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This service manual is intended specifically for the use of the service technicians of Electro-Voice dealers in servicing the Models 6215, 6220 and 6221 electronic organs.

### The Electro-Voice Organ Guarantee

The following guarantee applies to Electro-Voice Models 6215, 6220 and 6221 electronic organs; it is printed in the Owner's Manual which is supplied with each organ.

The Electro-Voice organ is guaranteed for one year from date of purchase by original owner to be free from any defect in workmanship or material. Electro-Voice, Incorporated agrees to repair or replace, at its option, within that year, any part used in its manufacture. Finishes are excepted. All transportation charges incurred in the carrying out of the terms of this guarantee are to be borne by the purchaser.

This guarantee becomes void if the organ is in any way not subjected to normal use and care as outlined in the owner's manual, or if unauthorized parts or service are employed, or if there is evidence that the serial number has been removed, defaced or changed. This guarantee is in lieu of all other guarantees, expressed or implied, and no representative or person is authorized to assume for Electro-Voice any liability in connection with the sale of the Electro-Voice organ.

The dealer implements the guarantee on all organs, whether or not the one-year period is applicable, by removing from the organ any modular unit which is defective and replacing it with a similar working module. The defective module is then returned to Electro-Voice, who will then repair or replace the module before returning it to the dealer. A nominal handling charge will be made by Electro-Voice, on all modules covered by the one-year guarantee period; an appropriate charge for labor and materials is made on all modules out of warranty.

Tubes and loudspeakers are included in the one-year guarantee. Should these items become defective, they should be returned to Electro-Voice who will make replacement at no charge.

The woodwork of the cabinet is guaranteed only against defects which are caused by manufacturing errors.

Damage to the organ after it leaves the Electro-Voice factory cannot be handled under guarantee. Claim should be made against the carrier for all damage incurred during transportation.

NOTE CAREFULLY: This manual includes instructions and warnings concerning certain types of repair operations which persons not directly employed by Electro-Voice are unauthorized to perform. Contravention of these rules may, at the option of Electro-Voice, entirely or partially void the guarantee.

### Limits of Field Service

Models 6215, 6220 and 6221 are manufactured in modular form. This means that each of the major components of the organ is a separate assembly which can easily be removed from the organ and replaced with a similar section.

Repairs made to Electro-Voice organs outside the factory should, therefore, be confined almost entirely to

Tube replacement (not including neon generator tubes),

Replacement of complete modules,

Readjustment of keyswitches, and

Readjustment of synchronizing potentiometers, tuning potentiometers and tuning coils.

The only exceptions to this rule cover such actions as resoldering of a wire which may have been broken through rough handling and similar very minor electrical work.

### Servicing Procedure

When an organ owner reports that his organ is faulty, the following procedure is normal:

The dealer's service technician visits the customer's home and determines which module is responsible for the trouble.

If the trouble is in a tone generator and appears to be lack of octave synchronization or bad tuning, the technician adjusts the synchronization potentiometers, the tuning slugs of the master oscillator coils and/or the tuning potentiometers of the high- or low-end oscillators.

If such adjustment does not cure the trouble, a new 12AX7 tube is substituted in the generator at fault.

If a new tube does not cure the trouble, the ailing generator is removed as a module and a new one of identical designation is installed and, if necessary, adjusted.

If the amplifier-power supply or reverberation unit appears to be at fault a repair may be attempted by replacing appropriate tubes. If this is not effective, the appropriate assembly should be replaced by a new one.

NOTE: If a generator or the amplifier-power supply is replaced, or if a generator 12AX7 tube or an OA2 or OB2 tube in the power supply is replaced, the tuning and octave synchronization of the generators should be checked and, if necessary, adjusted.

If loudspeaker, expression pedal, keyboards, pedals, or reverberation transducer are defective, a new component is substituted for the bad one. If the technician is experienced and sees an obvious and easily repaired cause for the fault without disassembling the individual unit, he may make a simple repair; but he does so at his own risk as improper repair may void the guarantee.

If the front panel volume, vibrato, or reverberation controls, or chord switch is faulty, the technician will replace the offending unit with one bearing the same stamped identification number. Use of controls other than those furnished by Electro-Voice voids the guarantee.

#### Model Identification

The Electro-Voice Models 6215, 6220 and 6221 electronic organs incorporate the same basic design; all have a 37-note upper keyboard, 13-note pedalboard, six voicing switches for the upper keyboard, pedal balance control, circuit-closing output jack and master expression pedal.

The Model 6215 utilizes a 30-note lower keyboard, preset voicing with a console balance control for the lower keyboard and a vibrato depth control.

