SERVICE MANUAL

HAMMOND GRAND

Part 1 100

HO-5502

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GENERATOR - The tone wheel generator used in the Grand 100 is similar mechanically and electrically to the generators used in other models of Hammond organs. The generator furnishes 144 sine wave tones to the keying circuits. Ninety-six (96) of the tones produce the regular "tempered scale" fundamentals and harmonics as used in previous Hammond organs with the exception that tone numbers 92, 93, 94, 95 and 96 have not been included in the earlier models. The remaining forty-eight (48) tones, arbitrarily number 46½ to 93½, furnish the 7th and 11th harmonics which are not available from the tempered scale tone wheels. The 144 generated tones pass through filters on the generator cover to insure purity. The filtered sine wave tones are brought out to the terminal strip which is located on the back of the generator frame. The tone wheel generator is driven at constant speed by a self starting synchronous motor. There are three (3) cables attached to the generator terminal strip. These cables carry the generated tones to the manual keyer, the pedal switch and the harp-chimes keyer assembly.

MANUAL KEYER RELAY ASSEMBLY - The manual keys of the Grand 100 do not physically operate audio signal contacts. In most Hammond organs, the manual keys operate the audio signal contacts directly by depressing plastic actuators through which the contacts pass. The Grand 100 manuals are connected to relay coils and the armature of these relays actuate the audio signal contacts. The relay keying power is obtained from a heavy duty 14 volt D.C. supply located in the auxiliary rack. There are seventy-three (73) great manual relays and seventy-three (73) swell manual relays. Sixty-one (61) relays of each set normally actuate the lower five (5) octaves of the associated manual are known as the unison relays. The remaining twelve (12) relays of each set actuate the highest octaves of the associated manuals, only when the respective 4' couplers are used, and therefore, are referred to as the 4' extension. (See "Couplers")

Each great manual relay actuates sixteen (16) individual contacts Fourteen (14) of these contacts carry the generated audio signals and, when actuated, connect the audio signals individually to the fourteen (14) great harmonic busses. The 15th contact of each great relay is used for keying of the harp. The 16th contact keys a D.C. voltage which is used as control intelligence for the great chorus circuitry in the auxiliary rack. Each swell manual relay actuates fifteen (15) individual contacts. The functions of these contacts are the same as the corresponding contacts in the great, except that there are no harp contacts in the swell. The generator tones are cables to terminals located in the center of the bottom of the manual keyer relay assembly. The generator tones are distributed from these terminals by specific lengths of resistance wire to the fourteen (14) rows of audio contacts for each manual. The specific wiring diagram and resistance values are indicated in Figure 10 in the schematic section.

When any manual relay is actuated, fourteen (14) audio circuits are completed, allowing the appropriate generated tones to appear on each of the fourteen (14) harmonic busses.* The harmonic busses collect the signals from the key contacts and feed them through band pass filters into individual bus amplifier circuits, which are located inside the manual keyer relay assembly. See Figure 6 in the schematic section. The harmonic bus bars for the eight (8) highest harmonics, 5th through 12th, are continuous, spanning the 73 note range of the relay assembly. These bus bars are connected to filters which pass the appropriate sine wave tones into the bus amplifiers, but attenuate all signals which are higher and lower in frequency than the desired harmonics. The six (6) lowest harmonics, which are, sub fundamental, sub 3rd, 2nd, 3rd, and 4th, in order, are collected on split busses, giving a high and low output for each harmonic. These busses are physically separated near their centers and separate electrical connections are made to each of the two sections of each bus. The high frequency and low frequency outputs from each harmonic bus are fed to separate band pass filters which are similar to the higher harmonic band pass filters, but are more selective since the desired pass band is smaller. The outputs of the high and low frequency filters for each harmonic are combined and amplified by a single transistor bus amplifier. There are, therefore fourteen (14) bus amplifiers for each manual. The outputs of these amplifiers are cabled to the voicing networks which are located behind the stop tablets.

The harp contacts in the great manual keyer are cabled to the harp keyer assembly which is located at the lower left side of the back of the console. The harp keying bus is at ground potential. The chorus control contacts in the great and swell manual keyers control the lighting of small bulbs in the chorus scanner assembly, which is located in the auxiliary rack. The voltages used to light the chorus control bulbs are obtained from a special regulate supply (power supply chassis) in the auxiliary rack. The common side of this supply is not grounded directly to the main organ ground, so the chorus control circuitry is "floating". For this reason, if any chorus control voltages are measured, they must be referred to the common terminal of this circuit in the auxiliary rack. See power supply schematic, Figure 14.

The relay magnets which operate the manual keying contacts are located on the top cover of the manual keyer relay assembly. The common side of all magnet coils is grounded to the negative side of the 14 volt keying supply. The positive side of the 14 volt supply feeds the great and swell keyboards. The key contacts in the keyboards are cabled to the relay magnet coils. Depressing any manual key completes the circuit from the power supply to the associated relay coil, actuating the audio signal contacts. An electrolytic capacitor and a silicon diode are wired in parallel with every magnet coil in the assembly. The capacitor and diode suppress sparks and mechanical noise of the keying magnets. Should replacement of a capacitor or diode become necessary, it is very important that polarity of the replacement is correct. If the polarity of a diode or capacitor is reversed, the component will be destroyed when the note is keyed, and subsequent damage to the silver key contact may result.

