ELECTRONIC ORGANS

Eby

VAN KAMPEN PRESS

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by ROBERT L. EBY

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A Complete Catalogue, Textbook and Manual

by

ROBERT L. EBY

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Foreword

Some of the organs described in this publication are models which are not now in production. Since many of these are sold or traded in on later models, this book will serve as a *used* organ as well as *new* organ buyer's guide. For the thousands who own these earlier instruments, this book should prove most informative.

For the convenience of readers who wish to obtain a "bird's eye view" of a particular organ, there is a nontechnical description at the beginning of each chapter and a models summary chart at the end of each chapter. Those who are interested in studying more thoroughly into the technical aspects of an instrument will find the detailed descriptive material most complete.

It is not within the scope of this book to serve as a maintenance manual. Qualified organ service men are available in most cities. However, a great deal of data is included which can serve as a guide to the more technically inclined and will prove valuable should minor emergency repairs be required.

The author acknowledges with sincere thanks the fine cooperation of the following firms in supplying written material and illustrations for this book:

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Introduction

The "Electronic Organ" is rapidly being accepted as a true musical instrument. Early attempts to simulate by electronic means the tones of pipe organs were naturally imperfect. Paralleling the efforts of electronic organ engineers toward improving methods of tone production, sound engineers have also been improving amplification and loud-speaker systems. As a result, the "coming of age" of the electronic organ has been much faster than the organ industry anticipated.

Increased activity in all branches of the electronic industry has also helped to supply much of the technical advice without which growth of the electronic organ would have been a long slow process. Some organists have been quick to criticize the electronic organ as being inadequate either as a pipe organ substitute or as an instrument in its own right. They forget that the pipe organ has been under steady improvement for over a thousand years and is still being perfected.

With the demands of war for skilled personnel and vital materials, this new industry has had repeated set-backs. Several inventors will never see their product reach the market. Some builders have produced only a few organs before their efforts were submerged with obstacles.

In spite of this uncertain beginning, the terms "electronic and electric organ" are common to both amateur and professional musicians. As an instrument of worship for all Faiths and Denominations, it already supplies music in thousands of churches all over the world. In the entertainment field, its portability makes it highly adaptable. In the home, its low cost and compactness has made it possible for thousands to create and enjoy their own organ music.

In the last 15 years, many more electronic organs have been produced in the United States than all the pipe organs ever built in this country. It is anticipated that this wide acceptance will continue. The love of music is a basic human characteristic and when a person finds self-expression through playing organ music, whether simple or complex, he gains the maximum return both for himself and all who listen.

ROBERT L. EBY

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CHAPTER I

History of Electronic Organs

An entire book could be written on the development of the electronic organ as we have it today. Such a book would no doubt be intensely interesting to historians, students and designers, but would not appeal to the larger group of readers for which "Electronic Organs" was written. For those interested in knowing something of the many facts in the development of electronic musical instruments, the following summary is given.

Many inventors have attempted to produce organs incorporating electrical and electronic devices. Most of this experimental work has been performed since the turn of the century. Few of these inventions have ever reached the marketing stage. Still each has no doubt contributed to the remarkable development of the electronic organ during the past twenty years.

No doubt each inventor has had in mind improving upon the pipe organ itself by reducing its bulk, making a more portable instrument and reducing the cost to make an organ more available to more people. Whereas only a few wealthy homes possessed pipe organs in the first quarter of this century, the electronic counterpart has opened a vast new market from house trailers to cathedrals, with the home market the biggest long-range potential.

Electrical production of musical sounds dates from 1903, when Dr. Thaddeus Cahill invented the "Teleharmonium." This instrument was exceedingly interesting, and the main reason for not attaining success at this early date, was that the science of electrical engineering was not advanced sufficiently to prevent interference between the "Teleharmonium" and the New York telephone system. This instrument was very costly and involved several carloads of tone generators and controlling apparatus.

About the same time, Farrington, inventor of the "Choralcello," developed the idea of producing various tone qualities by artificially adding harmonics of various degrees of intensities to the fundamental tone. Many of Farrington's tonal results were astonishingly good, but involved complex problems of producing and maintaining an even musical scale. Intricate mechanism and excessive cost prevented the instrument from becoming a success commercially.

Many experiments followed those of Dr. Cahill's and Mr. Farrington's, pertinent to the application of electricity to musical instruments. Some possessed good theories and sound musical understanding, and subsequently, led to a thorough scientific study of music and musical instruments.

Shortly following the appearance and demonstrations of the "Teleharmonium" and "Choralcello," Dr. Lee De Forest invented the vacuum tube which has proved to be an indispensable part of vacuum tube amplifiers, for amplifying the sound impulses of electronic musical instruments. The vacuum tube amplifier, loud-speakers, etc., provided the missing link so essential to the growth and development of these musical instruments, as well as unfolding new fields of endless possibilities.

One of the first electronic instruments, to be shown and demonstrated was the "Theremin." This instrument employed a radio frequency oscillator with a vacuum tube as the signal generator. The player moved his hand near a metal rod which changed the frequency of the beat oscillator and altered the electrostatic capacity of the circuit. The Theremin was capable of imitating the tones of different instruments but the most realistic imitation was the tone of a cello. A keyboard was later applied to this instrument.

Major Richard H. Ranger was one of the first to introduce an electronic organ. This instrument was known as "The Rangertone" and employed a series of twelve electrically controlled tuning forks, each a semi-tone apart in frequency. The forks were made to vibrate continuously. Suitable electrical pick-ups were associated with each fork and were connected to the input of an audio frequency amplifier in such a manner as to produce electrical waves in response to vibration of the forks. The electrical waves thus produced were amplified and then converted into sound by loud-speakers connected to the output of the amplifier. Major Ranger also experimented with neon light oscillators and tuned circuits of various types.

An electronic organ known as the "Photona" was demonstrated in 1926 by Mr. Ivan Eremeeff, but unfortunately was not very successful. This instrument was developed by Mr. Eremeeff in conjunction with Dr. Stokowski of the Philadelphia Symphony Orchestra. The Photona employed perforated discs, driven by a synchronous motor, with small light bulbs on one side. Photoelectric cells were placed on the other side and the light flickering through the rotating disc caused pulsating currents of simple sine wave to form in the cell circuits. Harmonics or subharmonics could be added in predetermined ratio to the fundamental tone.

History shows the peculiar fact that when a revolutionizing idea or design occurs it usually comes in waves, that is to say, various experimenters throughout different parts of the world seem to have simultaneously thought pretty much along the same idea. This has certainly been the case with respect to electronic organs, as for example, the ingenious inventions of the late James H. Nuttall, an organ builder in Los Angeles, California, and Edwin Welte, also an organ builder, of Freiberg, Germany. Both had the idea of building an electronic organ with photoelectric cells used in connection with their tone propagation and control. Some depended on oscillating tubes; others produced

their tones by electro-magnetic means.

The Hammond Organ was invented by Laurens Hammond of Chicago and made its first public appearance in 1934. This instrument employed a system of creating musical tones electro-mechanically. The tone generating elements were located inside the console and consisted of a mechanism having many tone wheels, all permanently geared together and rotated at a constant speed by means of a synchronous motor.

Also in 1934 the Everett Piano Company marketed their "Orgatron" in both one and two-manual models. These continued until World War II during which time their production was taken over by The Rudolph Wurlitzer Company. These instruments are now manufactured in a variety of sizes, all of which use a combination of wind blown reeds, electrostatic pickups and sound amplification.

Other electronic organ mechanisms were being developed in various laboratories during the thirties and early forties. After World War II these efforts began showing up on the market. Pre-war tone generators using hundreds of radio tubes were scaled down making them practical for marketing. The majority of the organ builders pursued the vacuum tube type of circuit in an attempt to keep bulk down, eliminate moving parts and produce acceptable tone quality. Some of the vacuum tube instruments and organs include: Solovox, Novachord, Hammond Chord, Allen, Minshall, Baldwin, Connsonata, Organo, Haygren, and Thomas. These are described in detail in later chapters.

Some brands have been in limited production, including Mastersonic, Radareed, Lowrey and Vega-Vox. Their non-existence is not necessarily a reflection on their quality of tone as some of the finest imitators of genuine pipe organ tone have never reached the production stage. Many factors including production costs, material shortages, design problems, and lack of promotion have taken their toll of projects which might have become outstanding electronic organs.

In 1945 The Allen Organ Company marketed their line of organs of which several prototypes had been built. Connsonata organs were introduced in 1947. About 1949 Haygren of Chicago and Thomas George of North Hollywood were starting to manufacture. All these organs use individual vacuum tube oscillators for each note or pitch of the organ keyboard.

The Baldwin, Minshall and Organo are also post-war products using specially designed "multivibrator" circuits which make possible fewer tubes and smaller components than those makes listed in the paragraph above.

The development of electronic music and electronic organs is still in its infancy. Where one designer is striving toward perfection in imitating pipe organ tone, another is developing an entirely new form of musical instrument. As the development of this relatively new industry unfolds, it becomes obvious that possibilities are only limited by the ingenuity of inventors.

For those not too familiar with the basic principle behind the electronic synthesis of a musical tone, we include the following brief explanation. If you were to listen to middle C played on a variety of instruments or organ pipes, you would easily detect a difference in tone quality. There would be little difficulty in picking out the violin from the flute or the diapason from the melodia. When an instrument produces a musical tone, it not only sounds the so-called pitch (in this example middle C) but also generates overtones or harmonics which are other notes of the musical scale, usually lying above the pitch note. There may be as many as a dozen notes coming from a violin string, including several C's, some G's and E's and some pitches which do not fall on any particular key of the scale. Were all these harmonies to be eliminated, the resulting tone would be "pure," like that of a tuning fork.

The generation of the pitch tone along with the desired harmonics has reached quite a degree of perfection in many contemporary organs. Just how this is accomplished is covered in the following chapters of this book.

It is no guesswork when an electronic musical instrument can produce from its loud-speaker a tone closely resembling a clarinet or diapason organ pipe. Whether the electrical impulses are derived from spinning discs, vibrating reeds, photographed sound waves, or oscillating vacuum tubes, the results can be musical providing the organ is properly played.

Several factors besides the harmonic content of a note may effect its tone quality. Most of these are of such a technical nature that their explanation lies outside the scope of this book. Needless to say, a total lack of knowledge relative to these acoustic factors will in no way limit one's enjoyment either in the playing of organ music or listening to it.

Allen Organs

CHAPTER II

Allen Organs

A. General Description

The Allen Organ Company of Allentown, Pennsylvania, has manufactured several sizes of electronic organs ranging from the one-manual organs (Fig. 2-1) to the three-manual concert series (Fig. 2-7). Basically, all the Allen series are similar, the chief difference being in the number of tone-producing elements. For example, the "S" series consoles produce three different families of tones, commonly described as diapason, flute, and string. These can be played to produce a wide variety of pitches and volumes.

Fig. 2-1. Model S Single-Manual Console

In the larger Allen organs additional "stops" have been added which imitate many pipe organ tones. In the three-manual models this process has been carried to its practical limit, there being over 40 stops (see paragraph C). All through the process of building Allen organs there has been a definite aim at imitating pipe organ tones, and in most models those of the more classic and liturgical design. As a result the Allen is often mistaken for a pipe organ, both because of its similarity in console design and its tonal approach to actual pipes.

Each note originates from oscillating (electronic) tubes similar to radio tubes, there being one dual tube for each two pitches on the keyboard. The smaller models house the tubes in the consoles, but larger models have these tone-generating portions separate since they would be too crowded in the console.

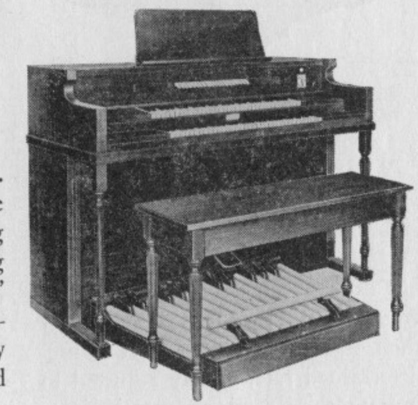


Fig. 2-2. Model S Two-Manual Console

Very large electrical parts are employed, such as air-wound copper coils, plastic condensers, standard vacuum tubes, and console components similar to those used by the pipe organ industry. Little effort is made to save weight or space as the builder feels this might defeat his purpose in trying to imitate the longevity of the pipe organ as well as its tone.

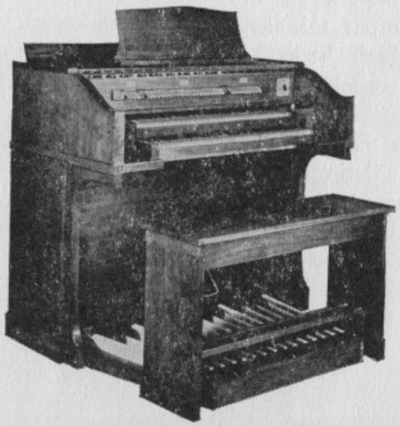


Fig. 2-3. Entertainment Model Console

What actually happens when a key is played on the Allen organ is briefed as follows: each tube is "lit" when the organ is turned on but does not receive its energizing voltage until the key is pressed. It then starts to oscillate at a predetermined rate, closely adjusted to imitate the speed of speech from organ pipes. The combined oscillation of all the tubes with their associated components are wired to tone changers. These give the organ its "stops" such as violin, flute or horn. If the organist has one of these stops pressed down, the electrical impulse will travel on to the amplification and speaker system. When the key is released the tube simply stops oscillating. Details of this cycle can be found later in this chapter.

B. Consoles

The "S" series organs have been designed for the home, chapel, or small auditorium where space does not permit the full-sized models. In the console is located all the tone-generating equipment and power supplies. The manuals are standard (61 notes) and a twenty-five note flat pedal clavier is provided. The latest consoles measure 55″ long, 29½″ deep, 43″ deep over pedals, 45″ high. Earlier models were about 6″ wider.

Fig. 2-4. Model WT and B-2 Console

The "Entertainment" organ (Fig. 2-3) is similar in size to the "S" series organs. The main difference is in the registration (see paragraph C), and in the Gyrophonic Projector (see paragraph F). This organ is a distinct departure from the more classic type of Allen tonal

design which includes different tone generators such as strings, flutes and diapasons. In the "Entertainment" organ the basic tone generator is of the flute quality. However, this tone is made available on both manuals at many pitches and is even grouped

Fig. 2-5. Model B-3 Console

to form "synthetic" stops of great contrast.

This type of tone and method of registration along with the "theatrical" type Gyrophonic Projector provides an instrument of the entertainment class in contrast with the other models which are basically for the playing of more serious organ literature.

The Allen "W" and "B" series consoles are of the large A. G. O. type as can be seen from Figures 2-4 and 2-5. They are usually of walnut construction with roll tops, but can be obtained in other woods.

The consoles of the models B-3 and larger Allen organs do not house the tone generator mechanism and, therefore, perform the same function as the console in a modern pipe organ in providing a key desk of standard specifications and an enclosure for the electrical contacts, switches, combination action, as well as expression and crescendo pedals, toe pistons, etc. Outgoing cables are permanently connected to the console and run to tone generator units (Fig. 2-9). The electrical structure of these Allen consoles are so much like that used in pipe organs that the cable could be connected to ranks of pipes instead of tone generators.

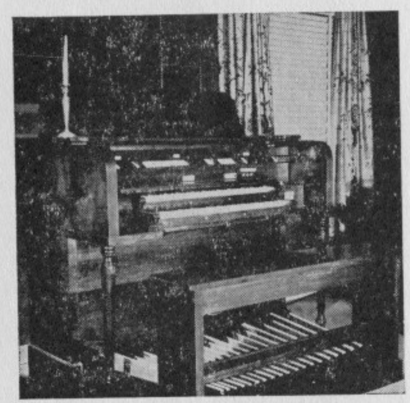


Fig. 2-6 Model B-4 Console on a Residence

The key contacts are of a multiple organ type. The coupler or slide switches are located inside the console. The manual couplers are a part of the key contact system and are shown in Fig. 2-10. The stop key switches on the stop board are also of standard pipe organ type and

Fig. 2-7. Model B-6 Console

are controlled by the tabs on the front of the console, each tab being marked to identify its function in the conventional manner.

The expression pedal or pedals are located in the usual position at the bottom of the console. They are connected to a volume control mechanism of the rotary type on some consoles or of the sliding type on other models, as in Fig. 2-11. These volume controls are "compensated"; i.e., they automatically regulate the relative volume of the pedal and manual tones to compensate for the variation in hearing ability of the human ear. As the expression pedal is closed, the volume of the manuals falls off more rapidly than that of the pedals.

The crescendo pedal on the larger consoles operates a contact strip bringing on the various speaking stops and couplers in the desired order, up to full organ. This is identical to the method used in modern pipe organ construction and can be adjusted by the service technician to the requirements of the organist.

The keying contacts (Fig. 2-12) under the pedal clavier are of a standard pipe organ type. These contacts are connected with the console by a cable running under the lower left end of the pedal clavier and through the front panel of the console. The pedal couplers use the multiple contact switch system.

C. Registration (Models W-T, B-T and S-5)

These models have the stop and coupler controls wired in groups so by simply depressing any one of the stop tablets a tonal combination is set up on the Pedals, the Great, and the Swell.

The first group of stops on the left are colored to designate them as solo qualities. The solo or melody tone will always be on the Great with an accompaniment on the Swell and a suitable Pedal stop.

By depressing any one of the white stop tablets, an ensemble is set up on both manuals and pedals. In accordance with standard pipe organ practice, the volume of the Great manual will be louder than that of the Swell.

The white stop tablets are arranged so that the combinations become progressively "bigger" with "Full Organ" being the last one to the right. They are divided into the

three main categories of strings, flutes and diapasons. The tablets marked "Baroque Ensemble" are of a somewhat different quality and reflect the present trend among pipe organ builders to recapture the tonal quality that was possible on the organs of late Renaissance Europe.

The Model S-5 stop list includes the following:

Doppel Flute Solo
Clarinet Solo
French Horn Solo
Horn Diapason Solo
Quint Solo
Viole
Dulciana Ensemble MF
Dulciana Ensemble
String Ensemble
Flute String Ensemble
Flute Ensemble
Diapason Ensemble
Diapason Ensemble FF
Baroque Ensemble
Baroque Ensemble FF
Full Organ
Blank or Harp
Gyro Celeste
Tremolo

Registration (Models W-T and B-T)

The present registration of these organs is similar to that of the S-5 in that one tablet draws various combinations of couplers and stops to provide a balance between Swell, Great and Pedals. These organs

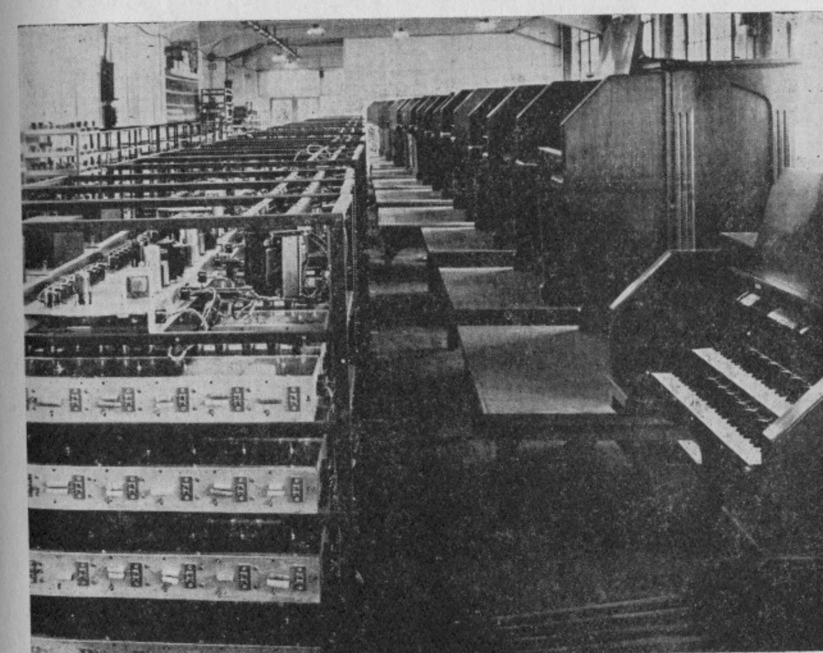


Fig. 2-8. Assembly line showing tone generators and consoles

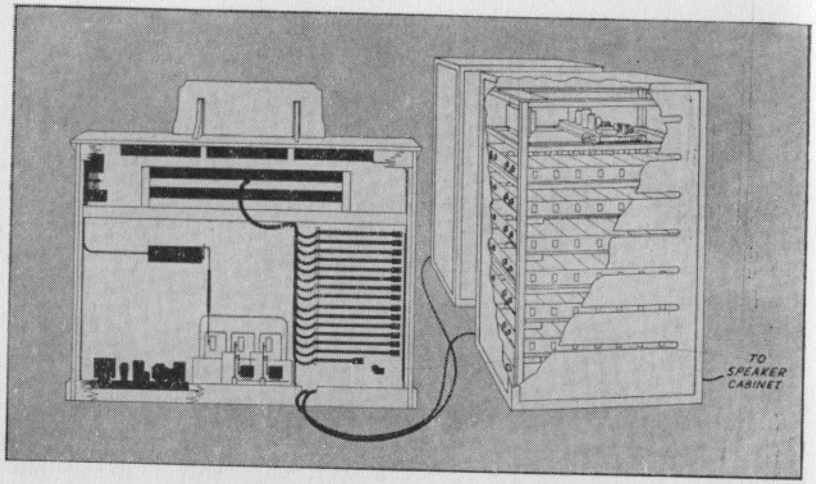


Fig. 2-9. Location of External Tone Generators

have more presets than the Model S-5 and the pedal is extended down one more octave to provide more variety and tonal range.

The W-T tone generator incorporates the following stop relays which are drawn in groups as described above:

Doppel Flute
Clarinet
French Horn
Diapason
Dulciana
Viole
Aeoline
Flute
Flute Dolce
Trumpet
Vox Humana
Pedal Bourdon
Lieblich
Gedeckt
Pedal Dulciana
Pedal Diapason
Pedal Tuba

The B-T stop list includes the following:

Doppel Flute
Clarinet
French Horn
Horn Diapason
Quint
Vox Humana
Dulciana
Ensemble MF
Dulciana Ensemble FF
String Ensemble
Flute and String Ensemble
Flute Ensemble
Diapason Ensemble
Diapason Ensemble FF
Baroque Ensemble
Baroque Ensemble FF
Full Organ Pedal Solo String
Pedal Solo Flute
Pedal Solo Diapason
Harp
Gyrophonic Control

Registration (Models B-2, S-6 and S-10)

The registration of these organs is similar to that found on many small pipe organs. There are four separate divisions of stop groupings. Starting at the right, the first category is "General." Under this group are the various basic tone stops. These "General" stops may be used in conjunction with one another or separately. The second category of stops is headed "Great" and these tablets make available at different pitches on the lower manual the quality or qualities selected from the "General" tablets. Similarly, the third grouping, headed "Swell," makes available at pitches designated on the tablets the quality selected under "General."

The fourth grouping of tablets headed "Pedal" makes the "General" qualities obtainable on the Pedal clavier at the pitches indicated on the tablets.

In pipe organ terminology, then, it may be said that the organ is unified—one rank of oscillator tubes running the gamut of the various pitches from the 16′ upwards. Moreover, it is also duplexed, to use another pipe organ term; that is, the several qualities derived from this rank of tubes may be had on Swell, Great, or Pedal.

The ensemble does not have the shrillness of a unit organ since many of the stops above 8′ have been "scaled" down as in a Diapason chorus. For example a given note on the 2′ stop is not as loud or as

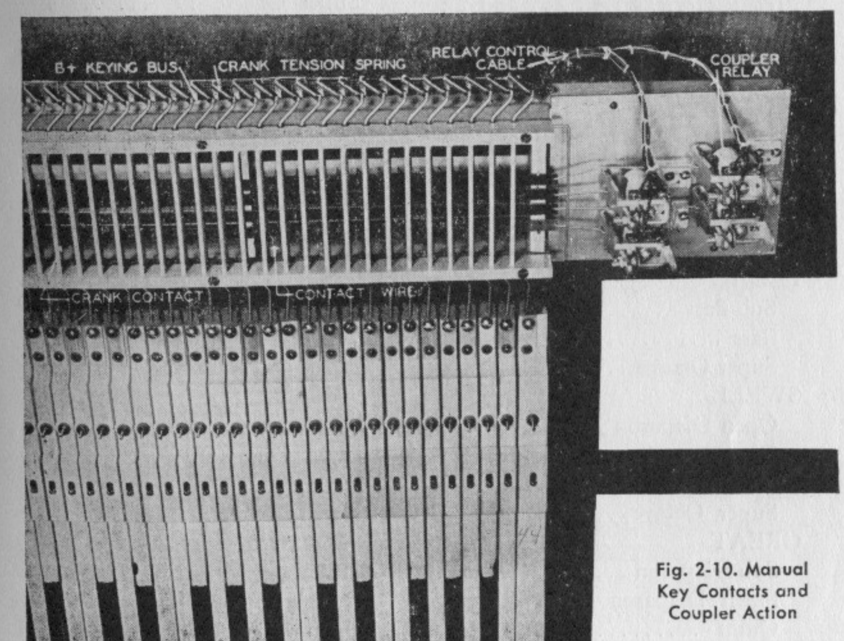


Fig. 2-10. Manual Key Contacts and Coupler Action

rich in harmonics as the same note on the 8′ stop.

By depressing the Flute tablet, the instrument is transformed to a unit Flute organ. Then the following solo voices can be obtained by de-

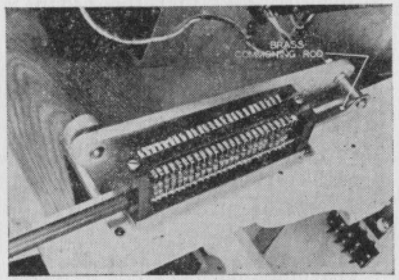


Fig. 2-11. Contact Type Attenuator

pressing tablets representing the following pitches:

Doppel Flute: 4′, 8′, and $2\frac{2}{3}$′;
French Horn: 8′, 4′, $2\frac{2}{3}$′, and 2′;
Horn Diapason: 16′, 8′, $5\frac{1}{3}$′, and 4′;
Quint: 16′, 8′, $5\frac{1}{3}$′, 4′, $2\frac{2}{3}$′, 2′, and $1\frac{3}{5}$′;
8′ *Oboe:* 8′, $5\frac{1}{3}$′, and 4′;
4′ *Oboe:* 4′, $2\frac{2}{3}$′, and 2′.

Registration—Model S-10

PEDAL
- Sub-Bass .... 16′
- Bass .... 8′
- Super Octave .... 4′

SWELL
- Open Diapason .... 8′
- Octave .... 4′
- Nazard .... $2\frac{2}{3}$′
- Super Octave .... 2′

GREAT
- Sub-Diapason .... 16′
- Open Diapason .... 8′
- Quint .... $5\frac{1}{3}$′
- Octave .... 4′
- Nazard .... $2\frac{2}{3}$′
- Super Octave .... 2′
- Tierce .... $1\frac{3}{5}$′

GENERAL
- Unit Diapason
- Unit Flute
- Unit String
- Clarinet Solo
- French Horn Solo
- Dulciana Ensemble
- Diapason Ensemble
- Baroque Ensemble
- Flute String Ensemble
- Blank Tablet
- Gyrophonic

Registration—Model B-2

PEDAL
- Open Diapason .... 16′
- Octave .... 8′
- Super Octave .... 4′
- Nazard .... $2\frac{2}{3}$′
- Doublet .... 2′

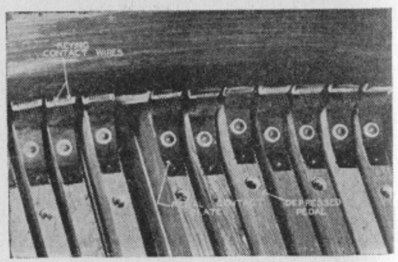


Fig. 2-12. Pedal Key Contacts

SWELL
- Open Diapason .... 8′
- Octave .... 4′
- Nazard .... $2\frac{2}{3}$′
- Super Octave .... 2′

GREAT
- Double Open Diapason .. 16′
- Open Diapason .... 8′

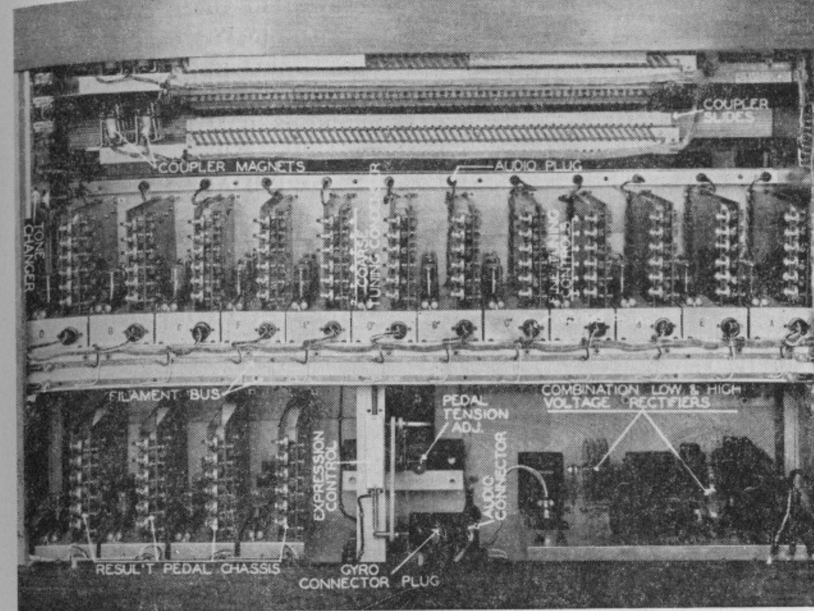


Fig. 2-13 Tone-Generating Chassis for Model "S" Console

- Octave .... 4′
- Nazard .... $2\frac{2}{3}$′
- Super Octave .... 2′
- Tierce .... $1\frac{3}{5}$′
- Larigot .... $1\frac{1}{3}$′
- Sifflote .... 1′

GENERAL
- Unit Diapason
- Unit Flute
- Unit Dulciana
- Unit String
- Clarinet Solo
- French Horn Solo
- Dulciana Ensemble
- Diapason Ensemble
- Baroque Ensemble
- Full Organ
- Gyrophonic

Registration (Models B-3, B-4, B-5, B-6)

The larger Allen organs are known as "straight" in that each speaking stop belongs to only one manual. These are usually at 8′ pitch; other pitches being obtained through the use of couplers. On some of the larger two- and three-manual organs a tone generator is unified, along with other straight generators to add variety and save space. Only the stops lists of the B-3 and B-6 are included here as these are typical of all others.

Registration—Model B-3

PEDAL — 32 notes

- Tuba 16′
- Diapason 16′
- Bourdon 16′
- Lieblich Gedeckt 16′
- Pedal Dulciana 16′
- Pedal Coupler 8′
- Great to Pedal 8′
- Great to Pedal 8′
- Swell to Pedal 8′
- Swell to Pedal 8′

SWELL — 61 notes

- Diapason 8′
- Melodia 8′
- Gedeckt 8′
- Dulciana 8′
- Aeoline 8′
- Viole 8′
- English Horn 8′
- Trumpet 8′
- Vox Humana 8′
- Swell Coupler 16′
- Unison Off 8′
- Swell Coupler 4′
- Echo Organ
- Main Organ Off

GREAT — 84 notes

- Open Diapason 8′
- Principal 8′
- Flute 8′
- Flute Dolce 8′
- String 8′
- Gemshorn 8′
- Oboe Gamba 8′
- French Horn 8′
- Harp
- Great Coupler 16′
- Unison Off 8′
- Great Coupler 4′
- Great Coupler $2\frac{2}{3}'$
- Great Coupler 2′
- Great Coupler $1\frac{3}{5}'$
- Swell to Great 16′
- Swell to Great 8′
- Swell to Great 4′
- Gyro Off

EXPRESSION PEDALS

- 1—Controlling SWELL and PEDAL
- 1—Controlling GREAT
- 1—Balanced Crescendo Pedal with indicator lights

3-SPEED GYROPHONIC CONTROL

Registration—Model B-6

(39 Speaking Stops)

PEDAL — 32 notes

- Tuba 16′
- Diapason 16′
- Bourdon 16′
- Lieblich Gedeckt 16′
- Pedal Dulciana 16′
- Tromba 8′
- Octave 8′
- Flute 8′
- Dulcet 8′
- Great to Pedal 8′
- Great to Pedal 4′
- Swell to Pedal 8′
- Swell to Pedal 4′
- Choir to Pedal 8′

SWELL — 61 notes

- Diapason 8′
- Gamba Celeste 8′
- Melodia 8′
- Gedeckt 8′
- Flute Celeste 8′
- Dulciana 8′
- Aeoline 8′
- Viole 8′
- Voix Celeste 8′
- English Horn 8′
- Trumpet 8′

- Vox Humana 8′
- Swell Coupler 16′
- Unison Off 8′
- Swell Coupler 4′
- Echo Organ On
- Main Organ Off
- Gyrophonic Off

EXPESSION PEDALS

- 1—Controlling SWELL and PEDAL
- 1—Controlling GREAT
- 1—Controlling CHOIR
- 1—Balanced Crescendo Pedal with Indicator Lights

GYROPHONIC CONTROLS

Two—3 Position Lever Switches

GREAT — 73 notes

- Open Diapason 8′
- Principal 8′
- Flute 8′
- Flute Dolce 8′
- String 8′
- Gemshorn 8′
- Oboe Gamba 8′
- Horn Diapason 8′
- Octave 4′
- Flute D'Amour 4′
- String 4′
- Dulciana 4′
- Chimes (tablet only)
- Great Coupler 16′
- Unison Off 8′
- Great Coupler 4′
- Swell to Great 16′
- Swell to Great 8′
- Swell to Great 4′
- Choir to Great 8′
- Choir to Great 4′

CHOIR — 84 notes

- Violin Diapason 8′
- Stopped Diapason 8′
- Salicet 8′
- French Horn 8′
- Oboe 8′
- Vox Humana 8′
- Harp
- Choir Coupler 16′
- Unison Off 8′
- Choir Coupler 4′
- Choir Coupler $2\frac{2}{3}'$
- Choir Coupler 2′
- Choir Coupler $1\frac{3}{5}'$
- Swell to Choir 16′
- Swell to Choir 8′
- Swell to Choir 4′
- Gyrophonic Off

COMBINATION ACTION
(Visible Registration)

- Swell 1, 2, 3, 4, 5
- Great 1, 2, 3, 4, 5
- Choir 1, 2, 3, 4, 5
- Pedal 1, 2, 3

Registration—
"Entertainment Model"

The basic tone of this organ is flute. Through the use of couplers this tone is made available at many pitches and in a variety of tonal combinations. This is the smallest of the present production line of Allen organs. (Although there have been one-manual organs manufactured they will not be covered here as there are so few in use).

SOLO MANUAL (SWELL) — 61 notes

- Lieblich Gedeckt 16′
- Flute 8′
- Melodia 8′
- Open Diapason 8′
- Gamba 8′
- Trumpet 8′
- Clarinet 8′
- French Horn 8′

Octave .... 4′
Flute .... 4′
Nazard .... $2\frac{2}{3}'$
Piccolo .... 2′
Tierce .... $1\frac{1}{3}'$
Fife .... 1′
Marimba*
Harp Celeste*
Music Box*
Glockenspiel*
Chimes*
Harp Sustain*
Vibrato
Tremolo

*These stops on organs with "Harp-Chimes" attachment.

ACCOMPANIMENT
MANUAL (GREAT) 61 notes
Lieblich Gedeckt .... 16′
Flute .... 8′
Doppel Flute .... 8′
Diapason .... 8′
Flute .... 4′
Nazard .... $2\frac{2}{3}'$
Piccolo .... 2′

PEDAL 25 notes
Sub Bass .... 16′
Bass .... 8′
Flute .... 4′

D. Tone Generators and Tone Changes

The smaller consoles contain the tone-generating chassis. Figure 2-13 shows the "S" model console; this is similar to the "B-2" console except that the latter contains twelve more pedal tube generators. The small chassis are removable. Each note is individually tunable with its tuning knob. These oscillators produce only the main tone families, *i.e.,* flute, string, diapason, and reed. These tones are further subdivided in the tone change chassis (upper left corner) into individual stops, such as Dulciana, French Horn, Clarinet, English Diapason, Concert Flute, etc.

The oscillator tubes (6SN7) are "turned on" with the organ power switch, but only when a key is depressed does high voltage reach the tubes. The oscillator components are so designed that they have a finite build-up and decay time that is characteristic of actual organ pipes. This feature also increases tube life infinitely in contrast to what it would be were the tubes drawing "B" current all the time.

Early models of the Allen tone generator used a separate tube to produce that family of tones known as "string." Later research developed a tiny dry rectifier known as a "diode" which accomplishes even better results yet consumes no power. In larger models an entire rank of these tone-producing elements is utilized to produce each family of string, reed or diapason tone. The Clarinet, due to its unusual harmonic structure, cannot be borrowed successfully from other string tone generators, so employs an entire set of these "diodes." Imitative organ reed tone is produced in larger models by the use of "electronic resonators" on each note. This follows the analogy of the pipe organ wherein resonators are used. These new reed families produce a tremendous amount of volume in the organ ensemble as well as softer solo voices. The resonator circuits also

make possible the scaling of a stop to produce the correct volume and timbre of each note in the scale.

The combined use of the "diodes" and "electronic-resonators" are considered by many organ engineers as the missing link between genuine pipe tone and synthesized electronic tone. So closely does the timbre and scaling of these new stops imitate those of actual pipes that on blindfold tests very few listeners can detect the difference.

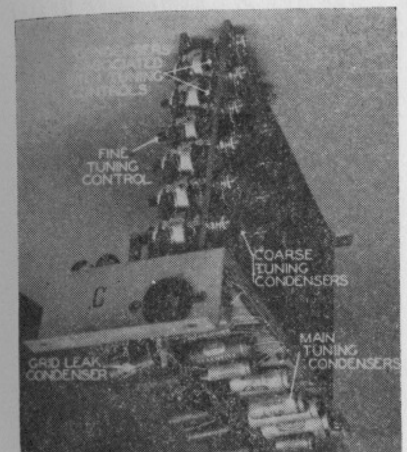


Fig. 2-14. Tone Generator of Self-Contained Organs

Larger Allen organs have their tone generators and tone changers mounted on steel racks (Fig. 2-8) at some distance from the console, connected to it by a multiple cable.

The volume of any note and any stop can be regulated by the installation technician. This "voices" the organ to fit the acoustics of the room in which it is located as well as providing regulation to fit the organist's tastes.

In a medium-size organ one rack supplies the Great and another one is subdivided for the Swell and Pedal. Each is under separate expression. Each rack in conjunction with a tone changer provides one pitch with several tonalities. A typical example would be one rack producing:

Open Diapason 8′
Principal 8′
Flute 8′
Flute Dolce 8′
French Horn 8′
Gemshorn 8′
Oboe 8′
Viole 8′

For other pitches, the organist can draw the 16′, 4′, $2\frac{2}{3}'$, 2′ and $1\frac{3}{5}'$ couplers located on the console.

A more complete Diapason Chorus is available through the addition of another tone rack of 4′ pitch. Since various tone qualities are available from a single tone rack, rather than merely producing an Octave Diapason quality one rack can add the following:

Trumpette 4′
Octave 4′
Flute 4′
String 4′

The same system is applied to the 16′ Pedals whereby the actual tone generators provide:

Bourdon 16′
Geigen Diapason 16′
Lieblich Gedeckt 16′
Dolce 16′
Tuba 16′

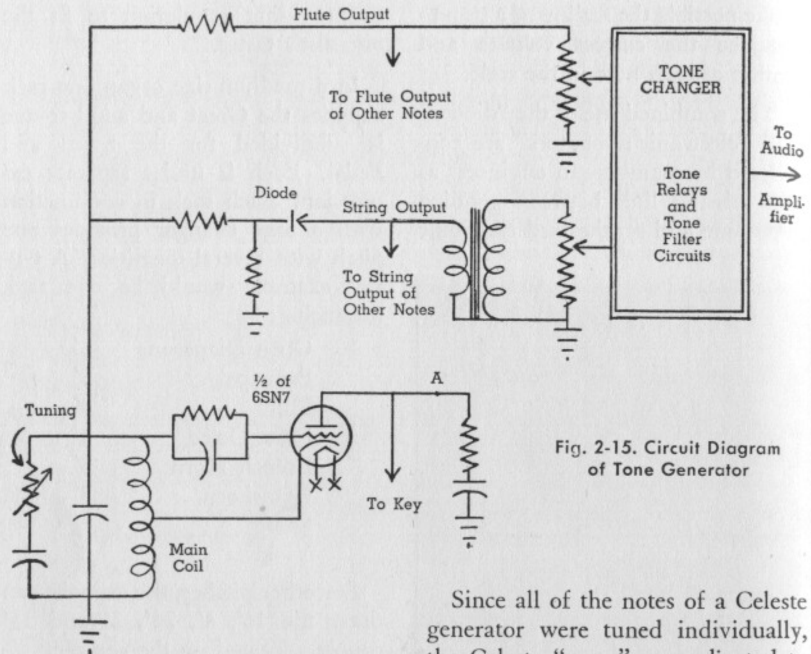


Fig. 2-15. Circuit Diagram of Tone Generator

If mixtures are desired they require more tone sources. A 3-rank mixture would require three tone racks with the desired progression and repeats of pitches. However, these three racks would supply not only one mixture but through the use of the "tone changer" a soft mixture, a mixture of medium intensity and brightness, and a loud mixture as well.

On early Allen organs if Celeste tones were desired, as in the pipe organ, it was necessary to have a separate tone generator tuned to a slightly different pitch. It produced several qualities, all from the same tone rack.

Unda Maris	8′
Gamba Celeste	8′
Flute Celeste	8′
Voix Celeste	8′

Since all of the notes of a Celeste generator were tuned individually, the Celeste "wave" was adjusted to the organist's taste. On current production the Celeste effect is produced by the "Gyrophonic Protector" (see Paragraph E). However, Celeste tone generators are still employed on larger organs and are available on order.

A circuit diagram of the tone generator is shown in Fig. 2-15.

E. Amplifiers and Power Supply

The smaller Allen installations have the amplifier mounted within the loud-speaker cabinet. Large installations develop so much sound energy from the loud-speakers that the amplifiers are usually moved to a separate room to prevent vibrations reaching them. The amplifiers range in size from 25 to 100 watts

of power output. They are all of the high-fidelity type designed specifically for faithfully amplifying frequencies from 30 to 20,000 cycles.

Located inside the console are two power supplies. The first of these supplies 120 volts DC to the plates of the oscillator tubes through the keying circuit. The second is a low voltage 12-14 volt DC supply which provides all action magnets.

F. Loud-Speaker Systems

Early models of the Allen organs used single radiator type, wide-range speakers mounted in large plywood cabinets. All tones from pedal and manuals were fed to one or more cabinets depending on the size of the room. Later an entirely new "Gyrophonic Projector" was developed (Fig. 2-16). This tone cabinet is used by itself on small installations, but for larger rooms a separate bank of fifteen-inch stationary speakers is used for the pedal organ and one or two gyrophonic projectors reproduce the manual organ tones.

When a separate tone cabinet is employed, it is usually placed in an organ chamber. The use of several loud-speaker units in a cabinet eliminates dead spots in the room caused by standing waves. The Allen pedal loud-speaker units are built to resonate at different pitches, rather than all at the same note, thus providing a more even volume throughout the pedal range.

The means of producing tremulant on the early tone cabinets was to rotate a baffle board in front of the manual speakers at tremolo speed (7 R.P.S.) driven by a small motor. This method produced a volume change which was mild and dignified.

The newer tone cabinet known as the "Gyrophonic Projector" includes a rotating tone disc, on which are mounted two special 25-watt capacity low-frequency reproducers and two high-frequency drivers. In the Allen tone generator the highest

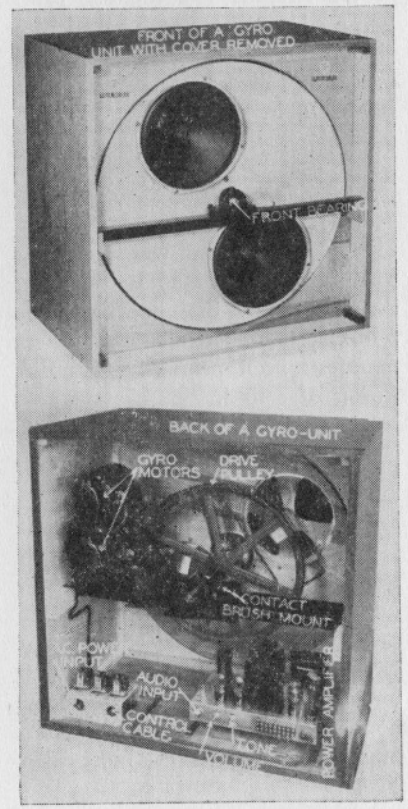


Fig. 2-16. Gyrophonic Projector Unit

pitch range normally found in organ music is present. Therefore, the high-frequency drivers are used especially to produce frequencies as high as 20,000 cycles.

A transformer is used on the disc which raises the load impedance to 500 ohms. The two 500-ohm windings are connected in parallel and fed through the slip ring commutator. The actual contact is made through special silver graphite brushes. There are two brushes connected in parallel for each pole of the circuit. The rotating baffle is caused to revolve by a belt driven electric motor. The speed control is accomplished by a relay system as shown in Fig. 2-16.

There are three speeds and three resulting effects provided:

1. The lowest speed ("gyrophonic") adds the warm singing quality which so far has been produced only by the pipe organ or symphony orchestra. This effect manifests itself primarily as a diffusion of sound.

2. The second speed ("celeste") produces a desirable multi-rank celeste quality. Since all of the stops on the organ are affected, it is possible to produce at will such qualities as voix celeste, flute celeste, unda maris, etc. A "gyrophonic projector" may be used on an organ which already has the extra generator necessary for a celeste. The compound effect produced by this combination is one which is most effective.