The Model 6220 is identical to the Model 6221 except that it has no reverberation unit and corresponding reverberation control.

The Model 6221 incorporates a 37-note lower keyboard, four voicing switches for the lower keyboard, vibrato on-off and depth switches, a chord-switching device with corresponding console chord unit on-off switch, and a reverberation unit and console reverberation control.

#### Theory of Operation

This section gives a technical explanation of how the 6215, 6220 and 6221 organs operate. While an understanding of the organ's functioning is not essential to servicing, it will be of great help in diagnosing trouble and locating the section at fault. The circuit diagrams given in connection with this section are only for the purpose of explanation and are not complete; a complete schematic diagram of each model is to be found inside the rear cover of this manual and that diagram should be used for actual servicing when a diagram is required. Most service problems, however, can be solved efficiently through the use of the sections on component removal and replacement and on trouble-shooting. Each technician

should read the Owner's Manual as the information contained therein is not generally repeated here.

Figure 1A is a block diagram of the Model 6215. Figure 1B is a block diagram of the Model 6220 and Figure 1C, of the Model 6221.

The instrument to be described is the Model 6221. This will provide sufficient information to understand the organization of the Models 6215 and 6220 without the repetition of unnecessary sections. Specific differences among the various models will then be described.

The Model 6221 incorporates tone generators covering the range from the lowest note on the lower manual (F-87.3 cps) up through and including the highest note on the upper manual (F-1397 cps). While the basic system of tone generation incorporates vacuum triode L-C and R-C master oscillators and neon-tube frequency divider stages, the actual methods by which this design is utilized may be divided into two types. The first type, which we shall hereafter refer to as "frequency-keyed", is employed for the seven lowest notes of the lower manual, (F-87.3 cps) through (B-123.5 cps) and for the five highest notes of the upper manual, (C#-1109 cps) through (F-1397 cps). A representative circuit diagram is shown in Figure 4. In this circuit the proper resistance value for the oscillator is selected by the key switch operated by the note being depressed. When this resistance is inserted into the grid circuit of the vacuum triode, the oscillator immediately begins to produce the desired output frequency. This output signal is immediately fed to a common bus bar for the manual being played. This bus bar mixes all keyed signals from that manual prior to filtering of the complex waveform.

The second type of generator applies to all notes beginning at (C-130.8 cps) and extending upwards through (C-1047 cps). Here all generators are running continuously; outputs from each stage are made available at the keyswitches of the notes for this range. When the key is depressed, the key switch merely connects the output of the generator in question through a LOOK isolating resistor to the common manual output bus. Hereafter we shall refer to this type of system as "output-keyed".

The generators themselves employ a 12AX7 triode as a Hartley oscillator for maximum frequency stability. The top twelve notes of the "output-keyed" generators operate in exactly this fashion, but in addition feed two neon-tube oscillators. These act as frequency dividers to provide signals one octave and two octaves below the Hartley oscillator frequency. Synchronization of these dividers to the Hartley oscillator is accomplished by means of 5-megohm potentiometers for each divider stage. The basic circuit of the Hartley oscillator and two neon-tube dividers is shown in Figure 2. The waveshape of all generator outputs is essentially sawtooth.

The "output-keyed" generator produces three outputs for each triode oscillator and its associated neon-tube dividers. The use of four "C"'s within the range of this generator, however, requires one additional neon-tube divider circuit and this is located on a separate module. This is shown in Figure 3.

The pedal switches are of the "transfer" type. Reference to Figure 8 will show how this is accomplished. The normally-open contact of each switch assembly is fed directly from the lowest-octave output of the "output-keyed" generator. When any pedal is depressed, the movable contact is then made to touch the contact carrying the generator signal for that note. The transfer system ensures that only one signal will appear at the pedal output bus bar, and that will be the lowest signal if more than one pedal is depressed.

The pedal signal, having been properly switched according to the pedal depressed, is fed to a multivibrator frequency divider to provide a pedal tone one octave below that of the original generator stage producing it. The multivibrator circuit is shown in Figure 8. The output signal from the multivibrator then goes to a pedal balance control located on the console front panel where the organist can set the level of the pedals to balance with that from the other keyboards. The complex pedal signal is then filtered with an R-C network to provide a fairly flute-like tone quality which will go well with most any tone color selection available from the keyboards.

The keyed output from each manual bus bar is fed to R-L-C filter elements for each manual. The exact filter components being used are determined by the setting of tone switches for each manual. Here the complex waveform is given musical tone quality by filtering out unwanted harmonics. A typical circuit diagram of these filters and their switches is shown in Figure 7. After these tone switches, the now-filtered outputs from each manual are mixed and also join the filtered and balanced pedal signal.