*NOTE: SOME HARMONICS DO NOT RUN ALL THE WAY UP THE MANUALS SO THERE ARE LESS THAN FOURTEEN (14) TONES KEYED ON THE HIGHER NOTES.

COUPLER - MANUAL KEYBOARDS - There are twelve black tablets on the stop tab panel of the Grand 100. These tablets control key contact switching functions of the manual keys. The great and swell unison off tablets are not couplers in the strictest sense, but since their operation is similar to that of the couplers they may be considered as special couplers. The couplers produce no sound by themselves and must be used in conjunction with stop or voice tablets.

Physically the couplers in the Grand 100 consist of sets of key contacts which may be engaged, at the desire of the organist, to play notes from any particular key, which are different from the notes normally operated by that key. These sets of contacts are engaged or disengaged by means of electromagnets which are controlled directly from the coupler tablet switches. When a coupler is off, the 61 key contacts for that coupler are held in a neutral position where operation of the manual keys cannot cause electrical connection to be made to the coupler contacts. When the coupler is turned on all 61 contacts for that coupler are moved to a "ready" position, where operation of the manual keys causes electrical connection to be made to the coupler contacts. The contacts which key the organ when no couplers are in use are called "unison" contacts. In other words, if the coupler and unison off tablets were removed from the organ it would play as a standard or "unison" organ. It is difficult to explain the relationship between the various pitches of stops, the keys, the couplers, and the manual divisions of an organ in terms of the musical nomenclature of the stops. A much clearer explanation of these relationships can be made by considering only the keys and the relays which are operated by these keys. It is important to keep in mind that each relay for either manual completes all of the circuits necessary to produce any voice appearing on the stop tablets for that manual, regardless of the pitch.

If an organist ignores the coupler and unison off tablets, no matter what stops he uses, every key on the organ operates only one associated relay. For example, on the great manual, key #1 operates relay #1, key #2 operates relay #2, etc. of the great relays. Similarly, on the swell manual, key #1 operates relay #1, key #2 operates relay #2, etc., of the swell relays. This is the normal or unison operation of the organ. If the organist should depress the great to great 4' coupler tablet, every key on the great manual will now operate two relays. The unison relays operate as before, and, in addition, the great relay one octave higher will also operate. For example, on the great manual, key #1 operates relay #1 and relay #13. Key #2 operates relay #2 and relay #14, and etc. If the organist should additionally depress the great to great 16' coupler tablet, every key on the great, (with the exception of keys #1 to #12 as no sub octave relays have been provided for these keys) will operate three relays. Example: Key #13 operates relay #13, relay #25 and relay #1, of the great relays. At times, the organist may desire to play the 4' and 16' coupler notes without the unison notes and he may do this by operating the unison off tablet. The unison off, as previously mentioned, is similar to the couplers in operation, with the exception that it works in reverse of the couplers. Depressing the unison off tablet, energizes a magnet which pulls the unison contacts out of operation rather than pushing them into operation, as the couplers do. The swell to swell 4' and swell 16' couplers perform the same function on the swell as the great couplers, already described. These couplers which provide only switching within the associated manual are called "INTERMANUAL" couplers. The other type of couplers found on the Grand 100 are "INTRAMANUAL" couplers. This type of coupler performs the same electrical function as the intermanual coupler, but the switching is done between the keys of one manual and the relays of the other. For example, if the swell to great 8' coupler is depressed and the great keys are operated, each great key will operate its regular unison relay and the corresponding relay in the swell relays. Great key #1 operates great relay #1 and swell relay #1, etc., specifically. If the swell to great 8' and 4' coupler tabs are depressed, great key #1 will operate great relay #1, swell relay #1 and swell relay #13. Note that the great keys ALWAYS OPERATE the great unison magnets UNLESS the great unison off tablet has been depressed. The swell to great 16' coupler works in a similar manner, but it brings in the swell relays an octave lower than the great unison relays.

The pedal coupler tablets perform the same function for the pedals as the intramanual couplers do for the great manual. If the great to pedal 8' tablet is depressed, pedal #1 operates great relay #1. If the swell to pedal 4' and swell to pedal 8' tablets are depressed, pedal #1 will operate swell relay #1 and swell relay #13. The regular pedal voices are not affected by the coupler tablets and may be used entirely independent of the couplers.

Some of the confusion about the footage numbers on the stop tablets and the footage numbers on the couplers may be cleared up if the following information is kept in mind. Conventionally, the footage numbers on coupler tablets relate only to the keying mechanism of the organ and not to the pitch of the voices.

Also, by convention, the NORMAL relationship between the keys and the actual keying devices, whether relays, pneumatics, tracker bars, or other is unison or 8'. The 8' nomenclature for couplers does not refer to pitch. It indicates only a unison or normal relationship between the keys and the keying mechanism. Some early theatre organs used the terms, sub-octave for the 16' coupler, and super-octave for the 4' coupler. These names more nearly describe the functions of the couplers, but they are not in common usage.

