference in pitch between two tones.

K

Keybed. The shelf or horizontal surface on which the keyboard is mounted.

Keyswitch. The switch which is closed when a key is depressed to allow a tone from the tone generator to sound.

M

Manual. A group of keys played with the hand. In two-manual organs, the upper manual is referred to as the solo or swell manual, and is normally used to play the melody. The lower manual is referred to as the accompaniment manual or great manual and is normally used to play the accompaniment to the melody. However, if desired, the melody may be played on the lower manual and the accompaniment on the upper manual.

N

Neon Lamp. A two-element, gas-filled tube which, when ionized by application of an external voltage, will allow current to flow through it. Below the ionization voltage, current will not flow. Thus, it acts as an electronic switch, conducting only when the ionization voltage is applied.

Note. A single musical tone. The notes of the musical scale are referred to by letters running alphabetically from A to G for the white keys. The black keys may be called a sharp of the note below it or a flat of the note above it. Each note has a frequency exactly one half that of the corresponding note in the next higher octave.

O

Octave. An interval of semitones in the diatonic scale, composed of seven white keys and five black ones. The interval between two tones, one having a frequency twice that of the other.

Oscillator. An electrical circuit consisting of a tuning coil and capacitor, a transistor or tube, and various other components, that generates an electrical signal which is one pitch of the musical scale.

Outphasing. A term applied to a method used in some organs for producing certain voices. Special circuitry, employed between the keying-system output and the formant filters, is used to either add or subtract harmonics or subharmonics from the tone-generator signal. Part of the circuitry may employ successive Eccles-Jordan stages to obtain square-wave signals of either polarity and of different footages (4′, 8′, 16′, etc.).

Overtone. (See Harmonic.)

P

Partial. One of the different frequencies which are combined to form a complex tone.

Pedal Clavier. The pedal keyboard of the organ which supplies all the bass accompaniment for the other manuals. It usually consists of one or two octaves.

Pedal Keyboard. (See Pedal Clavier.)

Percussion. The effect found in musical instruments in which tones are produced by plucking or striking strings, such as a piano or guitar.

Phase Inverter. A stage connected between a preceding single-ended stage and a succeeding push-pull stage which provides two signals 180° out of phase for driving the push-pull stage.

Pitch. The characteristic of a sound which the hearer perceives as being relatively high or low in the musical scale.

Potentiometer. A resistance unit having a rotating contact arm which can be set at any desired point on the resistance element.

Power. Power, when referring to electronic organs, usually refers to the sound output measured in watts; however, it can refer to the AC power consumed by the unit.

Power Supply. That portion of the organ which supplies the operating voltages for the various circuits.

Preset. A control which will turn on or off a group of voices or couplers without the necessity of changing the position of the individual stops. These controls may affect either or both manuals.

R

Rectifier. A device, either tube or semiconductor, which converts alternating current to direct current.

Reed. One of the four basic tone-color groups, so called because they resemble orchestral reeds, and often used as solo stops. Certain groups of reeds add much to the brilliance of the over-all organ tone.

Relay. An electromagnetic switch employing an armature to open or close contacts.

Resultant. The term applied to a tone produced when two notes a fifth apart and an octave higher than the desired note are sounded to produce the desired note.

Reverberation. The persistence of sound in a room after the source of the sound has stopped.

S

Scale. A series of eight notes, starting with C and running in alphabetical order as follows: C, D, E, F, G, A, B, C; plus the sharps of the notes.

Semitone. The relationship between adjacent pitches on the musical scale.

Sharp. A tone one-half tone above its related white key. The black keys of an organ. A black key will be the sharp of the white key directly below it and the flat of a white key directly above it. Musically, a sharp and flat are the same musical pitch. However, for standardization, technicians usually refer to it as a sharp.

Sine Wave. Waveform corresponding to a pure single-frequency oscillation.

Solo Manual. The upper manual of a two-manual organ, normally used for playing the melody. Also called the swell manual. (See Manual.)

Speaker. An electromechanical device for converting audio-frequency currents into sound waves.

Standing Waves. The nonuniform distribution of sound energy in a room, resulting from the fact that the floor, ceiling, and walls reflect sound waves. These reflected waves reinforce or cancel one another at various points in the room.

Stops. The switches or controls which provide for the selection and mixing of the various voices and footages.

String. One of the four basic tone-color groups which are more or less imitative of orchestral strings. They are rich in upper harmonics. Some are mildly voiced and others have a keener quality.

Sustain. The effect brought about by circuitry which will cause a note to continue to sound and gradually diminish after the key controlling the note has been released.

Swell Manual. The upper manual of an organ, normally used to play the melody. Also called the Solo Manual. (See Manual.)

T

Tablet. A rocker-type control which provides the selection of a voice or footage.

Temperament. The tuning of an instrument so the tones will be at specified intervals.

Tempered Scale. The arrangement of musical pitches according to a scale.

Timbre. The character of a musical tone. The difference between two steady tones having the same pitch and degree of volume is called the difference in timbre. Timbre depends mostly on the relative intensity of the different harmonics and the frequencies of the most prominent harmonics.

Tone. The fundamental sound of any musical note.

Tone Colors. The quality of an instrument or voice. In organ work the four principal tonal groups are: Diapason, Flute, String, and Reed.

Tone Generator. That portion of an organ which generates the electrical impulses which later are modified and amplified and then converted into sound by the speaker.

Transistor. A small semiconductor device which can be used as an oscillator or amplifier, instead of a tube.

Tremolo. The effect when the intensity of a tone is varied at a rate of approximately seven times per second.

V

Vibrato. The effect when the frequency of a musical tone is varied at a rate of approximately six or seven times per second.

Voices. The resultant tone output obtained through the mixing of various harmonics to imitate a musical instrument or other effect.

Voltage Regulator. A device or circuit which maintains the output voltage at a predetermined value.

Volume. The intensity or loudness of the sound produced. Also called expression in organ work.

W

Watts. The unit of measurement for the power consumed by the organ, or of the maximum undistorted output power of the amplifier.

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