3. The third speed ("tremulant") provides an acoustic tremulant which is quite different from any vibrato produced electronically, as it does not change the pitch of the notes. This gives a tremolo having amplitude and phase modulations. These modulations caused by the rotation of the speakers come from standing acoustical wave pattern variations within the room and from motion of the direct radiation characteristics of the loud-speakers.

The "gyrophonic" method should not be confused with electronic tremolo devices as it is basically acoustic in function.

It should be remembered that the movement of this device in the "gyrophonic" position is very slow and at all times the effects produced are dignified in character. Its tonal properties are adaptable especially to the church or concert organ. An interesting point is the fact that the listener loses cognizance of the fact that the "gyrophonic projector" is on or that any specific tonal phenomenon is occurring. When a comparison is made with stationary loud-speaker systems the differences are obvious.

As shown in Fig. 2-17 the "Gyrophonic Projector" mechanism is sometimes housed in a hand-rubbed walnut cabinet which provides an attractive addition to any type of room or auditorium. Utility finish cabinets are available for installations where the loud-speaker equipment is to be concealed.

Three different sizes of Type "G" Gyrophonic Projectors are available:

	Height	Width	Depth	Power
Small	34½″	32″	20″	25 watts
	(Walnut Finish)			
Medium	36″	36″	21″	60 watts
	(Walnut Finish)			
Large	41″	41″	24″	60 watts
	(Walnut Finish)			

Fig. 2-17. Sixty-Watt Gothic Style Gyrophonic Projector

One-hundred watt cabinets are available on special order. These include two additional stationary projectors.

A plurality of "Gyrophonics" can be used on installations requiring additional power. It is not necessary that the "Gyrophonic" cabinet be placed in an "acoustic" chamber. Invariably a "Gyrophonic Projector," placed in a convenient position, will produce results that are far superior to those which can be expected from fixed loud-speakers which are installed in an acoustic chamber.

Theatrical-Type Gyrophonic Projector

A "Gyrophonic Projector" especially designed for the playing of theatrical-type music is also available. This unit is known as the "Model T," and is 33″ wide, 23″ deep and 46″ high. A deep theatrical *vibrato* is produced rather than the more conservative tremolo as in the "Model G."

The "theatrical" type tone cabinet has only one moving loud-speaker; the other loud-speaker being mounted directly above the disc on a stationary baffle. This enables the organist, through vibrato controls on the console, to provide three variations; (1) full vibrato, (2) partial vibrato, and (3) no vibrato. The changes are instantly available as the motor driven mechanism is left in operation at all times.

G. Accessories

Electronic Harp

This is a built-in attachment, available on any Allen organ, which makes it possible to produce percussive tone qualities, such as those of the Celeste, Music Box, Harp, Vibraharp, Harpsichord, Glockenspiel, Marimba, and Chimes. This is accomplished by the use of special circuitry incorporating a large capacity condenser on each note which discharges through the oscillator, giving a long "decay" time after the note is released.

Electronic Carillon

By combining certain couplers, the Electronic Harp, and the Major

Flute stop, a very close imitation of a large carillon is produced. This stop can be added to existing consoles. By connecting the output of the Allen organ to amplifiers and loud-speaker projectors in the belfry of the church, no further equipment is needed to produce tower chimes.

Echo Organs

Because of the multiple generator system used by Allen it is possible to install tone cabinets in the rear of an auditorium playable from one of the manual amplifiers. True echo and antiphonal effects can thus be produced. On most echo installations the entire organ is playable from either main speakers, echo speakers, or both. In large auditoriums, for example, the "both" position is especially useful. It helps those singing at the rear of the church to keep in time with those at the front, eliminating the bad time lag prevalent in long buildings.

Celeste

The use of a separate tone generator rack to produce celeste effects has been described previously. Such a rack can be added to existing organs as can any other Allen accessories.

H. Installation

Acoustics

Room acoustics greatly affect the quality of the sound we hear. Not only is this true for music but speech as well. A difficulty exists, however, when an auditorium is to be used for both. For the clearest interpretation of speech, the time for a given sound wave to be reduced to low intensity should be small. For music, this represents an "acoustically dead" room. For beauty of music the walls should be non-absorbent. Large cathedrals having hard surface walls where the seating area is small in comparison to the total wall, ceiling, and floor space, give beauty and resonance to organ music.

A room that has been acoustically treated may be good for speech, but poor for organs. Many broadcast studios of today have such things as rotating panels acoustically treated on one side, drapes that can be easily withdrawn, and rugs that can be rolled back so that the reverberation time can be changed according to the program material.

Basically, hearing is a process whereby we change variations in sound pressure into the hearing sensation. The quality of the sound is controlled by many factors; *i.e.*, the sound source, the medium or mediums by which it is transmitted to the ear, and the ear itself. Part of the sound source characteristics and the entrance of the sound into the air are factors usually under the control of the installation engineer. It is very important that good architectural design be exercised in all possible ways.

Auditorium acoustics should be calculated by the architect according to the use to which the room is to be put. Church sanctuaries are becoming increasingly dead with the trend toward carpeting, drapes

and acoustical tile. For speech this is beneficial but for organ music a live room is more desirable. A compromise must be reached. Architects should consult with the organ installation engineers well in advance of the final stages of building.

Home acoustics are not so variable. The average home is far from reverberant. The installation of artificial reverberation chambers as in an auditorium would not be practical. About the simplest rule is to place the tone cabinet at quite some distance from the console and facing away from the organist so the sound will have an opportunity to reflect and mix in the room. Tone cabinets can be placed in basement or attic chambers to enhance the reverberation, or artificial reverberation units can be purchased where the room is far too "dead."

Because of the "Gyrophonic Projector" principle which utilizes loud-speakers in motion, there may never be a room where a good tonal installation cannot be made.

Placement

The console placement is important in that it should be on a level floor and should satisfy the buyer as to convenience and visibility. The placement of the speaker cabinets or units is most important. Some of the basic rules to follow for auditorium installations are:

(1) Let the gyrophonic projector speak into the long dimension of the room. Do not aim the speaker directly at the audience or choir.

(2) In many acoustically-dead rooms, placement of the speaker in a corner improves the tone.

(3) It is a good practice to have as large an opening as possible between a room used as a sound chamber and the listening room itself. Unless this is followed, undesirable resonances may occur within the sound chamber causing some notes to sound louder than others.

(4) If the auditorium is acoustically dead, an increase in apparent reverberation time can be obtained by first projecting the sound onto a hard-surface ceiling or wall. This will require more audio power, but is worth the cost of extra amplification.

(5) Tone chambers are often designed for pipe organs and are, therefore, finished in hand plaster. When the chamber is full of the organ pipes the reverberation is eliminated because of the hundreds of irregular shaped parts. However, when an empty chamber is used for an Allen tone cabinet the reverberation may be excessive, requiring the installation of acoustic material over a large area. Since the Allen tone generator produces all the natural harmonics of organ music and the correct attack and decay time are built into the organ there is almost never a need for artificial re-

verberation to be introduced into the system.

(6) Since nearly as much sound emanates from the back side of a speaker as from the front, one tone cabinet can be placed to serve both the choir and nave areas of a church. The tone cabinet could either be placed in the open or the chamber could have tone openings on two sides. Installing extra tone cabinets or speaker units will improve the tone of the organ in any type of installation.

Wiring

The 110-volt power is brought to the organ console through a heavy rubber-covered cable. For a fixed installation this should be secured to a fused power source, not merely plugged into a lamp receptacle. Audio and control cables are usually run between the console and the speaker cabinet through ducts or conduit. In very large installations it is best to locate the amplifiers and tone generators near the console to keep the audio lines shorter whereas the speaker wires can be any length. Where a Gyrophonic Projector is installed there should be a 110-volt outlet provided to supply power for the three-speed motor. This eliminates an otherwise long run of 110-volt cable from the console to the speaker.

Fig. 2-18 shows typical church installations for the guidance of architects in designing buildings. When using consoles which are self-contained, only a 1″ conduit is required between the console and the tone cabinets. On larger models where the tone generators are separate a 4″ conduit or duct is required to

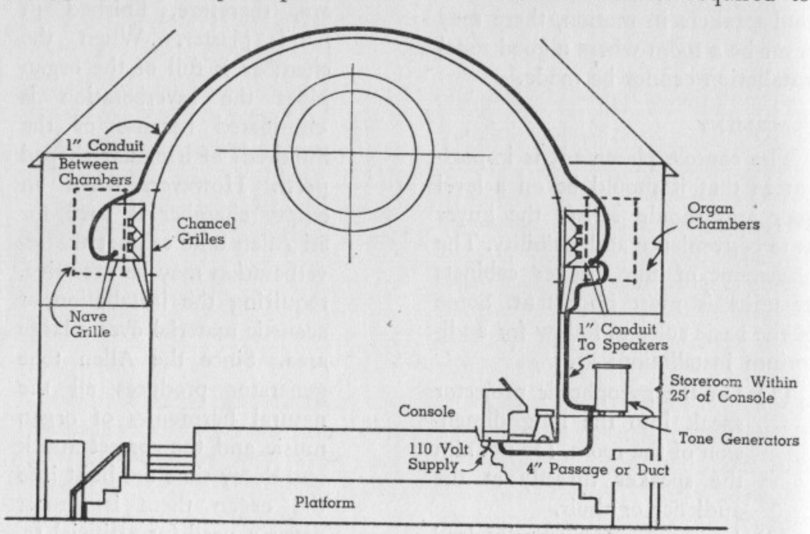


Fig. 2-18. Typical Church Installation

contain the multiple keying cables between the console and the tone generator room. From this room on to the tone chambers a 1″ conduit is ample.

Space Requirements

The "S" series organs require a floor space of 60″ wide, by 50″ deep including the bench. The standard two-manual consoles require 62″ width by 60″ depth. The three-manual require 65″ width by 65″ depth. This allows space to slide the bench back for tall organists.

The "S" series organs usually require but one model "G" Gyrophonic Projector. When a tone cabinet is placed in an organ chamber, this room should be large enough so that the cabinet can be turned to the desired angle and so the parts are accessible for lubrication.

The "W" and "B" series organs usually use the large tone cabinets. Where a separate pedal cabinet is employed it can be placed in a chamber opposite from the manual chamber. Where two cabinets are placed in one chamber it should be twice as large. Architects should avail themselves of factory advice to eliminate having to make changes in the building or in the tone cabinets to accommodate the organ.

I. Care and Maintenance

Far less service is required on electronic organs than on pipe organs. However, as with any complex instrument a certain amount of preventive maintenance and care will prolong the life of an organ and keep it working at optimum efficiency. This work is usually performed by a factory trained service man. In the event he is not available, the following pointers will assist the organist in making minor adjustments.

Keyboards

Access to the keyboards may be had by opening the top of the console. This will expose the stop switches, the rear ends of the Swell keyboard, and the contacts associated with each key. The underside of the Swell keyboard is exposed by simply lifting the entire Swell section after release of the fastening screws. This in turn exposes the upper side of the Great keyboard contacts. The underside of the Great keyboard can be reached by removing wood screws under each end of the key bed. The entire Great and Swell key beds can be tilted back on the hinges provided for this purpose.

Gyrophonic Projector

The ball bearings in the "gyro" unit are initially lubricated by their manufacturer and should be again lubricated once every year. Use only the lubricant known as "Lubriplate Bearing." This can be obtained from most hardware stores.

Dual or single motors supply the three gyrophonic speeds. On dual installations the smaller motor (used for the slowest speed) is 1/20 H.P. and when used as the driver operates at 1100 r.p.m. The larger motor is a two-speed, 1/6 H.P. motor rated at 1725 r.p.m. and either 1100 r.p.m. or 860 r.p.m., depending on the motor used. Both machines have sleeve bearings for quiet operation. The bearings are wool packed and should be lubricated about once a year with a good motor bearing oil. This information also applies to the Entertainment gyrophonic speaker.

VOLUME ADJUSTMENTS

Located on the tone changer chassis are controls to adjust the volume of the various tone families such as reed, flute, or string stops. These controls should be so adjusted that a correct balance exists between the voices and such that one of the controls is near its maximum position. Since the flute tones are relatively pure, it is important that the flute control be kept lower than the others so as not to produce excessive intensity. A flute tone normally sounds much quieter than a string tone of corresponding audio power especially in the pedal register. Flute stops should be adjusted so that their audio loudness is appreciably less than the diapason and "string" stop.

A master volume control is located on each amplifier. This control should be adjusted so that at full organ with the expression pedal open, there should be no distortion in the system. If any slight amount of distortion appears when large chords are played, the gain should be decreased.

AMPLIFIERS

The Allen amplifiers use standard parts and can be checked by a sound service firm as well as organ service men. By replacing the amplifier tubes every two or three years and the condensers every ten years, the life of the amplifiers will be almost unlimited.

TONE GENERATORS

If a tube should fail to oscillate, only one note in the organ will go dead. Since the tubes draw current only when a key is down, their lives are very long. Replacing a suspected dead tube with one from a socket nearby which is playing is a quick way of checking. Since all the tubes are Type 6SN7 it is an easy matter to replace one should it become inoperative. All tube positions are labeled, the first octave being the bottom octave of the manuals. The lowest octave of the pedals is labeled the "zero" octave.

Should the entire organ go dead the fuses should be checked. These are located as follows:

1. A "Fusestatt" is in the console alongside the Great manual. This controls keying current.
2. A tubular glass fuse is in the power supply chassis.
3. A "Fusestatt" is at the base of each separate tone generator.
4. A tubular glass fuse is in each amplifier.
5. The main 110-volt power fuses to the console are at the center of the console behind the Swell pedal.

If the fuses are good, the tubes in the keying power supply should be checked. These type 83 tubes glow with a fluctuating bluish light when operating properly.

J. Models Summary Chart

Model	Brief Description
S-1	One-manual organ produced in 1947.
S-3 to S-7	Two-manual, 25-note pedal, all pre-set registration; 60″ console, built-in generator.
S-10	Two-manual, 25-note pedal, both couplers and pre-set registration; 55″ console with folding top, built-in generator.
S-11	"Entertainment Model" organ, console 52″ wide, two-manuals, special registration for entertainment type playing, built-in generator, 25-note flat pedal clavier.
W-T	Full size AGO console, roll top; all pre-set registration, tone generator separate from the console, uses 6SN7 tubes for "string" tone families.
W-3 to W-6	Full size AGO console, external tone generators, uses 6SN7 tubes for string tone families, individual registration for all manuals and pedals.
B-T	Full size AGO console, roll top, both couplers and pre-set registration, tone generator separate from the console, uses diodes for string tone families.
B-2	Full size AGO console, built-in generator; both couplers and pre-set registration.
B-3 to B-6	Full size AGO console, separate tone generators. B organs use diodes for string, diapason and reed tones, other tonal requirements, individual registration of all manuals and pedals.
G	Gyrophonic projector in utility or walnut case; three-speed motor, two moving coaxial loud-speaker units.
T	Gyrophonic projector in walnut case, designed for playing theater-style organ music; one-speed motor, one moving loud-speaker, one stationary loud-speaker.

Baldwin Organs

CHAPTER III

Baldwin Organs

A. General Description

The Baldwin instruments are purely electronic, *i.e.,* tones originate from vacuum tubes located in the console. The arrangement of stops, keys, and pedals is similar to that of the traditional pipe organ console. Some of the stops approximate the tone of certain organ pipes. The solo voices are the most successful in this regard. Other stops have a distinct quality of their own.

The Model 5 was the first to be introduced to the market (in 1946). This model is for smaller homes and churches whereas the Model 10 (1950) was designed primarily for larger homes and churches. A more skilled organist, familiar with traditional pipe organ technique, would be able to manipulate the Model 10 Console. It incorporates AGO pedals, combination pistons, couplers, and separate expression pedals for the Swell and Great manuals.

From the tone generating chassis in the console the electrical impulses or tones are fed through special mixing and tone forming circuits behind the stop tablets. From here the tones are wired to the amplification system and tone cabinets which are usually installed at some distance from the console. There are no motors, blowers or fans used in these instruments. All components such as vibrato, combination pistons and couplers are electrically operated.

B. Consoles

MODEL 5 CONSOLE

Fig. 3-1 is a view of the Model 5 Console. It contains the tone generator assembly, the Great and Swell manual switch assemblies (Pedal switches are in the base of the console), the tone color box, the junction box, and the Swell pedal.

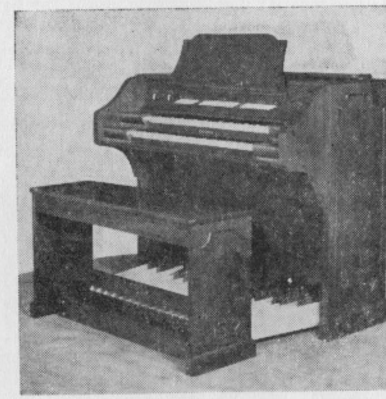


Fig. 3-1. Model 5 Console

A block diagram of the Model 5 organ is shown in Fig. 3-2. The following description of the overall layout of the instrument is based upon this block diagram. Some of the details of the tone generator, and of other complex parts simplified in the block diagram, are given later in this chapter.

The generator power supply, shown in Fig. 3-4 at the extreme right end of the generator assembly, provides the power for the vibrato oscillator which is on the same

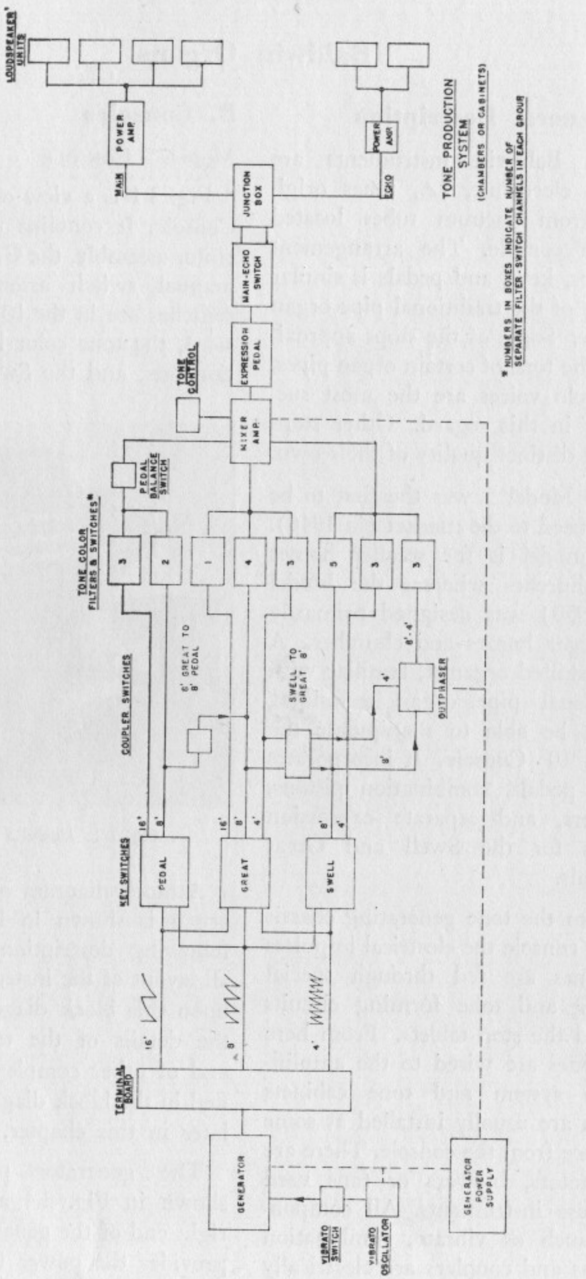


Fig. 3-2. Block diagram Model 5 Organ

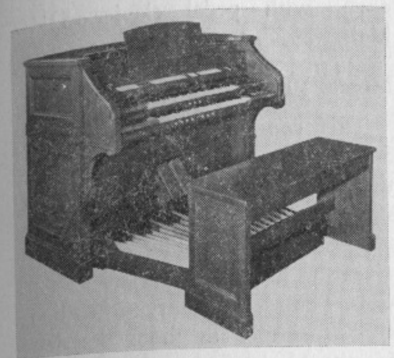


Fig. 3-3. Model 10 Console

chassis, for each generator sub-chassis in the tone generator assembly, and also for the outphaser and a mixer amplifier mounted on the back of the tone color box.

The generator produces 73 complex tone waves of different fundamental frequency corresponding to notes of the equally tempered scale. All of the tone frequencies can be modulated by the vibrato oscillator, the amount of modulation depending upon the position of the vibrato switch located on the tone color panel. The generator tube oscillators operate continuously. The sound does not reach the amplifier unless both a stop and a key circuit are closed.

The individual electrical waves are conducted from the generator to a terminal board which runs lengthwise of the console. From the terminal board, three groups of cables lead to the Pedal, Great, and Swell switch assemblies. The Pedal switches receive frequencies of 8′ pitch (normal) on one set of switch terminals, and waves having another set of frequencies an octave lower on 16′ switch terminals. The

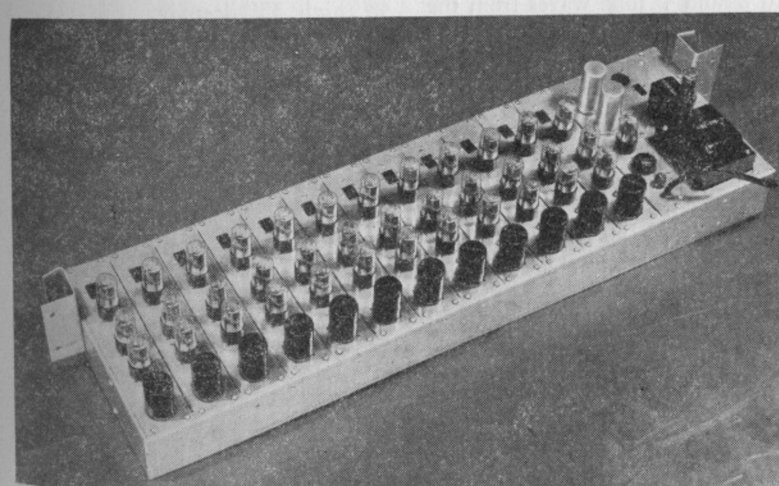


Fig. 3-4. Tone Generator and Power Supply (Model 5)

Great manual employs three-deck switches, receiving not only those frequencies transmitted to the Pedal switches but also waves having 4′ frequencies (one octave higher). The Swell manual receives 8′ and 4′ frequencies only. The key switches of the manuals and pedals provide the means for selection of the desired frequencies.

The coupler switches permit tone colors associated with one manual to be used on another manual or on the pedals. The coupler tabs, which actuate the switches, are in appropriate positions on the tone color panel, along with the tone color (or stop) tabs. The "Great to Pedal" coupler supplies the combined 8′ output of the pedals to the input of the 8′ tone color filters of the Great manual. Thus the lower 8′ tones of the Great manual may also be played upon the pedals. The "Swell to Great" coupler supplies both 8′ and 4′ tone waves from the output of the Swell manual to the inputs of the tone color filters of the Great manual. In effect, this permits the addition to the Great manual of all of the tonal resources of the Swell manual.

Three of the Swell manual tone color filters receive the output of the outphaser circuit. Consequently, connection of the "Swell to Great" coupler into the outphaser input is necessary for these three tone colors to be available also to the Great manual.

The Console dimensions are: Closed, without pedal clavier—52½″ wide, 44″ high, 29″ deep; open, with pedal clavier—52½″ high, 42¼″ deep.

Model 10 Console

This console is shown in Fig. 3-3 and is much more massive than the Model 5. The addition of more stop tablets, combination pistons, toe pistons and another swell pedal gives the organist a variety of controls. The Model 10 organ functions are so similar to those described for the Model 5 that they will not be repeated here.

Most Baldwin organ consoles and tone cabinets are manufactured of walnut veneers. However, the organs are available in a variety of woods making it possible to match almost any interior.

The Console dimensions are: Closed, without pedal clavier—65″ wide, 48″ high, 26″ deep on bottom, 36″ deep in mid-section on arm; open, with pedal clavier—65″ wide, 48″ high, 55″ deep.

C. Registration

Model 5

GREAT

Bourdon	16′
Open Diapason	8′
Melodia	8′
Dulciana	8′
Trumpet	8′
Octave	4′
Violina	4′
Clarion	4′

SWELL

Violin Diapason	8′
Stopped Flute	8′
Salicional	8′
Trompette	8′
Clarinet	8′
French Horn	8′
Oboe	8′
Vox Humana	8′
Flute	4′
Salicet	4′
Dolce Cornet	

PEDAL

Open Diapason	16′
Dulciana	16′
Bourdon	16′
Cello	8′
Flute	8′

COUPLER

Swell to Great	8′
Great to Pedal	8′

Model 10

GREAT

Double Dulciana	16′
Open Diapason	8′
Dulciana	8′
Clarabella	8′
Gemshorn	8′
Octave	4′
Octave Gemshorn	4′
Fifteenth	2′
Tromba	8′
Tromba Clarion	4′
Chimes	
Stop-key prepared for optional use	

SWELL

Lieblich	16′
String Diapason	8′
Stopped Flute	8′
Rohr Flute	8′
Salicional	8′
Orchestral Flute	4′
Salicet	4′
Flautino	2′
Clarinet	8′
Oboe	8′

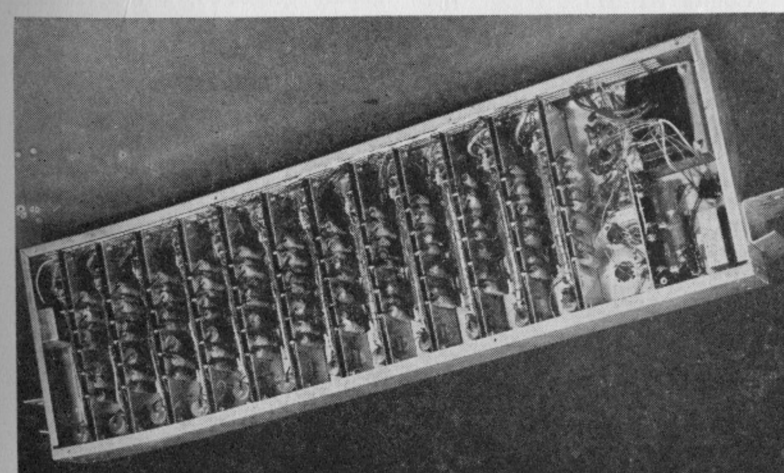


Fig. 3-5. Underside of Tone Generator (Model 5)

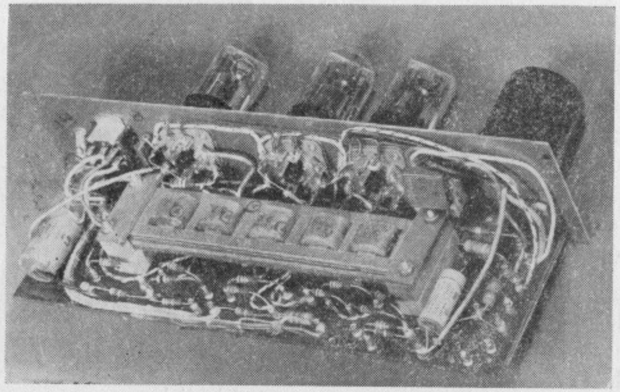


Fig. 3-6. One Note Chassis of Tone Generator

French Horn .... 8′
Vox Humana .... 8′
Trompette .... 8′
Clarion .... 4′

PEDAL

Open Diapason .... 16′
Dulciana .... 16′
Bourdon .... 16′
Contra Bassoon .... 16′
Flute .... 8′
Cello .... 8′
Choral Bass .... 4′

COUPLERS

Great to Great .... 4′
Swell to Great .... 16′
Swell to Great .... 8′
Swell to Great .... 4′
Swell to Swell .... 16′
Swell to Swell .... 4′
Swell to Pedal .... 8′
Swell to Pedal .... 4′
Great to Pedal .... 8′
Great to Pedal .... 4′

VIBRATORS

Light, Medium, and Full

D. Tone Generators

The four general types of organ tone color (Diapason, Flute, String, and Reed), are available individually and collectively with variations and in several pitch "lengths." The outphaser provides an entirely different type of wave from that originally generated, a type suitable for use in a group of "stopped" tone colors. These tones are noted for having a rather small amount of harmonic content, similar to the stopped pipes of a pipe organ and to certain orchestral instruments.

The pedal balance switch provides adjustment of the balance between the pedal tones and the manual tones, as required by the particular acoustical conditions where the instrument is to be used. Because this requirement is determined at the time of installation, the switch is not on the tone color panel. The outputs of each of the manuals and of the pedals are com-

bined and amplified in a mixer amplifier, located at the back of the tone color box. An over-all tone control on the panel provides a moderate amount of variation in the entire tonal output, for artistic or novel requirements as desired. The combined tonal output wave is controlled in magnitude by the position of the expression pedal. The ouptut of the expression pedal may be switched either to the main tone production system, or to the echo tone production system, or to both at the same time.

The console output and the electric power for each time production system are transmitted by a cable from the junction box in the console to the power amplifier in the tone chamber or cabinet. There the console output is amplified and fed to loud-speaker units operating in the tone cabinet or on baffles.

In the block diagram of Fig. 3-2 a single line is shown connecting the generator with the terminal board. This represents a group of cables carrying 73 different tone waves. The generator assembly consists of 12 sub-chassis and the power supply. Each sub-chassis supplies six octavely related frequencies. In other words, all of the tones having the same letter notation originate in the same sub-chassis.

The oscillator is of the tuned grid type, with transformer coupling from its plate circuit back to the grid. All of the electronic vacuum tubes in the sub-chassis are dual triodes, type 6SN7. The master oscillator tube is one section of the lowest tube on the sub-chassis. The other section of this tube and the four triode sections in the other two tubes on the sub-chassis provide five stages of frequency division by octaves. In other words, each successive oscillator divides the frequency by two, so that the second triode section of the top tube in this sub-chassis generates a tone wave having a frequency five octaves below the frequency of the master oscillator. Each sub-chassis operates on the same principle, the essential difference being only in the frequency of the master oscillator. One additional oscillator is required for the lowest frequency of the instrument, corresponding to the lowest key or pedal operating with a 16′ stop. This oscillator, which generates 32.7 cps, and is a sixth stage in the cascade of C tones, is located on the power supply chassis. The triode section for this generator is in the same 6SN7 tube with that for the vibrato oscillator. From each oscillator a tone wave is conducted to the terminal board, from which the tone wave is distributed to the key and pedal switches.

The "master-slave" relationship between the oscillators on a sub-chassis greatly decreases the possibility of the instrument's being out of tune. It also simplifies the tuning of the instrument, a single adjustment being required for each sub-chassis. The tone wave generated by the oscillators are complex, containing the many harmonics required for production of the many tones required in organ music. These

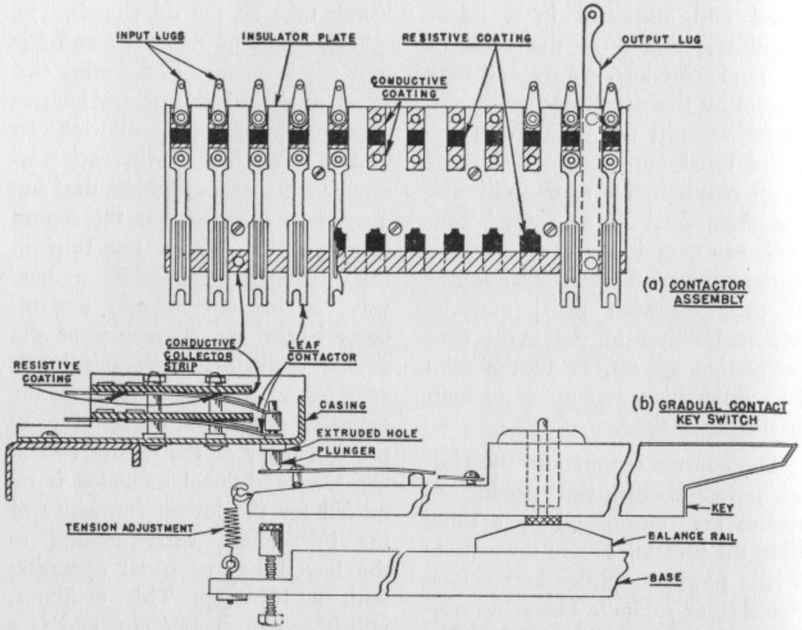


Fig. 3-7. Gradual Contact Switch-Principle of Construction

harmonics are filtered and selected by the tone changer or tone color box (see paragraph F).

E. Keying System

In order to prevent a sudden explosive tonal attack when the output circuits of the continuous generator are closed, the Baldwin uses gradual contact switches. The principle of construction of these switches is shown in Fig. 3-7. In view (a) is a contactor assembly, which is a printed circuit for twelve switches with silverplated, beryllium copper, leaf-spring contactors. This assembly serves an octave of keys. The printed circuit, which consists of two different types of coating, one electrically conductive and the other electrically resistive, is deposited upon an insulator plate. The conductive coating provides a good surface for electrical connection to the input lugs and leaf contactors, and to the resistive coating. The resistive coating adjacent to the conductive collector strip at the front of the plate serve as variable resistors of approximately 250,000 ohms. The resistive coatings between the input lugs and the leaf contactors are fixed 5000-ohm resistors. The output lug is on the other side of the plate and is connected to the collector strip.

The mechanical action of the switch is apparent from view (b).

Motion of the key moves a plunger in and out of an extruded hole in the switch casing. The plunger engages one or more leaf contactors depending upon the number of tone frequencies which the key can select. In the case shown there are two contactor assemblies, and consequently two contacts for each key. This is for the Swell manual where each key can select either an 8′ or a 4′ tone frequency or both. As a leaf contactor moves toward the plate it first contacts the edge of the variable resistance, then rolls across the resistance to the collector strip. When the key is released, the tension spring restores the key to its original position and the contactor rolls back across the resistor and finally breaks electrical contact. The rubbing action of the switch contact makes it self-cleaning.

F. Tone Changers

Before examining further the method of tone color selection, one should consider first the general requirements for tone modification. Musical tone quality has captured the imagination of both musician and scientists. Some factors of tone quality are only partially understood at present and are the subject of research. However, a number of factors which contributes to tone quality are now well known, such as the following:

1. Harmonic Content
2. Formant Characteristics
3. Wave Envelope
4. Sound Intensity
5. Vibrato

Of these factors, the first is most widely discussed and understood. It is also quite important. For example, flute-like tones require a small amount of harmonic content, especially the flute tones of high pitch. Stringlike tones, by contrast, require a large number or relatively prominent harmonics of high order, as many as twenty or more being common for low and medium pitches.

It is not so generally understood, outside the field of musical instrument research, that the harmonic content for the tones of all natural instruments is more or less dependent upon the fundamental frequency of the wave. For some instruments such as the oboe, bassoon, French horn, and trumpet, the dependence is quite pronounced. To the extent that this dependence follows a definite pattern the tone color is said to possess a formant characteristic. The Baldwin method of tone color selection not only provides various amounts of harmonic content and tone colors having either even or odd harmonics prominent, but also provides a variety of formant characteristics.

Organ tones have a rather constant wave envelope, in contrast to piano tones, for example, where a rapidly rising wave front is followed by a gradual decrease in tone level. The swell control, however, is an envelope control device. The gradual contact switches can also be used for envelope control, if desired. However organ compositions do not call for this kind of tone color variant.

The effect of sound intensity upon the tone quality is caused by the relative ability of the sense of hearing to respond to sounds of different pitch at different loudness levels. Low pitches tend to disappear from the ensemble as the overall loudness is decreased. The swell control compensates for this effect.

Vibrato is of the frequency-modulation type and occurs in the generator, as previously mentioned. However the radiation of a frequency-modulation sound wave in a room always results in some additional modulation of the amplitude type, caused by room acoustics.

Although the tone spectrum of an organ stop or a single instrument will vary considerably with fundamental frequency, there are large differences between the spectra of various stops or instruments for the same fundamental frequency. For tones in the octave range above middle C, for examples, the spectra shown in Fig. 3-8, for flutes, reeds, and strings, are fairly typical. Each successive harmonic of a flute tone wave will be ten db. or more lower in level than the preceding harmonic. For higher pitches the higher harmonics are even less apparent. Reed instruments and the reed class of organ stops generally have well-defined formant characteristics, while strings have a large number of harmonics of comparable intensity. The string spectrum shown is for a tone on a violin E string. When the complex generator tones are electrical filters or tone changers of the general types shown in Fig. 3-8, several variations in tone colors are possible from but one tone generator.

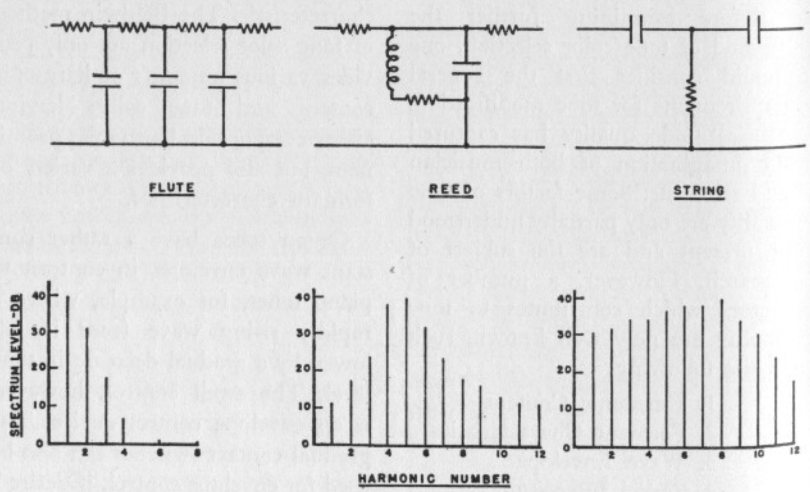


Fig. 3-8. Tone Color Filters and Spectra, Illustrative Examples

When a stop tablet on the console is depressed it brings into the audio circuit one of the tone changer networks consisting of a combination of resistors, condensers, and chokes. This alters the harmonic content of the note. Naturally if a loud stop is being played which contains most of the harmonics available from the generator, then another softer stop is added; this second stop may not even be heard since it is adding nothing new to the formant.

Two other classes of organ tone color which are very important are the diapason family, found only in the organ, and "stopped" tone colors. Both of these classes have alternately prominent harmonics, rather than groups of strong adjacent harmonics. The even harmonics, especially the second, are more prominent in diapason tone. The odd harmonics are prominent in the stopped tone colors which in the pipe organ are generated by pipes closed at one end. The stopped tone colors have a "hollow" sound, like the low register of a clarinet. In the Model 5 and 10 organs, production of these tone color classes is accomplished by addition and subtraction of the proper amount of complex wave of twice fundamental frequency.

The tone color filters and switches are shown in groups in the block diagram of Fig. 3-2. Three input conductors are used, for 16′, 8′, and 4′ pitches. Tone waves of 16′ frequencies collected from the Great manual key switches are conducted to the input of the Bourdon 16′ filter. As the organist selects this particular tone color his action in pressing the stop tab marked "Bourdon 16′ " closes the associated gradual-contact switch. The use of gradual-contact switches in the selection of tone color permits the organist to change stop combinations smoothly while holding a chord or while modulating from one key to another.

Tone waves from the combined output of the 8′ key switches in the Great manual are conducted to the inputs of all four of the 8′ tone color filters. Open Diapason 8′ has a double contact switch, because it contains 4′ frequencies for reinforcement of the even harmonics.

Tone waves of 4′ frequency are supplied to three tone color filters: the Octave, Violina, and Clarion.

A fixed resistance of approximately 5000 ohms, provided by a resistive coating in each switch assembly, prevents interaction between the various stops selected. The combined outputs of all stops of the Great manual are conducted to the mixer amplifier.

In addition to the selection and combination of various tone colors, the tone of the instrument may be modified by the use of the couplers previously described, and by the expression pedal which varies the over-all level of the console output. A tone control located at the extreme left of the tone color panel may also be used to vary within moderate limits the over-all tone color of the entire console output.

G. Amplifiers

The console output (from the pre-amplifier) is transmitted over a 500-ohm line to the input of the power amplifier. A variable potentiometer in the amplifier input circuit is adjusted to provide the re-

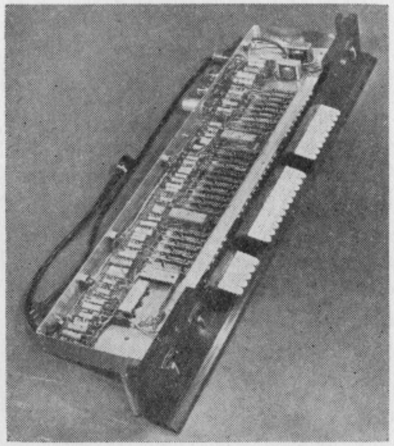


Fig. 3-9. Tone Changer and Stop Key Assembly (Model 5 Console)

quired output level from the tone production system. The amplifiers are so wired that they will not turn on until all the speaker units are plugged, since the speaker fields form a part of the filter and bias circuits of the amplifiers.

H. Loud-Speaker Systems

The technique of production of the acoustical tone wave of the Baldwin organ is quite different from the techniques of speech-music sound systems. In the interests of intelligibility conventional speech-reproducing systems are made directional. This assures a large amount of direct sound compared to that reflected from the walls, thus preventing undue interference between successive speech sounds. It also enhances the illusion of the talker's presence, making him appear to be located at or near the loud-speaker.

The sound of organ music, however, is expected to be diffused. This requires that much of the sound reaching a listener be reflected from the walls and ceiling. Also organs have traditionally been played in large reverberant rooms. In order to take advantage of the reflecting surfaces available for diffusion, and to get the full benefit of room reverberation, the tone cabinets of the Baldwin organ radiate the sound upward principally, with some also coming from ports in the lower part of the cabinet.

A majority of Baldwin organs have tone chamber installations. This type of tone radiation is used wherever possible. The sound is first radiated from loud-speakers mounted on large flat baffles in reverberant, rigid-walled chambers which are built into the walls of the church, auditorium, or home. The sound, after multiple reflection in the chamber, is radiated through grilles into the room where the tones are heard. The tone chamber is designed to spread the sound in a non-directional manner, and to improve the tone reverberation.

Tone Cabinets

Dimensions of the tone cabinets are given in next paragraph. One

MODEL	*DIMENSIONS*	*WATTS*	*WEIGHT*	*SPEAKERS UNITS*
A	H 60 W 38 D 38	40	290	Four 15-inch
B	H 40¼ W 31 D 18	20	139	Two 15-inch
D	H 61¼ W 38 D 22	40	335	Four 15-inch
F	H 31¼ W 38 D 22	20	145	Two 15-inch
FF	H 61¼ W 38 D 22	20	205	Two 15-inch
H	H 37 W 30½ D17¾	20	125	Two 15-inch

forty and one twenty-watt tone cabinet may be connected by special cable to the console for electrical power. When additional cabinets or separate amplifiers are used, a relay box is required. The tone cabinet should not be turned on its side, or shipped, with the amplifier mounted in this way. If the tone cabinet must be moved around, the amplifier should be removed and carried separately or else bolted down with packing blocks.

Baffleboards

The baffleboard is used in a Tone Chamber type of installation. The baffleboard enhances the low tones of an organ. Good musical results can only be obtained from a properly installed baffle and speaker system. The 40-watt speaker mechanism consists of a 40-watt amplifier with four 15″ dynamic speakers. The 20-watt speaker mechanism consists of a 20-watt amplifier with two 15″ dynamic speakers.

I. Installation

The location of Baldwin organ equipment in various types of installation is discussed in this section, and the mechanical and electrical details connected with installation are given. Acoustical factors are discussed in the next section.

Equipment Location

There can be no hard and fast rules for equipment location, because each building is different, and the role of music differs from one installation to another. Examples are given of rather typical cases from both architectural and equipment location standpoints.

Fig. 3-10 is a large church building with architectural features tending to identify it with the Roman Catholic Church. The console and choir are in the balcony at the rear. The console faces the choir, permitting the organist to direct. Tone-

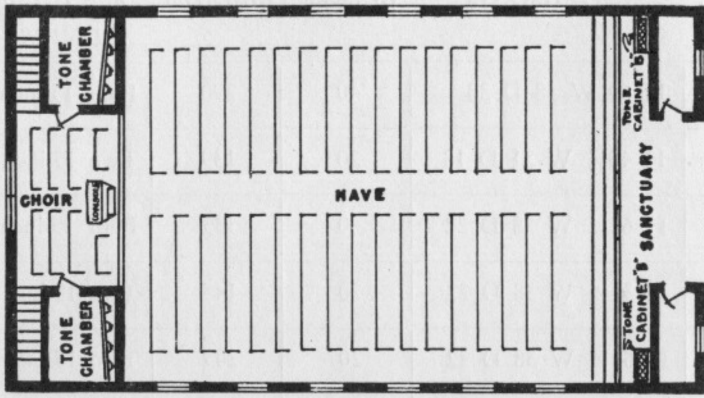


Fig. 3-10. Large Church Installation

chamber systems are installed on each side of the choir, with the sound ports opening into the balcony space from the chambers. A Tone Cabinet B is unobtrusively placed in each front corner, to improve the acoustical balance.