PEDAL SWITCH - There are 12 audio contacts per each of the 32 pedals in the G-100. The harmonics keyed directly for the pedal voices are; sub fundamental, fundamental, sub third, second, third, fourth, fifth, sixth, eighth, tenth, twelfth and sixteenth.

Each of the 32 pedals operates twelve audio contacts directly and the signals are collected by busses and carried to band pass filters in the same manner as the manual signals. Resistance wire length may be obtained from Figure 12 in the schematic section. The filtered outputs are then amplified by 12 individual transistor bus amplifiers. See Figure 17 in the schematics section for a circuit description.

The location of the pedal bus amplifiers is in the harp and chimes keyer assembly. After amplification, the 12 pedal signal outputs are cabled to the voice

mesh. Located just behind the termination panel of the console are three gang switches. These multiple contact switches activated by individual 12 V. D. C. relays (keyed by the stop tablet switches), electrically connect the three intramanual pedal couplers to their respective manual keyer circuits.

HARP AND CHIMES KEYERS - The harp-chimes keyer assembly is located at the lower left corner of the back of the console. The harp and chimes percussion voices are produced by keying combinations of sine waves with special transistor percussion keyers. Each of the transistor keyers has two inputs, one of which is a sine wave tone obtained directly from the tone wheel generator, and the other is the keying input which "fires" the keyer. When one of these keyers is keyed, it momentarily allows the sine wave tone to pass at full level, and then, slowly cuts it off again, regardless of whether the keying voltage is maintained or not. A true percussive effect is obtained in this manner, in contrast to that obtained with ordinary sustain type keyers where the key must be released to effect the sustained decay. For the harp effect, the keyers are keyed singly from the harp contacts in the great manual relay, at 8' pitch. Since the harp keying is obtained from the great manual relay, the harp is affected by the great intermanual couplers. The chime effect is produced by simultaneously keying five individual harp keyers when a single key is depressed. The chimes contacts are mounted on the underside of the great manual keys, so the couplers DO NOT affect the chimes keying. The keyin schedule for the chimes is determined by cross wiring which is located within the chimes contact strip, under the great manual. When any chimes key is depressed, a shorting bar electrically connects six contacts together. One of the contacts supplies the keying potential (which is ground in this case) and the other five contacts are wired to the various keyers. Normally, the harp and chimes contacts are not connected to the keyers. When the harp or chimes tablet is depressed, the appropriate connections are made by multiple contact gang switches located on the back of the harp-chimes keyer assembly. One of these gang switches connects the harp contacts in the great manual relays to the keyers, and the other connects the chimes contacts to the keyers. The resistors wired into the chimes gang switch circuit, at the switch, attenuate the keying level of the highest and lowest harmonic or tone for each chime note, for accurate synthesis of the chime sound.

VOICE MESH - The voice meshes receive the individual harmonic outputs from the 28 manual bus amplifiers and the 12 pedal bus amplifiers. These signals are connected to the tapping busses of the voice mesh assembly which is divided into four sections: Swell, Antiphonal, Great, and Pedal. If a playing key is depressed, the harmonic signals will be present at these tapping busses, regardless of whether a stop tablet is engaged or not. The Antiphonal portion of the tapping busses receives swell signals, and this, in effect, provides a third manual with its own voiced stops, and audio channels. The Antiphonal division is played from the Swell keyboard; Swell and Antiphonal divisions can be played simultaneously by engaging stops in each section and playing on the Swell keyboard. Traditionally, the Antiphonal voices are heard from the opposite end of a building from the organ console, while the Great, Swell, and Pedal are located near the console.

Each of the harmonic signals appears at full level on the tapping busses, to which the groups of voicing resistors are connected. Eight different resistance values are utilized to control the levels at which the various harmonics appear at the outputs of the individual voice meshes. The loudness or strength of any particular voice or stop is determined by the ohmic value of the resistances connected to each bus bar of the busses selected to make up the voice. See Figures 15, 16, and 19 for identification of the particular resistors used to make up each of the 48 voices that are available.

The organ voices are now established. A wire connects each voice mesh composite signal to a tablet switch controlled from the front of the console by the stop tablets. Each stop tablet represents an individual bank of resistors on the voice mesh. In the OFF position of a stop tablet, the harmonics making up the voice are returned to ground.

Now, we list all stop tablet voices according to their general family for greater understanding later on in the text, and to help in servicing. The four general categories are Flute, Diapason, String, and Reed voices. In addition, there are Percussion, Compound voices, Intramanual, and Intermanual couplers operated by tablets and their associated switches.

Antiphonal (Played on Swell Manual)
61 notes .... C to C5 (5 octaves)

Swell Manual
61 notes .... C to C5 (5 octaves)

Great Manual
61 notes .... C to C5 (5 octaves)

Pedal Keyboard
32 notes .... C to G3 (3 octaves)

Chimes Keyboard (Played on Great Manual)
25 notes .... G2 to G4 (2 octaves)

Harp Keyboard (Played on Great Manual)
49 notes .... C2 to C5 (4 octaves)*

*NOTE: Intermanual (Great) couplers affect Harp Keyboard. Above 49 note range refers to unison pitch only.

SWELL STOP LIST	TYPE TO STOP
Geigen Diapason 16'	Diapason
Bourdon 16'	Flute
Diapason 8'	Diapason
Geigen Principal 8'	Diapason
Concert Flute 8'	Flute
Aeoline 8'	String
Dulciana Celeste II	2 Rank Diapason Celeste
Gamba 8'	String

VOICE MESH (CONTINUED)

SWELL STOP LIST	TYPE TO STOP
Octave 4'	Flute
Nazard 2-2/3'	Diapason
Flautino 2'	Flute
Tierce 1-3/5'	Diapason
Larigot 1-1/3'	Diapason
Mixture III	3 Rank Compound
Vox Humana 8'	Reed
Oboe 8'	Reed
Clarinet 8'	Reed
Clarion 4'	Reed
Tremulant	Tremulant
Swell to Swell 16'	Intramanual Coupler
Swell Unison Off	Intramanual Coupler
Swell to Swell 4'	Intramanual Coupler

The above stops make up the swell organ.

ANTIPHONAL STOP LIST	TYPE OF STOP
Open Diapason 8'	Diapason
Gedeckt 8'	Flute
Salicional 8'	String
Viola Da Gamba 8'	String
Gemshorn Celeste II	Diapason
Principal 4'	Diapason
Flauto D'Amore 4'	Flute
English Horn 8'	Reed
Trumpet 8'	Reed
Tremulant	Tremulant
Swell to Swell 16'	Intramanual Coupler
Swell Unison Off	Intramanual Coupler
Swell to Swell 4'	Intramanual Coupler

The above stops make up the Antiphonal organ.

PEDAL STOP LIST	TYPE OF STOP
Countra Bourdon 32'	Flute
Gedeckt 16'	Flute
Bourdon 16'	Flute
Violone 16'	String

VOICE MESH (CONTINUED)

PEDAL STOP LIST	TYPE OF STOP
Principal 8'	Diapason
Gedeckt 8'	Flute
Super Octave 4'	Diapason
Bombarde 16'	Reed
Great to Pedal 8'	Intermanual Coupler
Swell to Pedal 8'	Intermanual Coupler
Swell to Pedal 4'	Intermanual Coupler

The above stops make up the Pedal organ.

GREAT STOP LIST	TYPE OF STOP
Bourdon 16'	Flute
Open Diapason 8'	Diapason
Melodia 8'	Flute
Gross Flute 8'	Flute
Dulciana 8'	Diapason
Cello 8'	String
Octave 4'	Diapason
Gedeckt 4'	Flute
Nazard 2-2/3'	Diapason
Fifteenth 2'	Diapason
Mixture IV	Compound 4 ranks
Trumpet 8'	Reed
Harp	Percussion
Chimes	Percussion
Tremulant	Tremulant
Great to Great 16'	Intramanual Coupler
Great Unison Off	Intramanual Coupler
Great to Great 4'	Intramanual Coupler
Swell to Great 16'	Intermanual Coupler
Swell to Great 8'	Intermanual Coupler
Swell to Great 4'	Intermanual Coupler

The above stops make up the Great organ.

STOP SWITCHING - After the organ voices are formed, as described above, an output wire from each voice mesh is connected to a voice tablet switch. The location of the voice tablet switches are immediately below the voice mesh assembly. Voice tab switches are opened and closed by the operation of the stop tablets through mechanical linkage.

With the stop tablet in the OFF position, voice mesh signals are connected to ground. Those stop tablets which do not switch audio signals ON OR OFF, for instance, tremulants, couplers, harp, and chimes, operate their respective tablet switches for D. C. control switching.

Certain voices are NOT affected by the Crescendo-Sforzando switch. These voices are connected to ground by the appropriate voice tablet switches.

Those voices which ARE affected by the Crescendo-Sforzando switch, pass through the "off" contact of the appropriate voice tablet switch and on to the center pole of the Crescendo-Sforzando switch for that voice. The voice can then be switched ON OR OFF according to the action of the Crescendo Pedal or the Sforzando pistons (thumb or toe).

A particular voice can continue to an output channel from EITHER a voice tablet switch or a Crescendo-Sforzando switch since, the same voices are connected by a jumper wire.

The Crescendo or Sforzando switches do not physically operate the stop tablets.

One other effect is obtained from the Crescendo switch. There is a solenoid connected to the switch bar which can instaneously turn on all of the Crescendo switches plus two couplers, which do not appear in the Crescendo, as operated by the pedal. This device is called "Sforzando" and is operated by the Sforzando reversible pistons, both thumb and toe. A "Reversible" piston turns the device on with one push and turns it off with another push. The thumb piston is located at the extreme right and just below the Swell keyboard. The toe piston is located to the far right of the knee board.