A church building of medium size with a small rear balcony is shown in Fig. 3-11. This is one of the styles of Protestant church buildings, with the choir separated into two groups facing each other at the front of the room, behind the pulpit. The console is located again in a position where the organist can lead the choir if necessary. A tone chamber system is installed behind the choir and above choir level. The baffle does not reach the ceiling of the chamber in this case, where the rear part of the chamber

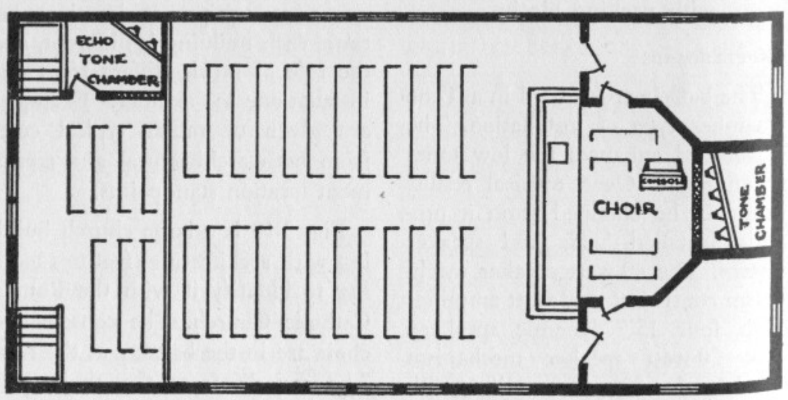


Fig. 3-11. Medium Church Installation

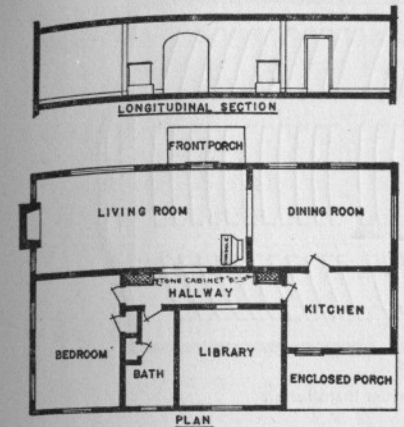


Fig. 3-12. Home Installation

is relatively isolated by the baffle from the front part of the chamber. A smaller tone chamber system is installed in the balcony.

Two home installations are shown in plan view in Fig. 3-12 and Fig. 3-13. One installation has a tone chamber under the stairway. The location will tend to restrict the sound to the living room area. In the other home, the central hallway which is a tone chamber of sorts, distributes the sound throughout the house. In both cases the console is situated in a corner, away from doors and windows, with the organist facing the room. In neither installation are the tones produced directly in the principal listening space, the living room.

Distribution

The problem of sound distribution is to create as nearly as possible the same loudness of tone throughout the listening space for any given tone level. The installation examples shown illustrate the application of the following principles.

1. Choose sound source locations which are as equidistant as possible from all listeners in the audience.
2. Choose locations close to the console and choir, but not too close to either. Height of source location aids greatly in following this principle.
3. Use the echo tone chamber or cabinet with the main source for best distribution.
4. Locate the console where the balance between instrumental and vocal music can be heard much as it will be heard by the audience.

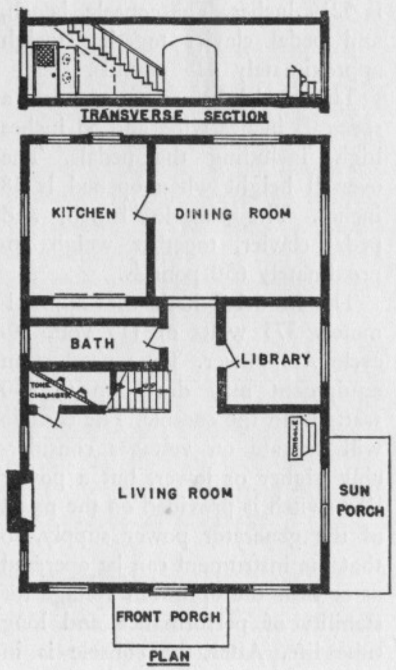


Fig. 3-13. Home Installation

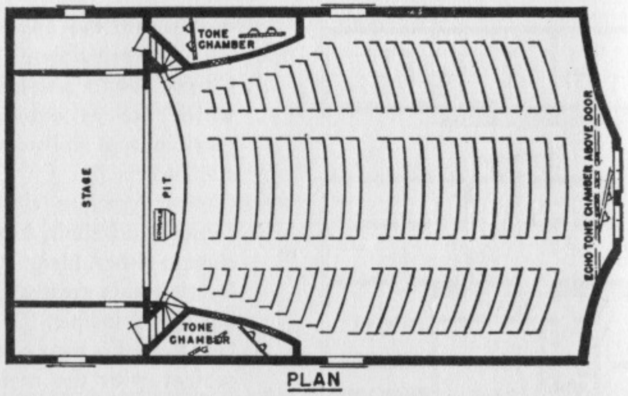


Fig. 3-14. Auditorium Installation

Console Space Requirements

The minimum floor space for Console Model 5 is four and one-half feet square. This includes the pedal clavier. The over-all height is 52½ inches. The console, bench, and pedal clavier together weigh approximately 425 pounds.

The Model 10 console requires a space 65 inches wide and 55 inches high, including the pedals. The over-all height when opened is 48 inches. The console, bench, and pedal clavier, together weigh approximately 650 pounds.

The Model 5 itself uses approximately 375 watts of 115 volt, 60-cycle AC power. Tone production equipment may draw up to 450 watts from the console. The console will operate on voltages considerably higher or lower, but a power line switch is provided on the panel of the generator power supply, so that the instrument can be operated at or near the optimum voltage for stability of performance and long tube life. After the console is in place, and the tone production system has been connected, measure the line voltage with the instrument turned on and with all building lights on. Inquire from some reliable source about the stability of the line voltage. If the line voltage is consistently 110 to 120 volts, leave the switch on the power supply in Position 2. If the line voltage is consistently low, use Position 2 (intended for 100 to 109 volts). If the line voltage is consistently high, use Position 1 (121 to 130 volts) in order to lengthen tube life.

The loud-speaker units are mounted in tone cabinets at three points on resilient washers. If the units are removed or replaced for any reason, save the mounting hardware and replace it in the same order, with the felt washers between the loud-speaker gaskets and the cabinet baffleboard.

Tone Chamber Systems

Tone chamber systems are shipped with the 20 or 40-watt amplifier in one package, and with

the loud-speakers (two or four, depending upon the system) in pairs in other packages. The mounting hardware in a cloth bag and a loud-speaker installation instruction sheet are included with the loud-speakers in each system. A minimum baffle thickness of three-quarters inch is recommended. Plywood, at least 5-ply, is recommended for the material. Holes of 13⅞ inches diameter with three mounting screw holes (for 12-24 machine screws) on a diameter of 14½ inches are needed for each loud-speaker unit. The two top screw holes are equally spaced from the vertical 90° apart with the bottom hole on the vertical center line. Felt punchings provide a resilient pad between the loud-speaker and the baffle at each screw.

The baffle should be ideally at least 8 feet square. 2 x 4 re-enforcing strips, screwed to the baffle at frequent intervals, with the 2-inch face against the baffle, are recommended for making the baffle more rugged mechanically, and more rigid at low frequencies from an acoustical standpoint. The loud-speakers should be mounted in the central part of the baffle for best results. The method of supporting the baffle is not critical. However, it should be free from rattles; consequently felt padding between the supporting edge and the floor of the chamber, and under any supporting feet, is recommended as a rattle preventive.

The amplifier may be mounted on a shelf near the baffle, within the length of the loud-speaker cables. The amplifier dimensions are 19 x 9¾ x 8 inches over-all.

Tone chambers should not be used as storage rooms. Otherwise rattles of incidental boxes will be blamed upon the loud-speaker.

On the back of the console tone box is a screw-driver operated switch which varies the relative level of the pedal output. It has three positions. In small rooms it is usually set for minimum pedal tone, and in large rooms for maximum pedal tone. The selection is based upon the acoustical properties of the room and upon individual taste.

The volume control on each power amplifier may be used, within the limit of amplifier overload for full organ, in order to set the over-all level of the instrument and the relative level of the main and echo systems. The lower it is set, the less possibility there is of distortion, but there are few instances where sufficient power is available with a very low setting of the volume control. The maximum position of the control without overloading the amplifier is usually approximately 4/5 of a full rotation, but this will vary somewhat from one amplifier to another.

The console tone control, although intended primarily for tonal effects controlled by the organist, has been used in some instances to adjust the over-all tone to a particular acoustical environment or to the taste of an organist.

J. Acoustics

Observance of the following rules is essential for successful installations of the Baldwin organ.

1. Provide enough acoustical power output.
2. Make use of architectural features which will increase tone reverberation.
3. Select sound source locations for uniform sound distribution in the auditorium. Also locate the console and the sound sources to give good instrumental-vocal balance for the organist, audience, and choir.

The major acoustical factors affecting the choice of power for the tone production system are the following.

1. Auditorium size.
2. Total sound absorption (including audience).
3. Auditorium shape.
4. Sound level of music to be accompanied.
5. Background noise level.

These factors are arranged in order of general importance. However, circumstances may change the order. For example, in a crowded, noisy amusement place the background noise level might be the controlling factor.

More power is required in a large room than in a small one for the same loudness of tone, other things being equal. Fortunately, the apparent "volume" of tone is enhanced by the spaciousness of large reverberant auditoriums. Consequently the actual loudness can be somewhat less for large than for small rooms. Although the power does not need to be proportional to the volume, the power requirements do increase considerably as the volume increases.

A more reverberant room gives a higher sound level for the same sound source. More power is necessary in a crowded room, or in one with heavy drapes, carpets, upholstered chairs, or acoustical tile, than in a reverberant hall of the same size and shape.

A room with an irregular shape, or having alcoves, requires more power than a similar room of regular shape and unbroken lines.

Recognizing that all of the factors above affect the power requirements, and that some of them are difficult to evaluate, the following table is suggested only as a guide to the power required for different size rooms. The power values are given for typical adequate installations. They are in multiples of forty and twenty-watts, corresponding to the peak audio power ratings of the power amplifier used in tone cabinets and the 40 and 20-watt tone chamber systems. When selecting a value from the table, adjust for the effects of the factors above, and revise the power upward for installations requiring outstanding performance.

Volume Cu. Ft.	Estimated Audience Capacity persons	Rate Peak Audio-Power watts
10,000	60	40
20,000	100	60
50,000	225	80
100,000	425	120
200,000	850	200
500,000	2000	320

In any case the important power quantity is the acoustical or sound power output of the instrument. The electrical power is a good indication, but does not allow for factors tending to decrease acoustical efficiency. Such factors are draperies hanging near tone cabinets or over tone chamber ports, acoustically treated ceiling over tone cabinets, porous or vibratile interior surfaces in tone chambers, open doors or windows near tone cabinets and chambers. All of these are undesirable and should be avoided or eliminated.

Architectural Advice

Tone chambers have other advantages over Baldwin tone cabinets besides reverberation, and these advantages are important in some installations where the reverberation is adequate without the tone chamber. A tone chamber installation is more likely to be complementary to the church architecture and is more in keeping with organ tradition. It usually raises the location of the sound sources well above audience level. This improves the distribution of sound and helps to improve the auditory perspective. It also eliminates the floor space requirements for tone cabinets within the auditorium of sanctuary. It helps make the sound more diffused and less easily localized.

The principles of construction of a tone chamber for a Baldwin organ are very important. The rules for volume, shape, baffle size, and location, port areas, and wall construction have some flexibility, in order to be applicable to a wide variety of local situations. Compromise with the rules will compromise the acoustical performance of the chamber. The rules follow:

1. *Volume.* A minimum of 600 cubic feet is recommended. Up to twice this volume, although not frequently available or economically feasible, is desirable providing the rule for wall construction is followed.
2. *Shape.* Avoid identical and multiple dimensions and extreme dimension ratios. See the table below.
3. *Baffle.* A minimum distance of four feet from loud-speaker to free edges of the baffle is recommended. Face the baffle away from the port at an angle with the walls. Use plywood at least ¾″ thick and reënforce.
4. *Port Area.* Make the area three to five per cent of the total interior surface area of a chamber in the recommended volume range. Grillwork should not obstruct more than one-fourth of the port area. Decorative fabric, if used at all, should be very open in weave.
5. *Wall Construction.* Use rigid, non-porous walls. This applies also to the ceiling and floor of the chamber. Glazed plaster is recommended.

The need for volume can be seen from the reverberation equation. As an example, consider a chamber 10¾ feet wide, 6¾ feet high and 8½ feet deep, having a volume of approximately 615 cubic feet. The total surface area is 443 square feet, five per cent of which for port area is 22 square feet. If the absorptivity of the chamber walls is neglected, assuming rigidity and complete sound reflection (a condition not practically realized), and the entire absorption of sound in the chamber is through the port into the auditorium, the reverberation time is calculated, $t=.05\ (615)/22\ (1)=1.92$ seconds. Plaster, concrete, and glazed tile or brick surfaces have absorptivities of one to two per cent generally, which would increase chamber absorption and decrease chamber reverberation by twenty to forty per cent of the value calculated. Increasing the reverberation time will require a larger volume or a smaller port. Carrying either to an extreme will seriously reduce the available sound level.

If a lower volume is an absolute necessity as a compromise, the tone chamber cannot be expected to add much reverberation, but some of the other advantages are yet worthwhile.

The shape of the tone chamber affects the ratio between volume and surface area and, therefore, the reverberation time. This is one of the reasons for avoiding extreme dimension ratios. A long chamber of small cross-sectional area will have more surface per unit volume, and less reverberation time. Another disadvantage of a long chamber is that its lowest resonance frequencies will be widely separated and will consequently make certain frequencies more prominent than others. The other extreme case, that of equal dimensions, is less desirable acoustically because the natural frequencies are not only widely separated, but are also the same for different dimensions of the room. It is very easy to avoid these extreme conditions, and to spare the natural frequencies quite uniformly for good chamber response. A good practice, although not the only one for good results, is to use dimension ratios which are multiples of the cube root of two. These ratios insure that the chamber dimensions, and consequently the wave lengths of sound at the resonance frequencies, are well distributed in the musical scale. The preferred ratios are 1 to 1.26 to 1.59. These are the ratios of dimensions in the chamber example above. Dimensions deviating from these ratios by as much as five per cent are quite satisfactory. Sometimes the available space does not permit these ratios, and the following possibilities are suggested as alternates, in order of decreasing preference:

Preferred Ratio	1	1.26	1.59
Alternates	3	4	5
	1	1.59	2.52
	1	2.52	3.16

The purposes of a loud-speaker baffle are to isolate the front from the back of the loud-speaker cones, and to increase the effective area of the cones at low frequencies, making them more efficient. If the recommended baffle size is compromised, a loss in low-frequency response will result. This will be most noticeable on pedal 16′ Bourdon. The term "free edge" as applied to the loud-speaker baffle means an edge separated from the wall or floor of the room. Smooth contact between the baffle and one or more

room surfaces effectively increases the baffle size. For example, in the tone chamber described above (10-¾ x 8½ x 6¾ feet high) a baffle for four loud-speaker units could run from floor to ceiling, and be only 6½ feet wide, by having one edge against a wall and by locating the loud-speaker units clustered near that edge. Or if eight units are used, they could be spaced along a line one foot above the chamber floor on a vertical baffle 12 x 5 feet, with the bottom edge of the baffle on the floor and the ends against the walls. Ozite blanket (rug-padding) should be used between baffle edges and the wall or floor as a rattle preventive. Sealing off part of the chamber, by having the baffle edges contact all surfaces, is not generally recommended. Where this appears to be a necessary expedient, the volume behind the baffle should be at least twelve to fifteen cubic feet per loud-speaker unit. This volume is required to prevent the back enclosure from raising the resonance frequency of the loud-speakers appreciably.

In shallow tone chambers an 8 x 8 foot baffle with the loud-speakers mounted near the center is frequently used. This same size is very good in deeper chambers if there is sufficient space.

If a tone chamber of non-rigid or acoustically absorptive construction is absolutely necessary, allow more port area and face the loud-speakers toward the opening. This practice will result in lower reverberation and less diffusion of sound, but it will prevent the sound level from falling below an acceptable standard.

Baldwin tone cabinets should be located in "live" (sound-reflective) surroundings if possible. Avoid acoustically treated ceilings particularly. Choose high locations where possible but do not let the top grille of the cabinet be closer to the ceiling than three feet, with a greater distance being preferred in medium and large rooms. The cabinets should be used in the normal position, and should not be laid on a side and pointed toward the audience.

K. Care and Maintenance

Baldwin service representatives should be contacted for all repair work on Baldwin organs. Emergency repairs usually amount to the replacing of a defective generator tube which can easily be done by the organist. If all the "C's," for example, on a manual are dead, one 6SN7 tube in the C generator may be inoperative. Replacing one at a time with a new tube is the quickest means of locating the trouble.

If the console is operating but no sound comes from the speaking system, check the amplifier. It may have a blown fuse or defective tube.

Tuning the organ should be done by a qualified organ service technician. Adjustment of the volume of the organ is easily done by the organist or service man. Not only are there volume controls on each amplifier, but the relative balance between manual and pedal volume can be adjusted by the "pedal balance switch."

L. Models Summary Chart

MODEL	BRIEF DESCRIPTION
5	Two manual, 32-note concave, detachable pedals, 25 stops and two couplers. One vibrato (variable). One expression pedal. Tone provided by vacuum tubes (12 oscillators for each manual and pedals); total number of tubes 36, Type 6SN7.
10	This largest model includes combination pistons, 10 couplers, two expression pedals, crescendo pedal, and toe pistons.

NOTE: Much of the material in this chapter has been prepared by the following Baldwin personnel: Paul Mooter, John Jordan, Dan Martin, and Dewey Ferrell.

Connsonata Organs

CHAPTER IV

Connsonata Organs

A. General Description

The pitches and tones of these organs are provided by electronic tubes called oscillators, without the use of moving parts. Dual-type tubes and small associated components make it possible for all pitch and tone generators to be housed inside the consoles.

There is an oscillator for each note of the keyboard with twelve additional, providing an octave extension of the treble and an octave extension in the pedals down to 16 foot pitch on most models. Variation in tone is derived from circuits which mix the harmonics from the oscillators in the proper proportions to produce the desired organ-like tones. The output of the several mixers is combined, controlled by the expression pedal, amplified by power amplifiers, and fed to loudspeakers in tone cabinets. In larger installations, pedal tones are handled by tone cabinets separate from those handling manual tones, thus improving volume and distribution.

The Connsonata line starts with one-manual organs and includes a full two-manual and pedal instrument built to AGO specifications. The Connsonata was introduced to the market in 1947. The basic circuits of the Connsonata are not new. They are circuits which have been used in the electronic field for many years. The organ is an assembly of audio tone generators, filters, and amplifiers—combined in the form of a key-board instrument. Considerable research and development have produced tone generators of wide musical variety. Modifications have been made on a principle which is literally as old as radio and, therefore, fully proven.

Fig. 4-1. Model 1-A Console

B. Consoles

The *Model 1-A* Connsonette is of mahogany, weighs 310 pounds, including pedals and bench, and has one manual with 73 notes. This not only provides a wide range, but by being divided (electrically) also allows accompaniment stops to be registered for the left hand and solo stops for the right hand. This simulates a two-manual console. Tones are controlled by 35 small slider-type switches instead of the conventional tablets. The speaker is built into the console. Fig. 4-1 shows the complete instrument which measures 40 inches high, 48 inches wide and 26 inches deep (38 inches with pedals).

The pedal board is of 25 notes. With pedal board in playing position, the depth is 38 inches. There are two PM type loud-speakers in the console, one 15 inches and one

Fig. 4-2. Model 1-E Console

10 inches. Provision is made on the amplifier for an external tone cabinet.

The expression pedal on this organ covers the entire range of volume from full organ to zero, rather than simply down to approximately one-third volume as in other models.

The *Model 1-E* organ is shown in Fig. 4-2 and is 4 inches narrower than the 1-A. Basic differences include a shorter keyboard (61 note) and two couplers at the extreme left end and a shorter pedal clavier (18 note). One row of 16 slider-type control switches operate the stops. The woodwork is of mahogany. Two built-in loud-speakers are mounted behind a single grille. The total weight is 216 pounds.

The *2-A "Cloister" Model* is the largest of the organs, (Fig. 4-3) being designed for larger churches, chapels, and auditoriums. The console, pedal board and bench were designed according to AGO specifications, with dimension 56″ long, 31½″ deep, 46″ high. The floor space required, with pedal board and bench in playing position, is approximately 56″ by 48″. Most of the consoles were of oak, but the same design was also supplied in walnut.

This model is similar in operation and appearance to conventional pipe organ consoles. There are two ex-

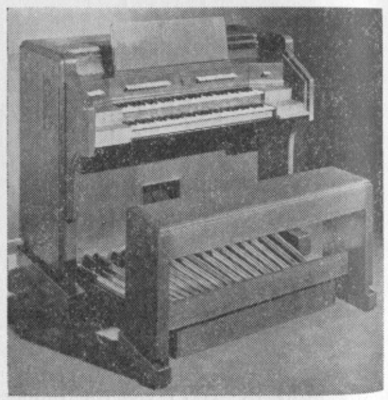


Fig. 4-3. Model 2-A Console

pression pedals: one to control the Great manual and the flute and reed voices of the Pedal, and one to control the Swell manual and the soft flute and string voices of the Pedal. This arrangement enables the player to contrast one manual

with another, to balance light registrations with heavy, to select registration for color only without regard for volume, to phrase and accent, and to give greater expression control in many other ways. No crescendo pedal is provided.

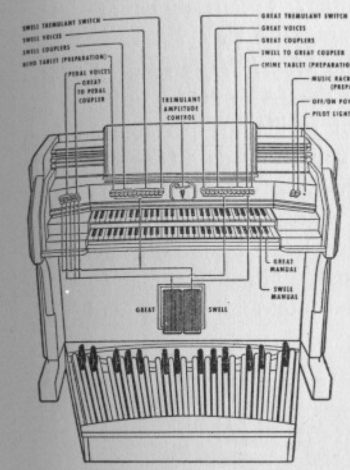


Fig. 4-4. Model 2-A Console (Diagram)

Since the potentiometer controlling the pedal voices has less range than that controlling the manual voices, it compensates for reduced sensitivity of the ear at low sound levels. This maintains a balance between voices in the pedal division and those in the manuals. (This feature is incorporated in all the organs).

The *Model 2-C* Connsonata (Fig. 4-5) was patterned after the 2A model insofar as tone generation and tone qualities are concerned. Certain design innovations were introduced together with simplifications in construction which reduced the cost. Only one expression pedal was provided. The number of stop tablets was reduced and all were mounted directly over the Swell manual.

Being comparatively light in weight and of reduced dimensions in comparison with the 2A console, the 2C organ represented a further step in compactness and portability. Appearance-wise the design of the 2C console was intentionally neutral in character, not only to blend into church architecture, but also to fit into the decorative scheme of homes and mortuaries.

The construction within the 2C console was simplified from that of the 2A. The unitized construction of the 2A, wherein four oscillator

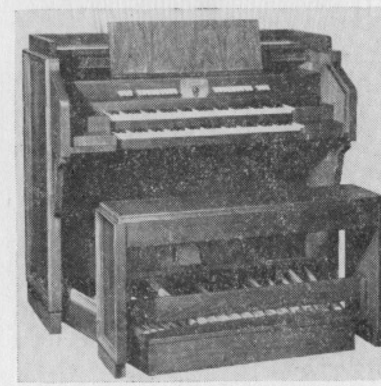


Fig. 4-5. Model 2-C Console

circuits or two mixer circuits were grouped together on a single chassis, was modified in the 2C, so all tone-generating and control components were grouped together on four main movable chassis within the console. One chassis contains all the Swell oscillator circuits, another contains the Great oscillators, and still another chassis has all the oscillators for the Pedal. The mixers are grouped together on the fourth chassis, located immediately behind the tablet control panel, thus giving closer linkage.

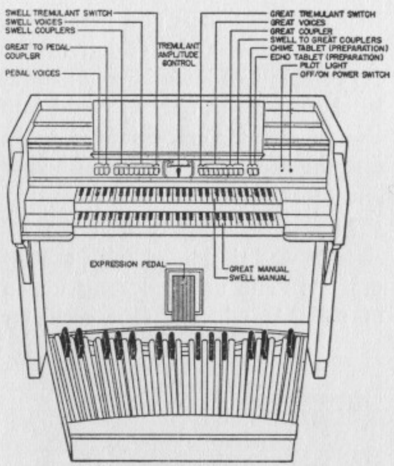


Fig. 4-6. Model 2-C Console (Diagram)

Since the 2C console itself contains no amplification for the speakers, all the necessary amplification for each unit is housed in the base of the speaker cabinet or near it. Basic AGO specifications are used throughout.

Standard pitch level for the manuals is 8-foot; for the pedals, 16-foot. Other pitch levels are made available through the use of couplers.

The 2C console dimensions are 54″ long, 28″ deep, 46″ high. Depth of console with pedal clavier in playing position is 45″. Weight of console is 364 pounds.

The *Model 2C2* organ is the largest of the current models (Fig. 4-7). It incorporates separate generators for the Swell, Great and Pedal sections. Incorporating the newest type tone generator chassis, it is a further step toward simplified construction as well as improved tone qualities. Specifications are given in paragraph C.

The *Model 2D* is reduced in size from the 2A or 2C by utilizing one set of oscillators, playable on both manuals and pedals. (See Fig. 4-8.)

The basic voices of the 2D model are controlled by 16 organ-type tablets, located centrally above top manual. Three volume *levels* of both Flute and String and three

Fig. 4-7. Model 2C2 Console

qualities of Reed are available. There are also tone controls to provide three degrees of treble brilliance and three degrees of bass depth. Finally there are three degrees of tremolo. The complete complement of 11 couplers is controlled by key-type

switches, located at the left end of respective manuals. This large number of couplers, added to the basic voices and other controls makes possible many special effects.

The pedal section consists of 25 notes sounding down to 16′ pitch.

Fig. 4-8. Model 2-D Console

It weighs 35 pounds, The bench weighs 20 pounds. Keyboard cover, lock, and finished back are standard equipment. Floor space required for console, bench, and pedal in playing position is 50″ wide, 42″ deep.

The 2D console, bench, and speaker units are of mahogany. Cabinet dimensions are as follows: height 44″, width 50″, depth 29″, depth with pedal board in playing position, 42″.

The console contains all the oscillators and other assemblies. Its weight is 335 pounds, including pedals and bench, and power consumption is 250 watts. Audio output of console amplifier is 15 watts.

A single cable connects the No. 7A speaker unit with the organ. This speaker unit, driven by the amplifier in the organ, generates volume sufficient to fill rooms of average size, churches, or chapels seating to 200 people. Where more sound is required, additional or larger units may be added. (See chart in Installation Section).

The *Model 2-E* and *2-D* incorporate an under-key coupler system unlike earlier models, which had the couplers located above the key mechanism.

The *Model 2-E* (Fig. 4-9) is slightly smaller than the 2D console. The 16′ octave of oscillators is elimi-

Fig. 4-9. Model 2-E Console

nated. The pedal clavier is reduced to 18 notes. The number of couplers is reduced to 9, still providing a wide variety of tones and pitches for a single generator instrument. The console contains two ten-inch PM speakers, so the organ is a relatively

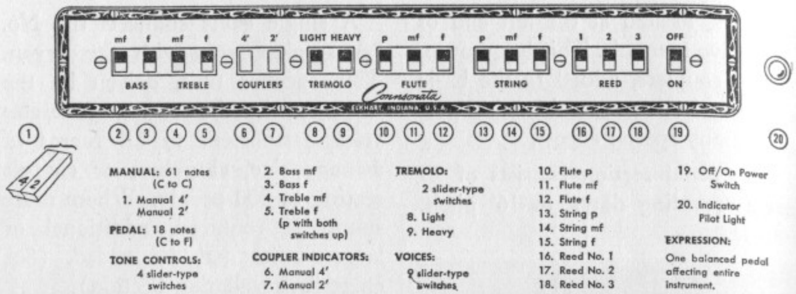


Fig. 4-10. Model 1-E Registration

light-weight, self-contained unit, adaptable to homes and smaller chapels.

The 2E console consumes 250 watts and has an audio output from its amplifier of 15 watts. The woodwork is of mahogany and includes a finished back. The dimensions are 43″ high, 50″ wide and 27″ deep. The console depth with pedals in playing position is 36″. The weight of the console is 248 lbs., and the pedals is 26 lbs.

C. Registration

Because the expression control of the Connsonata gives it a dynamic range several times broader than that of the conventional pipe organ, this instrument cannot be properly evaluated by consideration of its stop list alone. Like all electronic organs it should be heard under varying conditions to determine its possibilities.

In pipe organ terminology, the larger models are "straight" organs free from unification. Their voices may be combined many ways; each tablet when depressed brings a separate character of sound into the total ensemble. Although each division (Great, Swell, Pedal) has but one basic pitch level, other commonly used pitch levels (16, 4, and 2-foot) are obtained through the use of couplers. The instrument has been scaled with full consideration of such usage.

The smaller organs are of necessity unified and duplexed to provide the largest possible variety of pitches and tones from the number of oscillators available.

Model 1A Registration

Tone Color Controls:
- Flute for upper sec. of manual: 5 switches pp p mf f ff
- Flute for lower sec. of manual: 5 switches pp p mf f ff
- String for upper sec. of manual: 5 switches pp p mf f ff
- String for lower sec. of manual: 5 switches pp p mf f ff

Couplers—4 grouped as follows:
- Manual to pedal 16′ and 8′
- Manual 4′ and 2′

Tremolo Controls:
- Two speeds, three amplitudes, four switches

Tone Controls—6 grouped as follows:

- Treble: 3 switches mf—f—ff
- Bass: 3 switches mf—f—ff

Expression Pedal:
- One pedal controls volume of entire instrument

Model 1E Registration—See Figure 4-10.

Model 2A Registration

PEDAL	32 notes
Soft Flute	16′
Flute	16′
String	16′
Reed	16′
Great to Pedal Coupler	8′
SWELL	61 notes (with octave extension)
Echo	(preparation only)
Swell Coupler	16′
Swell Unison Off Coupler	8′
Swell Coupler	4′
Swell Coupler	2′
Diapason	8′
Melodia	8′
Flute	8′
Vox Humana	8′
Full String	8′
Light Reed	8′
Tremulant	
Tremulant amplitude control	
GREAT	61 notes
Tremulant	
Diapason	8′
Flute	8′
Chorale	8′
Soft String	8′
Full String	8′
Reed	8′
Great Coupler	16′
Great Unison Off Coupler	8′
Great Coupler	4′
Swell to Great Coupler	8′
Chimes	(preparation only)
Console Light	
Master Switch	

NOTE: Standard pitch level for manuals is 8′; for the pedals it is 16′.

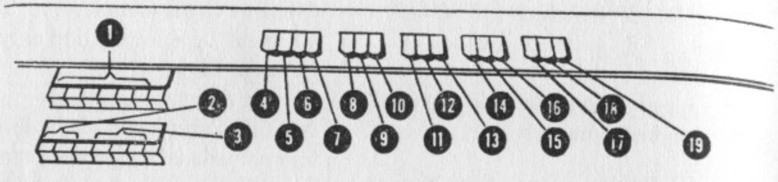
EXPRESSION:
Two balanced Pedals

Model 2C Registration

PEDAL	32 notes
Flute	16′
Soft Flute	16′
Great to Pedal Coupler	8′
SWELL	61 notes
String Diapason	8′
Flute	8′
Bright String	8′
Vox Humana	8′
Light Reed	8′
Tremolo	
Swell Coupler	16′
Swell Unison Off Coupler	8′
Swell Coupler	4′
GREAT	61 notes
Diapason	8′
Flute	8′
Soft String	8′
Full String	8′
Reed	8′
Tremolo	
Great Coupler	4′
Swell to Great Coupler	8′
Swell to Great Coupler	4′

OTHER CONTROLS:
- Echo ......(preparation only)
- Chimes ....(preparation only)
- Off/on power switch

EXPRESSION:
One balanced pedal, affecting entire instrument.



SWELL: 61 notes (C to C)
1. Swell 16′
 Swell Unison Off
 Swell 4′
 Swell 2⅔′
 Swell 2′
 Swell 1-3/5′

PEDAL: 25 notes (C to C)

2. Pedal 16′
 Pedal 8′

GREAT: 61 notes (C to C)

3. Great 16′
 Great Unison Off
 Great 4′

TONE CONTROLS: 4 tabs

4. Bass mf
5. Bass f (p with both tabs up)
6. Treble mf
7. Treble f (p with both tabs up)

TREMOLO: 3 tabs

8. Light
9. Medium
10. Heavy

VOICES: 9 tabs

11. Flute p
12. Flute mf
13. Flute f
14. String p
15. String mf
16. String f
17. Reed No. 1
18. Reed No. 2
19. Reed No. 3

EXPRESSION: One balanced pedal affecting entire instrument.
Off/on power switch with pilot light on right end of tab panel.

Fig. 4-11. Model 2-D Registration

PEDAL	32 notes
Major Bass	16′
Gedeckt	16′
Bourdon	16′
Dulciana	
Great to Pedal	8′
Swell to Pedal	4′

SWELL	61 notes
Geigen Diapason	8′
Harmonic Flute	8′
Gedeckt	8′
Echo Salicional	8′
Viola da Gamba	8′
Vox Humana	8′
Oboe	
Swell	16′
Swell Unison Off	8′
Swell	4′
Swell	2⅔′
Swell	2′
Swell	1⅗′
Swell Tremolo Off	

GREAT	61 notes
Open Diapason	8′
Melodia	8′
Gross Flute	8′
Dulciana	8′
Gamba	8′
Trumpet	8′
Great Unison Off	8′
Great	4′
Swell to Great	16′
Swell to Great	4′
Swell to Great	2⅔′
Swell to Great	2′

ECHO

ECHO AND MAIN

*TREMOLOS:
 Tremolo—Light
 Tremolo—Medium
 Tremolo—Heavy

Balanced expression pedal controlling over-all volume of entire instrument.

Model 2C2 Registration

Off/On power switch with pilot light.

*Tremolo is activated on entire organ by depressing any of the tremolo switches. Is cancelled on individual manuals by using Tremolo Off switches.

Model 2D Registration
See Figure 4-11.

Model 2E Registration
See Figure 4-12.

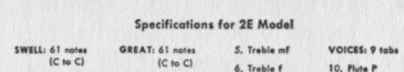
D. Tone Generators

Vacuum tube oscillator circuits are used throughout all the organs. On earlier models the oscillator tubes are biased to cut off and are controlled by removing this bias with the key switches. The tremulant effect is accomplished by grid-modulating the oscillators through the keying circuits, thus producing frequency and amplitude modulation. A low-frequency Hartley oscillator generates the tremolo (modulation) signal. The flute signal (sine wave) is collected by wiring the oscillator transformer secondaries in series, each of which has an individual level-setting potentiometer. The string (pulse) signal is collected by a common resistor feeding an impedance-matching transformer.

On a later model the oscillator is keyed by applying plate voltage to the plate of the tube. There is no voltage applied to the coil or other components of the generator (except for the heaters) until the key is depressed. The string (pulse) and flute signals from each generator are collected as in previous models through fixed resistors which control the desired volume of each note.

The iron core oscillator coil in the current models has only one winding with a center-tap whereas older models use a coil with two windings. A one-note organ schematic typical of all current models is shown in Fig. 4-19.

The use of many oscillators provides an independent source of pitch and tone for each note. Using iron coils makes the generators compact enough to be incorporated inside the console. Tuning is accomplished by varying the air gap of the iron cores. Fig. 4-16 shows a 2A oscillator circuit. Oscillator tubes are twin triods (except Model 1A), mounted two to a chassis on 2A models, 16 to a chassis on 1A models, all on 3 chassis on 2C, and 12 to a chassis on 2D. The tremolo is produced by a separate low-frequency oscillator feeding approximately 5 volts through adjustable controls.



Specifications for 2E Model

SWELL: 61 notes (C to C)
1. Swell 16′
 Swell Unison Off
 Swell 4′
 Swell 2⅔′
 Swell 2′
 Swell 1-3/5′

PEDAL: 18 notes (C to F)

GREAT: 61 notes (C to C)

2. Great 16′
 Great Unison Off
 Great 4′

TONE CONTROLS: 4 tabs

3. Bass mf
4. Bass f
5. Treble mf
6. Treble f (p with both tabs up)

TREMOLO: 3 tabs

7. Light
8. Medium
9. Heavy

VOICES: 9 tabs

10. Flute P
11. Flute mf
12. Flute f
13. String P
14. String mf
15. String f
16. Reed No. 1
17. Reed No. 2
18. Reed No. 3

EXPRESSION: One balanced pedal affecting entire instrument.
Off/on power switch with pilot light on right end of tab panel.

Fig. 4-12. Model 2-E Registration

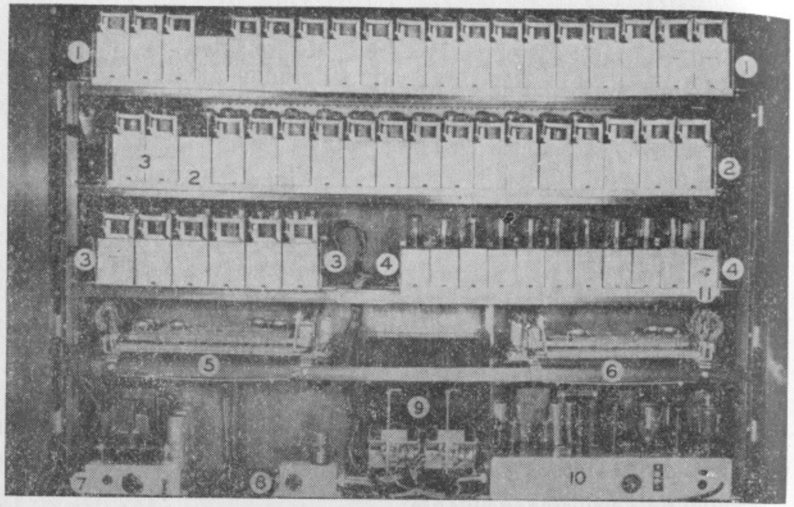


Fig. 4-13. Back View of 2-A Console

1. Swell oscillator rank
2. Great oscillator rank
3. Pedal oscillator #1-32
4. Mixer and booster amplifier rank
5. Swell coupler
6. Great Coupler
7. Coupler and filament supply
8. Isolation amplifier
9. Expression pedals
10. Main Amplifier
11. Tremolo Frequency Control

Fig. 4-17 shows a 2A tremolo circuit and Fig. 4-19 shows present type tremolo circuits.

In the later 2-manual models all tone-generating and control components have been grouped together on separate chassis. For example, the 2C has one for the Swell, another for the Pedals, and another for the Great. A fourth chassis holds the mixers located behind the stop tablets to provide close linkage and eliminate connecting plugs and sockets.

The tremulant frequency is adjustable in the model 2A by changing the potentiometer (Fig. 4-17). Its range is from 4 to 7 cycles, the normal being 6 cycles per second.

The tremulant amplitude is controlled on the 2A and 2C by the control knob on the stop cheek of the console and on later models by stop switches or stop tablets.

None of the note couples from the Great to the Pedal on the 2A and 2C have tremulant, even though the Great tremulant tab is in the down position.

The generator of the 2D, 2E and 1E model organs produces two basic musical tones, one of a pure nature (flute quality) and the other rich in overtones (string quality).

E. Mixers

The mixing of the various tones from the tone generator is accomplished by single-stage amplifiers. These mix the amount of fundamental and harmonics for the proper tonal result to produce a voice. Each voice is controlled by a stop tablet over the keys.

The output circuits of the mixers associated with a division of oscillators are paralleled. The circuit of a model 2A mixer is shown in Fig. 4-18. There are 8 separate mixer chassis providing 16 tone colors in the model 2A. The other models have a single mixer chassis. (Fig. 4-19 and Fig. 4-20.)

The oscillator signals are fed into a number of mixer units containing attenuation and/or frequency discriminatory and mixing circuits, an amplifier stage, and a mixing resistor. Each mixer has an external switch for cutting off the signal to the amplifier stage grid.

The mixer signals for each channel are collected and amplified by a single-stage booster amplifier which feeds the expression pedal control. Dual potentiometers are used on larger models for the expression pedals so that the levels of the pedal and manual signals are controlled independently yet simultaneously.

F. Couplers

The oscillators are keyed with conventional (pipe organ type) couplers. Any key is able to con-

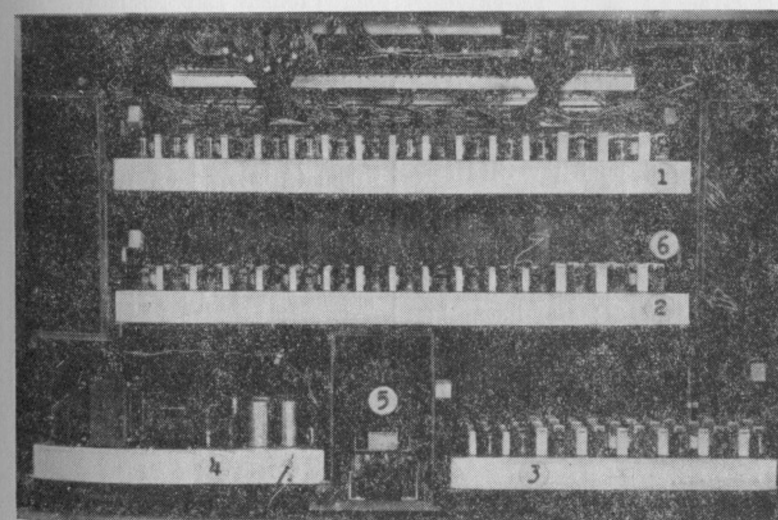


Fig. 4-14. Back View of 2-C Console

1. Swell oscillator rank
2. Great oscillator rank
3. Pedal oscillator rank
4. Power supply and isolation amplifier
5. Expression pedal
6. Oscillator note #13 (Great)

trol several oscillators through appropriate couplers.

When the Swell division oscillators are keyed from the Great manual they sound with the voices set up for the Swell manual, which may be quite different from those

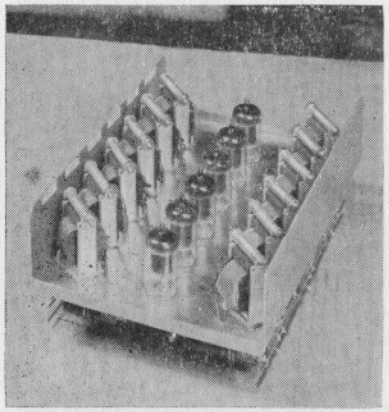


Fig. 4-15. One-Octave Tone Generator

selected for the Great manual. The same considerations apply when the Great oscillators are keyed from the Pedal clavier through the Great to Pedal coupler.

The coupler system of the 2A console is located in the back lower section shown in Fig. 4-13. The couplers of the 2C are shown in Fig. 4-21. The 2D and 2E couplers are below the keys, and the coupler controls are located to the left of the manual keys (see Fig. 4-11).

G. Amplifiers

Three basic amplifiers are used to handle all sizes of installations. Fig. 4-22 shows the 8-15 watt amplifier, which is actually two amplifiers on one chassis. The 8-watt section drives a single 12-inch manual speaker unit in the tone cabinet, and the 15-watt section drives a single 15-inch pedal speaker unit.

The 15- and 30-watt amplifiers are heavy in construction as can be seen from Figs. 4-23 and 4-24. These are usually mounted in the base of the tone cabinets when shipped but can be removed, to prevent vibration, when finally installed in organ chambers.

Conventional circuits with adequate feedback are used, providing wide-range, low-distortion amplification.

H. Loud-Speaker Systems

Various loud-speaker systems and tone cabinets are employed on

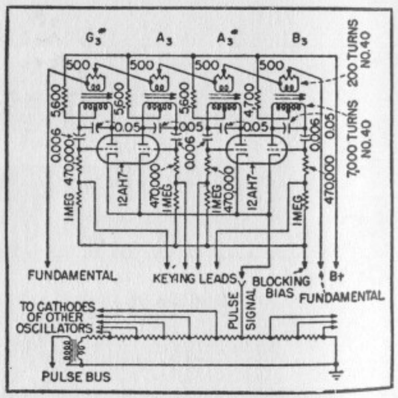


Fig. 4-16. Circuit of Four-Note Oscillator Chassis on 2-A Model

Connsonata organs depending on the power required or the type of console. The most used speaker units are described below:

No. 7A—Styled to match 1A, 2D, and 2E console, for medium-size installations; contains one 10-inch and one 15-inch speaker, facing upwards, mahogany finish.

No. 7—Similar to 7A but with 15-watt amplifier included, used when additional power is required.

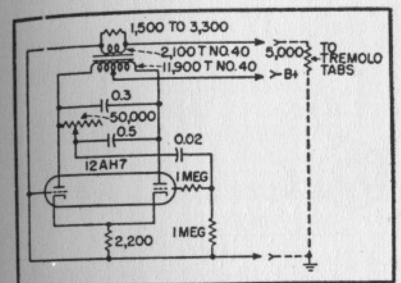


Fig. 4-17. Tremolo Oscillator Circuit on 2-A Model

No. 1—Similar to No. 2 but smaller (28″ x 19″ x 37″), oak or walnut finish. One 12-inch speaker and 15-watt amplifier.

No. 2—Oak or walnut, contains one 15-inch and one 12-inch speaker with 15-watt amplifier; size 38½″ wide, 20″ deep, 46″ high.

No. 20—Similar to No. 2 except utility finish.

No. 80—Speaker is a utility finish cabinet for concealed installations, containing two 10-inch and two 15-inch speakers with a 30-watt amplifier.

No. 8—Similar to No. 80 but finished in mahogany.

No. 30—Double cabinet 48″ wide, 24″ deep, 66″ high. Top chamber contains two 12-inch speakers for the manuals, bottom chamber contains two 15-inch speakers for the pedals. Amplifiers are included; utility finish.

Many larger installations are made without tone cabinets, using flat baffles instead. Where organ chambers are provided the baffle type installation is recommended. The natural reverberation of the chamber can thus be utilized and the acoustic efficiency of the system is usually increased.

I. Installation

The information which follows is primarily for the organ service engineer as he is the one normally called upon to handle such matters as installation, assembly, tuning and leveling. However, this information is included here as a guide to the buyer or the organist.