Not all voices and couplers are affected by the Crescendo and Sforzando devices. The following list of functions makes up the Crescendo sequence. These functions are listed in order of operation.* Four green indicator lights are lighted to indicate approximate position of the Crescendo pedal, as the pedal is depressed. One red light indicates when the Sforzando is engaged.

*NOTE: (Looking at rear of Console at switch from left to right.)

Crescendo light #1	Swell Aeoline 8'
Great Melodia 8'	Pedal Bourdon 16'
Swell Concert Flute 8'	Great Dulciana 8'
Swell Chorus Control See later section on chorus generator control	Great Chorus Control See later section on chorus generator control
Pedal Chorus Control See later section on chorus Generator control	Swell Gedeckt 4'
Great Gedeckt 4'	Pedal Gedeckt 8'
Crescendo light #2	Swell Diapason 8'
Great Octave 4'	Swell-to Swell 4' Coupler

Swell Nazard 2-2/3'	Great Cello 8'
Swell Gamba 8'	Great Gross Flute 8'
Pedal Super Octave 4'	Great-to-Great 4' Coupler
Swell Octave 4'	Great Open Diapason 8'
Crescendo Light #3	Pedal Gedeckt 16'
Swell Clarinet 8'	Great Mixture IV
Pedal Violone 16'	Great Nazard 2-2/3'
Swell Mixture III	Swell-To-Swell 16' Coupler
Great Trumpet 8'	Crescendo Light #4
Swell-To-Pedal 8' Coupler	Pedal Bombarde 16'
Swell-to-Great 4' Coupler	Swell-To-Great 8' Coupler

The last two couplers are activated by the Sforzando Solenoid, but not by the Crescendo pedal. The Sforzando Solenoid is operated by a reversible switch and does not affect the 4 green Crescendo lights.

In total, there are 65 voice tablet switches; 34 switches are double-pole double-throw and 31 switches are single-pole single-throw.

Thirty-two(32) of the DPDT switches are for the series connected pairs of stop tablets which activate chorus control lamps. See schematic Figure 2 for identification of the tablet pairs. The reason for the paired voices being used is to simulate the pipe organ effect of one rank of pipes beating against another. The remaining two DPDT switches are the Great and Swell Tremulants which control narrow and wide vibrato channels with the non-vibrato channels.

For reference we now list those voice tablet switches in each category.

GRAND 100 VOICE TABLET SWITCHES

SPST AO-29019	DPDT AO-29018
Swell-to-Great 4' (Gt.)	Trumpet 8' (Ant.)
Tremulant (Ant.)	English Horn 8' (Ant)
Swell-to-Great 8' (Gt.)	Flauto D'Amore 4' (Ant.)
Swell-to-Great 16'(Gt.)	Principal 4' (Ant.)
Great-to-Great 4' (Gt.)	Tremulant (Gt.)
Great Unison Off (Gt.)	Salicional 8' (Ant.)
Great-to-Great 16' (Gt.)	Gedeckt 8' (Ant.)
Gemshorn Celeste II (Ant.)	Open Diapason 8' (Ant.)
Chimes (Gt.)	Gedeckt 4' (Gt.)
Harp (Gt.)	Tremulant (Sw.)
Trumpet 8' (Gt.)	Octave 4' (Gt.)
Mixture IV (Gt.)	Clarion 4' (Sw.)

GRAND 100 VOICE TABLET SWITCHES (CONTINUED)

SPST AO-29019	DPDT AO-29018
Swell-to-Swell 4' (Sw.)	Cello 8' (Gt.)
Fifteenth 2' (Gt.)	Clarinet 8' (Sw.)
Swell Unison Off (Sw.)	Dulciana 8' (Gt.)
Nazard 2-2/3' (Gt.)	Oboe 8' (Sw.)
Swell-to-Swell 16' (Sw.)	Vox Humana 8' (Sw.)
Gross Flute 8' (Gt.)	Melodia 8' (Gt.)
Mixture III (Sw.)	Open Diapason 8' (Gt.)
Larigot 1-1/3' (Sw.)	Gedeckt 4' (Sw.)
Bourdon 16' (Gt.)	Octave 4' (Sw.)
Tierce 1-3/5' (Sw.)	Trompette 8' (Ped.)
Flautino 2' (Sw.)	Gamba 8' (Sw.)
Swell-to-Pedal 4' (Ped.)	Gedeckt 8' (Ped.)
Nazard 2-2/3' (Sw.)	Aeoline 8' (Sw.)
Swell-To-Pedal 8' (Ped.)	Principal 8' (Ped.)
Great-to-Pedal 8' (Ped)	Violone 16' (Ped.)
Super Octave 4' (Ped.)	Geigen Principal 8' (Sw.)
Dulciana Celeste II (Sw.)	Diapason 8' (Sw.)
Concert Flute 8' (Sw.)	Gedeckt 16' (Ped.)
Bourdon 16' (Ped.)	Bourdon 16' (Sw.)
	Countra Bourdon 32' (Ped.)
	Geigen Diapason 16' (Sw.)
	Viola Da Gamba 8' (Ant.)

CONSOLE OUTPUT AMPLIFIERS

The outputs of the tab preamplifiers are the inputs to the next stage of amplification. Here, the channeled signals are boosted to a level strong enough to leave the console, enter the auxiliary rack and drive the vibrato delay lines. This nine-channel amplifier employs the only vacuum tubes in the console. Eight of the nine inputs are from the tab preamplifiers and the ninth input is from the harp and chimes keyer.

See Figure 23 for a schematic of the console output amplifier in the schematic section.

After amplification, the channels which are affected by the tremulant tablets, deliver their signals back to the voice tablet switch assembly where the switching is effected. If the tremulant tablets are engaged, the signals are sent to the appropriate vibrato channel. If the tremulant tablets are not engaged, the switch will deliver the signals to the associate non-vibrato channel.

On leaving the console then, there are twelve channels

CONSOLE OUTPUT AMPLIFIERS (CONTINUED)

present at the terminaiton panel:

Term. Number 25 (Blk-Yel)	Pedal
Term. Number 16 (Grn)	Great Wide Vibrato
Term. Number 14 (Yel.)	Great Narrow Vibrato
Term. Number 9 (Brn.)	Great Non-Vibrato
Term. Number 19 (Gray)	Swell Wide Vibrato
Term. Number 18 (Blu)	Swell Narrow Vibrato
Term. Number 11 (Red)	Swell Non-Vibrato
Term. Number 28 (Blk-Blu)	Swell Celeste
Term. Number 21 (Blk-Red)	Antiphonal Vibrato
Term. Number 26 (Blk-Gn.)	Antiphonal Celeste
Term. Numter 12 (Orn)	Antiphonal Non-Vibrato
Term. Number 23 (Blk-Orn)	Harp-Chimes

VIBRATO SYSTEM

The last of the twelve channels coming to the rack is #23, the Harp-Chimes signals. This information is fed into the Great audio channel where it combines with Great signals and receives the same phase shifting and expression treatment as the Great signals.

There are special features in the vibrato system which are unique to the Grand-100 organ.

The first notable feature of the vibrato system is the application of vibrato rates which are different for the Great, Swell and Antiphonal divisions. The vibrato scanners are all driven from one synchronous motor by a belt and pulley system. Different rates for the scanners are obtained by using drive pulleys of different diameters. The vibrato speeds are 5.5 (Swell), 6.0 (Ant.), and 6.5 (Great) cps. respectively. These speeds more closely approximate the speeds found in church pipe organs and they are slower than on some other Hammond organs.

The second feature of the vibrato system is the application of different widths of vibrato, available from the different sized delay lines described above. An organist may, for instance, use the 8' Gross Flute Stop, which receives wide vibrato, and the 8' open Diapason stop, which receives narrow vibrato, simultaneously on the Great Manual. Again, this treatment follows pipe organ practice for greater authenticity. The Antiphonal Division uses only one medium width of vibrato.

The third feature of the vibrato system is the addition of a carefully determined amount of tremolo to each of the vibrato sections. Organ pipe output was sutdied under conditions of varying air pressure such as produced by the pipe organ.

CHORUS AND CELESTE SYSTEM

The abbreviation LDR means "light dependent resistor". The general term, "photo-cell" refers to any one of a number of devices which are sensitive to light. Generally, a photo-cell is a photo-voltaic device which will

produce a measurable voltage across its terminals when it is exposed to light. The light dependent resistors which are used in the Grand 100 are NOT photovoltaic and will produce no voltage across their terminals when exposed to light. If an external voltage is impressed across the terminals of a light dependent resistor, the amount of current which will flow through the LDR depends on the intensity of the light falling on its surface, and the current may be controlled by varying the intensity of the light. In effect, the RESISTANCE of the LDR varies with illumination, and for this reason the LDR is a PHOTORESISTIVE device. However, LDR's are commonly referred to as photocells, so this term will be used in the discussions.

The Grand 100 organ makes use of these solid state devices in the Chorus-Celeste generator and the expression control circuits.

The Chorus-Celeste generator located in the Auxiliary Rack just above the power supply chassis has six signal inputs (See Figure 20-Schematic Section). Eleven 12AU7 tubes are used; (dual triode tube), five triode sections are used as amplifiers, and sixteen triode sections are used as phase shifters, containing LDR's on the cathodes of each respective triode section.

A 12 RPM synchronous motor, powered from the AC supply, is mounted on the Chorus chassis and drives a glass disc with a black coating on which openings are etched. Nine tungsten filament light bulbs are mounted on the chassis in such a way so as to shine through the openings in the disc. See Figure 20 for a diagram of the circuitry which controls the brightness of the light bulbs.

You will note from the diagram, that manual keys and selected combinations of stops on the organ, as they are activated, increase the brightness of the respective light bulb for the Chorus circuit involved. The effect is additive as more keys and stops are used.

The light bulbs shine through the rotating openings in the disc on to the sensitive surface of the LDR's connected to the cathode side of the phase shifters. The amount of light falling on the sensitive side of the photocell determines the degree of phase shift. The rate at which the intensity of light is varied directly controls the CHANGE of degree of phase shift. The circuit is designed so that when no light falls on the photocell, the LDR resistance is about 1 megohm; and there is no appreciable phase shift at the output. With partial light, the resistance is about 40,000 ohms; with high light, the resistance is about 5,000 ohms and the phase shift is maximum. Note that the two parameters referred to above are the brightness of a bulb and the position of the opening in the disc in relation to the bulb.