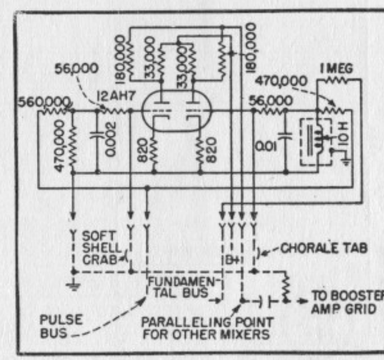


Fig. 4-18. Mixer Circuit on 2-A Model

The organ consoles are shipped complete, and no assembly is necessary upon installing. Slide pedal board assembly in place, making sure it hooks on the supports mounted on the console. Remove back panel of the console by first

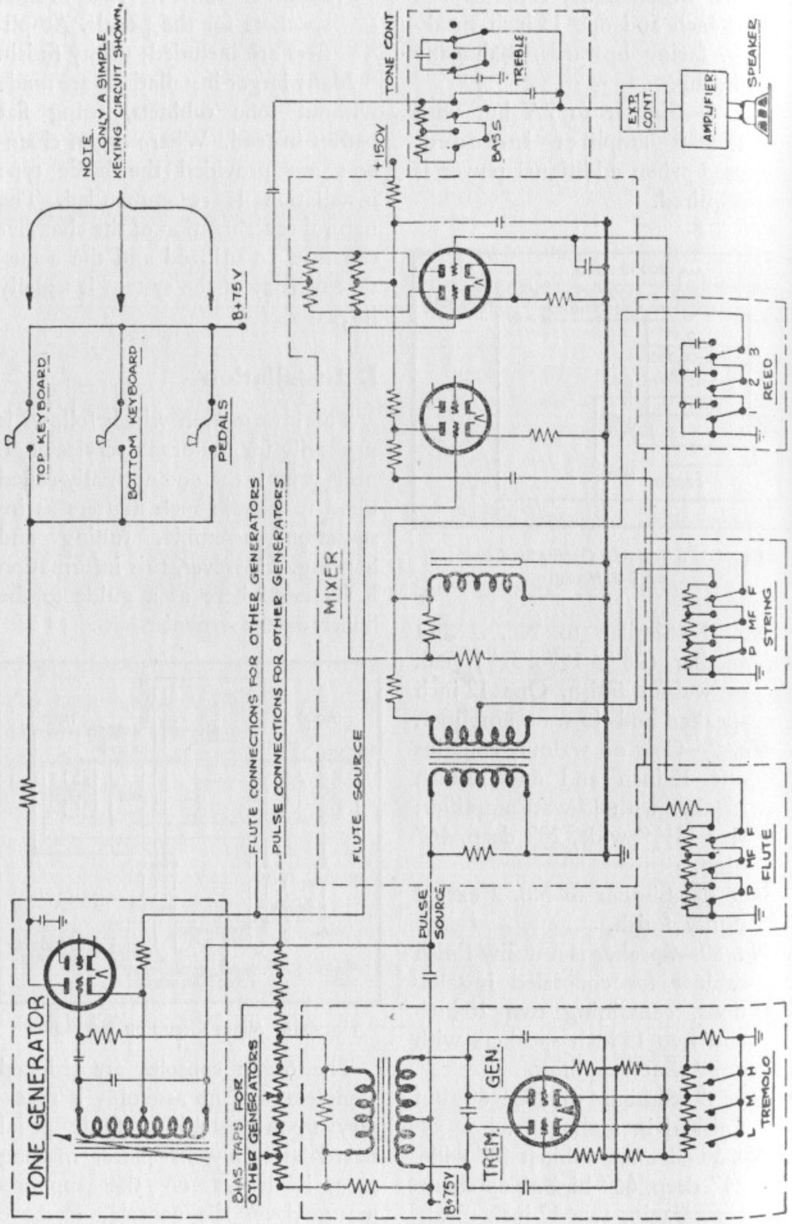


Fig. 4-19. One-Note Organ Schematic

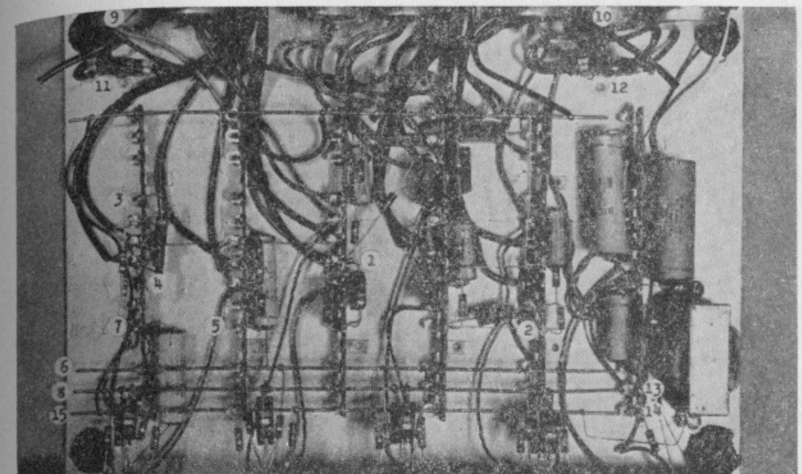


Fig. 4-20. Mixer and Tremolo Generator Chassis on 2-C Model

1. String input terminal—Swell
2. String input terminal—Great
3. Flute input terminal—Swell
4. Flute input terminal—Great
6. Flute input terminal—Pedal
6. Swell and Great output terminal
7. Pedal output terminal
8. D.C. supply bus (250 V)
9. String transformer—Swell
10. String transformer—Great
11. String leveling resistor—Swell
12. String leveling resistor—Great
13. D.C. Supply terminal 105 V (tremolo)
14. Tremolo ground
15. Mixer ground

removing the screws around the outside of the panel. Visually inspect the assemblies for any damage that might have come about in shipping. Inspect all of the assemblies to see that each tube is down firmly in its socket. Connect the organ to its speaker equipment, referring to the diagrams on back of speaker cabinets. Check power circuit, making sure the frequency and voltage are correct (50-60 cycle, 105-125 volts), and adjust tap switch on the console to the *up* position. Connect power cord to the power outlet and turn on the master switch. Recheck the line voltage. If the voltage has lowered more than 3 volts, it is recommended that the power outlet circuit be investigated.

The main organ fuse, switch, and wiring are capable of handling the console and an external load of 450 watts. External loads of more than 450 watts should be controlled by a magnetic contractor, excited by the console master switch.

Because of the varying acoustical conditions of churches, chapels, public auditoriums, and so forth, it is difficult to determine the proper requirements. A practical and reasonable approach can be made by using the seating capacity as a guide. Sound is absorbed by carpets, drapes, acoustically treated walls (sound absorbing), and by the clothing of the people present. Clothing, in most cases, is more sound-absorbent than drapery material.

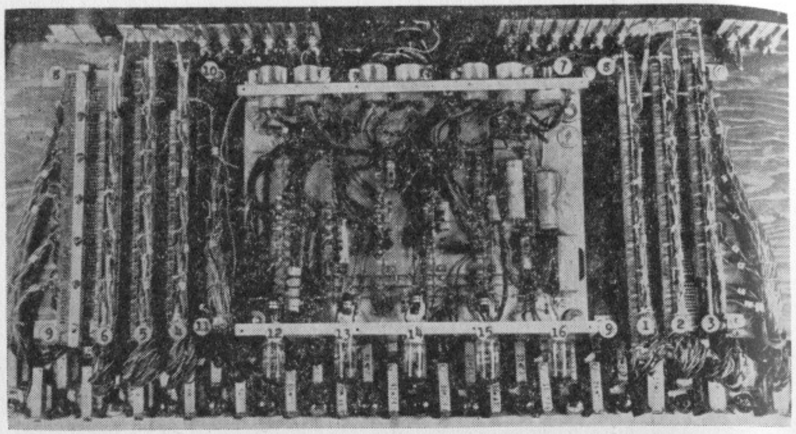


Fig. 4-21. Top View of 2-C Console with Fall Board Removed

1. 4′ coupler Swell
2. Unison coupler Swell
3. 16′ coupler Swell
4. 4′ coupler Great
5. 8′ Swell to Great coupler
6. 4′ Swell to Great coupler
7. Tremulant frequency control
8. Busbar note #13—Swell
9. Busbar note #73—Swell
10. Busbar note #13—Great
11. Busbar note #73—Great
12. Mixer tube (manual and Pedal flute)
13. Mixer tube (Swell string diapason and bright string)
14. Mixer tube (Swell light reed and vox, Great soft string and diapason)
15. Mixer tube (Great full string and reed)
16. Tremolos generator tube

Experience indicates that with average empty auditorium acoustical conditions (technically speaking, an auditorium has "average empty auditorium acoustical conditions" if the reverberation time of the space is close to one second when a note of approximately 500 cycles is sounded) we can use the following table to determine the number of speaker units for proper organ volume when the auditorium is fully occupied.

Seating Capacity	Speaker Cabinets
250- 300	1—#7A
300- 500	1—#7A and 1—#7
500-1000	1—#7A and 2—#7
500-1000	1—#7A and 1—#80
1000-2000	1—#7A and 4—#7
1000-2000	1—#7A and 2—#80

When reverberation time is less than 1 second, and approaches 0.5 second, the above recommendations may fall short of sufficient power. Additional speaker power is then required—possibly up to twice the normal amount.

When the reverbation time runs longer than 1 second or approximately 1½ to 2 seconds, more than enough power has been recommended. Fewer speakers could then be used—possibly one-half of the normal amount.

Leveling the Manual Notes (1A, 2A and 2C Organs)

Since each oscillator in these models has its own individual volume control it is possible to "level" the notes to the same volume. This

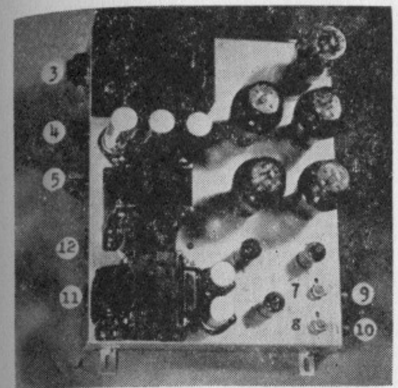


Fig. 4-22. 8-15 Watt Amplifier

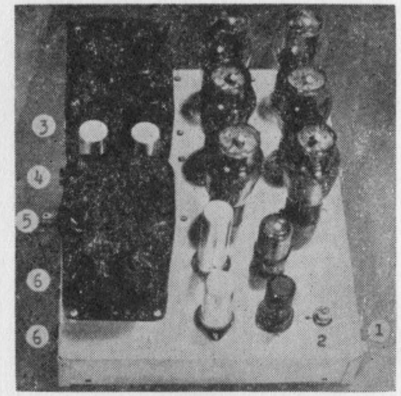


Fig. 4-24. 30 Watt Amplifier

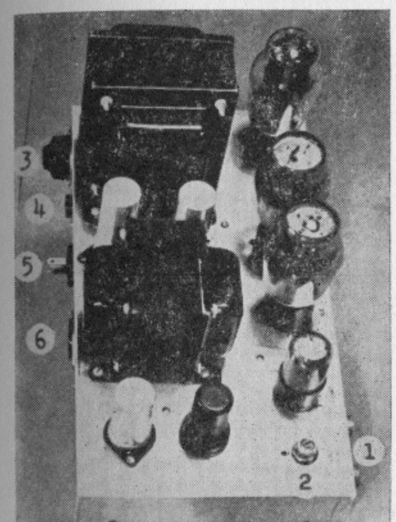


Fig. 4-23. 15 Watt Amplifier

1. Input connections
2. Gain control
3. Tap switch for adjusting to voltage
4. Amplifier fuse
5. Power receptacle (105-125 V AC)
6. Receptacle for speaker plug
7. Gain control-manuals
8. Gain control-pedals
9. Input connection-manuals
10. Input connection-pedals
11. Receptacle for speaker plug-manuals
12. Receptacle for speaker plug-pedals

may be necessary because of room acoustics, speaker resonance, or variations in tubes.

Before making any adjustment to individual notes it is important to have the manuals and pedals balanced. The amplifier gain controls should be set so that there is no distortion even when the organ is played in full chords with all stops and couplers down, and the Swell pedal(s) wide open. Should the manual(s) seem to drown out the pedals, reduce the manual amplifier gain to the desired balance.

Leveling of Individual Pedal Notes (1A, 2A and 2C Organs)

In some installations the location of the speakers and the acoustics of the room or auditorium may affect the volume of individual pedal notes, making some sound louder than others.

It is possible to adjust these notes so that all sound at uniform levels. This is done by adjusting the variable resistor on each oscillator. It is recommended, however, that when such leveling is done, the loud notes be reduced to the level of the soft ones. The observer should stand at several points in the room to get an average indication of volume; otherwise, standing waves at these low frequencies can be very deceiving.

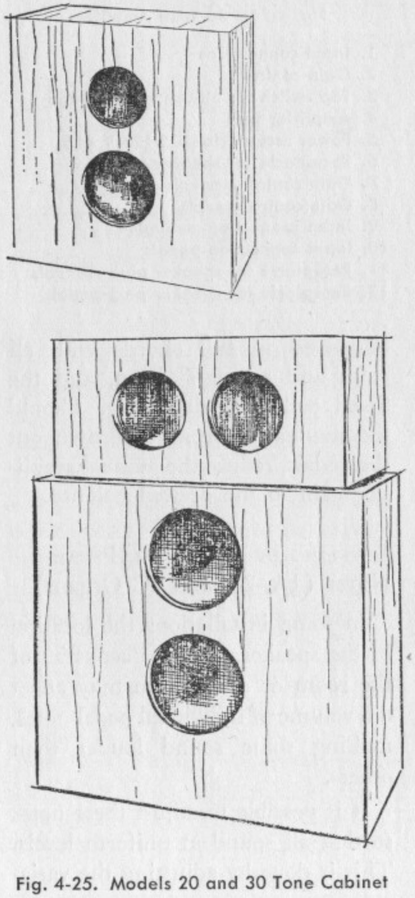


Fig. 4-25. Models 20 and 30 Tone Cabinet

J. Care and Maintenance

Tuning

The Connsonata organs are tunable by adjusting the air gap of the oscillator transformers. Each note has its own transformer with an adjusting screw. As with pipe organs and pianos the temperament should be laid in the middle octave (Swell manual) and all other notes tuned to this octave.

When tuning the earlier models of the Connsonata care should be exercised in setting the adjustment screws. Manufacturing and inspection procedures at the factory have proved highly effective in eliminating any electric causes for instability. When tuning the instrument, the manner in which each oscillator tuning screw is "set" will determine how well the instrument stays in tune, and how frequently it has to be retuned.

Regardless of whether a note to be tuned is sharp or flat, a procedure should be followed so that the final adjustment of the tuning screw will be a clockwise turn. It is important to set up a condition of absolute equilibrium between the screw, the spring, and the movable top of the transformer. Specifically, when a note is sharp, the screw should be tightened (moved clockwise) so that the note is definitely flattened. Then turn the screw in the opposite direction until the note is again sharp. Finally, turn the screw clockwise until the proper frequency is attained. When a note to be tuned is flat, begin by turning the screw

in a counter-clockwise direction so that the note will be made sharp. Then as the final adjustment, turn the screw clockwise until the proper frequency is attained.

The organs should have a slight warm-up period before tuning, depending on room temperature. (For best results tune the Connsonata at the approximate room temperature in which it will be used. Under such a condition a 15-minute period is sufficient).

The Connsonata is designed to give easy access to all parts for rapid servicing. Electrical components, standard with the electronic industry, are readily available. In sections where a regular organ technician is not available a sound engineer or radio service man can usually take care of minor repairs.

The simplest failure would be a dead note and is easily remedied by locating the defective tube and replacing it with a new one. Or in an

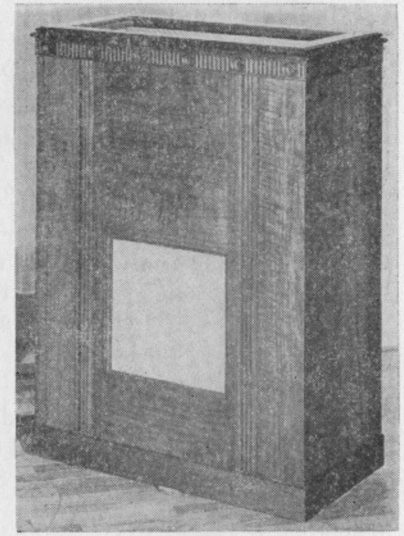


Fig. 4-26. Furniture Model Tone Cabinet

emergency a tube can be borrowed from a seldom used high note.

Amplifier and power supply tubes should be checked annually and replaced regularly so that the organ is kept at top performance.

K. Models Summary Chart

MODELS	DESCRIPTIONS
Model 1A	Single manual, 73 notes, split registration, built-in speakers, 25-note flat pedals. Total number oscillators 73, (Type 6BJ6). Total watts 200. Introduced in 1949.
Model 1E	Single manual, 61 notes, built-in speaker, 18-note flat pedals. Total number oscillator tubes 31, (Type 12AU7). Couplers on side of manual. Two 10-inch speakers. Introduced in 1951.
Model 22A	2-manual, 25-note pedals. First of the Connsonata organs, introduced in limited quantity in 1947. Later redesigned to Model 2A.
Model 2A	2-manual, 32-note concave radiating pedals, two expression pedals. Oak or walnut case. External tone cabinets. Many individual chassis in console. Total number oscillator tubes 84, (Type 12AH7).
Model 2C	2-manual, 32 notes, AGO pedals, one expression pedal. Of lighter weight than the 2A. Four main chassis in console. Total number of oscillator tubes 77, (Type 12AU7). Introduced in 1948.
Model 2D	2-manual, 25-note flat pedals. One 85-note generator playable on both manuals at several pitches, couplers on side of manuals, external speaker, total number of oscillator tubes 43, (Type 12AU7). Introduced in 1951.
Model 2E	2-manual, 18-note flat pedals, one 73-note generator playable on both manuals at several pitches, built-in speaker, one expression pedal. Total number of oscillator tubes 37, (Type 12AU7). Couplers on side of manuals. Introduced in 1951.
Model 2C2	2-manual, 32-note concave radiating pedals, one expression pedal. Tremolo controlled by 3 tablets instead of dial (as on 2C). Introduced in 1952.

Hammond Organs

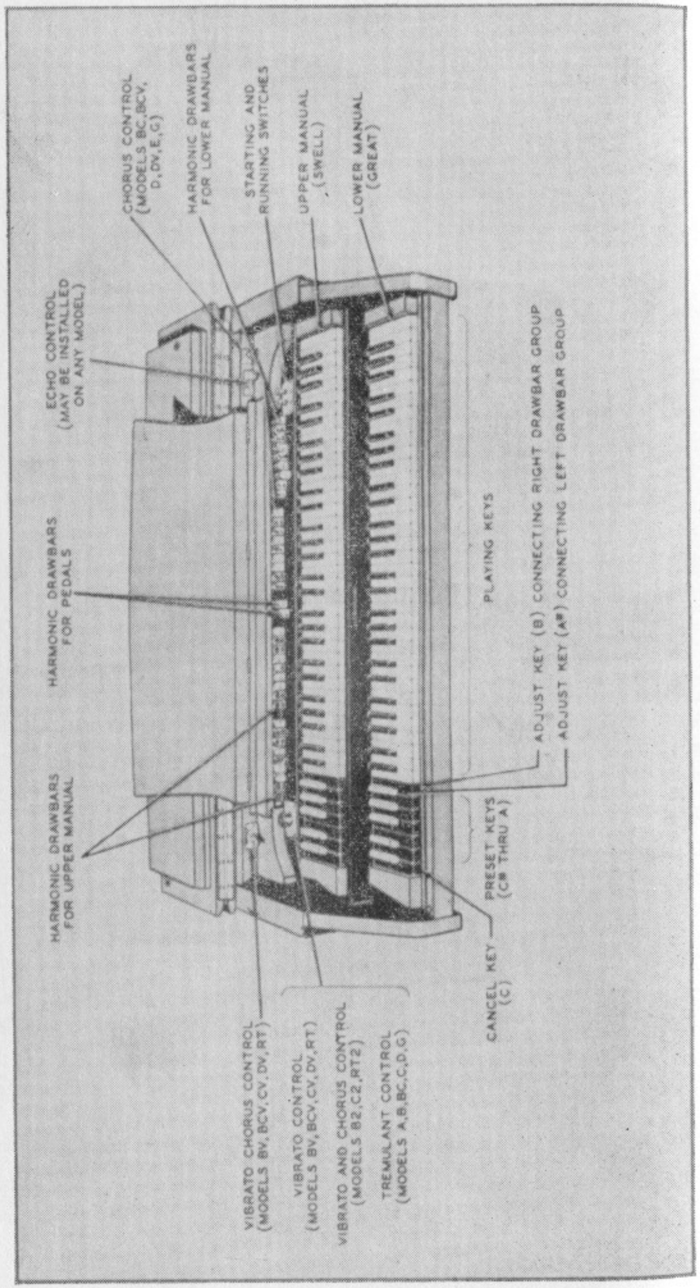


Fig. 5-1. Typical Arrangement of Manuals

CHAPTER V

Hammond Organs

NOTE: The term "electronic" organ is ordinarily defined as an instrument which generates its tones by utilizing oscillating vacuum tubes. Although the Hammond Instrument Company does not consider their larger instruments as "electronic" organs, common application of this term to all non-pipe or non-reed organs has led the public to include the Hammond in this category. Then too, some of Hammond's instruments (Novachord, Solovox, Chord organ, and Pedal of Concert organ) do utilize tubes in their tone-producing portions. For the sake of simplicity this book will refer to all the Hammond instruments as electronic.

A. General Description

The Hammond organ creates its tones through the use of an induction generator, and uses tubes only for amplification or special effects. In the Hammond organ, the tones are first generated as electric waves, then translated into sound waves. Visualize a small disc the size of a silver dollar, with teeth somewhat like those of a gear (see Fig. 5-18). The disc revolves at a constant speed so that the teeth or high spots pass a coil-wound permanent magnet, inducing a tiny electric current in the coil. If, for example, the high spots pass the magnet at the rate of 440 per second, and this current is amplified into sound, it is a tone with a frequency of 440 vibrations per second. This is the fundamental of the note "middle A" on the international scale. There is a separate disc or "tone wheel" for each musical frequency in the full range from the lowest to the highest note on the Hammond organ. Because these tone wheels are all driven at a constant speed by a synchronous motor, the organ is always in tune.

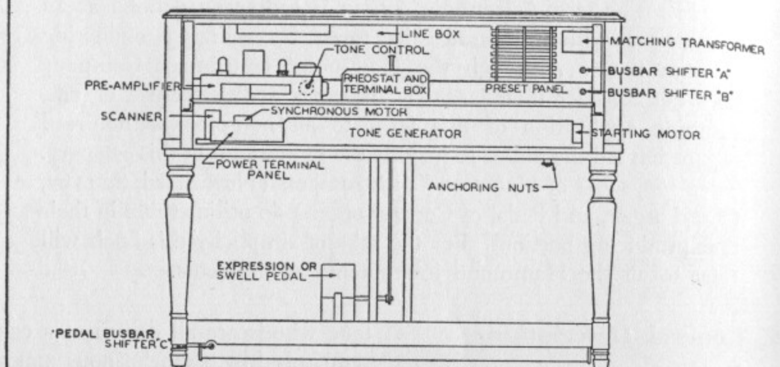
The console contains the entire tone-generating mechanism of the organ. The electrical waves are made audible by amplification and loud speakers, usually housed in tone cabinets.

A note of the organ, played on either manual or pedal keyboard, generally consists of a fundamental pitch and a number of harmonics. The fundamental and up to eight harmonics are individually controllable by either drawbars or set up in combinations by the preset keys. By adjustment of these drawbars or preset keys, the player can vary the tone color at will.

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

When a preset key is depressed it locks down and is released only

NOTE: The Spinet model and the Chord organ are covered at the end of this chapter in Sections K and L. The main portion of this chapter is devoted to the "home" and "church" models.



MODELS A,B,&BC ARE SIMILAR TO MODEL BV BUT HAVE DIFFERENT PREAMPLIFIER AND HAVE NO VIBRATO EQUIPMENT.
MODEL BCV IS SIMILAR TO MODEL BV BUT HAS CHORUS GENERATOR.
MODELS C,CV, D,AND DV ARE SIMILAR TO MODELS B, BV, BC,AND BCV BUT HAVE DIFFERENT WOODWORK.
MODEL G IS SIMILAR TO MODEL D.
MODELS B-2 & C-2 ARE SIMILAR TO MODELS BV AND CV BUT HAVE PREAMPLIFIER, PRESET PANEL, AND MATCHING TRANSFORMER LIKE MODEL RT-2.

FIG. 5-2 REAR VIEW OF CONSOLE (MODEL BV)

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

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

When either adjust key is depressed, the organ speaks with whatever tone color is set up on the harmonic drawbars associated with that key.

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

Two expression pedals are provided for the Model E Console. Adjustable pedal indicators are located at the extreme right side of this console above the Swell manual.

B. Consoles

Several styles of consoles have been manufactured since the Hammond Organ was introduced in 1935. These are illustrated on the following pages along with their specifications.

The model G consoles (not illustrated) were built for the Government, and now will be found in use throughout the United States and foreign countries in Government chapels, or may have been purchased by tax-supported institutions from the Government agencies. The console is identical to the Model D except for the absence of decorative woodwork and provision for detachable handles.

C. Tone Cabinets

On the following pages are illustrated most of the tone cabinets which have been built for the Hammond organs. Technical details on the components used in their construction can be found in section H and J.

Some of the tone cabinets radiate sound upwards, making it possible to place them in a home or small church where the sound reflects from the ceiling to all parts of the room. Other cabinets have the loudspeaker units facing out one side. These are usually placed high in an auditorium, on a shelf or in a chamber, to avoid direct sound radiation from reaching the audience.

All types of tone cabinets can be used singly or in groups to provide the necessary volume of sound. An additional cabinet can be used as an "echo organ" by connecting it through an "echo" switch which can be added on the console.

There are many rooms which are acoustically deadened to a point that the organ requires some artificial

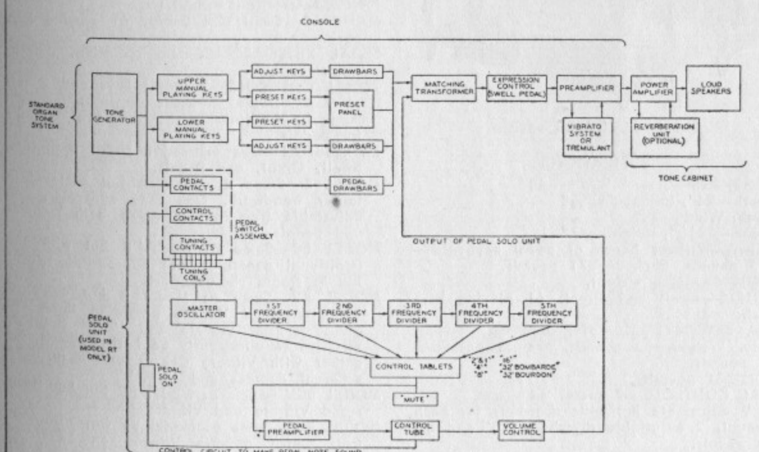


FIG 5-3 BLOCK DIAGRAM OF HAMMOND ORGAN
MODEL A, B, BC, BCV, BV, C, CV, D, DV, G, RT

reverberation. The Hammond Reverberation Control imparts the necessary "live" quality so important to organ music. The device is normally housed within the tone cabinet and can be added to any installation not so equipped. A tone cabinet having this unit must be handled in accordance with directions on the instruction card to avoid damaging the unit or spilling the oil. (See Section H for details of construction).

Tone cabinets having the letter "X" within their model designation contain a motor-driven drum mounted above the speakers. This produces a tremolo effect in all tones of the organ and is used independent of the tremolo and vibrato controls which may be in the console. (See Fig. 5-13).

D. Tone Generators (Main and Chorus)

Each Hammond organ console

Fig. 5-4. Model A Console

SPECIFICATIONS

DIMENSIONS—Closed: Width—48" Depth—24", Height—$37\frac{1}{2}$" Open: Width—48" Depth—$38\frac{1}{2}$", Height—47"
WEIGHT—Without bench or pedal keyboard—275 pounds. Packed—371 pounds.
FINISH—American walnut.
MANUALS—Swell and Great, 61 playing keys each.
PEDAL KEYBOARD—25-note, radiating, detachable. Weight—53 pounds. Weight packed—98 pounds.
BENCH—31 pounds.
ONTAL CONTROLS—9 preset keys and 2 sets of 9 adjustable harmonic drawbars for each manual; 2 adjustable drawbars (16' and 8') for pedals.
EXPRESSION—One expression pedal controlling Swell, Great, and Pedals.
MODEL A—One tone generator. One adjustable tremulant affecting both manuals and pedals.

Fig. 5-5. Model B Console

SPECIFICATIONS

DIMENSIONS—Closed, without pedal keyboard $48\frac{3}{8}$" wide, $28\frac{3}{4}$" deep, $38\frac{3}{8}$" high. Open, and with pedal keyboard on bench $48\frac{3}{8}$" wide, $49\frac{1}{2}$" deep, 46" high.
FINISH—American walnut.
MANUALS—Swell and Great, 61 playing keys each.
PEDAL KEYBOARD—25-note radiating, detachable.
TONAL CONTROLS—9 preset keys and 2 sets of 9 adjustable harmonic drawbars for each manual. 2 adjustable drawbars (16' and 8') for pedals.
EXPRESSION—One expression pedal controlling Swell, Great, and Pedals.
MODEL B—Same as Model A but enclosed in larger woodwork. One tone generator, one adjustable tremulant affecting both manuals and pedals equally.
MODEL BC—Same as Model B but with one additional generator and appropriate switching to create chorus effect.
MODEL BV—Same as Model B but equipped with Hammond Vibrato providing three degrees of true Vibrato and "off" position, effective simultaneously on both manuals, together with Vibrato Chorus usable in three different degrees and "off."
MODEL BCV—Same as Model BC but has Hammond Vibrato and Vibrato Chorus.
MODEL B-2—Same as Model BV but with controls which provide Vibrato on either or both manuals. Also additional control for "normal" or "soft" overall volume.
AC INPUT—Approximately 30 watts.
WEIGHT—As illustrated, approximately 425 lbs.

has a main generator within it, and in some cases, depending on the model, a chorus generator.

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

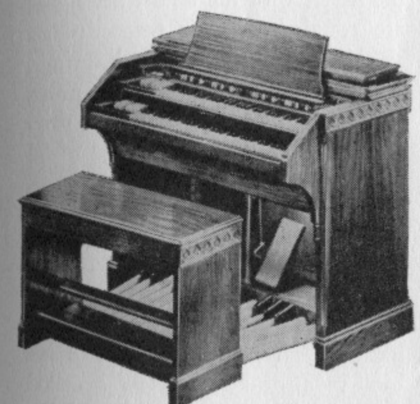


Fig. 5-6. Models C & D Console

SPECIFICATIONS

DIMENSIONS—Closed, without pedal keyboard $48\frac{3}{4}$" wide, 29" deep, $38\frac{3}{4}$" high. Open, and with pedal keyboard and bench $48\frac{3}{4}$" wide, 47" deep, 46" high.
FINISH—American walnut.
MANUALS—Swell and Great, 61 playing keys each.
PEDAL KEYBOARD—25-note, radiating, detachable.
TONAL CONTROLS—9 preset keys and 2 sets of 9 adjustable harmonic drawbars for each manual; 2 adjustable drawbars (16' and 8') for pedals.
EXPRESSION—One expression pedal controlling Swell, Great and Pedals.
MODEL C—Same as Model B but with different style woodwork. One tone generator, one adjustable tremulant affecting both manuals and pedals equally.
MODEL CV—Same as Model C but equipped with Hammond Vibrato, including Vibrato Chorus.
MODEL C-2—Same as Model CV but with controls which provide Vibrato on either or both manuals. Also additional control for "normal" or "soft" overall volume.
MODEL D—Same as Model C but with one additional tone generator and appropriate switching to create chorus effect. Similar to Model BC.
MODEL DV—Same as Model D but with Hammond Vibrato, including Vibrato Chorus. Similar to Model BCV.
AC INPUT—Approximately 40 watts.
WEIGHT—As illustrated, approximately 450 lbs.

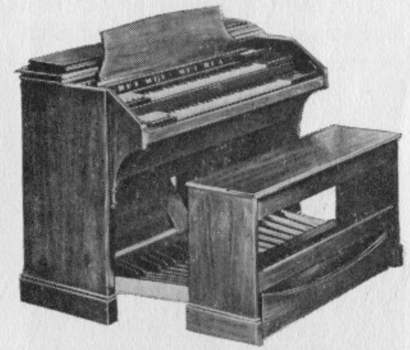


Fig. 5-7. Model RT Console

SPECIFICATIONS

DIMENSIONS—Closed, without pedal keyboard—57" wide, 40" high, 29" deep. Open, and with pedal keyboard—57" wide, $46\frac{7}{8}$" high, $47\frac{5}{8}$" deep.
FINISH—American walnut.
MANUALS—Swell and Great, 61 playing keys each.
PEDAL KEYBOARD—32-note, concave, radiating, detachable, built to AGO specifications.
PEDAL SOLO SYSTEM—Has pedal solo system with separate volume control, providing following solo effects: 32-foot Bourdon, 32-foot Bombarde, 16-foot Solo, 8-foot Solo, 4-foot Solo, 2 and 1-foot Solo. Also tablets for Mute Control, Pedal Solo On.
TONAL CONTROLS—9 preset keys and 2 sets of 9 adjustable harmonic drawbars for each manual; for pedals, two adjustable drawbars (16' and 8').
EXPRESSION—One expression pedal, controlling Swell, Great, and Pedals.
CONCERT MODEL RT—Equipped with Hammond Vibrato providing three degrees of true Vibrato and an "off" position, effective simultaneously on both manuals, together with Vibrato Chorus usable in three different degrees and "off."
CONCERT MODEL RT-2—Same as Model RT but with controls which provide Vibrato on either or both manuals, also additional control for "normal" or "soft" overall volume.
AC INPUT—Approximately 110 watts.
WEIGHT—As illustrated, approximately 525 lbs.

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

The main generator proper is a long structure in which are mounted 48 rotating assemblies, each consisting of a shaft and two discs known as tone or phonic wheels. These assemblies are coupled resiliently to the drive shaft. Each of the brass drive gears engages two bakelite gears associated with opposite rotating assemblies. (See Fig. 5-17). These bakelite gears rotate freely on the shafts with the tone wheels, and are coupled to their respective assemblies by a pair of coil springs. There are 12 sizes of bakelite gears, corresponding to the 12 sizes of driving gears. Thus 4 of the tone wheel assemblies, each with 2 tone wheels, run at each of 12 speeds.

Each tone wheel is a steel disc about 2 inches in diameter, accurately machined with a definite number of high and low points on its edge. (See Fig. 5-18). Each high point on a tone wheel is called a tooth. The number of teeth on each of these tone or phonic wheels,

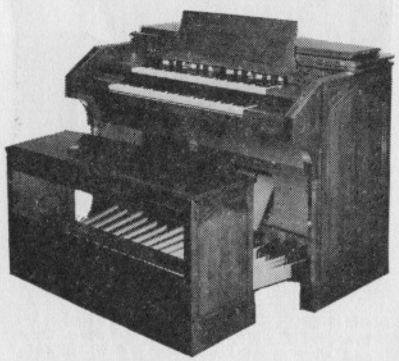


Fig. 5-8. Model E Console

SPECIFICATIONS

DIMENSIONS—Closed: without pedal keyboard 57" wide, 40" high, 29" deep. Open: and with pedal keyboard 57" wide, 46⅞" high, 47⅝" deep.
WEIGHT—Without bench or pedal keyboard—441 pounds. Packed—504 pounds.
FINISH—American walnut.
MANUALS—Swell and Great, 61 playing keys each.
PEDAL KEYBOARD—32-note, concave, radiating, detachable, built to AGO specifications. Weight—91 pounds. Weight packed—150 pounds.
BENCH—47 pounds.
TONAL CONTROLS—9 preset buttons and 2 sets of 9 adjustable harmonic drawbars for each manual; for pedals 4 numbered and labeled toe pistons, 2 adjustable drawbars (16' and 8') and Great to Pedal 8' Coupler.
EXPRESSION—2 expression pedals, one for Swell and one for Great and Pedals. Visual position indicators of sliding rod type.
MODEL E—Separate adjustable tremulants for Swell and Great Manuals. Standard Main and Chorus generator units; on and off switch for Chorus.

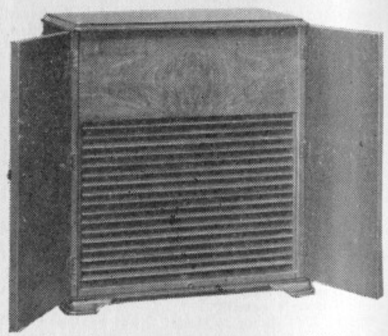


Fig. 5-9. Tone Cabinet (Model A-20)

SPECIFICATIONS

DIMENSIONS—Width 27", Depth 15", Height 30".
FINISH—American walnut.
WEIGHT—113 pounds.
OUTPUT—20 watts—1 amplifier, 2 speakers.
This small, decorative power cabinet employs one power amplifier and a pair of 12" dynamic speakers. It is used for homes, mortuaries, and small churches, seating not over 100 persons, where a limited amount of power is required.

in conjunction with the speed at which the tone wheel is revolving, determines the frequency of the tone generated.

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

All four tone wheels in any one compartment run at the same speed. The individual tone wheel shafts are mounted in bearings made of a special porous bronze, and each of these bearings is connected to the oiling system by a cotton thread from the oil trough. Thus, oil from the trough is carried by capillary action to all bearings, penetrating them and lubricating the actual bearing surface. The drive shaft and both motors are lubricated in a similar manner.

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

Associated with each tone wheel is a magnetized rod about ¼ of an inch in diameter and 4 inches in length, with a coil of wire wound

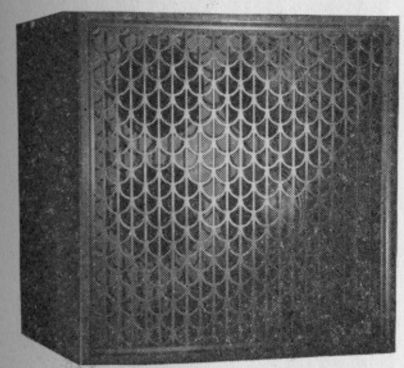


Fig. 5-10. Tone Cabinet (Model B-40)

Fig. 5-10
MODEL A-40 TONE CABINET
SPECIFICATIONS

DIMENSIONS—Width 26½"—Depth 19"—Height 28"
FINISH—Black lacquer.
WEIGHT—155 pounds.
OUTPUT—40 watts—2 amplifiers, 4 speakers.
A non-decorative, double-strength cabinet, designed for use in banks of four or more, in large installations where the cabinets are concealed. Two power amplifiers and four 12" speakers are used.

FIG. 5-10
MODEL B-40 TONE CABINET
SPECIFICATIONS

DIMENSIONS—Width 36" Depth 28½"—Height 36"
FINISH—Walnut stain.
WEIGHT—225 pounds.
Weight packed 285 pounds.
OUTPUT—40 watts—2 amplifiers, 4 speakers.
A semi-decorative, double-strength cabinet designed for use individually or in groups. The B-40 is found desirable for many churches and for large installations, for it may be used appropriately in almost any setting. Two power amplifiers and four 12" speakers are used.

FIG. 5-10
MODEL F-40 and FR-40 TONE CABINET
SPECIFICATIONS

DIMENSIONS—Width 32-15/16—Depth 28⅜—Height—39-3/16.
FINISH—Walnut stain.
WEIGHT—F40 208 lbs.—Packed 240 lbs.
WEIGHT—FR40 228 lbs.—Packed 260 lbs.
Output—F40 40 Watts 2 Amplifiers 4 Speakers
Output—FR40 40 Watts 2 Amplifiers 4 Speakers
The F-40 replaces the B-40 tone cabinet. Dimensions of the woodwork have been altered so that a reverberation unit may be accommodated. With the addition of the reverberation unit it is designated as FR-40.

near one end. The tip of the magnet at the coil end is ground to a sharp edge and mounted near the edge of the tone wheel. Each time a tooth passes this rod it causes a change in the magnetic field which induces a small voltage in the coil, the frequency being determined by the number of teeth and the wheel speed.

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

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

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

Fig. 5-11. Tone Cabinet (Model C-20)

SPECIFICATIONS

DIMENSIONS—Width 29"—Depth 18¼"—Height 53"
FINISH—Matched American butt walnut and antique brass hardware.
WEIGHT—153 pounds.
OUTPUT—20 watts—1 amplifier, 2 speakers.
Designed for vertical tone projection so as to obtain proper tone diffusion. One amplifier and two 12" speakers are used.

to emphasize the fundamental and suppress harmonics.

The purpose of the chorus generator is to add a series of sharply and slightly flat tones to the true tones produced by the main generator. The resulting electrical wave contains a complex series of undulations which enhance many tone qualities, notably string and full organ combinations.

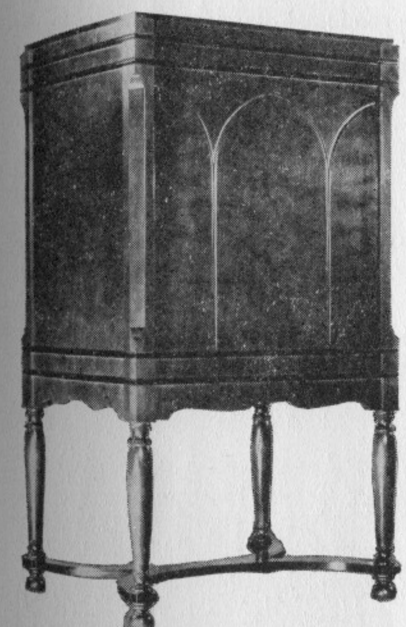


Fig. 5-12. Tone Cabinet (Model C-40)

SPECIFICATIONS

DIMENSIONS—Width 38"—Depth 27½"—Height 71"
FINISH—Walnut stain.
WEIGHT—313 pounds.
OUTPUT—40 watts—2 amplifiers, 4 speakers.

The C-40 cabinet is especially adapted for use in enclosures where the indirect projection of sound is desirable. Very often the ceiling and floor are the only "live" or reflecting surfaces and this type of cabinet makes use of these.

The C-40 cabinet utilizes two power amplifiers and four speakers.

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

The chorus generator assembly, like the main generator, has a drive shaft with twenty-four brass gears. Each gear drives a single assembly consisting of two tone wheels. The drive gears vary as to the number of teeth, and the tone wheels operate at twenty-four different speeds. This generator has forty-eight tone wheels, each with a separate magnet and pick-up coil. Of these tone wheels, twenty-four are single and twenty-four are double (see Fig. 5-19). The double tone wheels consist of two discs with different numbers of teeth mounted on one brass hub. The single wheels are electrically connected in pairs, each pair being so connected as to have the same effect as one double wheel.

E. Keying Systems

MANUAL CHASSIS ASSEMBLY

The manual chassis assembly which includes the upper and lower manuals and the preset panel, has a terminal strip under each manual made up of 82 or 91 terminals, depending on the generator being used, to accommodate the frequencies from the tone generator assembly. Each manual has 61 playing keys, 9 preset keys, and 2 adjust

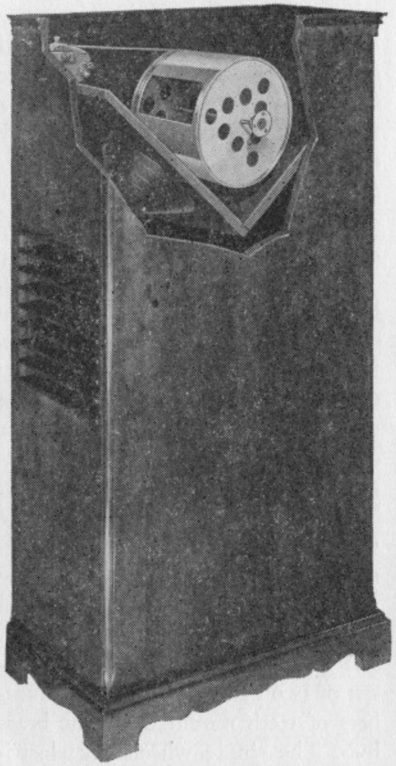


Fig. 5-13. Tone Cabinet (Model DX-20)

SPECIFICATIONS
DIMENSIONS—Width 28"—Depth 16¾"—
Height 56"
FINISH—Face and sides of American walnut.
WEIGHT—149 pounds—D-20: 171 pounds—
DR-20: 178 pounds—DXR-20.
OUTPUT—20 watts—1 amplifier, 2 speakers.
D-20—tonally identical with Model C-20, the D-20 fills a need for a cabinet for use in a wide variety of installations where decorative qualities are a secondary consideration.
DX-20—equipped with rotor tremulant.
DR-20—equipped with reverberation unit.
DXR-20—equipped with rotor tremulant and reverberation unit.

Only one R type cabinet is required to furnish reverberation control for any installation.

One power amplifier and two 12" speakers are used.

The type of speaker mounting (flat or V baffle) in the above cabinet is dependent upon the design prevalent at the time of manufacture.

keys, each of which operates nine small bronze contact springs with precious metal points. When a key is pressed these points make contact with nine busbars extending the entire length of the manual. The busbars also have precious metal contact surfaces.

The nine contact springs on each key carry an equal number of harmonics of the particular note with which they are associated and are connected by resistance wires to the proper terminals on the terminal strip. Therefore all key contacts are alive whenever the generator is running.

When a playing key is pressed, its nine frequencies are impressed

Fig. 5-14. Tone Cabinet (Model ER-20)

SPECIFICATIONS
DIMENSIONS—Width 31"—Depth 18"—
Height 38¾"
FINISH—Walnut.
WEIGHT—144 pounds.
OUTPUT—20 watts—1 amplifier, 2 speakers.

The ER-20 tone cabinet is electrically equivalent to other cabinets having R-20 in the model designation. However, the woodwork is designed for use in homes where a more artistic cabinet is preferred.