The chorus and celeste effects in a pipe organ depend on the same kind of variables as does the Hammond Grand 100; the more pipes that are activated, the more chorus effect takes place; the more of the Grand 100 keys and stops that are activated, the more chorus takes place.

CHORUS & CELESTE SYSTEM (CONTINUED)

The different audio channels, high, mid, and low pass filter circuits are shifted at fast, medium, and slow rates of change to produce authentic pipe organ effects. These chorus rates are obtained from the design of the scanning disc by incorporating different numbers of slots in each track. Therefore, Pedal chorus: 0.6 cps (3 openings), slow chorus (low pass): 0.8 cps (4 openings), medium chorus (mid pass): 1.0 cps (5 openings), fast chorus (high pass): 1.4 cps (7 openings). The outer two tracks are the celeste openings and are 1.8 cps and 2.2 cps (9 and 11 openings), respectively . The celeste channels operate in much the same manner as the chorus, except the light bulbs remain at full brilliance at all times.

The brightness of the chorus phase shifter lamps is controlled separately for the Great, Swell, and Pedal divisions. The filament current for the swell shifter lights comes from any or all of three separate paths. In the swell manual relays, one row of relay operated contacts, supplies current to the output bus through 100 ohm resistors on each contact. The inputs of all the resistors are bussed to a regulated 7 volt DC supply (from power supply chassis). Then, as more and more keys are depressed, the current passing into the output bus increases by virtue of paralleling the resistors. The output bus is wired directly to the chorus lamps for the swell voices. (Antiphonal voices use the same lamps, but different photocells). Certain pairs of stop tablets in the swell division are wired so that when both stops of any pair are engaged, another current path through a 47 ohm resistor is connected from the DC supply voltage to the respective chorus lamps. This current, then, is additive to any supplied from the manual relays, and to any from other pairs of stops in similar use. See Figure 2 in the schematic section for the paired stops which are connected to the 47 ohm resistors. The third path for current to the shifter chorus lamps is through a contact on the crescendo switch, which also has a 47 ohm resistor in series with the supply voltage. The Great shifter lamps are supplied current from similar manual relay key contacts, pairs of stops, and a crescendo contact. Provision has also been made to light the Great chorus shifter lamps to almost full brilliance when the Chimes stop tablet is operated, since the chorus effect greatly enhances the chime tones.

The pedal chorus lamp is controlled only by the pedal stop tablets and one contact of the crescendo switch. Certain combinations of two similar toned pedal stops turn the pedal chorus lamp on to full brilliance, and the crescendo switch contacts have a single 47 ohm resistor in series for partial lighting of the lamp.

REVERBERATION PREAMPLIFIER

Three 12BH7 tubes and three chokes, plus other components, amplify the signals to drive the reverberation units. The function of the choke on the plate side of the tube is to provide constant current drive.

Three inputs become the reverb, drive channels: Antiphonal B #79, Swell B #77, and Great B #74. The actual connections to the three identical reverb, units are Antiphonal Reverb. Drive #73, Swell Reverb. Drive #72, and Great Reverb. Drive #71. These audio drive signals plug into the input jacks of the reverb. units. The outputs of the reverb. units return to the Inter-

REVERBERATION PREAMPLIFIER

mediate Amplifier as: Antiphonal Reverb. Input #62, Swell Reverb. Input #63, and Great Reverb. Input #64. Obviously, inputs and outputs must belong to the same division or channel.

The three reverberated signals are now amplified by the three preamps which have not been used of the Intermediate Amplifier namely, Antiphonal: V1316 and V1317, Swell: V1311 and V1312, and Great: V1305 and V1306. (Left side of Intermediate amplifier).

The A and B channels now merge at the potentiometers that are ganged together and which control the gain, tone, and reverberation levels. Finally, the signals go to the power amplifiers and out to the speaker systems.

EXPRESSION CONTROL

Each of the two console expression pedals (Great-Pedal and Swell-Antiphonal) is equipped with a potentiometer to which three wires are connected. The composite six wire cable is connected to the rack power supply and the expression control circuits at the intermediate amplifier.

The power supply delivers a regulated 7 V.D.C. potential. As the expression pedal is depressed, the resistance of the circuit changes, affecting the brightness of light bulbs in various encapsulated light dependent resistors, resembling plug-in crystals, located at the Intermediate Amplfier.

Seven channels are controlled by the two expression pedals. The Great-Pedal (expression pedal) controls the pedal, Great A, and Great B channels; the Swell-Antiphonal expression pedal controls the Swell A, Swell B, Ant. A, and Ant. B channels. Each LDR is matched with a 5% resistor and the two multi-channel groups are matched at the factory for equal tracking. Then, the factory recommends that in the event of a defective LDR, replace the 3 and 4 LDR's with their matching resistors to retain the tracking characteristics as when new.

See Figure 22 in the schematic section for the circuit locations of the 7 LDR's. As with the Chorus-Celeste LDR's, the brightness of the light bulbs shining on the photo-conductive cells determines the resistance of the circuits.

POWER AMPLIFIERS

The Grand 100 uses two types of power amplifiers; bass AO-59,70 watts (Music Power Rating) for the Pedal division, and treble AO-58, 85 watts total (Music Power Rating) for the Swell, Antiphonal, and Great divisions.

BASS MONAURAL POWER AMP.

Two types of amplifiers are used which are interchangeable; namely, the Dynakit and the Rauland-Borg. See the indicidual schematics for the circuit details of each unit.

The amplifier uses a pentode voltage amplifier (6AN8) directly coupled to a cathode phase inverter. A capacitive feedback loop is employed for high frequency compensation which also correct the inherent unbalance of this type of phase inverter. The two, push-pull output tubes (KT88) are operated with fixed bias and

BASS MONAURAL POWER AMP (CONTINUED)

are driven by the inverter. The load impedance is comparatively uncritical due to the small percentage of screen loading which improves the regulation of the stage. Phase compensation is provided across the entire frequency band and eliminates any tendency towards motor boating or oscillation.

The full wave rectifier employed is a (GZ34, 7Z34 or 5AR4) tube. It is recommended that the output tubes be replaced by a matched set for maximum efficiency.

The Dynakit amplifier, only, is a commercial model and contains an external pre-amplifier multi-connector which, for our purposes, is not used. The silicon rectifier used in the Rauland-Borg power supply can be replaced with the silicon diode of the Dynakit amplifier. See the semi-conductor parts list for the commercial number of the diode.

TREBLE STEREO POWER AMPLIFIER

As with the bass amplifier above, two different manufacturers have been used, but the two makes are interchangeable. See the schematic diagrams for the minor circuit differences of each amplifier.

The two non-interacting channels of the stereo amplifier provide the power for the loud speakers with great efficiency . The high power capacity and low internal impedance provide excellent damping for the Grand 100 quality speaker systems without need to make adjustments to match specific installations. The amplifier does not exhibit bounce and flutter when pulsed with a transient signal. Thus, a sharp percussive signal will be reproduced with sharpness and clarity with neither overhang nor muddiness. The power handling capabilities are maintained over the entire audio band without the sharp rise in distortion which characterizes most amplifiers at the extremes of high and low frequencies.

The 7199 tube is used as a pentode high gain voltage amplifier directly coupled to a cathodyne phase inverter. This type of phase inverter has the unique advantage that its operation is independent of tube aging, so that no adjustments are necessary for maintaining optimum performance.

POWER AMPLIFIERS

The internal capacitive feedback loop provides accurately balanced driving signals to the output tubes and balances the phase inverter. These output tubes are type EL34/6CA7; one pair for each channel. The connection of the output tubes includes a small percentage of screen grid loading which improves the regulation and makes the tubes comparatively uncritical of load impedance. The use of a minimum number of phase shifting stages, along with careful transformer design, makes the amplifier stable at all frequencies. This feature allows no tendency toward oscillation or motorboating under any condition.

SPEAKER SYSTEMS

The Grand 100 standard complement includes one bass and three treble speaker cabinets. The three treble speaker systems are identical.

The bass or pedal speaker cabinet contains one 15", heavy duty speaker of 8 ohms impedance. The special enclosure is a ported, bass reflex type. The function

of this speaker system is to produce sounds in the approximate frequency range of 32 to 200 cycles. This speaker is driven by the pedal power amplifier with its 70 watts (music power output rating).

The treble speaker cabinets each contain two channels. Each channel is made up of two (2) 12", 16 ohm speakers which are connected in parallel so that the 8 ohm tap may be used on the power amplifier. Each set of two speakers, then, is made up of a high and low frequency response type which overlap considerably. No crossover network is used for the pair of speakers since the overlapping is a design characteristic. The pair of treble speakers comprise either an "A" or a "B" channel. The approximate response of a low frequency speaker is 30 to 3000 cycles; that of the high frequency speaker is approximately 75 to 6000 cycles. See the installation manual for the dimensions and weights of each type of speaker cabinet, as well as recommendations on cabinet placement. Also, refer to this manual for specifications on larger speaker and amplifier complements.

The design of the power and speaker systems is such that overload will occur in the power amplifiers before the speaker system will distort.

POWER SUPPLY

The power supply assembly is comprised of three major divisions. The high voltage transformer supplies the plate voltage for all tubes with the exception of those in the power amplifiers. The voltage supplied is 280 volts. In addition, another winding of this transformer supplies the 25 volts for all transistor requirements. One further supply is derived from this transformer, that of the -4 volts which is used to control the harp and chimes keyers.

A second transformer supplies all filament requirements for the tubes, again, with the exception of the power amplifier tubes.

The third transformer is a low voltage type which supplies all of the 12 volt operated relays and solenoids with a 14 volt heavy duty supply as well as a regulate 7 volt supply for the expression control circuits and the chorus-celeste lamps.