One power amplifier and two 12" speakers are used.

on the nine busbars of the manual. As there are no wires connected to these busbars, a preset or adjust key

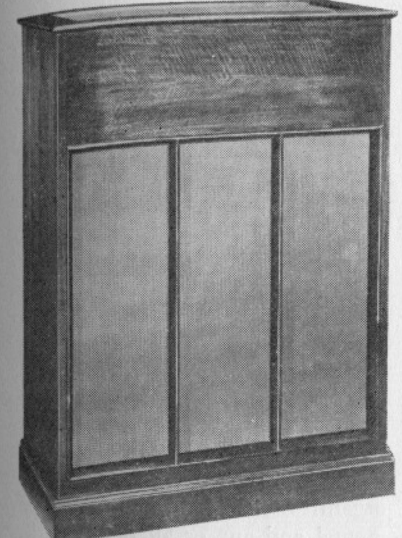


Fig. 5-15. Tone Cabinet (Model HR-40)

SPECIFICATIONS
DIMENSIONS—Width 33⅛" — Depth 16⅞" —
Height 48"
FINISH—Walnut Stain
WEIGHT—H-40—147 pounds
Weight packed—205 pounds
HR-40—162 pounds
Weight packed—220 pounds
AC INPUT—H-40 Early Units—234 watts
Later units—175 watts
HR-40 Early Units—240 watts
Later units—175 watts
OUTPUT—
H-40 —40 watts—1 amplifier—11 speakers
HR-40—40 watts—1 amplifier—11 speakers
(Two 12" treble and nine 10" bass speakers)

The H series tone cabinets are designed for use in all types of installations; church, home, school, and entertainment places. Its response is non-directional. The highs are projected vertically and lows horizontally.

The tone cabinet contains separate amplifier sections for treble and bass response with crossover point at 200 cycles.

Amplifiers are not interchangeable with amplifiers in other model tone cabinets.

The HR-40 has reverberation on treble section only. Reverberated signal *cannot* be fed from an HR-40 to another tone cabinet.

Earlier models of this tone cabinet were equipped with separate treble and bass amplifier units. These amplifiers were later consolidated in one unit.

For weight of earlier units add 31 pounds to above figures.

must be depressed before any circuit can be completed. Each preset and adjust key has nine contacts exactly like those of the playing keys. These keys have a locking and trip mechanism which allows only one key to be in operation at one time. The key at the extreme left end of the manual is a cancel key with no contacts, which releases any preset or adjust key that happens to be depressed.

The adjust keys, A♯ & B, are connected by flexible wires, color-coded for easy identification, to the corresponding nine drawbars. The drawbars slide over nine busbars which are connected to taps on the matching transformer. These busbars correspond to different intensities of sound as shown by numbers on the drawbars.

The nine preset keys, from C♯ to A inclusive, are wired to flexible leads terminating at the preset panel in the back of the console, where the various tone colors are set up connecting each wire to a screw terminal corresponding to the desired intensity of the harmonic.

Pedal Switch Assembly

The pedal switch is similar in construction to the manuals, except that only four busbars are included instead of nine. Each of the 25 pedals actuates a double set of contact springs, making eight contacts available for each note. Each note consists of a fundamental and a number of harmonics, no sub-harmonics being used. The pedal contact springs are connected to terminals by resistance wires similar to

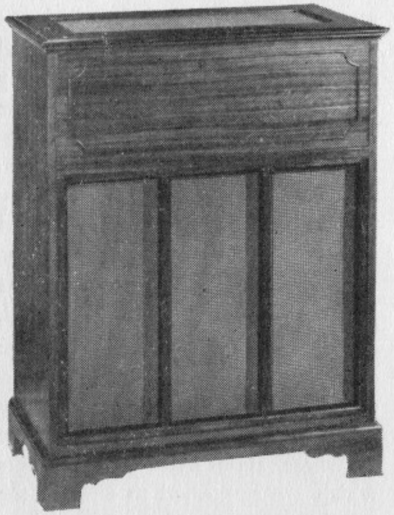


Fig. 5-16. Tone Cabinet (Model JR-20)

SPECIFICATIONS

DIMENSIONS—Width 29¾"—Depth 15⅞"—Height 39¾".

WEIGHT—120 pounds.

The JR-20 Tone Cabinet is finished in walnut panels. This cabinet is similar to the H Series Hammond Tone Cabinets in that treble and bass tones are sounded through separate loudspeaker systems. The treble tones are produced by a twelve-inch dynamic speaker and are projected vertically through a top grille opening. The bass tones are produced by a bank of four ten-inch dynamic speakers mounted on a vertical baffle and speaking through the front grille.

The JR-20 Cabinet may be used singly or in groups to provide additional volume. Such additional tone cabinets may be connected direct to the JR-20 to sound whenever the organ is being played, or they may be connected through an echo switch so that either cabinet may be sounded independently of the other at the player's option.

The JR-20 Tone Cabinet contains the Reverberation Control.

The JR-20 is unique among Hammond Tone Cabinets in that the reverberative effect may be introduced into the treble tones, or the bass tones, or both optionally. This is accomplished by use of two Reverberation Selector Switches, one for "Treble" and the other for "Bass" tones. For example, if the JR-20 is installed where carpets, draperies, and other acoustic absorbent materials are found, the reverberation selector switch for the treble and for the bass would probably both be set in the "high" position. When the JR-20 is installed as one of several tone cabinets in a larger enclosure such as a church, the player will probably find that he wishes to have the treble tones reverberated but not the bass tones so he would set the treble selector switch in the "medium" or "high" position and the bass selector in the "low" or "off" position.

those used in the manual assembly, and a cable connects these terminals through a wiring tube to the proper terminals on the generator terminal strip.

Four colored wires carry the pedal tones from the busbars to the pedal drawbars. In some models the wires are connected first to a resistor panel on the back of the manual assembly. A small choke coil and resistor mounted on the manual assembly are wired to the lower drawbar and serve to filter out any higher harmonics which might be present in the lower pedal frequencies.

F. Harmonic Drawbars

Fig. 5-20 shows one group of harmonic drawbars, by which the organist is enabled to mix the fundamental and any or all of eight different harmonics in various proportions. The third bar from the left controls the fundamental, and each of the other bars is associated with a separate harmonic. If a drawbar is set all the way in, the harmonic it represents is not present in the mixture.

Each drawbar may be set in eight different positions by the organist in addition to the silent position. Each position, as marked on the drawbar, represents a different degree of intensity of that harmonic.

A tone color is logged by noting the numerical position of the various drawbars. For instance, the tone set up on Fig. 5-20 is known as tone 23 6444 222. After a tone is so logged it may be made available again

by setting the harmonic drawbars to that number.

In the pedals the harmonic resources have been combined into two drawbars which may be used separately or in combinations. When the left drawbar is used emphasis is given to the lower bass tones, and similarly the higher tones are emphasized when the right drawbar is used.

G. Vibrato and Tremulant

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

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

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

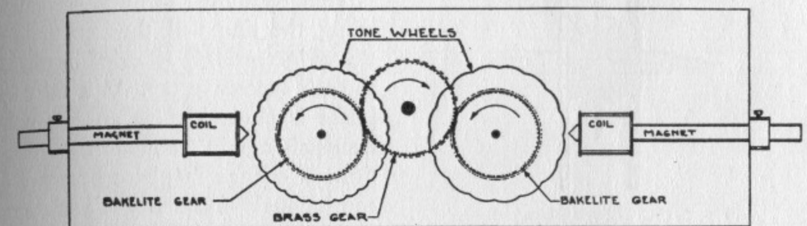


Fig. 5-17. Section of Main Generator

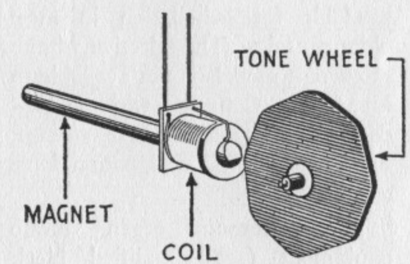


Fig. 5-18. Tone Generator (Sketch)

Hammond organ consoles equipped with vibrato differ from tremulant models in the omission of the tremulant switch, tremulant control, and non-vibrato preamplifier, and in

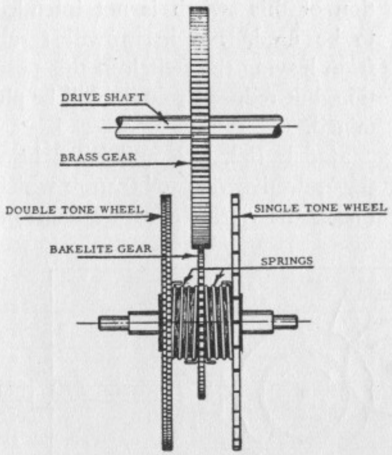


Fig. 5-19. Chorus Generator Tone Wheel Assembly

the addition of the vibrato line box, scanner, vibrato switch, vibrato chorus switch, and vibrato pre-amplifier. Three degrees of vibrato are available, and in addition the vibrato chorus switch offers a different degree of chorus or celeste effect with each of the three degrees of vibrato. A conversion kit is also available for installation in most older consoles. The selective vibrato of current models is not available in kit form. Consoles with a "V" designation have a single vibrato; those with a "2" designation have a split vibrato.

The Hammond organ vibrato equipment (see simplified block diagram, Fig. 5-21) varies the frequency of all tones by continuously shifting their phase. It includes a phase shift network or electrical time delay line, composed of a number of low-pass filter sections, and a capacity type pickup or scanner, which is motor-driven so that it scans back and forth along the line.

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

The scanning pickup traveling along the line will thus encounter waves increasingly retarded in phase at each successive tap. As a shift in phase is equivalent to an instantaneous change in frequency, the continuous change in phase becomes a continuous frequency variation. Since the scanner sweeps from start to end of the line and then back, it alternately raises and lowers the output frequency, the average remaining equal to the input frequency.

The exact amount of frequency shift depends not only on the amount of phase shift in the line but also on the scanning rate. This rate, however, is constant because the scanner is driven by the synchronous running motor of the organ.

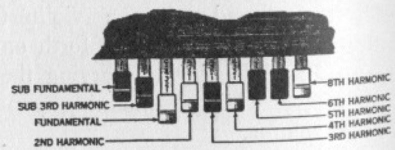


Fig. 5-20. One Harmonic Drawbar Group

The degree of vibrato (or amount of frequency shift) may be varied by a switch (not shown in Fig. 5-21) which causes the whole line to be scanned for #3, (wide) vibrato, half of it for #2, and one fourth for #1.

A vibrato chorus effect, similar to the effect of two or three slightly out-of-tune frequencies mixed together, is obtained when the vibrato output signal is mixed with a portion of signal without vibrato. With the vibrato chorus switch in "vibrato

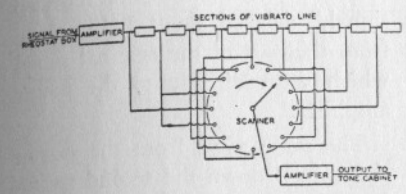


Fig. 5-21. Diagram of Vibrato Equipment

chorus" position, part of the incoming signal appears across the vibrato line and the rest across a resistor in series with the line. As the vibrato effect is applied to the part of the signal appearing across the line but not to the part appearing across the resistor, the combination produces a chorus effect.

The tremulant or tremolo is a periodic variation in intensity of all tones without change in pitch. When the tremulant control is turned as far as possible to the left, the tremulant is entirely off. As it is turned to the right (clockwise) the degree of tremolo gradually increases until it reaches the maximum at the extreme right position. The white dot marker on the knob indicates at a glance the degree of tremolo present. Two tremulant controls are used on the Model E console, one for each manual. These are controlled by separate levers located on the console. The tremulant is not incorporated on models having vibrato.

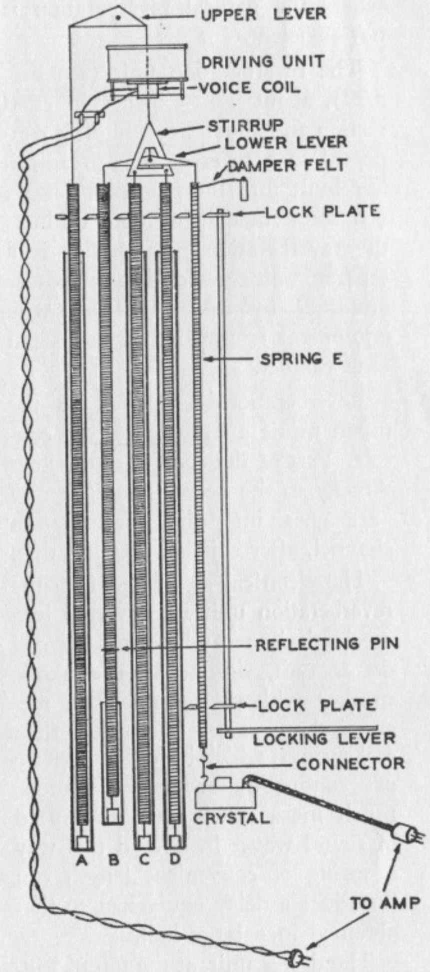


Fig. 5-22. Reverberation Unit

H. Reverberation Control

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

The reverberation unit (see Fig. 5-22), about 4 x 5 inches in cross section and about 4 feet high, is connected to a reverberation preamplifier built into the power amplifier. (In some models of tone cabinets the reverberation preamplifier is a separate unit connected to the power amplifier by cables.) The entire equipment is attached to the organ tone cabinet.

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

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

The driver unit, at the top of Fig. 5-22 introduces up-and-down vibrations into the stirrup directly under it. The two enclosed springs under stirrup hold it in position but permit it to move freely up and down, and the spring at the far left balances the pull of the others. These three springs are almost entirely immersed in oil, as they act largely as dampers to stabilize the response of the driver and prevent undesired reflections.

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

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

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

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

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

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

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

In a reverberant room it may happen that the reflected waves of some low-frequency note will return at just the right instant to produce partial cancellation of the original note. The same thing may happen in the spring system, particularly on some low pedal notes. This effect may often be reduced by turning the 2-pin driver unit plug a quarter turn in its socket on the amplifier, thereby reversing the phase of the reverberated signal.

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

An exception occurs in the case of Type HR-40 tone cabinets, in which reverberation is applied only to the treble channel and no reverberated signal is available for addi tional cabinets. If reverberation is desired on several H series cabinets, each must be equipped with a reverberation unit. If any cabinets of other types are used in addition, a single reverberation unit will be sufficient for all of them. However, several reverberation units in one installation will give better ensemble results.

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

I. Pedal Solo Unit (RT and RT-2 Organs)

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

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

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

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

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

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

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

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

The *tuning coil assembly* contains 32 adjustable inductance coils, which tune the master oscillator to

the frequencies of the 32 pedal notes. It is mounted above the pedal switch assembly, near the right side of the console as viewed at the rear.

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

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

J. Amplification System

The electrical impulses which produce the tones of the Hammond organ are given their original amplification by a preamplifier located in the console, and are then transmitted to the power amplifiers which are located in the tone cabinets. It will be noted that no power transformer is included in the preamplifier on organs up to those having selective vibrato but that the required plate current on these earlier models is supplied by the power amplifier in the first tone cabinet.

A tone control is included in the preamplifier whereby the relative intensity of the high and low frequencies may be changed to suit acoustical conditions by varying the amplitude of the higher frequencies. The tone control will be found on the preamplifier. The JR tone cabinets have an additional tone control on their power amplifiers.

A microphone or phonograph pickup may be used with the organ if special circumstances make it desirable. On vibrato consoles the input terminal, located under the cap marked "HI IMP INPUT" on the preamplifier, goes to the grid of one input tube. This circuit has an input impedance of 1 megohm and requires an input signal of about 60 millivolts maximum.

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

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

K. Spinet Organ (Models M and M-2)

GENERAL DESCRIPTION

The Spinet Model console is completely self-contained with its own

12-inch loud-speaker. It has two manuals of 44 keys each, a 12-note pedal keyboard, and an expression (or swell) pedal for controlling the volume. All tones are produced by electromagnetic tone generators and electrically amplified, as in other models of the Hammond organ. Selection of tone colors is made by adjusting 9 drawbars for the upper manual, 8 for the lower manual and 1 for the pedals. Other characteristics of the music are adjusted by

Fig. 5-23. Complete Spinet Organ

means of six or seven tilting control tablets. (The M-2 has seven tablets including split vibrato). A push button and a toggle switch, located in the front of the console beneath the manuals, are used to turn on the organ.

Fig. 5-23 shows the front of the console and Fig. 5-24 is a rear view, with the dust cover removed. Fig. 5-25 is a block diagram of the M-2 organ.

Manuals

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

The two manuals do not cover exactly the same pitch range, but they are arranged so that keys of like pitch are in line.

Under each key are nine contact springs (for the fundamental and eight harmonics of that key) which touch nine busbars when the key is pressed. (Some keys at the right end of each manual have fewer springs). All contact springs and busbars have precious metal contact surfaces to avoid corrosion, and the manuals are sealed to exclude dust insofar as possible.

Harmonics Drawbars

The left group of eight harmonic drawbars (Fig. 5-26) is associated with the lower manual, and the right group of nine drawbars controls the upper manual. By sliding these drawbars in and out the organist is able to mix the fundamental and harmonics (or overtones) in various proportions. The distance a bar is pulled out determines the strength of the corresponding harmonic; and if a drawbar is set all the way in, the harmonic it represents is not present in the mixture. Neither manual will play unless at least one of its drawbars is pulled out at least part of the way.

The drawbars slide over nine busbars extending the length of the

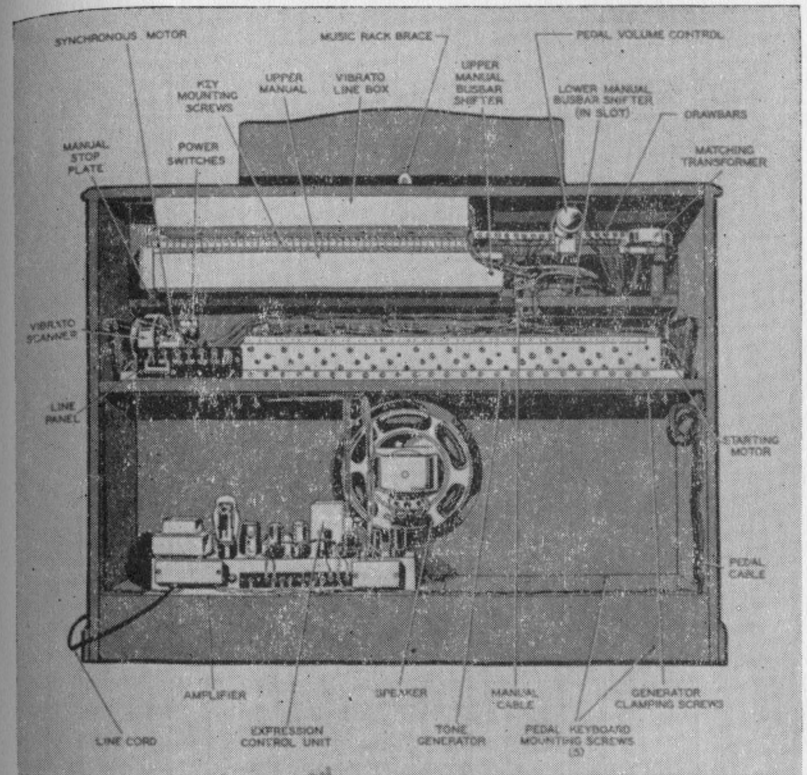


Fig. 5-24. Back View of Spinet Organ

drawbar assembly, representing the intensity levels, and each drawbar has two contacts connected together by a one-ohm resistor. As the drawbar moves, at least one of the contacts is touching some busbar at all times, and therefore there is no "dead spot" in the drawbar motion. The one-ohm resistor avoids an actual short circuit between adjacent busbars.

The busbars are connected to taps on a resistor to provide the nine steps of volume available on each drawbar. The tapped resistor, with a total resistance of about half an ohm, is located at the end of the drawbar assembly, and is connected to the low-impedance primary of the matching transformer. The high-impedance secondary of this transformer is wired to the amplifier input terminal.

Pedal Drawbar

The center drawbar adjusts the volume of the pedals. It operates a variable condenser which is connected to the pedal section of the amplifier.

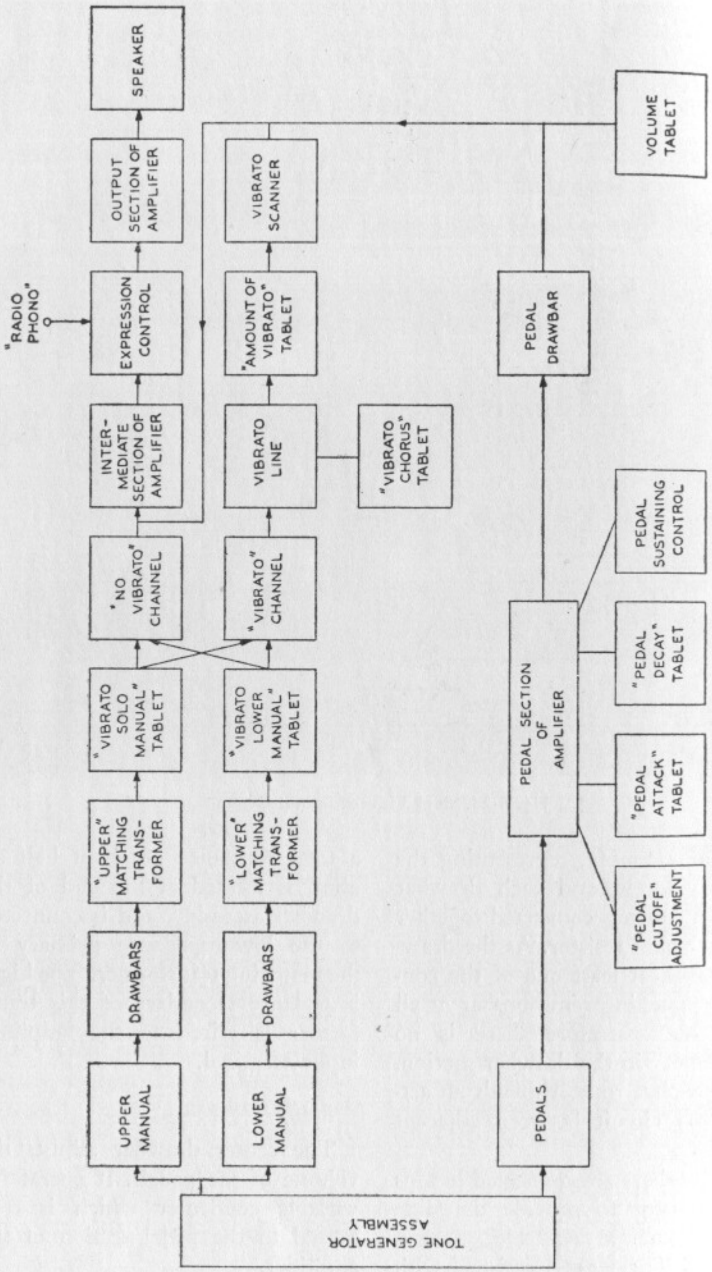


Fig. 5-25. Block Diagram (Model M-2)

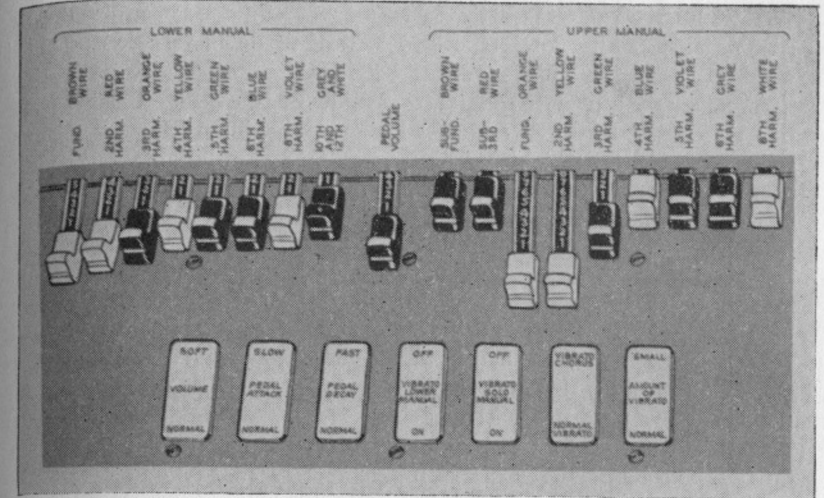


Fig. 5-26. Drawbars and Control Tablets (Model M-2)

Pedal Keyboard

The twelve playing pedals are operated by the left foot and are connected to the lowest twelve frequencies of the generator. Like the manuals, they have light and dark keys arranged in the standard octave pattern. Fig. 5-27 identifies the pedals and shows the generator frequency number associated with each.

A "pedal contact" on each pedal opens when the pedal is pressed, thereby allowing the correct generator frequency to reach the amplifier. In addition there is a "pedal keying contact" for all pedals, which closes when any pedal is operated. It serves to key the pedal amplifier, causing the note to sound at the desired rate in accordance with the setting of the "pedal attack" tablet.

When a pedal is pressed its "pedal contact" opens first, selecting the correct note. Immediately the "pedal keying contact" closes, causing the note to sound. When the pedal is released a mechanical latch keeps the "pedal contact" open, so that the last-played pedal note continues to sound for a length of time determined by the setting of the "pedal decay" tablet and a "pedal sustaining control" attached to the expression pedal.

Expression Pedal

The "expression" pedal, sometimes called "Swell" pedal, is operated by the player's right foot and varies the volume of both manuals and pedals together. It is connected mechanically to a special variable air condenser mounted on the amplifier. When the pedal is tilted back ("closed") by the player's foot, the music is softest, and when pushed forward ("opened"), the music is loudest.

Attached to the expression pedal is a "pedal sustaining control" lever, which is operated by sliding the foot sidewise on the pedal. If this lever is not pressed, each pedal note dies away rapidly or slowly, depending on the setting of the "pedal decay" tablet. If the lever is pressed to the left, the last-played pedal note dies away much more slowly.

Control Tablets

Each of the six or seven control tablets (Fig. 5-26) has two positions. The "volume" tablet changes the over-all volume of the organ and thus supplements the expression pedal. The "pedal attack" tablet determines how fast a pedal note sounds after a pedal is depressed, and "pedal decay" determines how fast the sound dies away after the pedal is released.

The "vibrato" tablets turn the vibrator on and off for each manual, and the next tablet provides a choice of "normal vibrato" or "vibrato chorus" (it is effective only when a "vibrato" tablet is "on"). The last tablet can be set for "small" or "normal" vibrato to adjust the extent of the pitch variation provided by the vibrato mechanism.

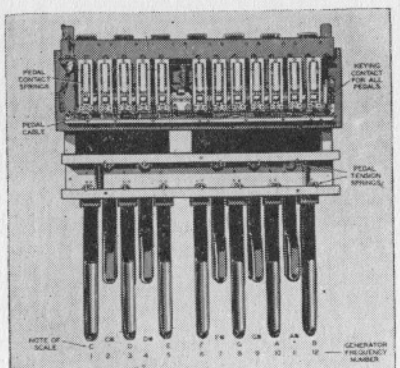


Fig. 5-27. Pedal Keyboard (Model M)

All of the control tablets are equipped with precious metal contact surfaces to minimize the effect of dirt or corrosion.

Amplifier Assembly

The amplifier assembly is on a single chassis but is actually composed of four sections: manual, pedal, intermediate, and output, as indicated in the block diagrams.

The manual section (M-2 organ) is composed of two channels connected to the "vibrato" and "no vibrato" input terminals. Either of the two matching transformers can feed a signal into either input channel, depending on whether the corresponding control tablet is set for vibrato "on" or "off."

Signals entering the "no vibrato" channel are amplified and fed directly into the intermediate section of the amplifier, while signals going into the "vibrato" channel pass through the vibrato system first. The output signal of the vibrato system is combined with the "no vibrato" and pedal signals at the grid of the intermediate amplifier.

Suitable tonal balance is secured in the "no vibrato" channel by a feedback network. Similar tonal balance is provided in the "vibrato" channel by a feedback network. The two channels are matched at the factory.

The pedal amplifier, composed of one tube, receives its signal directly from the pedal generators. When a pedal key is pressed its "pedal contact" opens, delivering a signal voltage of the proper frequency to this tube. The note cannot sound instantly, however, because the tube is normally cut off by a negative 21 volt grid bias.

Near the end of the pedal stroke the "pedal keying contact" (common to all pedals) closes. This shunts a resistance from the bias point to ground, discharging the bias condenser and allowing the note to sound.

If "pedal attack" is at "normal" only a single resistor is placed across the bias condenser when the pedal keying contact closes. This very quickly discharges the condenser, and the note sounds quickly, although not abruptly.

In case "pedal attack" is set at "slow," the shunting resistor is increased and so the bias condenser cannot discharge as quickly. It takes an appreciable time, therefore, for the bias to drop low enough so that the note sounds.

When the pedal key is released, the pedal keying contact opens, allowing cutoff bias to be applied again to the tube. With "pedal decay" set at "fast" this occurs rapidly. With "pedal decay" set at "normal" the increased resistance delays the charging of the condenser and permits the tone to sound for a longer time.

If the "pedal sustaining control" is operated (lever on expression pedal pressed to left), an additional resistor is introduced. This delays the charging of the condenser still further and causes the note to sound for a much longer time.

A latching mechanism holds the last-played pedal contact open until some other pedal is operated, in order to insure that the correct note will sound throughout the decay period.

To prevent a pedal note from sounding when the organ is first turned on, a resistance of five ohms inserted in series with the heater of the pedal amplifier tube lengthens its warm-up time so that the cutoff bias is applied before the tube is conductive.

Intermediate Section of Amplifier

From the plate of the pedal amplifier tube the pedal signal passes through a variable air condenser (operated by the pedal drawbar) to the intermediate amplifier. At this point the pedal signal is mixed with the vibrator and non-vibrato manual signals.

Moving the "volume" tablet to "soft" reduces the overall volume of both manuals and pedals by shunting a small condenser across the input of the intermediate amplifier. At the same time it provides pedal compensation by adding a resistor in series with the pedal generators and thereby increasing the relative volume of the pedals.

The small feedback condenser from plate to grid of the intermediate amplifier is a means of increasing the effective input capacity of the tube. In this circuit the effective input capacity is this value multiplied by the amplification factor of the tube, or a total of about 2500 micromicrofarads. This provides a suitable load for the output of the scanner and the pedal drawbar.

The combined manual and pedal signals go through the intermediate amplifier to the expression control (operated by the expression pedal), which is a special variable air condenser with a single set of movable plates and two sets of stationary plates. With the expression pedal in "loud" position the signal is transmitted directly to the grid of the following tube, while in "soft" position the signal goes through a tone-compensated attenuating network. At intermediate positions the signal is obtained from both sources, providing a continuously varible control.

Output Section of Amplifier

The second half of the 6SN7 tube is a phase inverter driving push-pull output tubes. A small feedback condenser from voice coil to grid of the 6SC7 makes the pedal response more uniform by reducing speaker resonance. This condenser (located in the expression control unit) is variable and is adjusted at the factory.

Special Equipment

Radio, Phonograph, or Microphone

A phonograph, radio, or microphone amplifier will play through the organ speaker if connected to the pin jack marked "RADIO-PHONO" on the organ amplifier. This terminal has an impedance of 100,000 ohms to ground, and a ¼ mfd. blocking condenser must be used in series with the input signal. The device should have an output level of about ½ volt maximum, and must have its own volume control, as neither the expression pedal nor the "volume" tablet will affect it. The organ may be played at the same time. The pin jack takes a standard single-conductor shielded connector.

Occasionally for special effects it may be desirable to apply vibrato to the signal from a phonograph, radio, or microphone. In this case connect to the pin jack marked "SPEC. INPUT." This point has a low impedance to ground (about 7000 ohms) and may conveniently be driven from the voice coil terminals of an amplifier having a level of about 5 volts maximum. The expression pedal, "volume" tablet, and three vibrato tablets will then be effective on the input signal just as they are on the organ music.

Extension Speaker

An additional tone cabinet may be attached to the organ if special circumstances make it desirable. It should be connected through an "echo" speaker kit mounted on the console. It is essential that the speaker be designed for this purpose to bring out the full tones of the organ. The console speaker may be left operating or not, as desired.

Hammond organ tone cabinets may be used as extension speakers for the Spinet model. If the echo kit is not available, connections can be made as follows: Connect the two grid input terminals of the tone cabinet amplifier to the two voice

Specifications

Dimensions:	With music rack—45⅝″ wide, 25⅜″ deep, 42″ high; without music rack, 34¾″ high. Depth with bench in normal playing position, 43″.
Weight:	Console, 243 pounds; bench, 18 pounds.
Manuals:	Swell and Great (upper and lower) 44 keys each.
Pedal Keyboard:	12-note.
Expression:	One expression pedal controlling Swell, Great, and Pedals; dynamic range, 28 decibels.

coil terminals of the Spinet amplifier, and connect the ground terminal of the tone cabinet amplifier to the Spinet amplifier chassis. The ground wire can conveniently be placed under a screw holding the shielded wire terminal cover on the spinet amplifier. The AC power for the cabinet must be supplied through an external switch, as the Spinet console wiring is not designated to carry any additional load.

NOTE: In Model M console below serial number 3000 (with amplifiers marked type M-A) the output transformer does not have a grounded center tap, and therefore a center tap for the push-pull tone cabinet input must be provided by connecting two resistors in series across the voice coil terminals, with the junction of the two resistors connected to the chassis. If the console speaker is to be left connected, two carbon resistors of about 100 ohms each may be used. In case the console speaker is to be disconnected, use two 5-watt wire-wound resistors of not more than 10 ohms each, in order to avoid unloading the amplifier and thus injuring the amplifier.

Ear Phones

Ear phones may be connected to the organ if someone wishes to practice without disturbing others. They will generally give adequate volume when connected to the "voice coil" terminals of the amplifier, with the speaker disconnected. *Caution:* In consoles below serial number 3000, a 10-watt, wire-wound resistor of 6 to 10 ohms resistance must be placed across the terminals to avoid unloading the amplifier.

L. Chord Organ (Model S)

General Description

The Hammond Chord Organ is completely self-contained (see Fig. 5-28). It has a 37-note keyboard played with the right hand; a set of 96 chord buttons played with the left hand; a chord bar operated by the palm or thumb of the left hand to accent chord rhythms; two bass pedals played with the left foot;

twenty stop tablets for controlling the character of tones produced; three balancers for adjusting the volume of the various divisions; and a knee-operated expression control to regulate volume of the entire instrument.

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

Full instructions for connecting a radio, phonograph, microphone, extension speaker, or ear phones to the Chord Organ can be obtained from the factory.

Turning On and Off

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

Musical Divisions

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

The "Organ" Division is independent of the solo division but is played by the same keys. Its tones augment those of the solo division

Fig. 5-28. Complete Chord Organ

and also make it possible to play full chords with the right hand.

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

The "Chord" Division has 96 Chord Buttons, played with the left hand, which furnish accompaniment to harmonize with the melody. As each button selects a full chord (along with the accompanying bass note), only one button is played at a time. The chord division also includes the Chord Bar, which is

played with the palm or thumb of the left hand to sound the chord selected by the chord buttons. (If the "Sustain Cancel" tablet is off, the chord sounds softly but is made louder by pressing the chord bar).

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

Expression Control and Balance

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

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

Control Tablets

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

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

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

"Mute" makes the chord button tones more mellow.

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

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

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

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

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

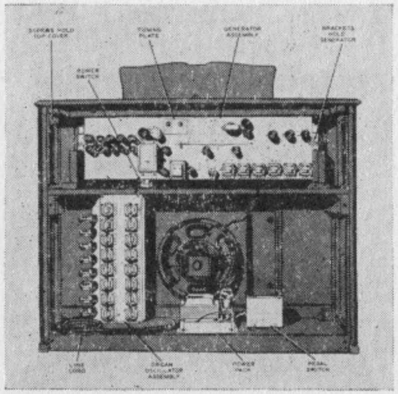


Fig. 5-29. Back View of Chord Organ

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

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

"Solo Fast Attack" and "Solo Accent." When neither control is used, the tonal attack of the solo division is very smooth and is well-suited for playing slow moving melodies such as ballads. When "Solo Fast Attack" is used, the attack becomes very prompt and is useful for fast moving melodies. When "Solo Accent" is used the attack is so rapid as to appear percussive, and accents may be produced by releasing one note before playing the next one.

The Solo Timbre Controls—"Deep Tone," "Full Tone," "First Voice," "Second Voice," and "Brilliant." These five tone controls alter the frequency characteristic of the solo division to modify the quality of the tones selected by the Solo Register controls. "Deep Tone" emphasizes the low frequencies to provide a pure mellow type of tone, while "Full Tone" leaves the frequency characteristic essentially flat and gives a generally useful bright quality. "First Voice" puts a resonance in the 750 cycle zone and "Second Voice" puts a resonance near 1000 cycles, producing imitative solo voices of the horn type.

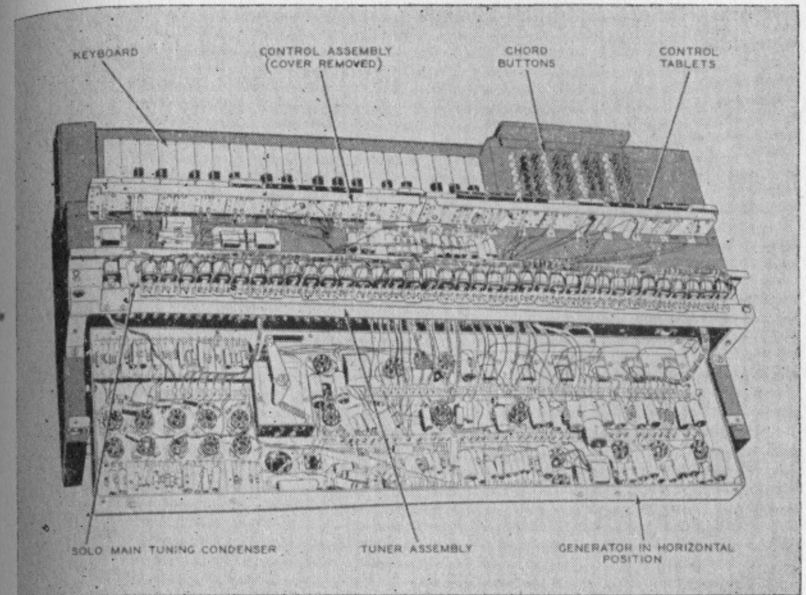


Fig. 5-30. Generator, Tuner Assembly, and Control Assembly Exposed

"Brilliant" emphasizes the higher frequencies and gives a piercing quality. These controls can be used singly or in various combinations to produce a great variety of effects. At least one of the five timbre controls must be used in order to obtain a solo tone.

How the Chord Organ Works

All tones of the instrument are generated by vacuum tube oscillators and are mixed and emplified by additional vacuum tube circuits. Fig. 5-32 is a simplified block diagram of the entire instrument. As this figure indicates, the playing keys control the "solo" and "organ" tone generating systems. Tones from either or both systems may sound, depending on the setting of the corresponding control tablets, and the relative volume levels may be regulated with the balancer knobs.

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

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

Description of Components

Most of the assemblies comprising the instrument are visible in figures 5-29 and 5-30.

Generator Assembly

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

This chassis is pivoted between the keyboard chassis blocks. By removing two screws (see figure 5-30), it can be unfastened so that it will swing down (as shown in figure 5-30) to expose the components inside the chassis. The instrument can be operated (but the expression control will not work) with the generator in this position.

Keyboard Chassis

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

Keyboard

The keyboard itself includes 37 molded plastic keys and a contact mechanism sealed against dust. Fig. 5-36 shows the locations of busbar shifters for the keyboard and the chord switch.

Chord Switch

The chord switch assembly includes the chord buttons, the mechanism under them, the chord contacts and busbars, and some electrical components associated with them.

Control Assembly

This unit includes all the control tablets and their contacts, the tone control networks, the register control circuits, the balancers, and the pilot light.

Tuner Assembly

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

Expression Control and Power Switch

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

Pedals and Pedal Switch

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

Power Pack

The power pack includes only the power transformer, the rectifier tube, and one resistor.

Specifications

Dimensions:	With music rack—43″ wide, 21-1/32″ deep and 41″ high. Without music rack—$34\frac{5}{16}$″ high.
Weight:	156 pounds.
Manual:	One three-octave (37-note) standard keyboard that plays single notes or chords.
Chord Section:	Individual buttons control 96 different standard organ chords.

M. Installation (2-Manual Organs)

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

When the console is set up for operation it is necessary to unfasten the four hexagonal nuts anchoring the generators. Otherwise generator noise will be transmitted to the woodwork. If the organ is moved some distance, the generator must be tightened down to avoid damage to the generator within the console.

Each power amplifier in a tone cabinet is clamped by screws which are to be removed on installation. These should also be replaced in case of moving. If the cabinet has

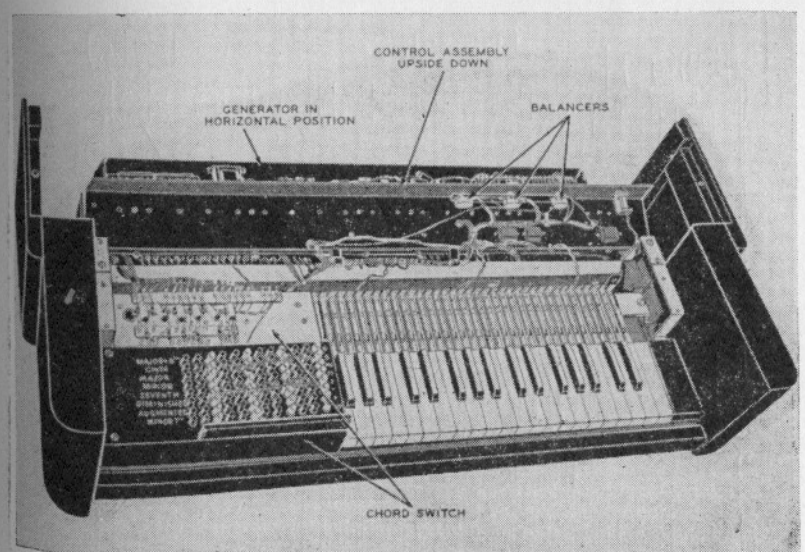


Fig. 5-31. Keyboard, Chord Switch, and Balancers Exposed

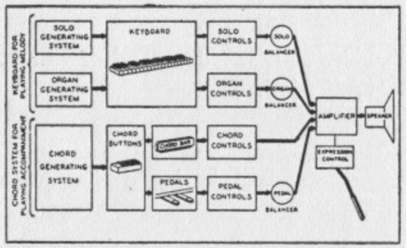


Fig. 5-32—Simplified Block Diagram

a reverberation unit, it should be locked and the oil removed as instructed on the card attached to the tone cabinet.

ADVICE FOR ARCHITECTS AND INSTALLATION ENGINEERS

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

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

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

POWER

There are so many factors which have a bearing on the amount of power or sound energy necessary for best musical results in a given en-

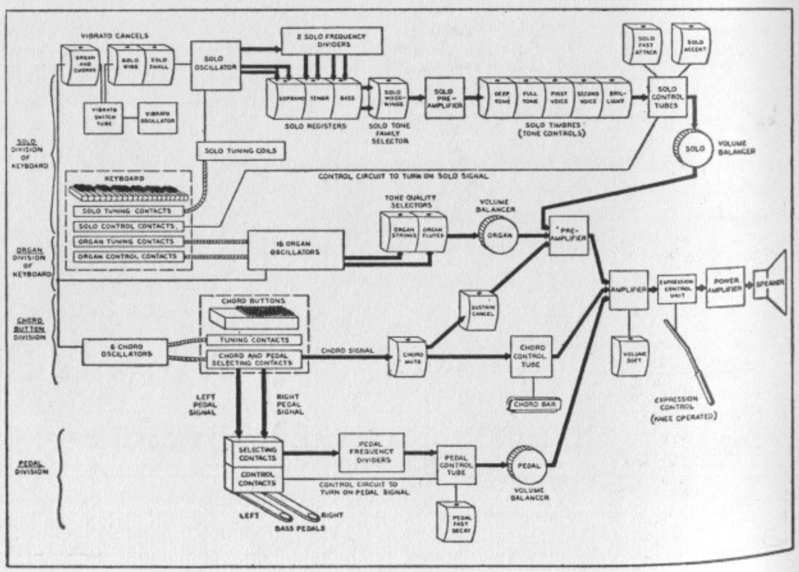


Fig. 5-33—Complete Block Diagram of Chord Organ

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

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

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

DISTRIBUTION

The sound energy from the organ should be distributed as evenly as possible throughout the enclosure. In order that this may be accomplished, it is important that the sound be distributed in the auditorium above the listeners and that a large percentage of the sound reaching the listener is by numerous reflections from the walls and ceiling. Direct projection as well as direct reflection from the speakers should not reach the listener. Focusing effects of curved surfaces such as

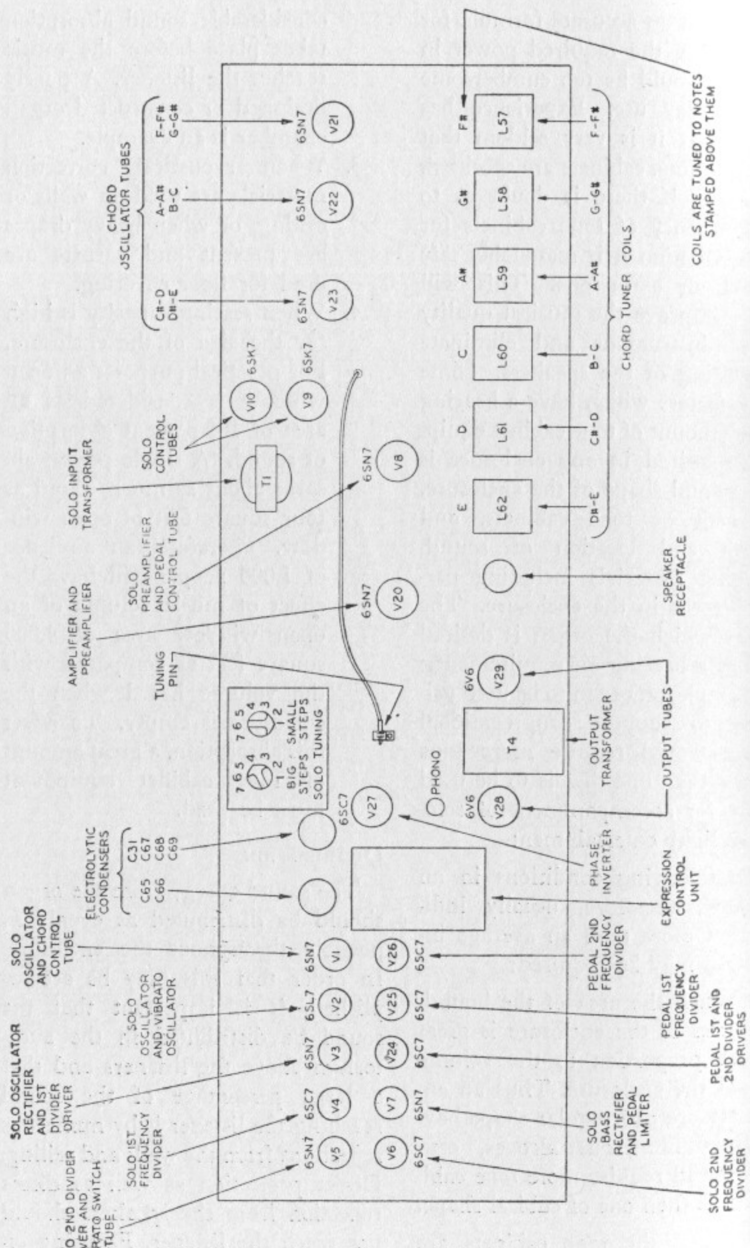


Fig. 5-34—Generator—Chord Organ

barreled ceilings often cause difficulty in sound distribution unless the tone cabinet is so located as to reduce the direct sound energy that reaches these surfaces.

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

Balance

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

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

Reverberation

Reverberation is the prolongation or persistence of sound by reflection.

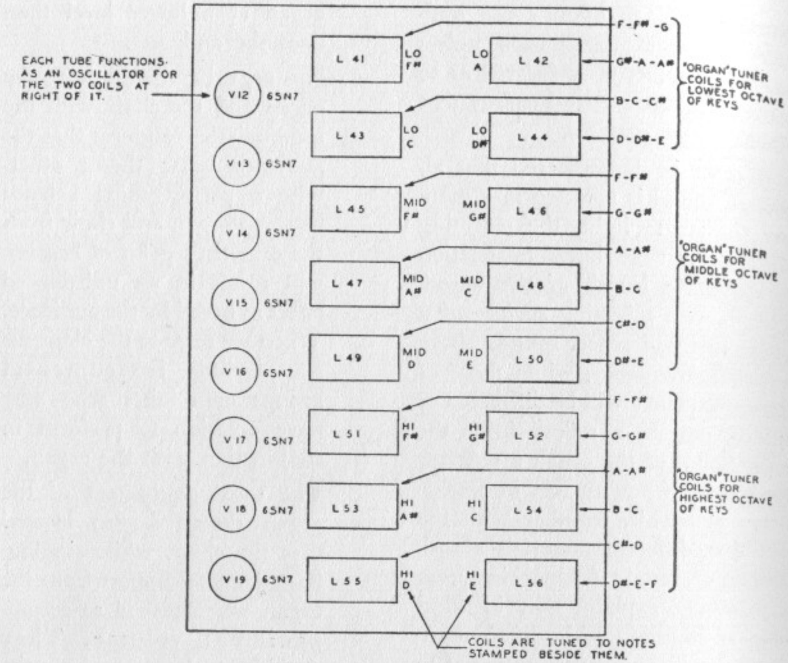


Fig. 5-35—Organ Oscillator Assembly—Chord Organ

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

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

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

Reverberation in the Auditorium

The reverberation that results from the successive reflections of sound back and forth by the boundaries of the auditorium itself is most desirable from the installation engineer's point of view. (By auditorium

we mean any audience room such as a church or concert hall.)

In a reverberant auditorium less power is necessary and problems of sound distribution are greatly simplified, and, therefore, the best possible musical results are usually ob-

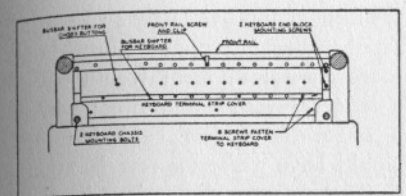


Fig. 5-36—Underside of Keyboard—Chord Organ

tained as a matter of course. Unfortunately, however, the reverberation characteristics of an auditorium usually are not alterable by the installation engineer, and he must accept them, good or bad, as the case may be.

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

Hammond Reverberation Control

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

Reverberation Chambers

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

Size

Since the reverberation time increases as the size of the chamber increases, the chamber should be as large as possible. Experience has shown that practically the only exceptions to this rule are when the shape of the chamber may be improved by reducing its size or when the tone opening cannot be made large enough in proportion to the size of the chamber. For best musical results the chamber should be at least 800 cubic feet in volume. The dimension of the chamber are in most cases ideal if they are in the ratio of approximately 2 : 3 : 4½. A chamber of equal volume but more cubical in form would have a longer reverberation time; while a chamber of less cubical form would have a shorter reverberation time; however, dimension in the above ratio usually are most desirable. Chambers of complex shape or chambers of regular shape whose greatest dimension is more than three times its least dimension should be avoided.

Construction and Finish

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

Tone Openings

The reverberation time of an organ chamber is greatly influenced by the size of the tone opening. For a chamber of given dimensions, the reverberation time is increased as the area of the tone opening is reduced. A large chamber, therefore, may have a large tone opening and still furnish sufficient reverberation,

whereas a small chamber might require a very small opening. A chart is shown in Fig. 5-37, giving the area of tone opening required to furnish one second reverberation time when the volume of the chamber is known. This chart is

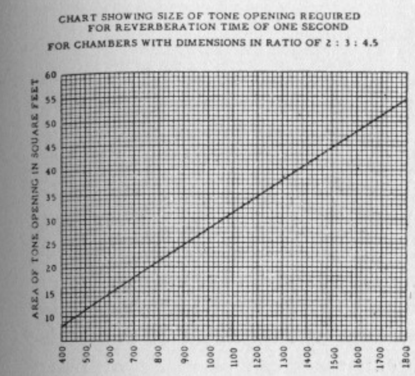


Fig. 5-37—Reverberation Chart

for chambers with dimensions in the ratio of 2 : 3 : 4½ only; however, in practice the areas of tone opening shown are generally satisfactory.

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

N. Care and Maintenance

Lubrication

The tone generator is lubricated by putting oil into cups inside the console. It is recommended that the cups be filled three-fourths full every four months, using only the oil supplied for this purpose by the Hammond dealer. It is very important that the recommended grade of oil be used regularly, for it is essential to the proper operation of the organ that the generator be well lubricated. If oil of varying grades is used, it is likely that the generator may be sluggish in starting, and in time the threads may gum up and prevent the proper flow of oil.

Tuning

Tuning the organ is limited to the Pedal Solo Unit on the concert Model RT and RT-2. (Tuning the Chord organ is covered by "Owner's Service Suggestions" booklet obtainable from the factory.)

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

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

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

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

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

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

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

Leveling

Leveling the organ is a matter of adjusting the volume of each note. This is done by changing the gap between each tone wheel and pickup coil on the tone generator to give the proper output voltage. Since this is a factory procedure requiring special instruments it will not be covered here. A certain amount of adjustment of the treble organ tones can be made with the tone control. Should the organ seem too brilliant, this control can be turned to mellow the higher tones.

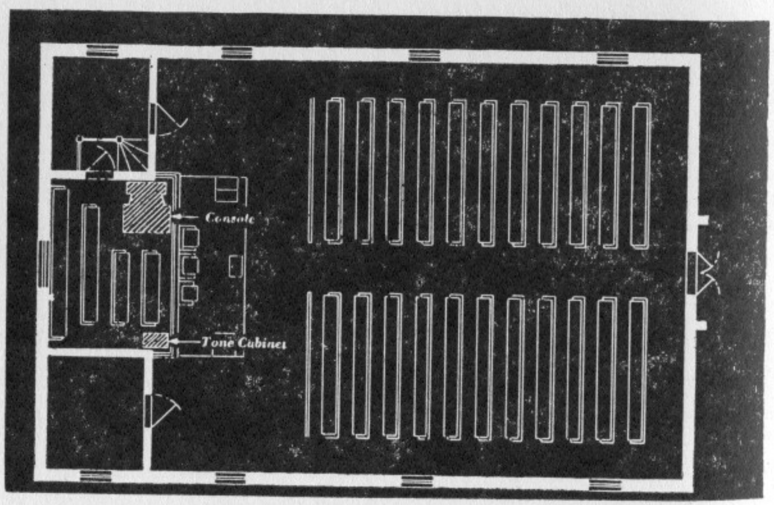


Fig. 5-38—Small Church Installation

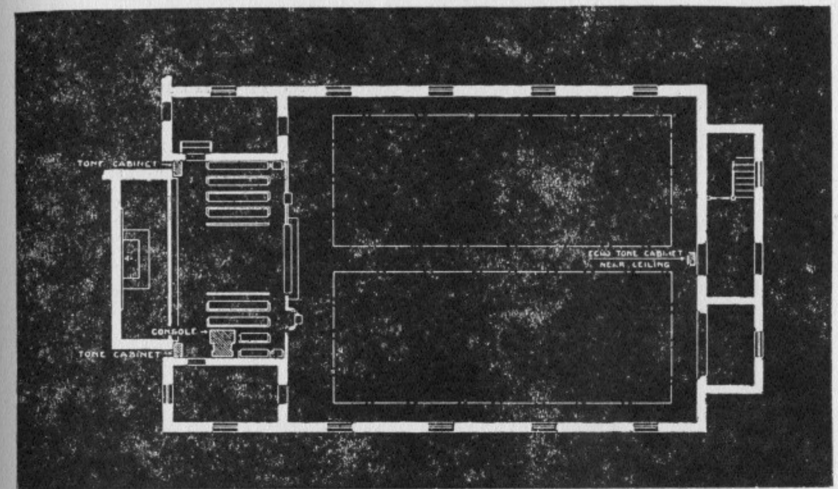


Fig. 5-39—Large Church Installation

Parts

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

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

The reverberation unit appears to be a delicate device but when once set up it is very dependable and requires no further attention. When a tone cabinet is moved even a few feet the reverberation unit must be locked to avoid excessive vibration of the springs. If the cabinet must be tilted more than 45 degrees while moving, oil must be drained and later replaced. Hammond damping oil is a grade especially selected for this purpose, and no other kind should be used.

Manual Busbar Shifters

(All Organs Except "A" Below 995)

The precious metal contact surfaces on the key contacts and busbars are not subject to corrosion, and the manuals are sealed to exclude dust as far as possible. In spite of these precautions an occasional particle of dust may lodge on a contact and cause the note to be scratchy, noisy, or silent, and for this reason a busbar shifting mechanism is provided on each manual to slide the busbars endwise and thus provide a fresh contact surface. The busbar shifter for each manual is a slotted stud near the right end of each manual as viewed from the back of the console.

If any note becomes scratchy or silent, it should first be struck 15 or 20 times in a rapid staccato manner to loosen the dirt. This will usually dislodge the particles and clear the note.

In case this procedure is not effective, the busbar shifter for that manual may be adjusted by turning the stud ⅛ to ¼ turn in either direction. It may sometimes be necessary to hold down the offending key while turning the busbar shifter, in order to wipe the contact clean. If the shifter is found to be at the end of its range, turn it a full turn to take up the play and then make the adjustment as above.

Pedal Busbar Shifters

Pedal switch in all consoles (except Model A consoles below serial number 995) are equipped with busbar shifters similar to those on the manuals. The pedal busbar shifter is a slotted stud on the rear surface of the pedal switch, near the left end as you look in at the back. It should be adjusted as described under "manual busbar shifters" in a previous paragraph.

Pedal Keyboard Adjustment

Pedal keys are set at the factory for the average tension, but are adjustable to fit the requirements of the individual organist. Adjustment is accomplished by removal of the top cover at the back of the pedal keyboard and setting the tension nuts as desired.

Minshall Organs

CHAPTER VI

Minshall Organs

A. General Description

Two completely different types of organs have been manufactured by the Minshall-Estey Organ Company, Brattleboro, Vt., the first using reeds as tone generators and the second using vacuum tube oscillators. The former type (known as Minshall-Estey organs) were marketed soon after World War II. The latter type (known as Minshall organs) are now in production. For those who own the earlier models, they are described in chapter 8.

The Minshall organs are no doubt the simplest of the purely "electronic" organs to be produced so far. Whereas it has been necessary in some organ designs to utilize hundreds of vacuum tubes and many associated components, the Minshall circuit makes possible a full two-manual and pedal organ with 16 speaking stops all derived from only 36 tubes. The advantages of simplicity in organ design are reflected in lower cost, less maintenance and reduced weight or bulk. Most 2-manual electronic organs which contain only one rank of tone generators have no means of providing separate registration on the two manuals. Yet the Minshall organs are so constructed that the Swell and Great stops are entirely independent of each other.

The Minshall electronic organs employ no moving parts, but use a master oscillator frequency divider principle of tone generation. The two-manual models use a tone generator similar in appearance to that of the one-manual model. Models H, J, and K are designed primarily for homes and chapels and include a loud-speaker and tone chamber in the lower half of the console (see Figs. 6-1, 6-2 & 6-3). The largest model (E) has no built-in speaker but uses a separate tone cabinet in matching walnut (see Fig. 6-4).

Fig. 6-1. Model H (with Spinet Legs)

Increased power can be obtained from any of the models H, J or K by adding one or more booster tone cabinets. The built-in speaker can even be removed from the console and placed at some remote point.

The following description of the tone-generating mechanism specifically covers the single-manual organ but applies basically to the two-manual models as well.

Fig. 6-6 shows in block diagram one of the twelve tone generator assemblies of the instrument. This assembly comprises three 12AX7 twin triodes, with associated circuits. One-half of the first 12AX7 tube is a master oscillator, tuned to one

Fig. 6-2. Model J Minshall Organ

of the notes in the top octave of the organ. The second half of this tube serves as a buffer amplifier to isolate the master oscillator from the effects of keying, and also operates so as to produce a sawtooth output wave form. One half of the second 12AX7 operates as a first frequency divider, producing in its output a sawtooth wave form one octave lower in frequency than the output of the buffer amplifier. The second half of this tube operates as a second frequency divider, while the third 12AX7 provides a third and a fourth frequency divider. Thus if the master oscillator is tuned to oscillate at the frequency 1760 c.p.s., which is the frequency of the note A^3 in the musical scale, a sawtooth wave form of this frequency will appear on the output lead 5. A similar wave form but of frequency 880 c.p.s., which is the note A^2, and octave lower than A^3, will appear an output lead 4. Likewise a sawtooth wave form at 440 c.p.s. (the note A^1) will appear on output lead 3, at 220 c.p.s. (the note A) on output lead 2, and at 110 c.p.s. (the note AA) on output lead 1. Thus all the A's of the musical scale are derived from the one tone generator assembly. Similar tone generator assemblies are used for

Fig. 6-3. Model K Minshall Organ

the other notes of the tempered scale.

The outputs of the twelve tone generator assemblies are conducted through the manual or pedal keying circuits and click filters to three manual collector busses and one pedal bus. Three switches are actuated by each manual key of the instrument. Thus if the middle A key is depressed the frequency 440 c.p.s. (the note A^1) will be transmitted to the unison or 8′ bus, 880

c.p.s. (the note A^2) to the octave or 4′ bus, and 220 c.p.s. (the note A) to the sub-octave or 16′ bus. Each pedal operates a single switch, so that when a pedal is depressed, the corresponding note is transmitted to the pedal bus.

The three manual busses and one pedal bus are connected to the tablet board of the instrument. Two tablets are provided for controlling the amplitude of the signal on the pedal bus, which is then passed through a low pass filter to the amplifier. Each of the three manual busses is controlled by one of the three manual coupler tablets. The signals from these three busses are then combined into a single lead. Shunting this lead to ground is a complex tone filter network, the characteristics of which are controlled by the six registration tablets. In this manner the tone filter shunts to ground greater or less proportions of the various frequency components in the signal, and so modifies the tone quality. The resulting modified signal is next combined with the pedal signal and transmitted to the audio amplifier.

B. Consoles

The Minshall consoles are made in a variety of styles; walnut, mahogany, bleached, with spinet legs or without spinet legs. The tone generators are mounted in the upper half of the console leaving the lower half for the loud-speaker or amplifier and expression pedal control. The pedal clavier is easily removable making the smaller models quite portable.

Fig. 6-4. Model E, largest Minshall Organ

Model	Depth	Width	Height	Weight
H	25½" (over the pedals)	43"	37½" (45¼" over the music rack)	158 lbs.
J	41"	43"		245 lbs.
K	46" (over bench)	41"		

C. Registration

MODEL H

PEDALS
- Bourdon
- Gedeckt

COUPLERS
- Manual (Sub)
- Manual (Unison)
- Manual (Super)

MANUAL
- Vibrato
- Diapason
- Melodia
- Flute
- Horn
- Cello
- Strings

MODELS J, K AND E

GREAT MANUAL
- Open Diapason
- Dulciana
- Flute
- Horn
- Viola
- Strings
- Great Sub Coupler
- Great Unison Off
- Great Super Coupler

SWELL MANUAL
- Geigen
- Stopped Diapason
- Salicional
- Clarinet
- Strings
- Oboe
- Vox Humana
- Swell Unison Off
- Swell Super Coupler

PEDALS
- Bombarde
- Bourdon
- Gedeckt
- Full Organ
- Vibrato

CHIMES

D. Tone Generators

Each of the twelve tone generator assemblies of the Minshall organ is built on a rectangular chassis about twelve inches long and two inches wide, with a five-prong connector at each end. The front end of each tone generator chassis plugs into the front or switch channel of the organ, and the rear end into the power channel. Power connections provided are B+ for the dividers and buffer amplifier; separate B+, which may be modulated to produce vibrato, for the master oscillator; heater potential; and ground. Connections to the switch channel are the five output leads shown in Fig. 6-6.

The master oscillator is a specially designed phase shift oscillator which utilizes one section of the 12AX7

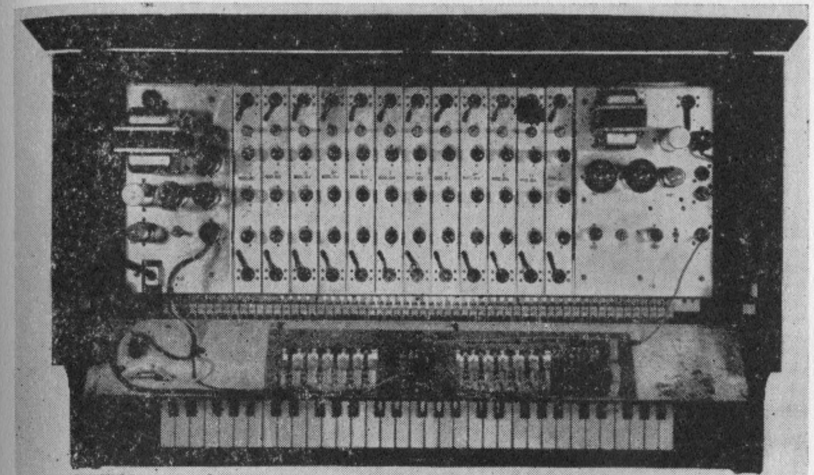


Fig. 6-5. Top View of Model H Console

twin triode tube nearest the rear of the chassis. The phase shift network, Fig. 6-7, No. 1, is assembled as a unit with the tuning control, No. 3, a 5 thousand ohm wirewound rheostat. The buffer amplifier, which utilizes the other section of the same 12AX7 tube, is provided to isolate the master oscillator from detuning effects which might otherwise be caused by keying, and also to provide a sawtooth output wave form.

The master oscillator is so designed as to minimize the effect of tube constants, which may vary from tube to tube, on the oscillation frequency. However, this effect cannot be entirely eliminated. For this reason, when a master oscillator tube is replaced, it may be necessary to retune slightly. This will be covered more fully below in the section on tuning.

A complete analysis of the frequency divider circuit would be too long and involved for inclusion in this manual. The following is intended to give a general understanding of the divider function. A schematic diagram of the frequency divider circuit is shown in Fig. 6-8. It will be noted that if the connection through the feedback coupling capacitor C3 were omitted this circuit would be essentially the same as that of the buffer amplifier. The input signal amplitude is reduced by the capacitive voltage divider comprising C1 and C2, but is still sufficient to drive the stage to cut-off. Therefore, the tube would conduct on the peaks of the input cycle, discharging the plate capacitor C4 through the tube, and the plate capacitor would charge more slowly through the plate load resistor R3 over the remainder of the input cycle. Thus a sawtooth wave form would be produced at the plate of the tube, as it is in the buffer, even though the input signal were not a sawtooth.

However, in the actual frequency divider, the drop in plate voltage occasioned by tube conduction on the first peak of the input signal is fed back to the control grid through C3 and R2. This feed-back drop in voltage is delayed in time by the time constant of R2 and C2. (C3 is a DC blocking capacitor only, R1 is provided to complete the DC path to ground for the control grid, and C1 is essentially in parallel with C2 as far as the feed-back signal is concerned). Thus when the second peak of the input signal arrives the grid potential is more negative, because of the feed-back signal, than when the first peak arrived. The input amplitude is not sufficient to overcome this additional bias, so that the second input peak causes little or no tube conduction. The plate capacitor C4 is therefore not discharged, but continues charging undisturbed. By the time the third input peak arrives, the bias has returned to its original value, the tube conducts, and the plate capacitor is again discharged. The resulting plate voltage drop is fed back to the grid, disabling the fourth input peak. The cycle continues in this manner, with the tube conducting an alternate peak of the input signal. Thus frequency division is accomplished.

Four different tone generator assembly designs are used in the organ. Since there are four different frequency divider designs in each assembly, this makes a total of sixteen frequency divider designs. These designs all conform to the circuit of Fig. 6-8, however, and differ only in the values of the capacitors C1, C2, and C4. Each frequency divider is designed to operate satisfactorily on any one of the three notes. Thus the C's, C♯'s, and D's of the organ are all derived from three tone generator assemblies of identical design. These three assemblies differ from one another only in that the master oscillator phase shift network installed in each is selected for its ability to be easily tuned to the correct frequency. Similarly the D♯'s, and E's, and F's of the organ are all derived from three tone generator assemblies of a second design, the F♯'s and G♯'s from assemblies of a third design, and the A's, A♯'s, and B's from assemblies of a fourth design.

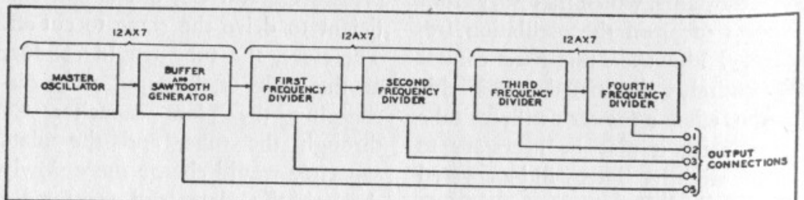


Fig. 6-6. Tone Generator Assembly (Block Diagram)

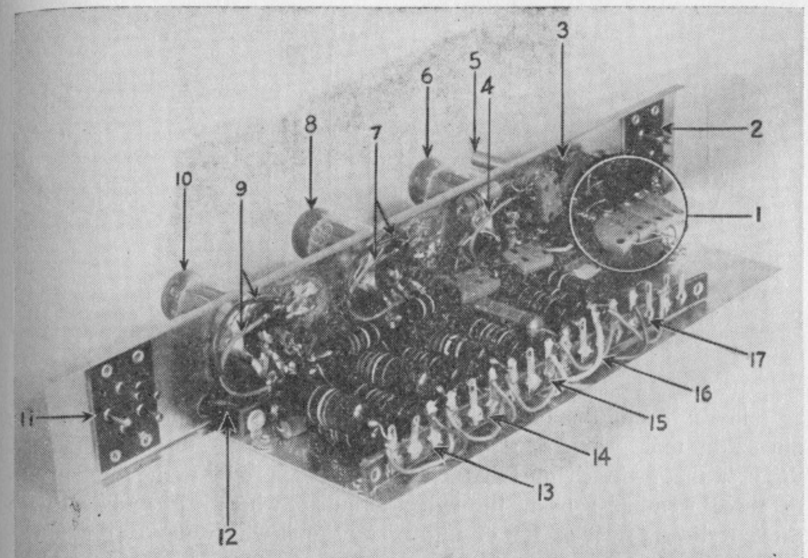


Fig. 6-7. Tone Generator Assembly

1. Master oscillator phase shift network
2. Power plug
3. Tuning control
4. Buffer plate lead
5. Tuning shaft
6. Master oscillator—buffer tube, 12AX7
7. Second divider grid and plate leads
8. First and second divider tube, 12AX7
9. Fourth divider grid and plate leads
10. Third and fourth divider tube, 12AX7
11. Output plug
12. Output leads
13. Fourth divider circuits
14. Third divider circuits
15. Second divider circuits
16. First divider circuits
17. Buffer circuits

E. Keying System

Manual Keyboards

The outputs of the twelve tone generator assemblies are distributed by a main channel harness to terminals on a terminal strip adjacent to the proper manual switches. A stack comprising three leaf-type switches is actuated by each playing key. Each stack includes three moving and three fixed switch leaves, all supporting palladium contacts. The moving leaves, which are slightly longer than the fixed leaves, are grounded by an internal shim in the stack. When the playing is depressed, its switch contacts are permitted to spring apart, so that the fixed leaves are no longer grounded.

The three switches of each stack control the 16′, 8′, and 4′ pitch signals of the key. Correspondingly, there are three manual busses which run the length of the manual and collect the 16′, 8′, and 4′ signals as controlled by the switches.

To sum up, the path taken by a given generated note may be traced

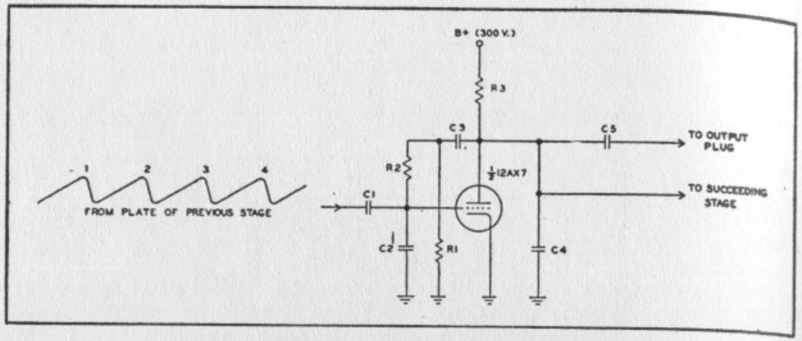


Fig. 6-8. Frequency Divider—Schematic

as follows: From the output plug pin of the tone generator assembly, through the main channel harness to three terminals; next, through three resistors, such as R1 of Fig. 6-10, to the 8′ switch of one playing key, the 4′ switch of the playing key an octave lower in the manual, and the 16′ switch of the playing key an octave higher; next, if these three keys are depressed, through three resistors such as R2 to three octave collector busses. In each of these octave busses the note is combined with such other notes of the same octave as may be called for by depressing the appropriate keys. The note next passes through three resistors such as R3 to the three manual busses, where it is combined with any signal which may be present on the other octave collector busses. The three manual busses are connected through a cable to the tablet board.

Pedal Keyboard

The pedal keyboard of the Model H Minshall Organ covers the octave from low C at approximately 64 c.p.s. to B at approximately 119 c.p.s. The pedal keying circuit differs from the manual keying circuit in that

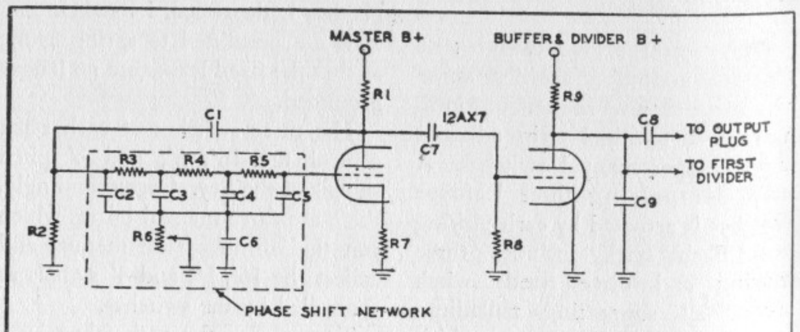


Fig. 6-9. Master Oscillator and Buffer—Schematic

only one switch is actuated by each pedal, and in that each switch is connected to two tone generators. The circuit for the C pedal is shown in Fig. 6-11. The resistors R1, R2, and R3 are located in the front channel of the organ, together with the

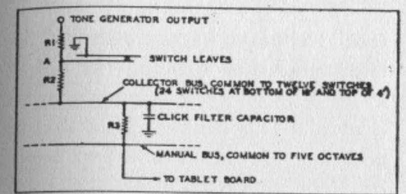


Fig. 6-10. Manual Keying Circuit—Simplified Schematic

manual keying resistors. Twelve leads such as lead (a), together with a common ground lead, extend from the channel to the pedal assembly.

Referring to Fig. 6-11, it may be seen that the signal from the C tone generator at approximately 64 c.p.s. and that from the G tone generator at approximately 96 c.p.s. are connected through resistors R1 and R2 respectively to the C pedal switch. Thus, when the switch is opened by depressing the pedal, both notes are present on the lead (a). The C note predominates, since the resistor R2 is of about twice as great resistance as R1. This combined tone is fed through the resistor R3 to the pedal bus, where it is combined with the other pedal notes.

In a similar manner, each pedal switch is connected through a resistor such as R1 to the tone generator of that note, and through a resistor such as R2 to the tone generator of the note a fifth interval higher in the musical scale, which is the sub-third harmonic. When two such combined notes are present in the correct proportion, there is generated in the ear of the listener an apparent tone, the frequency of which is the difference between the frequencies of the two notes present. Thus in the case of the C pedal, the ear perceives the difference (32 c.p.s.) between G at 96 c.p.s. and C at 64 c.p.s. This is C an octave lower than the lowest tone generator output. In this manner, a pleasing 16′ "resultant" bass is achieved.

Tablet Board

The three manual busses, the pedal bus, and a ground lead are connected through a shielded cable to the tablet board. A separate cable from the power supply carries the two pilot lamp leads, the two power switch leads, and the two vibrato control leads. The tablet board in-

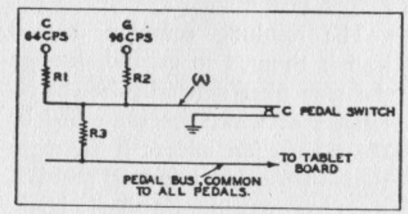


Fig. 6-11. Pedal Keying Circuit—Simplified Schematic

cludes two groups of six tablets each. Each tablet operates a single switch which is closed when the tablet is in the *up* or *off* position and open when the tablet is depressed.

The pedal bus is shunted to ground through two resistors, in series with each of which is a tablet switch. When the pedal tablets are depressed, the shunt resistors are disconnected and the pedal amplitude increased. The pedal signal is then fed through a low-pass filter. Each of the manual busses is shunted directly to ground through one of the coupler tablet switches. When all coupler tablets are in the *off* position, the busses are grounded and no signal from the manual can be present. As each coupler tablet is depressed, the ground is removed from the corresponding bus so that a signal will be present if manual keys are played. The vibrato tablet, when in the off position, shunts the vibrato oscillator grid circuit and stops oscillation.

Following the coupler tablets, the three manual busses are combined through mixing resistors. The 16′ bus is attenuated, relative to the 8′ and 4′ busses, by use of a larger mixing resistor.

The resulting common manual lead is shunted to ground through the tone filter network, the characteristics of which are controlled by the registration tablets. If all registration tablets are in the *off* position, the filter constitutes a short circuit, and no signal can be present. As the various tablets are depressed, various sections of the filter network, having frequency characteristics, are introduced. In this manner the *tone timbre* of the instrument is varied.

The resulting modified manual signal, and the output of the pedal low pass filter are *now* combined and fed through a shielded lead to the audio amplifier.

Mixture Stops

Certain stops of the Minshall Organ employ a similar technique to that of the "mutation" or "mixture" technique in pipe organs. This is accomplished through the use of a "quint," or $2\frac{2}{3}'$ bus on the swell manual. This simply means that in addition to the unison and super couplers associated with the swell manual, a third bus or set of contacts is employed under each key to provide, when desired, the "quint" or $2\frac{2}{3}'$ rank, or in effect a note one octave and a fifth above the fundamental or unison rank. No couplers are provided for this rank since the individual tablets, such as Clarinet, Oboe, and Vox Humana, automatically couple in the "quint." Many of the voices are produced by an exclusive application of harmonic filters which select and augment certain desired harmonics. In the case of the "mixer" stops, these augmented harmonics further enhance the ensemble of the organ.

F. Amplifiers and Power Supply

The audio amplifier comprises a 6J7 preamplifier, 6SL7 phase inverter, 6SN7 cathode follower-driver, and two 6L6 output tubes. Earlier models use two 12AX7 tubes for the preamplifier and phase inverter.

The attenuator, which is operated by the expression pedal, presents a

variable shunt across the output of the preamplifier tube, and so controls the amplifier gain.

The power supply contains, in addition to the usual rectifier and filter circuits, the vibrato circuit of the organ. A portion of the rectifier output is regulated by means of two series-connected OD3 regulator tubes to provide a constant source of 300 volts for the master oscillators. Regulation is required to prevent voltage surges in the power line from temporarily shifting the master oscillator tuning, in the same manner that it is shifted by the vibrato signal. The vibrato oscillator is a modification of the standard cathode coupled multivibrator circuit, using a 6SN7 tube. The output wave form of the vibrato oscillator is a slightly rounded square wave. The B+ supply for the master oscillators is derived from a tap on one of the vibrato oscillator plate load resistors. It is therefore a DC voltage modulated by the vibrato signal. When the vibrato tablet is in the *off* position, the vibrato oscillator grid is shunted to ground so that oscillation stops without affecting the DC conditions.

The booster amplifier in the C-20 booster cabinet includes a power supply, using a 5V4G rectifier tube, and an audio frequency power amplifier using two 6L6 tubes. Instead of a power switch, a six-volt relay is used. This relay is connected through the cable to the filament supply of the organ. Thus when the organ is turned on the relay operates and turns on the booster amplifier.

The booster amplifier also includes an output socket for connecting a second booster. Similarly, a third booster amplifier may be plugged into the second, and so on. When a number of booster amplifiers are so connected, the 6L6 grid circuit inputs are all paralleled across the organ booster output. As many as eight or ten booster amplifiers may be used without overloading the source. The relay current for each booster amplifier is supplied from the filament supply of the preceding booster. Therefore, if the power plug of one booster amplifier is disconnected, neither it nor any succeeding booster will operate.

G. Loud-Speaker Systems

Those consoles with built-in speakers use a special heavy-duty 12-inch unit. In some installations this speaker is removed and placed at some remote point.

The Model C-20 tone cabinet contains a heavy-duty 12-inch speaker unit plus a booster amplifier. This cabinet is 15½″ deep, 50″ high, and 20½″ wide, weighing approximately 94 lbs.

The C-20 Booster cabinet comprises the Model C tone cabinet, plus a booster amplifier. The C-20 Booster Cabinet is used when additional output power is desired.

The Model C-40 tone cabinet contains two heavy-duty 12-inch loudspeaker units mounted facing directly up. This provides for sound diffusion in the room. The booster amplifier in the base of the cabinet is similar to that in the C-20 cabinet. Extra tone cabinets can be simply plugged into each other to provide ample power for large installations.

H. Installation

In homes and small chapels the built-in speaker feature of the Minshall Models H, J and K makes installation extremely simple. It may be better, however, to have the organ music coming from a place some distance from the organist. This can be accomplished either by the addition of a C-20 booster tone cabinet or by removing the built-in speaker and mounting it in a correctly designed enclosure. Merely placing the speaker unit in a box is not enough as the reproduction of all the frequencies of organ music (32 to over 15,000 cycles) requires that the loud-speaker be correctly installed. A Minshall factory technician or sound engineer should be consulted on such matters.

I. Care and Maintenance

TUNING

Each tuning adjustment, of which there are twelve, controls the pitch of all five octaves of its respective note; *e.g.,* the tuning adjustment on tone generator chassis marked "A" controls the pitch of all the "A" notes of the instrument. The individual "A" notes will all be in exact octave relationship with each other. Therefore, to tune all the "A" notes of the organ, it only remains to set the pitch of any "A" to the correct pitch dictated by, for instance international pitch standard (*i.e.,* 440 cycles for Middle A on the keyboard). It is recommended that tuning be carried out as follows: On the Model J, K and E with the unison coupler tablet on, tune on the Great Manual using the Diapason Voice tablet only. On the Model H use the 8′ coupler and also the Diapason Voice tablet only.

NOTE: In the case of the Model J, K and E, this really means that all coupler tablets will be up, since the "unison off" coupler operates in reverse.

If a note sounds without the key being played it may be caused by a particle of dirt holding a contact open. Blow the dirt out when the key is held down, or wash the contact with cleaning fluid applied with a medicine dropper. Later models of these organs have dust shields for both manual and pedal contacts, reducing the possibility of dust particles getting between the contacts.

Key tension can be easily adjusted by raising or lowering the leaf spring over the key pin. The correct pressure is 2½ to 3 ounces. Key contacts can be adjusted so the notes sound when the key is depressed ⅛th inch. The adjustment screw is located at the back of the key.

If it is necessary to service the booster amplifier, place the C-20 Booster Cabinet on its side and remove the six screws from the bottom. The bottom panel of the one cabinet, to which the booster amplifier is attached, can then be removed. To supply power to the booster amplifier when servicing, insert the cable plug in the amplifier's own output socket. The relay may then be closed manually, and will hold as long as the power is connected.

J. Models Summary Chart

MODEL	DESCRIPTION
H	One-manual (60 note), one octave of pedal keys; tone generator of vacuum tube oscillator type; built-in loudspeaker; mahogany woodwork, dark or blonde.
J	Two-manual (60 note each) two octaves of concave radiating pedals, tone generator similar to Model H, separate registration of Swell, Great, and Pedals. Built-in loudspeaker. Mahogany woodwork, dark or blonde.
K	Two-manual, similar to J except later design, walnut case, adjustable vibrato speed and brilliance control in front panel. Built-in speaker. Pedal contacts in console.
E	Two-manual, similar to Model K but large-style console of walnut. Tone cabinet separate from console, folding top and lock.
C-20	Small tone cabinet incorporating one 12-inch speaker and a booster amplifier.
C-40	Large tone cabinet incorporating two 12-inch speakers and booster amplifier.

Wurlitzer Organs

CHAPTER VII

Wurlitzer Organs

A. General Description

The Rudolph Wurlitzer Company has been manufacturing organs in their North Tonawanda, New York plant for over 43 years. Wurlitzer discontinued its pipe organ production some years ago to devote full research, engineering and production facilities to electronic organs. Small, medium, and large size two-manual organs, as well as single keyboard instruments are available in contemporary, early American, or in traditional 18th Century console designs, finished in mahogany and walnut. If the purchaser desires, special finishes can be provided.

All the Wurlitzer electronic organs are similar in their method of tone production and differ mainly in size. They use wind-blown reeds, vibrating close to electro-static pick-ups, which convert the mechanical vibrations to electrical impulses. These are filtered, amplified, and reproduced over loud-speakers. The blower, reed chests, stop mechanism, and coupler action are all contained in the console. On smaller models even the amplifiers and loud-speakers are in the console.

Action Principle

Located beneath each manual are its associated key contact blocks, the function of which is to select and electrically energize the proper chest magnet in the windchest. The blower supplies air to the under-chest. It consists of a small motor and impeller in a soundproof box.

In pipe organ terminology, these organs are "unified" to provide the maximum variety from the several sets of reeds. In other words, a single reed may be played on both manuals and on the pedals at several pitches. For example, the Great 8′ Diapason is also playable at 4′ and 2′ pitches on the Great. Likewise one set of flute reeds is wired to serve as many as twelve different stops very much as unit pipe organs are wired. This is illustrated in Fig. 7-1. When a note is held, current flows to the stop action. If a stop tablet is down, the switch magnet (SM) will have rotated the contact blocks (CB) to touch bus bars (BB). The chest magnet (CM) will then be energized and its armature with the soft pallet attached will be pulled away from the air entrance to the reed cell allowing the reed to vibrate.

Tone Principle

In the Wurlitzer organ, the tone screws are used as the fixed member of a condenser and the tongue of the reed as the opposite pole, similar to a condenser microphone diaphragm. A direct current voltage is applied to the reed and tone screw as shown in Fig. 7-2. More than one tone screw per reed is used in some models providing a wider variety of tones or stops.

The reed is set in vibration by air pressure. As it vibrates it

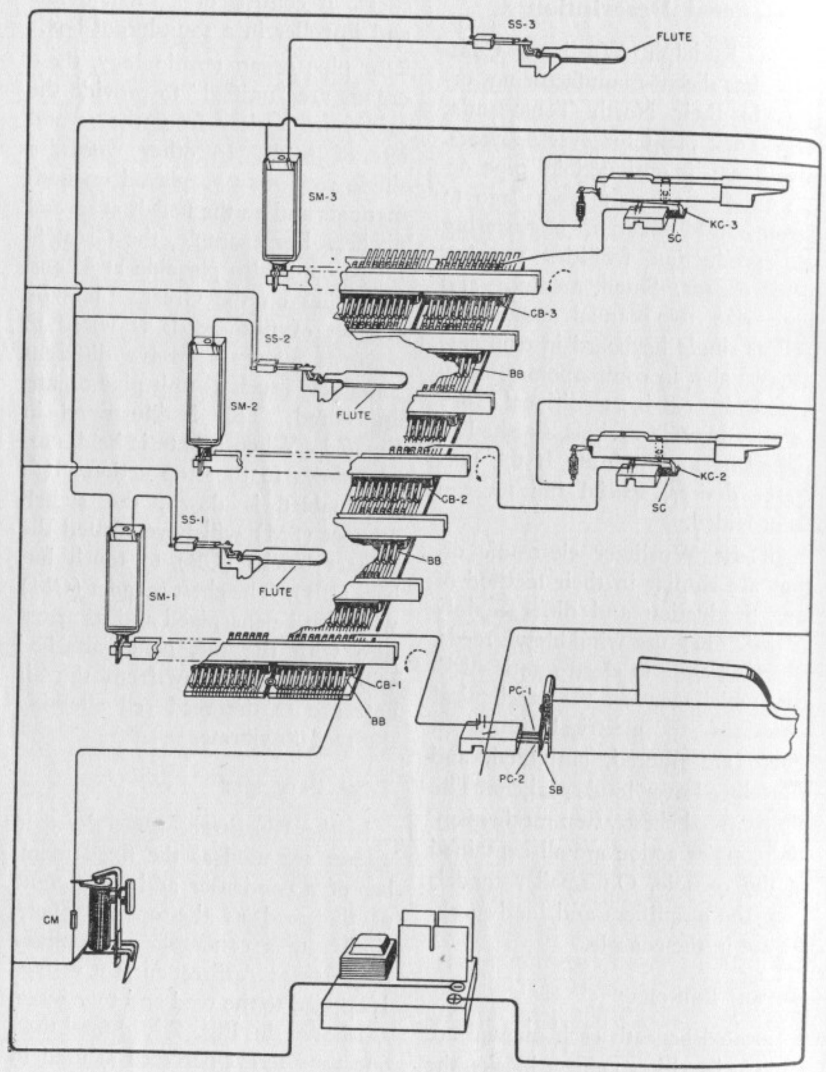


Fig. 7-1. Electric Action Diagram

changes the capacity of this condenser and causes a fluctuating charge and discharge current to flow through the resistor in series with the tone screw and reed. The fluctuating voltage developed is of a couplex wave form. The wave form is controlled by the twisting and bending of the tongue of the reed and also by the placement of the tone screw with respect to the vibrating tongue. The voltage is then amplified. It must be clearly understood that the ACTUAL TONE IN THE WURLITZER ORGAN IS NOT USED but is deadened by sound-absorbing material so that it is barely audible; only the electrical output of the vibrating reed is used.

Upon examination of a reed it will be noted that the tongue has twisted. The function of the curve and twist is to eliminate some of the unwanted harmonics and to impart to the reed a fuller tone. The twisting and bending of the reeds is known as voicing. The voicing of the reeds is done at the factory by experts.

The lowest octave of the 16′ pedal reeds employ "tone shells" as part of the acoustic structure of the unit.

REED CHART

Stop Name	Model 50	Models 10, 14 & 15	Models 5 & 6	Models 20 & 21	Model 25	Models 30, 31, 45 & 46
Flute	61	37	—	73	73	73
String	61	61	61	73	73	37
Pedal (bass)	12	—	—	24	12	—
Celeste	—	—	—	49	49	—
Diapason	—	61	61	73	—	—

B. Consoles (In Production Sequence)

The Model 20 organ (Fig. 7-3) was first produced in 1946. It is a two-manual instrument 61-notes each, with a concave and radiating 32-note pedal clavier. It includes

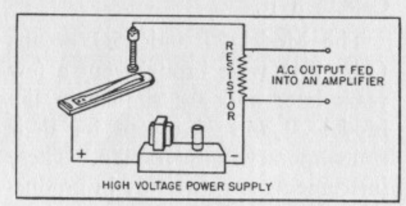


Fig. 7-2. Tone Reproduction

crescendo and expression pedals, combination pistons, and provisions for echo organ, chimes and tower amplification. All playing dimensions and console arrangements of the Model 20 conform to the recommendations of the American

Fig. 7-3. Model 20 and 21 Console

Guild of Organists. Complete specifications for this and other organs are listed on the pages that follows.

The Model 21 organ was brought out a short time later and is similar to the Model 20 except that it includes a great to pedal coupler which provides all the stops on the great manual in the pedal section except the 16 ft. pitches and the Celeste 8 ft.

The Model 25 and 25G organs (Fig. 7-4) were brought out a few years later and are similar to the Model 20 and 21 except for their contemporary case design. These instruments are currently in production. Their specifications are somewhat more different than those on the 20 and 21 as indicated in the pages that follow. Solo voices are provided on the five combination pistons with appropriate accompaniment on the other manual and pedals. A great to pedal coupler incorporated in the Model 25G permits the addition of 8, 4, $2\frac{2}{3}$, 2, and $1\frac{3}{5}$ ft. and a string mixture in the pedal division. The Model 40 Tone Cabinet and bench are also standard with the above models.

The Model 50 Wurlitzer organ (Fig. 7-5) is also a two-manual instrument, and includes a concave and radiating 32-note pedal clavier, with provisions for Echo organ, chimes and tower amplification. All Wurlitzer organs, except the single

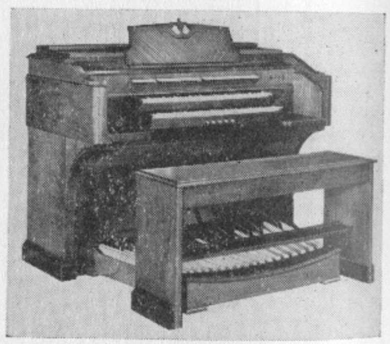


Fig. 7-4. Model 25 Console

manual models, have inclined and overhanging keyboards built in accordance with the American Guild of Organists specifications. It includes an expression pedal and electronic tremulant and is delivered with a Model 75 (40 watt) Tone

Cabinet. This is similar to the Model 40 used on the higher priced organs except that it is a standard cabinet.

The Model 30 and 31 organs (Fig. 7-6) vary in only one respect: The tone chamber for the Model 30 is contained in the organ console, while the Model 31 utilizes a separate tone cabinet. The console dimensions and stops of both instruments are identical as are the pedals, bench, and other appointment. They are two-manual instruments, standard 61-notes each, a 25-note pedal clavier. A patented re-entry system provides a faster action, yet smooth attack. Their specifications, listed later, include a variety of pitches

Fig. 7-5. Model 50 Console

which ensure many different tonal effects. The Model 31 Wurlitzer organ comes equipped with a Model 310 vertical type Tone Cabinet. Provisions are also included on these models for Echo organ, chimes, and tower amplification.

The Model 45 and 46 are similar to the Model 30 and 31 except that they have a contemporary console (not illustrated) instead of the modern lines of their counterparts. The Model 45 is self-contained and the Model 46 is furnished with a Model

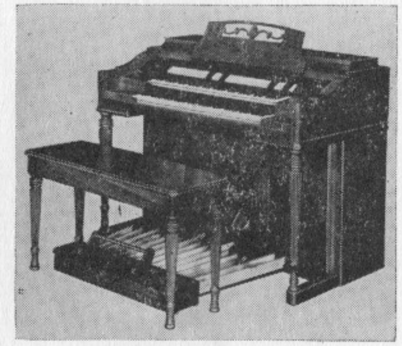


Fig. 7-6. Model 30 Organ

310 Tone Cabinet. Both Models 31 and 46 use an electronic tremulant in the bass and a mechanical tremulant in the higher registers (used on the 30 and 45).

The Wurlitzer Model 14 is a single keyboard instrument (Fig. 7-7) with conventional type tablets and 12 pedal notes. It has a self-contained tone chamber and can be delivered with a Model 150 vertical type Tone Cabinet. This Tone Cabinet gives increased tone distribution. The specifications of the Wurlitzer Model 14 (listed later) include independent tremulant and vibrato stops. The keyboard is divided with independent stops for the bass and treble registers to permit two-manual effects with the bass stops controlling the pedal section.

The Model 15 Wurlitzer organ is similar to the Model 14 with a Model 150 Tone Cabinet installed except that it does not include a self-contained speaker in the organ console.

Fig. 7-7. Model 14 Organ

C. Registration (In Numerical Order)

MODELS 5, 6 & 10

Stop Name Models 6 & 10	Stop Name Model 5	Pitch	
BASS:			
Open Diapason	Open Diapason	8 ft.	24 Notes
Dulciana	———	8 ft.	24 Notes
Violina	Violina	4 ft.	24 Notes
Dulcet	———	4 ft.	24 Notes
Tremulant	Tremulant	Affecting entire manual	
Full Organ (Model 6)			
TREBLE			
Open Diapason	Open Diapason	8 ft.	37 Notes
Dulciana	———	8 ft.	37 Notes
Violina	Violina	4 ft.	37 Notes
Dulcet			
Flute (Model 10)	———	2 ft.	37 Notes

MODELS 14 & 15

Stop Name

BASS

Open Diapason .... 8′
Dulciana .... 8′
Violina .... 4′
Dulcet .... 4′
Vibrato
Tremulant
Full Bass

TREBLE

Open Diapason .... 8′
Dulciana .... 8′
Violina .... 4′
Dulcet .... 4′
Flute .... 2′
Full Organ
Full Treble

BASS—PEDAL

Open Diapason .... 8′
Dulciana .... 8′
Violina .... 4′
Dulcet .... 4′

CONTROL

Power Switch (With Indicator Light)

PEDAL MOVEMENT

Balanced Swell Expression Pedal

MODELS 20 & 21

GREAT

	Pitch	Notes
Bourdon	16′	49
Viola	16′	49
Open Diapason	8′	61
Flute	8′	61
Flauto Dolce	8′	61
Viola	8′	61
Dulciana	8′	61
Celeste	8′	49
Octave	4′	61
Flute	4′	61
Violina	4′	61
Twelfth	$2\frac{2}{3}$′	61
Fifteenth	2′	61
String Mixture	2′	122 Ranks
Chimes (Stop Tablet only)		

SWELL

	Pitch	Notes
Bourdon	16′	49
Stopped Flute	8′	61
Flauto Dolce	8′	61
Viola	8′	61
Dulciana	8′	61
Voix Celeste	8′	49
Stopped Flute	4′	61
Violina	4′	61
Flute Twelfth	$2\frac{2}{3}$′	61
Flautina	2′	61
Oboe	8′	61
Tremulant		61

PEDAL

Major Bass	16′	32
Dolce Gedeckt	16′	32
Octave Bass	8′	32
Diapason	8′	32
Violoncello (Model 20)	8′	32
Flute	4′	32

CONTROLS

Echo to Main
Echo on—Main Off
Great to Pedal Coupler (Model 21)

PEDAL MOVEMENTS

Balanced Swell Expression Pedal
Balanced Crescendo Pedal with Indicator Light

COMBINATION PISTONS

Pistons Nos. 1-2-3-4-5 (Standard Equipment)
Actuating Stops in Great, Swell, Pedal Divisions (Under Great Manual)

MODEL 25

GREAT	Pitch	Notes
Bourdon	16′	49
Viola	16′	49
Open Diapason	8′	61
Flute	8′	61
Viola	8′	61
Dulciana	8′	61
Celeste	8′	49
Octave	4′	61
Flute	4′	61
Violina	4′	61
Twelfth	$2\frac{2}{3}'$	61
Fifteenth	2′	61
Seventeenth	$1\frac{3}{5}$	61
Mixture—IV ranks (8-12-15-19)		
Chimes		
Stop tablet and Stop Table Switch only)		

SWELL	Pitch	Notes
Bourdon	16′	49
Stopped Flute	8′	61
Quintadena	8′	61
Viola	8′	61
Dulciana	8′	61
Voix Celeste	8′	110
Stopped Flute	4′	61
Violina	4′	61
Flute-Twelfth	$2\frac{2}{3}'$	61
Flautina	2′	61
Oboe	8′	61
Tremulant		

PEDAL	Pitch	Notes
Major Bass	16′	32
Dolce Gedeckt	16′	32
Octave Bass	8	32
Quint	$5\frac{1}{3}'$	32
Super Octave	4′	32
Twenty Second	2″	32

CONTROLS
- Echo to Main
- Echo On—Main Off
- Great to Pedal (25G)

PEDAL MOVEMENTS
- Balanced Swell Expression Pedal
- Balanced Grand Crescendo Pedal (With Indicator Light)

COMBINATION PISTONS
- Pistons Nos. 1-2-3-4-5 (Standard Equipment)
- Actuating Stops in Great, Swell, and Pedal Division (Under Great Manual) Solo indicator above Swell Manual
- Great Horn
- Swell Cello
- Swell Oboe
- Great Clarinet
- Full Great

MODELS 30, 31, 45 & 46

SWELL MANUAL	Pitch
Bass Flute	16′
French Horn	8′
Clarinet	8′
Mixture	$5\frac{1}{3}'$
Orchestral Flute	4′
Mixture	$2\frac{2}{3}'$
Piccolo	2′
Mixture	$1\frac{3}{5}'$
Mixture	$1\frac{1}{3}'$
Fife	1′
Full Ensemble	
Vibrato	

GREAT MANUAL	Pitch
Cathedral Organ	
Bass Flute	16′
Diapason	8′
Tibia	8′
Strings	8′

	Pitch
Oboe Horn	8′
Cello	8′
Orchestral Flute	4′
Mixture	$2\frac{2}{3}'$
Piccolo	2′
Mixture	$1\frac{1}{3}'$
Fife	1′
Chimes (Tablet and Switch only)	

PEDAL
- Double Bass
- Octave Bass

MODEL 50

GREAT	Pitch	Notes
Bourdon	16′	49
Open Diapason	8′	61
Flute	8′	61
Viola	8′	61
Dulciana	8′	61
Flute	4′	61
Violina	4′	61
Fifteenth	2′	61
Chimes (Tablet only)		

SWELL	Pitch	Notes
Bourdon	16′	49
Stopped Diapason	8′	61
Viola	8′	61
Dulciana	8′	61
Flute	4′	61
Violina	4′	61
Twelfth	$2\frac{2}{3}'$	61
Oboe	8′	61
Tremulant		

PEDAL	Pitch	Notes
Major Bass	16′	32
Dolce Gedeckt	16′	32
Flute	8′	32
Violina	4′	32

CONTROLS
- Echo On—Main Off
- Power Switch

PEDAL MOVEMENTS
- Balanced Swell Pedal

D. Tone Generators

Free reeds are used in these instruments to produce the fundamental and harmonic frequencies. These reeds establish their frequencies by means of narrow tongues of thin and elastic metal, each of which is set in an individual metal frame, provided with a rectangular orifice, above which the tongues, being slightly smaller, are affixed at one end, so that when in movement, the unattached end is free to vibrate into and out of the orifice in the frame without touching at any point. All reeds used in this organ are tuned in accordance with the equally tempered scale. The harmonics created by the reed are natural ones, bound up with their corresponding fundamentals.

The reed, like a string or air column, does not usually vibrate at one frequency only, for, besides its fundamental, it produces overtones or harmonics. These are higher in rate of vibration than the fundamental. The number of each harmonics or partials depends to some degree upon the manner in which the reeds were originally put into vibration, their materials and distribution of the metal, scaling, voicing treatment, air chamber in which reed individually vibrate, and electronic control of all the vibratory elements.

Each reed has associated with it a "tone selector" adjusted over a predetermined portion of the reed tongue, according to the extent of harmonic elimination desired, to produce tones of various characteristics. The tone selectors are connected to the input of an audio frequency amplifier in such manner as to generate electrical impulses in response to the mechanical vibrations of the reeds. The reeds of the various tonalities are connected to polarizing voltages from the power supply. Between the tone selectors and the reeds exists what is known as an electrostatic charge. The movement of the reed tongue varies this charge, thus setting up an alternating current that is transmitted to the grids of the vacuum tubes. These electrostatic impulses created by the various tone-producing elements are then conveyed to the main amplifier, and to the speaker cabinets.

The underchest, magnet, and pallet board assembly is the heart of the organ. The underchest is in effect a reservoir which receives currents of air from the blower, storing it in a large volume and supplying it at constant pressure when needed. The pallets are a part of the chest magnets. They cover openings which lead into individual reed cells. When the chest magnets are energized through a key or pedal contact and the stop action switches, each pallet uncovers a hole which allows wind to vibrate the reed. Pressure is from 2½ to 3 inches. (See Fig. 7-10).

Since the reeds at the low end of the pedal chest are necessarily very

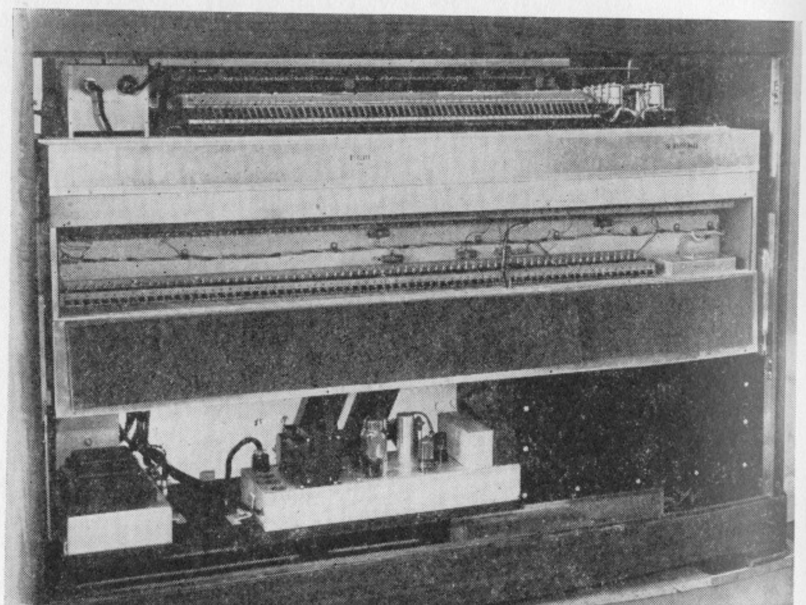


Fig. 7-8. Rear View of Model 25 Console

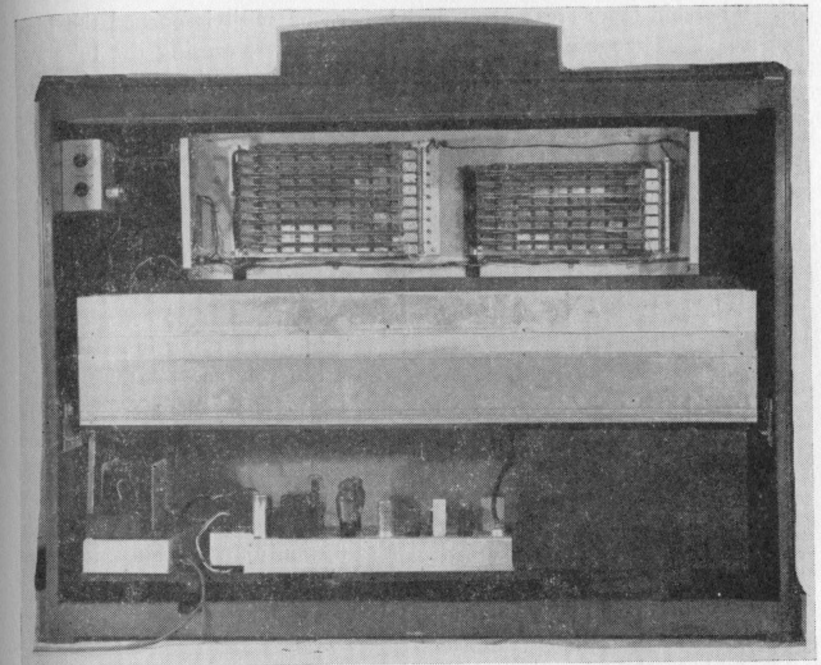


Fig. 7-9. Rear View of Model 50 Console

large, they have an inertia which keeps them vibrating a short time after the pedal key is released. Later organs used pedal-shorting switches which removed the polarizing reed voltage from the low 12 notes after the note was released. Latest models incorporate this feature on the lowest 24 notes.

E. Amplifiers and Power Supplies

The preamplifier is located inside the console (See Figs. 7-8 & 7-9). In this unit all electrical impulses from the reeds are mixed, classified, and amplified. They are then distributed to the tone cabinet junction units. Various adjustments are provided on the preamplifier such as tremulant, main tone cabinet volume, and pedal compensator. Receptacles are included for connections to the console, tone cabinet, echo cabinet, swell pedal, and windchest.

The line amplifiers or power amplifiers are mounted in the tone cabinet (except the Model 70 and 80 cabinets, which contain only speakers). The signal from the console preamplifier enters a junction unit on the 40, 42 and 75 cabinets, containing a bass-treble cross-over network. On the Model 310, 60 and 62 the network is on the output of the amplifier. By this means the bass and treble tones are separated, each frequency range affecting only its corresponding power amplifier. The treble and bass amplifiers are identical, one driving the 12-inch speakers and the other the 15-inch speakers.

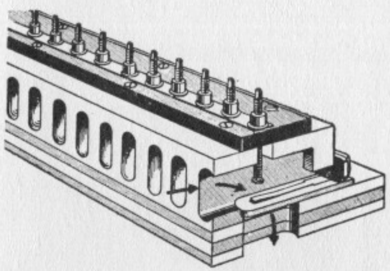


Fig. 7-10. Path of Wind Through Reed Cell

The tone cabinet junction provides a relay to control the power to operate the life amplifiers. An adjustment within this junction unit makes it possible to adjust the treble frequency volume level.

The power supply for the chest magnets is of the low-voltage, direct-current type. The rectifier unit is a full-wave selenium cell capable of handling more current than demanded by the full organ.

Incorporated in the newer preamplifiers is an electronic tremulant consisting of 6SN7 tube oscillator. This operates at 6½ c.p.s. to control the amplitude of the organ signal being fed to the first audio tube of the line amplifiers. The tremulant is turned on by the stop tablet. A three-stop amplitude control is included on the preamplifier.

The swell or expression consists of a bias control on the 6SK7 tube. When the swell is opened the bias goes negative, causing the tube resistance to go up, thus increasing the volume of the organ. When the pedal is closed the bias decreases, causing the tube resistance to lower. Early models used a tapped resistor control whereas newer models use a potentiometer control.

Tone compensators are provided on several models of consoles and tone cabinets, making it possible to adjust the volume and tone of an installation to fit room acoustics or personal taste. A pedal adjustment on the preamplifier provides a means of setting low frequency volume. A treble volume adjustment, located on the junction unit, regulates the relative high-frequency power being delivered to the treble speakers in that tone cabinet, with no effect on any other tone cabinets in the system.

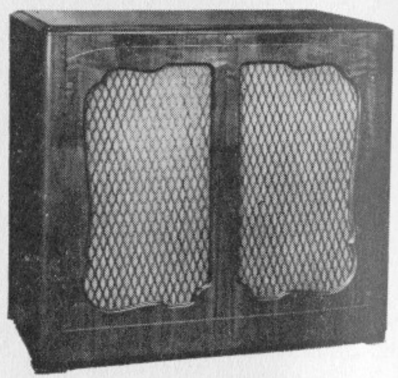


Fig. 7-11. Model 40 Tone Cabinet

F. Tone Cabinets

The Model 40 tone cabinet (Fig. 7-11) may be obtained for installation with the Series 20, two-manual Wurlitzer organ. Finished to match the console itself, this unit is recommended where the tone cabinet is visible. Dimension: 35 13/16″ high, 38 5/16″ wide, 21¼″ deep. Weight: approximately 250 lbs.

The Model 42 tone cabinet (not illustrated) containing the speakers, necessary electrical components, and cable is standard equipment with the Series 20, two-manual organ. This unit is for installation where the tone cabinet is concealed from view. Dimensions: 35¾″ high, 38⅛″ wide, 21⅜″ deep. Weight: approximately 250 lbs.

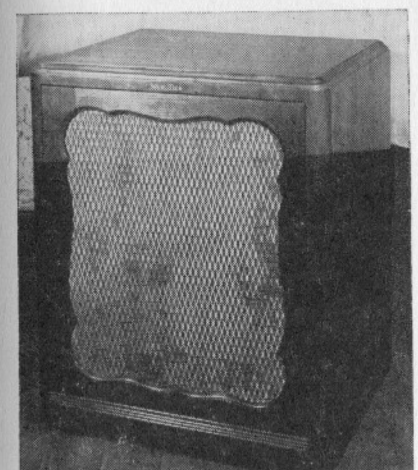


Fig. 7-12. Model 60 Tone Cabinet

The Model 60 tone cabinet (Fig. 7-12) is similar to the Model 62 cabinet, except for styling. The 60 case is finished in walnut and intended for a visual installation. Dimensions: 24⅝″ wide, 19⅜″ deep, 30¾″ high. Weight: approximately 110 lbs.

The Model 62 is for echo and antiphonal effects, and for processional and recessional music. It is designed for a hidden or concealed installation. Dimensions: 24⅝″ wide, 19¼″ deep, 28½″ high. Weight: approximately 110 lbs.

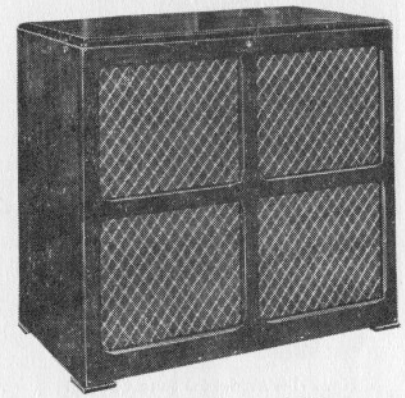


Fig. 7-13. Model 75 Tone Cabinet

The Model 75 tone cabinet (Fig. 7-13) is standard equipment with the Series 50 Console. It is designed for either concealed or exposed installation. Dimension: 38⅛″ wide, 21¼″ deep, 35″ high.

The Model 80 "Echo" tone cabinet (Fig. 7-14) is for echo or antiphonal effects, for processional or recessional music. Dimensions: 24⅜″ wide, 19⅜″ deep, 30¾″ high.

The Model 150 tone cabinet (Fig. 7-15) contains a 15-inch speaker, and a 20-watt amplifier. It is usually employed with the Model 14 Console.

The Model 310 is a vertical tone cabinet (Fig. 7-16) containing a 15-inch bass speaker at the bottom, a 12-inch treble speaker in the central portion, a tremulant vane and motor over this speaker, and two power amplifiers at the top (Fig. 7-19). Sound is distributed from several tone openings making the cabinet quite non-directional.

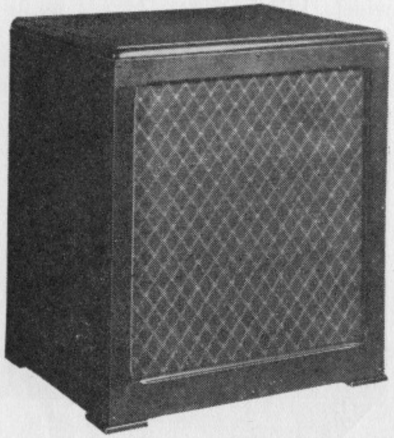


Fig. 7-14. Model 80 Tone Cabinet

G. Installation

The following advice for architects and builders includes a list of work which may have to be done to buildings before the organ can be installed to meet building code regulations. All of the items are subject to the recommendations of the dealer and his trained Wurlitzer Organ Technician.

ELECTRICAL

1. Check available power as to voltage, frequency, and stability.
2. Install electrical conduit and junction boxes for power lines, or revamp present wiring to meet electrical requirements.
3. Run connecting cables of Wurlitzer organ and auxiliary equipment through conduit.
4. Install terminal boxes, flush plates, and receptacles for power lines and Wurlitzer connecting cables.

STRUCTURAL

1. Provide necessary opening or openings in walls for tone cabinets.
2. Provide necessary supports for tone cabinet and all other auxiliary organ equipment. Supports to be rigid and safe.
3. Provide easy access to tone cabinet and auxiliary equipment for service purposes.

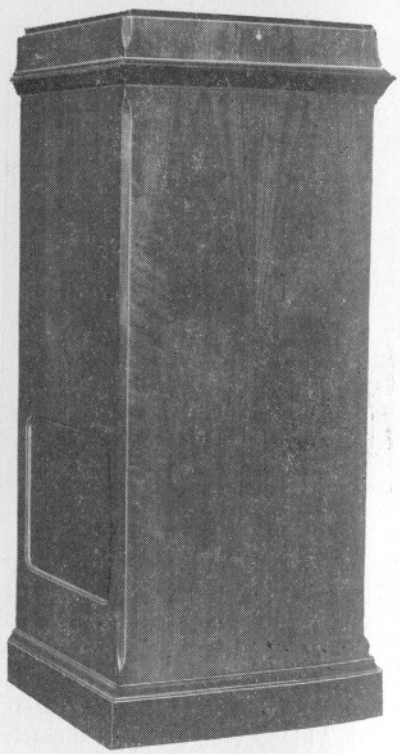


Fig. 7-15. Model 150 Tone Cabinet

4. Provide recess or pit for console if required.
5. Provide easy access to console for servicing.

PLACEMENT OF THE CONSOLE (Church Installations)

It is important that the organist be able to see the choir and choir director when seated at the console. Also, in some churches it is important for the organist to be able to see the clergy.

Fig. 7-16. Model 310 Tone Cabinet

Because the console may need proper servicing it is advisable that sufficient space be allowed around it. A minimum clearance between the back of the console and wall or other obstruction should be 36 inches.

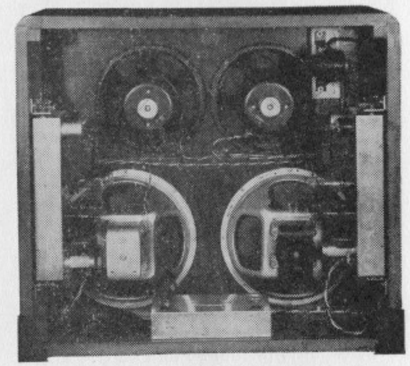


Fig. 7-17. Model 75 Tone Cabinet (Rear View)

LOCATION OF THE TONE CABINET (Church Installations)

In a church or an auditorium installation, a good location for the tone cabinet is the organ loft or chamber (Fig. 7-21). However, careful consideration should be given to the following points before the final location is decided upon.

The tone cabinet or cabinets should be located so that the organist received its tones directly without either blasting or being too weak. In addition, the choir should also receive the tones emitted without any acoustical obstructions.

A good rule to remember is to place the tone cabinet or cabinets so that the tones may be free and directly accessible to the place where it is to be heard. The congregation or audience should receive as many unobstructed tones from the tone cabinet as possible.

The tone cabinet or cabinets should be located near the console.

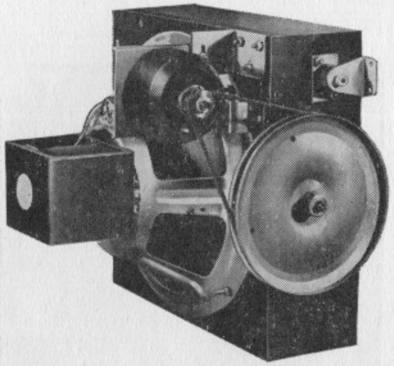


Fig. 7-18. Tremulant and Speaker Mechanism (Model 30 and 45 Organs)

If they are located too far away, the organist will find the organ difficult to play because of the time lag which may be present between the time the organist presses the keys and the time it takes the tone from the tone cabinet to reach the organist's ear. This is especially true in large churches and auditoriums.

The tone cabinet or cabinets may need service. Therefore it is advisable to provide easy access to these cabinets.

The opening in the organ loft or chamber should face the main auditorium. This opening should be large enough so that a minimum of 12 inches is allowed for clearance on both sides and top of the cabinet. Refer to the Typical Installation Diagram, Fig. 7-20. If the choir is situated behind and to one side of the main opening, another opening should be made facing the choir. The opening for the choir should be equivalent to the main opening, or slightly smaller, if space does not permit. The minimum should be equal to the area of the front of the tone cabinet. The front and side chamber openings can be covered with an appropriate grille.

The tone cabinet or tone cabinets sound best when they are elevated. A minimum distance of 7 feet from the floor level to the bottom of the openings is essential. The back of these cabinets should not be placed against a wall or obstruction so as to prevent the flow of air in and out. The minimum distance from the tone cabinet back to a wall or other obstruction should be 15 to 24 inches. Excessive blocking of speakers will cause distortion of low notes.

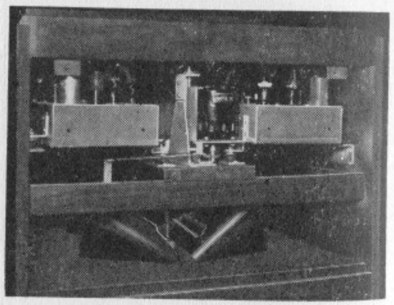


Fig. 7-19. Upper Portion Model 310 Tone Cabinet Showing Tremulant Mechanism

It is recommended that all tone cabinet cables be run in ¾ inch conduit. This conduit should run from behind the console to the back of the tone cabinet. If two tone cabinets are used, a ¾ inch conduit

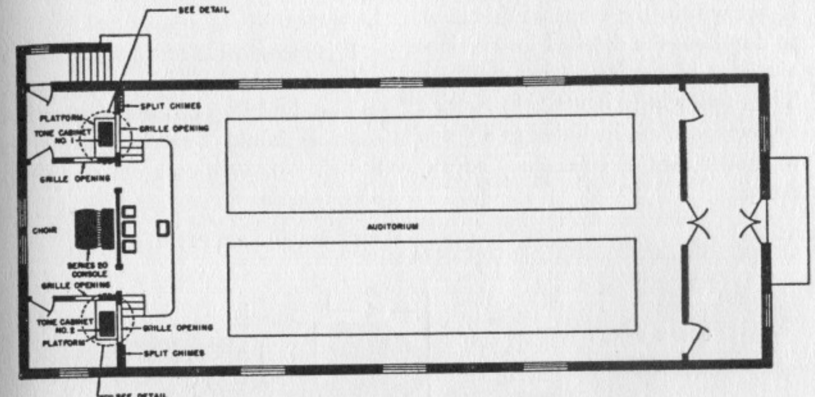


Fig. 7-20. Typical Church Installation Using Two Tone Cabinets

should be run from behind the console or from behind the first tone cabinet—whichever is closer to the back of the additional tone cabinet. Where more than two tone cabinets are planned, each succeeding tone cabinet should have a ¾ inch conduit running from behind the previous one to behind the new cabinet. This is similar to a series circuit.

All of the conduits to the console should terminate in a suitable box located 36 inches behind the console and approximately 15 inches from the left end of the console with the observer facing the back of the console. All of the cables to the tone cabinets should terminate in a suitable box located 25 inches behind the cabinets.

H. Maintenance and Adjustment

The Wurlitzer organs are unlike most of the other electronic organs in that they are a combination of three basic families of organ components. Some of the mechanism has been developed from pipe organ background; the tone-generating portions are familiar to the reed-organ industry; and the electronic elements are quite standard with modern audio industry. Because of these categories, it is not practical for the owner or organist to attempt his own care and maintenance work.

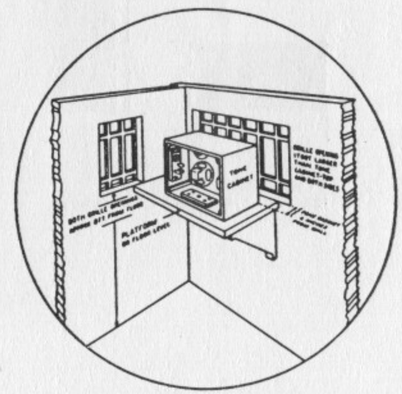


Fig. 7-21. Mounting Tone Cabinet in Organ Chamber

A school is maintained at the factory to train field personnel in the proper care of these organs. It is not within the scope of this book to duplicate the detailed instructions available in the Wurlitzer manuals. The following items of routine maintenance are included as a guide to proper care or emergency adjustments.

LUBRICATION

It is recommended that the blower motor be oiled at least twice a year.

The bushing on the expression control should be lubricated with S.A.E. No. 10 motor oil, one drop once a year.

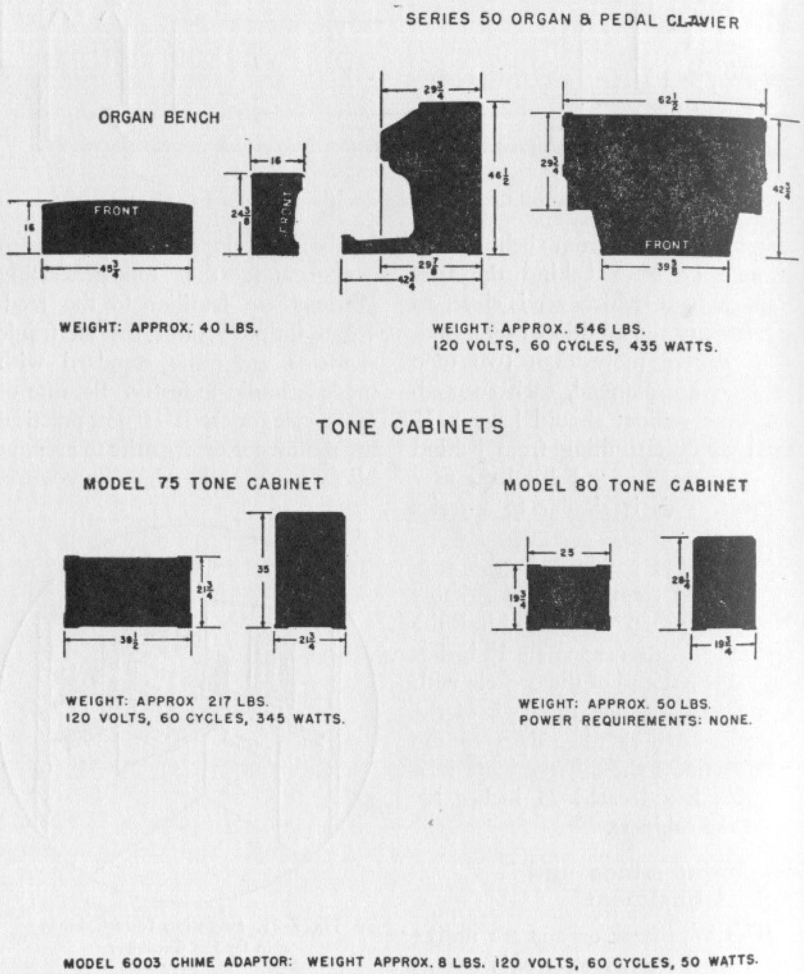


Fig. 7-22. Model 21 Organ Dimensions

ADJUSTMENTS

There are several points in the organ where tonal adjustments can be made by an organ technician. Some of these are listed here:

1. Overall volume of organ.
2. Pedal compensator volume adjustment.
3. Treble divider volume control.
4. Tremulant "depth" control.

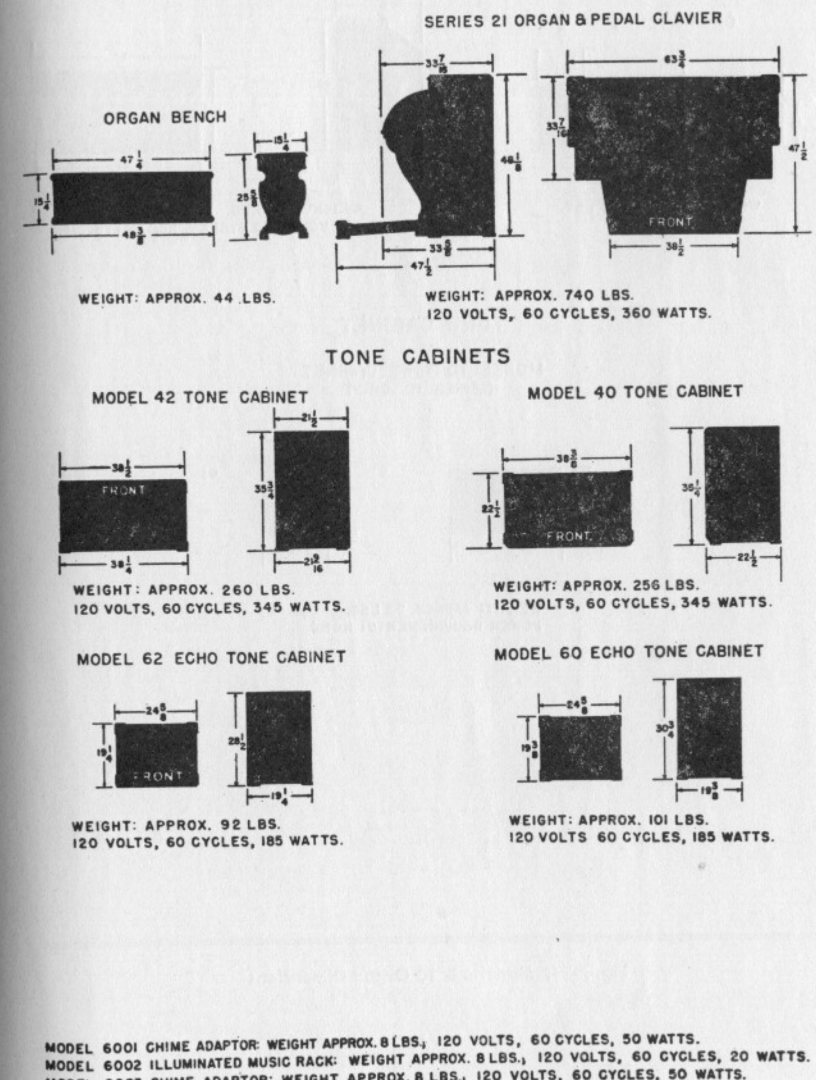


Fig. 7-23. Model 50 Organ Dimensions

5. Tone screw volume adjustment.

6. Dulciana and Dolce intensity adjustment.

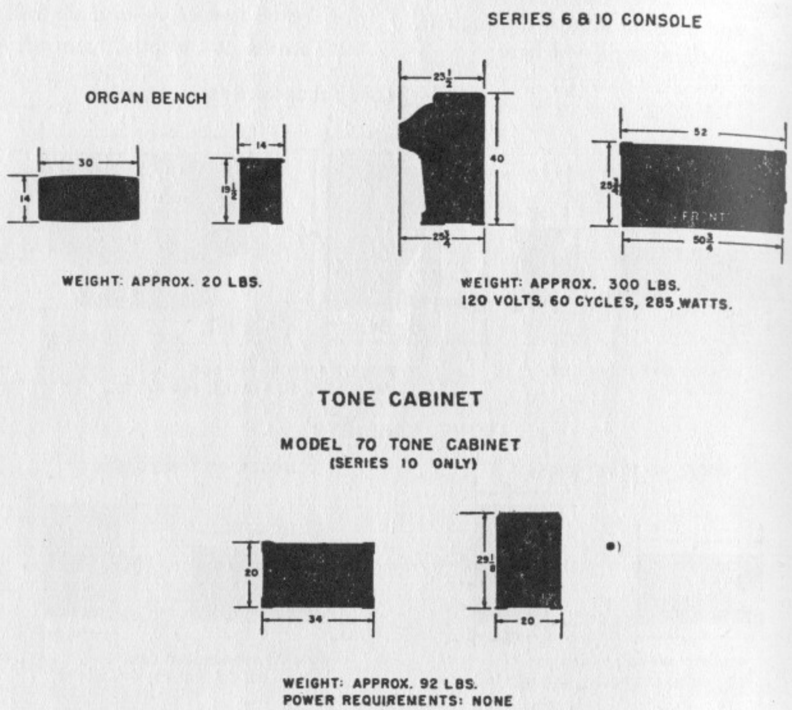


Fig. 7-24. Model 6 & 10 Organ Dimensions

I. Models Summary Chart

CONSOLE MODEL	DESCRIPTION
5 & 6	The smallest single manual (61-note) organ, no pedals, built-in speaker. Keyboard "split" at middle C.
10	Similar to Model 5 except for external tone cabinet.
14	Single manual, 12-note pedals, 5-octave keyboard, built-in speaker. Keyboard "split" at middle C.
15	Similar to model 14, except for external tone cabinet.
20	Two-manual, 32 note A.G.O. pedals, combination pistons. Swell and crescendo pedals, curved pull-down top.
21	Similar in appearance to Model 20, slight variation in registration including Great to Pedal coupler.
25	Two-manual, 32-note pedals. Combination pistons. Swell and crescendo pedals, folding top.
25G	Includes Great to Pedal coupler.
30	Two-manual, 25-note flat pedal, built-in speaker. Folding top, tilt tablet registration.
31	Similar to Model 30 except for external tone cabinet.
45	Similar to Model 30 except for Gothic style case. Built-in loud-speaker.
46	Similar to Model 45 except for external speaker.
50	Two-manual, 32-note pedals, one Swell pedal, stop key registration.

ELECTRONIC ORGANS

TONE CABINET MODEL	DESCRIPTION
40	De luxe Model contains two 20-watt amplifiers. Two 12-inch and two 15-inch speakers, mechanical tremulant.
42	Similar to Model 40 except for standard case.
60	De luxe Model tone cabinet contains one 12-inch and one 15-inch speaker and mechanical tremulant; and one 20-watt amplifier.
62	Similar to Model 60 except for standard case.
70	Used with Model 10 console, two 12-inch speakers. No amplifier; no tremulant.
75	Similar to Model 40 except later tremulant design.
80	De luxe model case containing one 12-inch speaker.
150	Vertical tone cabinet contains 20-watt amplifier. One 15-inch speaker.
310	Vertical tone cabinet contains two 20-watt amplifiers; one 12-inch and one 15-inch speakers; mechanical tremulant (12″ only).

Other Products

CHAPTER VIII

Other Products

NOTE: Because of space limitations it was possible to include complete data on only the organs produced by the major builders of this country. Rather than omit the many other electronic organs and instruments which have reached the market in the past, they are covered briefly in this chapter. Some of these organs are in current production on a relatively small scale and details of these can be obtained from the manufacturers. Others have been discontinued either through lack of materials, financing, or public acceptance.

A. Organ Attachments

1. Lowery Organo

This instrument, manufactured by the Central Commercial Industries, Inc., Chicago, provides the piano owner with a compact one-manual electronic organ. It can either be attached to any standard size piano or can be purchased already built into a new piano. Fig. 8-1 shows the Organo installed on a spinet type piano, using concealed keying contacts and pedal attachment. Fig. 8-2 shows the placement of key contacts below the piano keys. The key contacts are easily installed over the keys on existing pianos.

In some installations the tone generators, amplifiers and loudspeaker are installed within the piano, mounted as in Fig. 8-3. Where these components are external they are contained in a cabi-

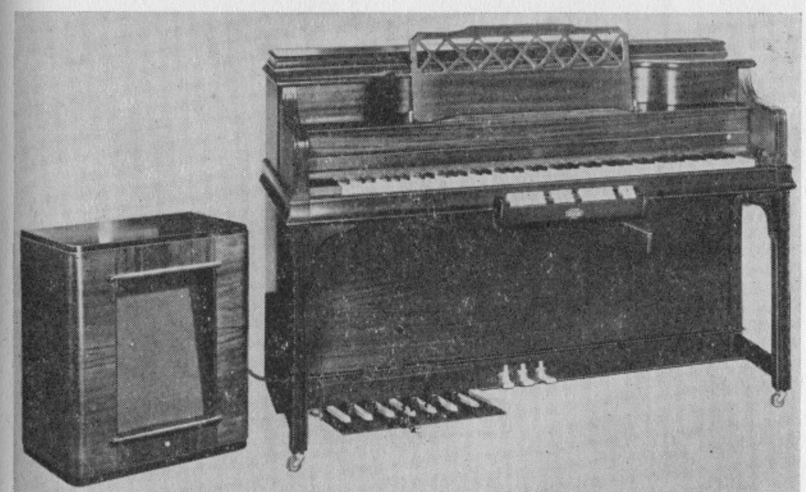


Fig. 8-1. Lowery Organo Installed on a Piano

net alongside the piano. An underside view of this unit is shown in Fig. 8-4.

The tone generator is of the vacuum tube type. A tone control panel fastens under the edge of the piano keyboard and provides vari-

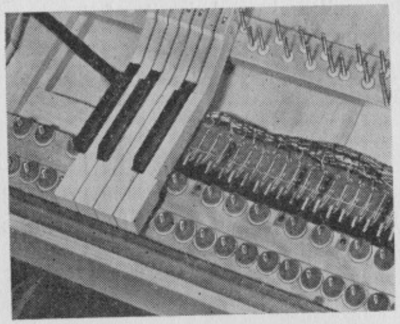


Fig. 8-2. Organo Under-Key Contacts

ous tone selection for both right and left hand as well as variations in vibrato and an expression control. There are 60 type 12AX7 tubes in the generator chassis (one for each note).

The unit consumes about 275 watts and uses 110-125 volts at 60 cycles.

The tone cabinet uses one 10-inch heavy duty speaker. Booster cabinets are available for large installations, using one 15-inch speaker and a booster amplifier. Several styles of tone cabinets are available to match the room decor.

The Organo is so designed that it can either be played alone (by silencing the piano hammers) or played with the piano or the piano played alone. These features coupled with the split keyboard registration provides a wide variety of musical effects.

Registration is as follows:

Lower Register
- Flute F
- Diapason F
- Horn F
- Cello F
- Viole P

Lower Solo Switch
Register Divide Switch
Upper Solo Switch

Upper Register
- Flute F
- Diapason F
- Horn F
- Cello F

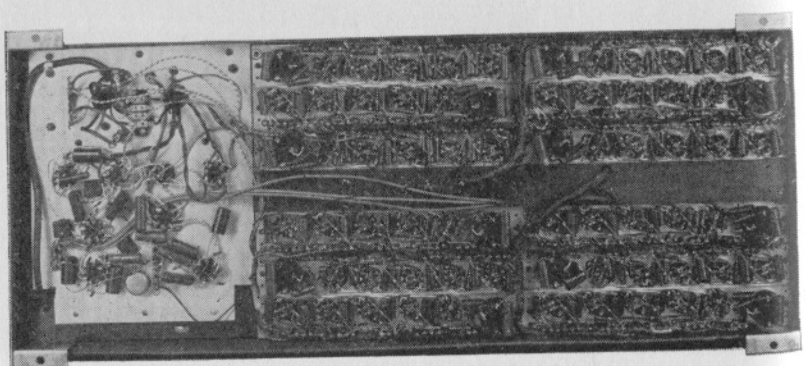


Fig. 8-3. Organo Built-in Installation

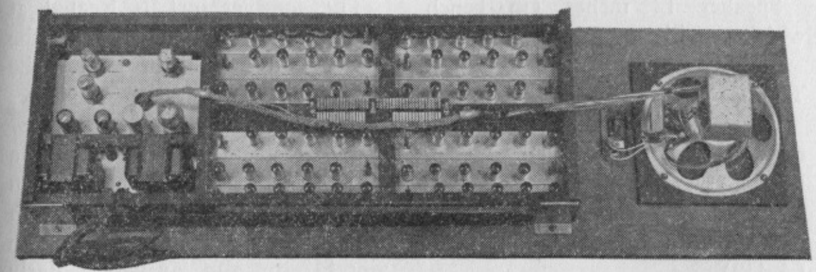


Fig. 8-4. Under Side of Organo Chassis

- Viole P
- Light Vibrato
- Heavy Vibrato
- Expression Control

2. Pedal-Vox

This attachment was manufactured by Michigan Tone Products in Detroit. It is a bass accompaniment for pianos and organs. With the piano it provides a means for practice in the home. With the organ it provides a means for an organist to provide bass with the feet.

SPECIFICATIONS

PEDALBOARD	Model 3B
Tension—	adjustable
Height—	3 inch (Blocks placed under the ends of the piano or organ will provide space for the pedalboard.)
Width—	50½ inches (There must be at least 50½ inches of space separating the blocks.)
Material—	All pedals hard wood maple
Measurement—	A. G. O., 32-note concave, radiating

BENCH

Detachable and adjustable.
Length—45½ inches.
Width—12½ inches.
Foot rest attached to bench.
Mahogany finish.

AMPLIFIER (in bench)

Tone control.
Swell control.
Stops 16′ and 8′
The above controls have cables of sufficient length for attaching to organ if desired.

Speaker 12 inches (in bench which provides a tone cabinet).

Output 5 to 10 watts.

TONE

Deep mellow diapason (rendered richer with tone control).

NOTES

Individually tuned to any piano or organ at international pitch (A-440).

Forty-four pitch controls; 16′ and 8′ tones.

3. Solovox

This instrument has been manufactured for several years by the Hammond Instrument Co. of Chicago. Earlier models were designated as J and K. Current models are type L. The keyboard and stop

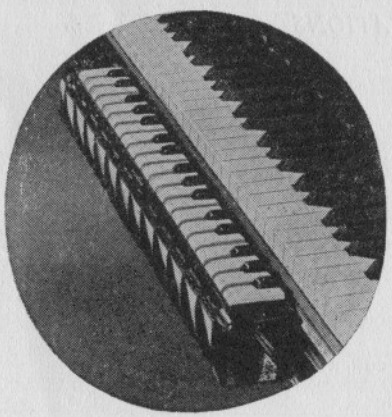


Fig. 8-5. Solovox Attached to Piano Keyboard

control box can be attached to almost any keyboard instrument such as a piano or organ (Fig. 8-5) to provide a variety of solo (single note) voices.

The tone cabinet is located at the end of a cable and houses the vacuum tube generators and the loud-speaker. A selection of pitches such as *soprano, contralto, tenor* and *bass* are available as well as a variety of tone colors. The unit can be tuned to the piano or organ on which it is mounted. Variations in vibrato are also available. Early models used a vibrating reed to produce vibrato whereas now a vacuum tube oscillator does this job.

Technical details of the Solovox can be obtained from the manufacturer.

4. Haygren Electronic Harp-Organs

This attachment is manufactured by the Haygren Organ Co. of Chicago as a supplement to pipe organs. It is completely electronic, using vacuum tube oscillators for tone generators. It provides not only a number of additional stops or voices for existing organs but adds percussion effect such as harp, vibra-harp, chimes, etc.

The organ builder can utilize the harp-organ for inclusion in new work, or when rebuilding for adding a choir division to existing two-manual organs. The specifications have been prepared with these applications in mind. An echo or antiphonal organ can easily be obtained from the harp-organ by the addition of one extra speaker unit.

The Model C harp-organ is a full range instrument of 61 notes. It has been designed to be played from the organ keyboard, usually

the Swell, by connecting it to the main junction board in the organ chamber. The relays used to key the harp-organ are very high resistance so that the load on the organ key contacts is not materially increased. When connected in this way the regular organ couplers effect the harp-organ thus making the harp-organ stops available at several pitches on each manual.

Three basic units comprise the harp-organ. These are the tone generator unit, the speaker unit, and the speaker unit, and the console control unit. The tone generator unit consists of the tone oscillators, the amplifier and power supplies, and the temperature compensating device. This unit is preferably placed in the organ chamber, but it can be located in some remote spot. The speaker unit is placed in the organ chamber behind the shutters so that the harp-organ is under the same expression as the rest of the organ. The console control unit mounts on the stop board or the side jambs of the pipe organ console. It contains twelve stop keys and two knob controls. One knob is a general volume control. With it the organist can instantly set the volume level of all stops. The second knob is a general tuning control. With it the harp-organ can be kept in tune with the pipe organ over a wide temperature range. More than this, detuning the harp-organ slightly by a touch of the tuning control makes possible a number of celeste effects, including a Flute Celeste, an Unda Maris, a Voix Celeste and a Harp Celeste.

SPECIFICATIONS

Stop Key Controls (8′)

1. Principal
2. Concert Flute
3. Flute Dolce
4. Violonello
5. Muted Viol
6. Dulciana
7. Clarinet
8. English Horn
9. Percussion (See note)
10. Light Tremolo
11. Full Tremolo
12. Harp-Organ Off
    Echo On

Knob Controls

1. Master Volume
2. Tuning

Space Requirements

Console control unit:
11½″ x 3″ x 2½″

Tone generator unit:
Floor area 18″ x 36″, 34″ high

Speaker unit:
12″ x 22″ x 28″

Power Requirements

Approximately 450 watts 110-120 A.C. 50-60 c.p.s.

NOTE: The Percussion Tablet applies the percussion effect to any stops registered on the harp-organ. If added to the concert flute, a beautiful organ harp is obtained, with or without tremolo. Added to a string tone, a harpsichord is produced. Played in the upper register with couplers, bell effects of many types can be obtained. By special wiring, a number of carillonic effects are possible. All of the percussions are well adapted to tower amplification.

5. Glenntone Organ Speaker

This attachment is manufactured by Mid American Enterprises of Chicago and consists of a tone cabinet complete with amplifier, speakers and mechanical vibrato. It is designed for any electronic organ where a different type of tone is desired than can be obtained from the loud-speakers supplied with the console.

Fig. 8-6 shows the complete Glenntone cabinet. The upper-half consists of a reverberant tone chamber housing one 15-inch Jensen speaker, for reproducing low tones down to 32 cycles (low C of 16′ organ pedals). The lower-half houses the power amplifier, two Jensen horns and a rotating agitator which produces the vibrato. The combined tones of the large and small speakers are "fanned" by this whirling baffle, throwing the sound in all directions.

The cabinet is 51 inches high, 30 inches wide and comes in a variety of finishes. A switch is provided which attaches to the console to give two variations in vibrato intensity. Built-in tone and volume controls make it possible to adjust the cabinet to the room acoustics upon installation.

B. Discontinued Electronic Organs

1. Orgatron

This line of organs was manufactured by the Everett Piano Co. of South Haven, Michigan, from 1934 to 1940. The manufacture of

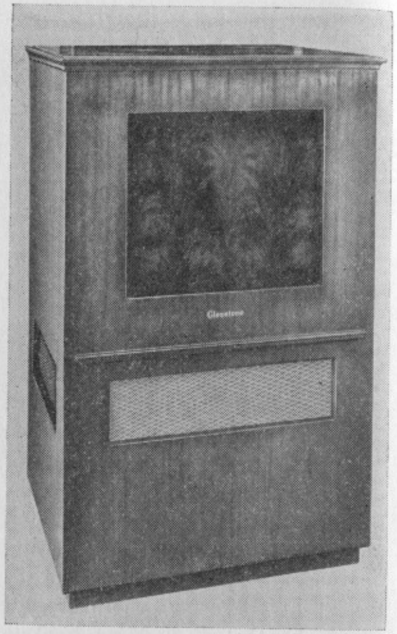


Fig. 8-6. Glenntone Speaker

the product was then taken over by the Wurlitzer firm which continued to build the organs under their own name after World War II. The latest of the Orgatrons, therefore, bear a similarity to the early Wurlitzers. Their technical aspects can be studied by referring to Chapter VII.

The first Orgatrons were one-manual models called LS-1 and LS-2, with draw-knobs on each end of the manual and a separate tone cabinet. Then followed the MD, two-manual and 32-pedal console, which is to this time the largest organ of its type. The key action was of the pneumatic type, operating up to 10 ranks of reeds. Two expression pedals were provided.

The next model was called STM; it was also pneumatic action but was reduced to about 5 sets of reeds. Two styles of consoles were built, one of which is shown in Fig. 8-7.

The next development was the electric key action which was employed on the Model 600, a 2-manual, 32 pedal console with separate tone cabinet. This organ had about the same registration as the STM.

The last of the two-manual models was the Model 700 which was produced in limited quantity. This utilized about 2½ sets of reeds in its tone generation system.

A single manual Orgatron was also produced, called the Model 5, which contained its own loud-speaker. Stop tablets were of the "domino" type, located at each end of the manual. These were registered in the "split keyboard" manner.

2. Novachord

The Hammond Instrument Company produced this one-manual, seventy-two note instrument (Fig. 8-8) before World War II. It is unique among organs in that the player may control the "attack" and/or "decay" characteristics of the tones produced. The control panel above the keyboard (Fig. 8-9 and 8-10) contains the various controls effecting the tones. Below the keyboard are the sustaining pedals and expression pedal.

The tones of the Novachord originate in vacuum tube oscillator and divider circuits. There is an oscillator and five dividers for each of the 12 notes of the musical scale. There are 72 control tubes plus 2 pre-amplifiers and seven amplifier tubes. The separate power supply contains 10 tubes. The loud-speaker system consists of two 12-inch units mounted below the keyboard.

Fig. 8-7. Orgatron Two-Manual Console

Tone Controls

The first six controls at the left side of the control panel are the tone controls. "Deep Tone" is a low pass filter which emphasizes the lower frequencies; "First Resonator," "Second Resonator" and "Third Resonator" are tuned circuits which emphasize particular ranges of frequency; "Brilliant Tone" is a high pass filter which emphasizes the higher frequencies; "Full Tone" passes all frequencies equally.

The tone controls are connected in the output circuit of the tone generator and act on all notes of the instrument. Each has three loudness positions in adidtion to "Off."

When all six are "Off" no sound may be produced by the instrument.

Balancer

The Balancer, located in the center of the control panel, slightly reduces the volume of the lower half of the keyboard by shunting fixed resistors across the output circuits. In position 3 (strong bass) it is open and has no effect.

Bright-Mellow Control

This control, located above the Balancer, effects the entire keyboard except the lower 18 notes. In the mellow position it closes switches which reduce the harmonic content of the tone by introducing condensers into the control tube circuits.

Attack Control

The tone of the Novachord may be made percussive, with a sharp attack after which the tone gradually dies away, or the tone may be made to have a perceptible period of growth after which it is sustained as long as a key is depressed. These effects are governed by the attack

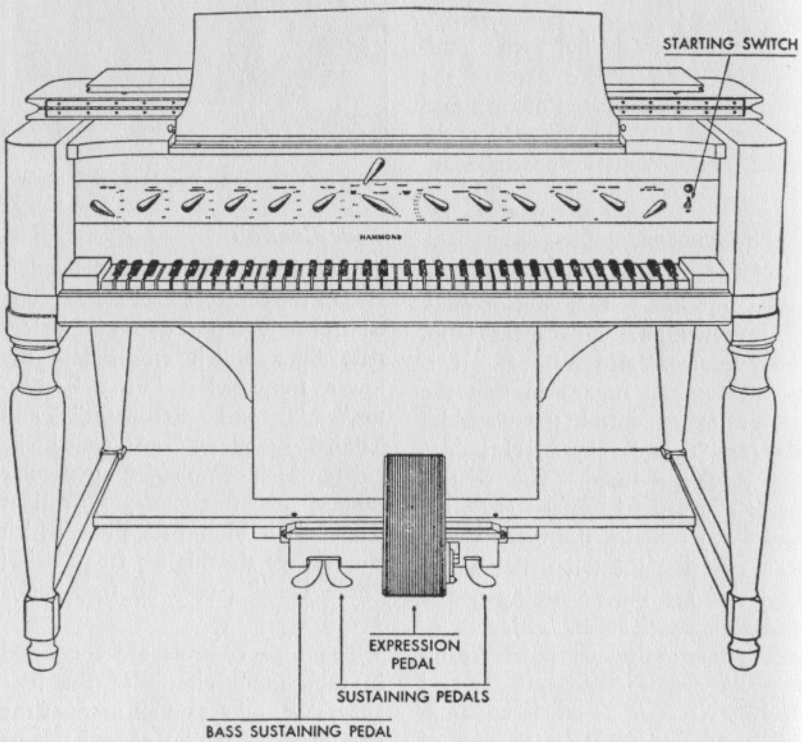


Fig. 8-8. The Novachord

control which is located at the right of the balancer. The attack control has seven positions ranging from "Fast" to "Slow" and operates a multi-contact switch which varies the operating voltage applied to the key circuits.

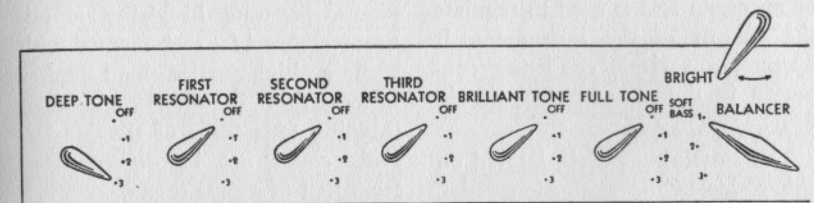


Fig. 8-9. Left Side of a Control Panel

Combination Control

The Combination Control is a mechanical device which simultaneously moves all controls necessary to obtain two contrasting types of tone most generally used. It has two positions, "Percussion" and "Singing." When the other controls are operated, the combination control in most cases returns to a neutral position half way between its operating positions.

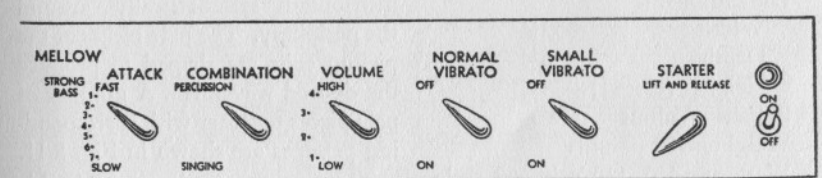


Fig. 8-10. Right Side of Control Panel

Volume Control

This control is supplementary to the expression pedal and serves to limit the maximum volume of the instrument yet preserves the full range of the expression pedal. It has four positions, position 4 being the loudest.

Vibrato Controls

The vibrato controls introduce a periodic variation in frequency or pitch of all notes. The effect is produced by six vibrating reeds within the instrument. "Normal Vibrato" and "Small Vibrato" controls each introduce a certain amount of this effect. "Normal Vibrato" produces a greater variation than "Small Vibrato," and both may be used together to increase the effect.

Vibrato Starter

This device is used to start the motion of the vibrato reeds each time the Novachord is turned on. The reeds will often start themselves, but for reliable operation they must be started manually, after which they are kept in motion by electrical means as long as the instrument is turned on. A gentle lift and release of the lever is sufficient to start the reeds.

Expression Pedal

The expression pedal of the Novachord is similar to the "swell" pedal of an organ and is used to regulate the volume of the instrument. It operates a variable condenser connected in the pre-amplifier circuit.

Sustaining Pedals

The sustaining pedals, located on either side of the expression pedal, are similar in effect to the "damper" pedals on a piano. They cause the tones of the Novachord to sustain after the playing keys are released by removing cut-off bias from the control tubes. The bass sustaining pedal, located at the left, affects only the lower 36 notes of the keyboard, while the other two operate over the entire keyboard. The pedals affecting the entire keyboard are duplicates in order to allow the player the option of using either foot for operation.

Specifications

Dimensions:
- Width —52¼″
- Depth —36¾″
- Height (closed)—38¼″

Finish—Walnut
Weight—500 pounds
Wattage—440, 110 volts, 60 cycle

Tuning

The Novachord is a tunable instrument. A knurled knob is provided for each pitch. Tuning and service of any kind should be performed by a Novachord technician.

3. Mastersonic

These instruments were developed and produced by John D. Goodell and Ellsworth Swedien in the shops of the Minnesota Electronics Corp., of St. Paul, Minnesota. In brief, tones were generated by regular teeth moving past shaped pole pieces. Separate hi-fidelity amplifiers were used for each manual with such a high-quality loud-speaker system that in direct-comparison listening tests tones of the Mastersonic could not be differentiated from that of a pipe organ.

In most mechanisms using rotary generators the basic approach has been to shape a tone wheel so that the desired waveform will be generated in a pickup coil as the surface of the wheel moves past a pole piece. There are many obvious difficulties connected with the production of such wheels with required tolerances, and the cost is very high for the number of wheels needed.

In this organ the rotating members are pitch rather than tone wheels. The wheels resemble conventional gears with teeth (vanes) distributed symmetrically around the periphery. The pole pieces of the pickup coils are shaped to produce the desired waveform. A number of pole pieces together with corresponding patterns are shown in Fig. 8-11.

There are many advantages in this system, not the least of which is the fact that a single pitch wheel may very often be used in conjunction with several coils and pole pieces oriented around its periphery to generate various waveforms. Pitch

wheels with 1, 2, 4, 8, 16, 32, and 64 teeth respectively are assembled on a single shaft so that each wheel corresponds to a successive octave of a single note. The shaft itself is made of non-magnetic stainless steel, and the spacers between the pitch wheels are of brass to avoid coupling between the circuits.

A total of twelve shafts with seven pitch wheels on each shaft produce all the fundamental frequencies of an organ keyboard. In order to generate the fundamentals corresponding to the 4-foot, 2-foot and 32-foot pipe pitches for various stops played in the top or bottom octaves of the keyboard respectively, it is necessary to add one or more pitch wheels to each shaft.

Each set of coil and pole piece assemblies generates a complete keyboard of corresponding waveforms. The output from the coils may be connected to one or more manuals of the organ. The only limitation on the number of stops that may be obtained in this manner is the physical dimension of each coil assembly by comparison with the outside circumference of the pitch wheels.

The complete generator assembly for a two-manual organ has twelve complete tone-wheel assemblies in the lower bank, corresponding to the complete organ keyboard fundamentals. Each tone wheel in this bank has four associated coil and pole-piece assemblies corresponding to flute, diapason, string and trumpet basic tone colors.

The upper bank of twelve complete tone-wheel assemblies includes only two sets of coil assemblies, corresponding to a flute and string tone color. The upper bank is tuned slightly sharp with respect to the lower bank and represents the celeste stops. This corresponds exactly to pipe-organ practice in which a

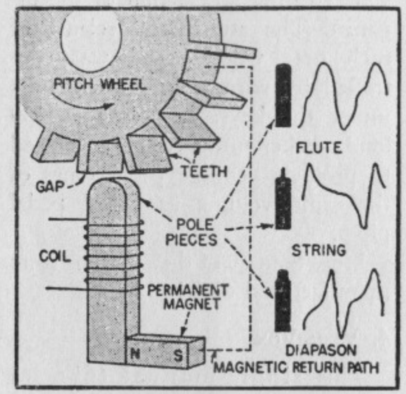


Fig. 8-11. The Mastersonic method for generating complex waveforms directly by shaping pole piece so air gap varies as each tooth moves past, and examples of waveforms.

separate rank of string pipes is tuned slightly sharp to provide a beat that sounds to the ear much like a vibrato, although the result is appreciably richer in quality than is achieved with the usual tremolo. This is one of the features of this design that contributes to its ability to conform to pipe-organ characteristics. Few pipe organs include more than a string celeste stop, but with the design described a flute celeste is not costly in comparison to adding a complete set of pipes in a pipe organ.

The organ included several features which contributed to its remarkable imitative qualities. The volume of each note was "scaled" similar to pipe scaling. Both string and flute celeste stops were incorporated. A true pitch change vibrato mechanism was made adjustable for a variety of effects. Pole pieces were adjustable so each stop could be voiced to the satisfaction of the organist. The attach and release of each note when keyed was controlled by wire wound attenuators under the keys. As many as 130 loud-speaker units were employed to produce genuine pedal tones of the same volume as actual pedal pipes.

More than 50 of these organs were manufactured and installed.

4. Vega-Vox

This single-manual (61-note) electronic organ was built in Boston, Massachusetts before World War II. The console was self-contained with a divided keyboard permitting tonal contrasts between right and left hands. A one-octave clavier was available as an attachment. Booster tone cabinets could be used for large rooms.

No moving parts were employed; the pitch, tones and vibrato generators being purely electronic. One swell pedal controlled the volume of the organ.

The spinet mahogany console measured 38″ high, 40″ long and 24″ deep and had a folding top. Twelve tone tablets, 4 in bass section, 5 in treble section, 1 tremolo, 1 octave coupler and 1 chorus tablet provided the player with a variety of effects.

Very little data is available on this organ.

5. Minshall-Estey

These one-manual organs were manufactured by the Minshall-Estey Organ, Inc., Brattleboro, Vermont, prior to their production of the Minshall organs described in Chapter VI.

Operating Principle

This Minshall-Estey organ uses wind-blown reeds as fundamental tone generators. Each generator (reed) is placed between the plates of a capacitor. But each reed is insulated from each plate so that the reed floats in the dielectric of the capacitor.

The reeds are actuated by air supplied by a suction pump whenever the keys of the organ are pressed down. The pressing of a key opens a valve. Air then flows through the valve and through the tongue of the reed. The activation of the tongue of the reed by the air creates both an audible tone (reed sound) and an electrical impulse.

The amplification system picks up the electrical impulse, feeds it into a specially designed amplifier and then to a tone cabinet.

The reed sound is subdued by shielding and padding placed over the reed chest. This padding keeps the reed sound at a minimum, so that it is negligible when the electronic system of the organ is turned on.

Several banks of tone generators are used to create variety and tonal range. These banks are controlled

electrically from the stop-tablets located on the panel above the keyboard. Thus when one key is depressed in the treble section, four tone generators are actuated at the same time; but the signal fed into the amplifier grid is derived only from the generator or generators that have been selected by the stop-tablet.

The tremolo effect is created by an electrical pulse oscillator which modulates the signal from the first tube in the amplifier, and imposes a pulse beat upon it at the rate of eight cycles per second. This pulse beat in turn is fed into the grid of the driver tube, creating a pulsating wave through the speaker. The amount of the action is controlled by a knob located on the instrument panel.

The keyboard has a total compass of six octaves. Division between treble and bass is at tenor—C, permitting a two-manual effect. The lower twelve notes are contra-bass and permit the playing of pedal-pitch notes from the keyboard.

Dimensions of the console are: Depth 29½″, height (closed) 40½″, height (open) 49″, width 54″. The net weight of the console is approximately 360 lbs.

The consoles are of dark mahogany with matching bench and folding top (Fig. 8-12). One expression pedal controls the volume of the entire keyboard.

Registration

Each stop, except those in parenthesis, introduces a complete set of tone generators (reeds). When full organ tablet is drawn, all stops are on. Those stops in parenthesis are variations of these same tone generators.

BASS
- Diapason .... 8′
- (Dulciana) .... 8′
- Octave .... 4′
- (Dulcet) .... 4′

TREBLE
- Bourdon .... 16′
- (Gedeckt) .... 16′
- Diapason .... 8′
- (Melodia) .... 8′
- Octave .... 4′
- (Flute) .... 4′
- Flautino .... 2′
- Contra Bass
- Tremolo
- Full Organ

Fig. 8-12. Minshall-Estey Organ (Model B)

C. Custom-Built Organs

1. Thomas

An instrument called the Thomas Electronic Organ is built in North Hollywood, California by Thomas

J. George. Using patented circuits, the Thomas organ controls the attack and release of the tones by electronic keying methods. This feature aids in simulating the attack and release of organ pipes, and also provides means for obtaining the effect

Fig. 8-13. A Thomas Two-Manual Console

of reverberation. (This latter feature is particularly useful where an organ is installed in a room having poor reverberation characteristics.)

The voices are quite reminiscent of pipe tones. This is largely due to the fact that the tones are generated by means of vacuum tube oscillators which are designed to generate natural harmonics or partials in the same family relationships as in pipe tones. The different tone qualities are obtained by the use of formant circuits and electric wave filters. A full compliment of stops is provided, including solo voices as well as the four basic voices of Reed, Diapason, Flute, and String. The flute is a round tone, without being completely devoid of all harmonics, yet having no trace of stringiness. The string provides a marked contrast, since it is very rich in harmonics, and when used with the pitch vibrato, sounds very instrumental.

Every effort has been made in the design, to provide an instrument at which the pipe organist feels at ease. Conventional organ keyboards and stop tablets are employed, and separate expression pedals are provided for each manual. Separate reproducers for each manual are also possible as well as Echo organ effects, when desired. The bass notes are also amplified separately for greater tonal clarity and better tonal balance.

The organs are custom-built throughout. Both standard models as well as instruments built to the purchaser's specifications are available, ranging in size from a small two-manual and thirty-two note pedalboard, practice organ, (Fig. 8-13) to a large three-manual concert organ. The practice organ is available without pedals, when desired.

All the Thomas organ generators use vacuum tube tone sources. The voices are additive as are the couplers, to produce the build-up obtained with a "straight" organ. This is possible because the oscillators are in continuous operation, with separate electronic keying means for each note. There is thus no borrowing, excepting in the case of inter-manual or manual to pedal couplers.

In the practice organ the amplifier and speaker are located in the console. The electronic generators in all 2-manual models are located in the console. In the three-manual models the generators are mounted

in racks which may be installed separately from the console if desired.

Tone generator racks may be installed in an organ chamber and connected to an existing organ console. This provides additional voices or a complete echo organ on an existing pipe organ installation.

2. Haygren Organs

These electronic organs are assembled by a Chicago firm. The basic principle of tone generation uses the vacuum tube oscillator circuit. One tube is employed for every note of each manual.

Most of the consoles are three-manual (stop-key or draw-knob) being built for Haygren by a leading pipe organ builder. The tone generating racks are connected by cables to the console. Multiple loud-speakers are installed in tone cabinets or organ chambers.

Specifications and other details can be obtained from the manufacturer. (See paragraph "A" in this chapter for description of Haygren Harp-Organ).

D. Foreign Models

1. The Compton Electrone

This electronic organ is being manufactured in London by John Compton Organ Company. It is similar in appearance and arrangement to the largest of the American makes in that the organ consists of three separate sections; the console, the tone generator and the tone cabinet.

Consoles are of the standard pipe organ variety. They contain no electronic tone generating equipment. The stop tablets, couplers, pistons and swell pedals are arranged in the usual manner. The stops range in pitch from 32′ to 2′ but only inter-manual couplers are provided.

The tone generator consists of twelve, motor-driven, disc units, one for each semitone of the scale. These produce, by an electrostatic system, all the harmonics found in the organ tones of diapason, string and reed. The tone generator is enclosed in a steel case, mounted on castors and is usually located at some distance from the console.

The basic circuit is such that the organ is of the "unified" class. However, a special keying system has been incorporated which provides that if a given pitch is already being played on one key and that same pitch is called for by another key, it will add to the volume of the note.

The tone cabinet houses the loud-speaker units. Separate treble and bass units are used and several tone cabinets are connected together in larger installations.

Several models of the Compton Electrone are available, covering both the church and entertainment market. A large 2-manual model specification follows:

Specification—Model 374

PEDAL

Acoustic bass	32′
Contrabass	16′
Violone	16′
Dulciana	16′
Bourdon	16′
Octave	8′

Flute .... 8′
Trombone .... 16′

GREAT
Contra Geigen .... 16′
Diapason I .... 8′
Gemshorn .... 8′
Hohlflöte .... 8′
Stopped diapason .... 8′
Dolce .... 8′
Octave .... 4′
Waldflöte .... 4′
Twelfth and Fifteenth $2\frac{2}{3}'$ & 2′
Cor anglais .... 16′
Clarinet .... 8′
Tromba .... 8′

SWELL
Contra Salicional .... 16′
Principal .... 8′
Viola da gamba .... 8′
Salicional .... 8′
Flauto pleno .... 8′
Lieblich gedackt .... 8′
Salicet .... 4′
Lieblich flöte .... 4′
Flageolet .... 2′
Mixture III ranks
Contra Fagotto .... 16′
Cornopean .... 8′
Hautboy .... 8′
Clarion .... 4′

COUPLERS AND ACCESSORIES
2 Tremulants — Great to Pedal
4 Pistons to Great — Swell to Pedal
4 Pistons to Swell — Swell to Great
Two Swell Pedals
Casework and seat of polished oak

2. Welte Phototone

The tone producing parts of the Welte Phototone organ were photoelectric. The tone generator consisted of 12 discs of plate glass, carrying the sound tracks which were recorded from actual stops of famous European organs. The work of making these precision, optical, sound tracks was performed by Mr. Edwin Welte, inventor of many other products including the Welte reproducing pianos, Welte pipe organs and Welte automatic roll players.

The Welte Phototone organ was first exhibited in Berlin in 1936 and met with great approval. This organ was destroyed during World War II but drawings and machinery were saved. The organ is not now marketed but its principle of tone generation is so unique that the inventor hopes someone may some day find a means of again producing the Welte Phototone, bringing the tones

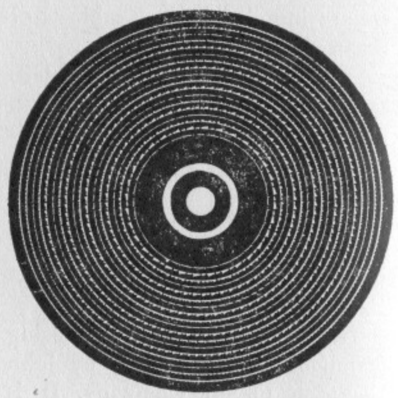


Fig. 8-14. Welte Tone Wheel

of world famous organs to music lovers everywhere.

Mr. Edwin Welte resides at Freiburg in Baden, Germany and is the last male member of his famous family.

Figure 8-14 is a reduction of a tone wheel showing the wave shapes of 18 different actual pipe organ stops. These discs were motor-driven at a constant speed. Referring to Fig. 8-15, a light source (L) and lens (Q) projected a beam past keying shutter (P), through disc (S) into photo electric cell (F). Electronic amplification from here on reproduced the exact tone of the organ pipe which was recorded on the optic disc.

3. Constant Martin Organs

These organs are named after the inventor who has marketed a considerable number of units in Great Britain. The consoles are built to R.C.O. specifications and the stoplist is similar to a "straight" pipe organ including pitches from 16 ft. to 2 ft. Several generators per note are employed, thus creating a full ensemble. A one-manual organ is produced for home use or chapels. The three-manual consoles are available with specifications to suit the purchaser.

The tone generators are oscillating tubes, there being one tube for each pitch. As yet this organ has not been marketed in the U. S. Reports on its tone would indicate that it is similar to American brands employing similar circuits. Details can be obtained from the builder: The Miller Organ Co., Ltd., Norwich, England.

4. Coupleux and Givelet Organ

Very little is known in this country about this pioneer electronic organ. Introduced in 1930 under British patents, it contained principles being used today by our Ameri-

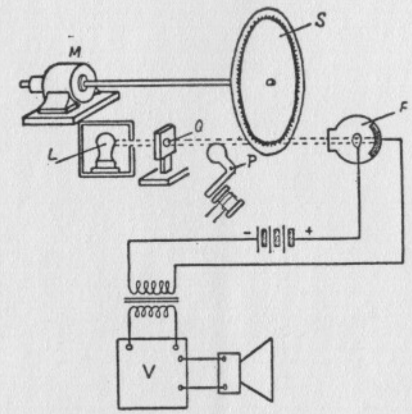


Fig. 8-15. Welte Operating Diagram

can builders. The very large console contained the tone generator, a series of vacuum tube oscillators, along with their associated coils, condensers and resistors.

The basic circuit used an oscillator for each note, producing a full chorus effect. Conventional pipe organ keys and stop mechanisms were used.

Selecting an Electronic Organ

CHAPTER IX

Selecting an Electronic Organ

It will become apparent from a study of this book that there is a wide selection of electronic organs available on today's market. These vary in price from one-manual models selling under one thousand dollars to three-manual instruments selling for over 15 thousand dollars. If one considers the various finishes and loud-speaker combinations available within the industry, multiplied by the number of models and brands, the selection would run well over one hundred.

It is essential, therefore, for a prospective buyer, first, to analyze certain basic requirements which the organ must meet and, second, to establish somewhat of a price ceiling. It is a sad thing that in selecting a musical instrument the matter of price is usually foremost, when this is the one factor which should be kept from influencing the buyer. However, since this is the case, it is best from the beginning to establish a budget and not waste time trying out organs which are not in the prospect's price range.

In the case of an *auditorium installation*: such as a church, lodge, school or chapel, there has been a wide variation in the ratio between seating capacity and money spent on the organ. However, taking a large number of installations as a guide, a certain ratio can be found which divides the user into two classes:

A. Those rooms where the organ is a primary unit of the service and is used throughout a large part of the service or program. These buildings include:

- Wedding and funeral chapels
- Major Protestant churches
- Minor Protestant Evangelical Denominations
- Radio broadcast studios.

B. Those rooms where the organ is a secondary unit of the service and is used only occasionally during the service or program:

- Schools
- Catholic churches
- Lodges

The Type A group usually requires an organ priced from 15 to 25 dollars per seat. For example, a new Baptist church building an auditorium to seat 350 persons should include in their budget an organ fund of from $5,250 to $8,750. This will probably run about the same cost as the seats themselves. It is said that more persons stay away from church because of poor music than because of hard seats. Even if the Type A prospect selects a console priced well below this formula, the reserve will provide adequate amplification and tone cabinets to make the difference between a really fine musical installation and an ordinary or mediocre one.

The Type B group usually finds a ratio of 5 to 15 dollars per seat adequate. For example, a school auditorium seating 500 could get by with a $2,500 organ; however, by installing a five or seven thousand dollar organ, the students would have the advantage of an A.G.O. console, larger variety of stops, and better amplification.

In larger buildings, seating upwards of 750 persons, it is usually the custom to provide pipe organ chambers. Here, too, the formula of spending the same amount for the organ as for the seating is a good one to start with.

In the case of the home installation, the market usually divides itself into two groups; those who are strictly amateurs and those who are professional. The former class can derive as much pleasure from a small organ, but often tire of a one-manual and trade it in on a two-manual. However, if a prospect with a one-manual pocket book waits to buy a two manual organ, he is depriving himself of the very thing he needs most. Do not be afraid of starting out with a small or second-hand instrument as this can always be traded in as funds permit.

The professional entertainment organist may select his instrument by such factors as portability and popularity. The classic organist may insist on such A.G.O. specifications as 32 note concave-radiating pedals and combination pistons. This is one reason why more amateur organists own organs than professionals.

Once the buyer or committee has established the approximate price range, all the organs in this group should be heard. There are very few places in this country where one cannot hear examples of the leading manufacturers' products. However, if such is not the case, advice from owners of the organs under consideration can be easily obtained. Haste in the selection of an organ can often lead to disappointment, not because any of the organs are poorly built, but because each has its own individual tone quality. It is that intangible thing called tone which is the end product of the organ and the quality which may appeal to one person and be obnoxious to another. A person's opinion or reaction to a particular organ tone may be based on their musical background; or having had no previous connection with pipe or electronic organs, they may establish certain strong likes and dislikes after the first hearing. These may even change after a few months to such an extent that the organ of their first choosing becomes unbearable, causing them to buy an entirely different type of instrument. It certainly does not pay to make a selection solely on the advice of friends or organists, advertising claims or a products reputation. So often a purchaser's search is rewarded only after trying *all* the available makes in his price range.

COMPARATIVE REFERENCE CHART OF LEADING TWO-MANUAL ELECTRONIC ORGANS

* = Under Approx. $3000 o = Over Approx. $3000	Allen	Baldwin	Connsonata	Hammond	Minshall	Wurlitzer	Remarks:
Number of Pedal Keys	* 25F o 32C	* 32C o 32C	* 25F o 32C	* 25F o 32C	* 25C ——	* 32C o 32C	F = Flat C = Concave
Number of Expression Pedals	* 1 o 2	* 1 o 2	1	1	1	1	
Crescendo Pedal	* No o Yes	* No o Yes	No	No	No	* No o Yes	
Combination Pistons	* No o Yes	* No o Yes	No	No	No	o Yes	Hamond has "Preset Keys"
"Duplexed" Generator	* Yes o No	Yes	* Yes o No	Yes	Yes	Yes	Duplexing here means one tone generator used on both manuals.
Type Pitch Generator	VT	VT	VT	TW	VT	R	VT = Vacuum Tube R = Reed TW = Tone Wheel
Tremolo, Gyrophonic or Vibrato	G	V	T	V	V	T	
Lowest Pedal Frequency-cycles	* 64 o 32	32	* 64 o 32	See Note	64	* 64 o 32	Older models go to 32 Newer models—Lowest fundamental—Low A
Generator Inside or Outside Console	* In o Out	In	In	In	In	In	
Toe Pistons	* No o Yes	* No o Yes	No	No	No	No	Hammond Model E has 4 pistons
Motors in Console	No	No	No	Yes	No	Yes	
Motors in Tone Cabinet	Yes	No	No	No	No	Yes	
Organ Tunable	Yes	Yes	Yes	No	Yes	No	

Glossary of Electronic Organ Terms

CHAPTER X

Glossary of Electronic Organ Terms

A

Acoustics—The science of sound.
A.G.O.—American Guild of Organists. Usually applied to a set of standard dimensions for organ consoles established by the Guild in 1933.
Amplifier—The device used to increase the electrical power from the tone generating portion to operate the loud-speaker system.
Audio Circuit—That portion of the organ circuitry carrying audible frequencies. Usually the wires between the tone generators and amplifiers are referred to as "audio cables."
Audio Frequency—Sound waves or electrical impulses lying between the limits of hearing (roughly 15 to 15,000 c.p.s.).

B

Baffle—A partition used to mount loud-speakers.
Bass Reflex—A loud-speaker enclosure in which a portion of the radiation from the rear of the diaphragm is utilized to increase certain bass tones.
Brushes—Blocks of conductive material used to transmit power to rotating loud-speaker or motor armature.
Bus—An electrical conductor which collects tones from several sources.

C

Carillon—The synthetic electronic device used to imitate the sound of large tower chimes and bells.
Celeste—A stop tuned slightly sharp or flat to the main portion of the organ.
Coupler—A stop tablet which connects two manuals together or connects octaves on one manual or connects manuals to pedals. Couplers are made which operate at different pitches.
Crescendo—(See Pedal-Crescendo.)
Crossover Frequency—The frequency at which equal power is delivered to adjacent channels of a sound system. (Usually applied to dividing networks.)

D

Dead Room—A room with a large amount of sound absorption.
Decay—The rate at which a note falls from its normal volume to zero.
Decibels—The unit as a scale for describing relative electrical and audio power (abbreviation is db.)
Diapason—The basic pipe organ tone usually produced by large metal pipes.
Diode—A small dry rectifier used in some tone circuits to filter out unneeded harmonics.
Distortion—A change in wave form. In organ music it is the audible tone in a musical note or chord which is not clear but has a buzzing or rasping quality; usually indicative of an overloaded amplifier or loud-speaker.

Dividing Network—A frequency selective component, usually consisting of condensers and chokes, which receives all incoming frequencies and divides the outgoing signal into high and low tones.
Doppler Effect—The change in pitch of a tone caused by a movement of the observer relative to the sound source.
Duplexed—Stops which are duplicated on more than one manual.
Dynamic Speaker—Common term applying to a modern loud-speaker unit in contrast to early forms of loud-speakers known as magnetic.

E

Echo—A wave which is reflected or repeated in some way with enough delay to be perceived as separate from the original sound.
Echo Organ—A separate loud-speaker system, located at a distance from the main system, providing antiphonal effects.
Expression—That which pertains to the control of loudness.

F

Flute—The family of organ tones either lacking or limited in harmonic development.
Formant—The natural frequency resonance of an instrument, organ pipe or electrical circuit. The fact that such a resonance exists effects the tone quality of an instrument over its range.
Frequency Response—This refers in many cases to the ability of a piece of audio equipment to reproduce various pitches of the organ.
Fundamental—The nominal pitch of a musical tone; usually the lowest frequency of its family of harmonics.

G

Gain—The amount of voltage amplification in a given system.
Grille—The ornamental covering over a tone opening.
Gyrophonic—A trade name used by Allen Organ Co. for its series of loud-speaker systems which incorporate rotating units.

H

Harmonic—A component of a complex sound whose frequency is a multiple of the fundamental frequency.
Harp—The electronic counterpart of the pipe organ harp. It contains no moving parts.
Horn Loud-Speaker—A loud-speaker in which the driving unit is attached to a horn. (See "tweeter.")

L

Live Room—A room with a small amount of sound absorption.
Loud-Speaker—The unit in a sound system used to convert electrical power to sound energy. Both electro-magnet and permanent magnet types are employed in present production. The tonal results of the two types are similar.
Loud-Speaker Systems—A combination of loud-speakers, baffles, horns, and dividing networks.

M

Mercury Vapor Tube—A type of rectifier tube employing mercury, giving off a characteristic blue light.
Mixtures—Organ stops which control pitches, other than the note being played. These are often drawn in groups, adding brilliance to the ensemble.
Multi-Vibrator—A vacuum tube circuit used in some electronic organs to generate a pitch from which other octaves of the same note can be derived.

O

Oscillator—A vacuum tube circuit used in many electronic organs to produce one pitch.
Overtone—A component of a complex sound having a pitch higher than that of the fundamental pitch.

P

Pedal Clavier—The bass notes of the organ, played with the feet. Pedal claviers range from two notes to 32 notes.
Pedal-Crescendo—The foot operated control which gradually turns on the various stops and couplers of the organ.
Pedal-Expression—The foot operated control which varies the volume of one or more sections of the organ.
Phasing—A term applied to the proper connection of two or more loud-speakers to obtain maximum efficiency.
Photo Electric Tube—A light sensitive device used to translate changes in light intensity into electrical impulses.
Pitch—The attribute of a sound which the ear translates as being relatively high or low in the musical scale.
Pistons—Push buttons used to control groups of stops or couplers. Most pistons are adjustable by the organist.
Potentiometer—A variable rotating resistor used to control the volume of an amplifier or division of the organ.
Power—The power of an electronic organ usually refers to its output watts. (Since the loudness of an organ depends on many factors, only one being the wattage output of its amplifiers, there is little value in knowing an organs power. Actual listening tests are the only means of determining whether the organ is of sufficient power.)
Power Supply—The electronic assembly used to operate various parts such as relays, switches, couplers, oscillators, amplifiers and tone changers.
Presets—Push buttons or stop tablets used to turn on a group of stops or couplers. These are wired in advance by the factory or installation engineer, thus the name "preset."

R

Rank—A complete set of tone generators of one tone family. This term may be applied to a set of oscillator tubes or set of reeds responsible for producing one entire scale on the manual or pedal keyboard.
Rectifier—An electronic device, either vacuum tube or metallic, used to convert alternating current to direct current.

Reed—A vibrating brass tongue used to produce musical tone.
Registration—The stop list on the console.
Regulation—The ability of a pipe organ to maintain a steady pitch even when heavy chords are struck in rapid succession.
Relay—A magnetically operated switch for controlling one or more circuits from a remote point.
Resistor—An electrical part used to control the voltage or current in a circuit.
Resonance Frequency—the frequency at which an audio device reënforces the sound being reproduced.
Resultant—The term usually applied to a pedal stop on any organ which derives its tone from two notes, a fifth apart, an octave higher than the key played. (To imitate low 16′C for example, some builders wire the low C pedal key to play 8′C and 8′G together.)
Reverberation—The persistance of sound in a room or tone chamber, usually rated in the number of seconds a tone can be heard after the source has stopped. This term also applies to devices used to add artificial persistance of sound to a loud-speaker system.

S

Scaling—The variation in volume between notes of a given stop. The process of leveling notes is called "scaling."
Setter Board—A switching panel, usually mounted below and to the side of the lower manual, on which groups of stops can be controlled by the combination pistons.
Shoe (Swell)—The expression pedal.
Sound—An auditory sensation produced by an alteration in pressure and particle velocity in an elastic material (such as air).
Sound Absorption—The ability of a material to prevent sound from passing through it or reflecting from it.
Standing Waves—Tones having a fixed distribution in space. Such waves (usually low pedal notes) sound louder at some points in a room than at others.
Stops—The switches which control the various voices of an organ.
String—A family of organ tone rich in harmonics.
Swell—One of the manuals of an organ; one of the sections of the organs tone generating divisions; one of the expression pedals.

T

Tone—That quality of a sound which makes it possible for the ear to identify or classify the sound as belonging to a certain instrument or more specifically, a certain organ stop.
Tone Chamber—A room or compartment where loud-speakers are installed, the purpose being to conceal the loud-speakers and/or enhance the tone quality.

Tone Changer—That portion of an electronic organ whose primary function is to alter the tone quality (harmonic content) of electrical impulses coming from the tone generator, to produce a variety of stops.
Tone Generator—That portion of the electronic organ which initiates the electrical impulses which later on through amplification are made audible.
Tremolo—The variation in volume of a tone. In organ practice this variation is usually in the form of a steady pulsation at about six cycles per second. (Also see Vibrato.)
Tubes—Common term for vacuum tubes used as oscillators, amplifiers, rectifiers, controllers, etc.
Tweeter—Common term for that part of a loud-speaker system which handles the high notes.

U

Unification—This term applies to the method of wiring between the keyboard and tone generator whereby one set of tone generators can be played at several pitches on one manual without the use of couplers.

V

Vibrato—The periodic variation in frequency of a tone. In organ practice this variation is usually in the form of a steady pulsation at about six cycles per second. Almost all vibrato devices introduce some tremolo effect; especially is this true of moving loud-speaker vibratos.
Volume—The intensity of a sound or magnitude of an audio wave.

W

Watts:

1. The power consumed by a given organ or tone cabinet.
2. The maximum undistorted output power rating of a given amplifier.
3. The acoustic output of a given loud-speaker system under actual operation.

Woofer—Common term for that part of a loud-speaker system which handles the low notes.