The composite signal now enters the amplifier (shown in Figure 12). After one stage of amplification the overall signal is controlled by the expression pedal potentiometer. It now enters the reverberation unit (Figure 12). Part of this signal is given additional preamplification, then is fed to a spring-type transducer which provides the reverberation signal. The reverberation signal is adjusted in level by a console front panel potentiometer, then mixed with the other portion of the original signal. After one stage of additional amplification it is returned to the amplifier module for final power amplification.

The output of the power amplifier (Figure 12) is supplied to the console speaker, but via a circuit-closing jack which permits the connection of high fidelity headphones or an external amplification system to the instrument. Use of headphones disables the internal speaker.

The power supply (Figure 9) is straightforward with the exception of the two voltage stabilization tubes, OA2 and OB2. These assist in keeping the B plus

voltages supplied to the generators constant for maximum frequency stability.

An interesting feature of Models 6220 and 6221 is the chord system. While most key switches are of the single-circuit type, seventeen keyswitches on the lower keyboard have three normally-open contact sets per key switch. One of these contact sets operates in the conventional manner providing a signal corresponding to the actual note depressed. This, as before, goes directly to the output bus bar for that manual. Inputs to the other contact sets, however, come from other "output-keyed" generator signals, chosen so that the three signals together will form a three-note chord. The outputs from these additional two contact sets are collected on a special bus bar whose output is either grounded or mixed with the lower keyboard output bus bar depending on the setting of the console front panel "chord" switch. Thus in the "off" position only the contact set corresponding to the note being played is utilized; in the "on" position all three contact sets are used, forming the three-note chord.

Vibrato is achieved by means of an oscillator operating at slightly over 6 cps to vary the grid potential of all Hartley oscillators. Since all frequency dividers divide exactly the signal fed to them, the vibrato also affects their outputs. A console front panel switch system is provided to control the amplitude and presence of this vibrato signal.

### Physical Organization

Figure 16 is a view of the rear of the Model 6215 console and Figure 13, of the Model 6221 with the back removed. The floor of the console is raised somewhat to permit installation of the complete pedalboard assembly underneath the floor. On the floor itself is the amplifier-power supply which contains, in addition, the vibrato oscillator circuitry, the pedal multivibrator and filter, and the filter circuitry for the upper manual. The expression potentiometer is physically mounted on the amplifier-power supply chassis and is linked mechanically to the expression pedal proper. The reverberation unit (on the Model 6221 only) is also placed on the console floor just to the right of the amplifier-power supply. The reverberation transducer is located to the right, on the side of the console. The loudspeaker is mounted directly above the amplifier-power supply on the front board.

All remaining components are mounted just under the keyboards. Here are found all generator modules. Six of these modules are used for most of the "output-keyed" generators; one module is used for the "frequency-keyed" generators; one module is used for the low-C neon-tube divider. Note also the circuit-closing output jack and a small connector plate for attaching the pedalboard to the generators in this area.

Each of the "output-keyed" generator modules contains the vacuum triode oscillators and two neon-tube dividers for two complete sets of notes (all E's and A's within the range of the output-keyed generators are produced by one module, for example). All leads to and from this (as all other) module are attached to the circuitry of the module by means of small pin-type or edge-on

connectors which may be easily disconnected when replacing a modular unit. The module itself is held in place with one or two screws for easy removal.

Each "output-keyed" module also contains two tuning slugs, one for each of the two highest notes pertaining to that module. Adjacent to these slugs are four 5-megohm printed ceramic potentiometers, two each for synchronizing the notes one and two octaves below that note tuned by the respective tuning slug. These are all clearly labeled. See Figure 6. Note that the controls affecting the lowest octaves are nearest the center of the generator and successively higher octave controls are correspondingly further from the center. To the immediate left of these six "output-keyed" generator modules is the low-C neon-tube divider with its own single synchronizing potentiometer. See Figure 6.

At the extreme left of the bank of generators and dividers is found the "frequency-keyed" generator module (see Figures 4 and 20). This contains two dual-triodes and four tuning potentiometers. Thus two oscillators (and corresponding tuning potentiometers) are utilized for the seven lowest lower-keyboard notes; one oscillator for the lowest four notes and the other for the next three. Similarly the remaining two oscillators are used for the five highest upper-keyboard notes; one oscillator for the highest two notes and the other for the next three. The tuning potentiometers associated with these oscillators are used simply to adjust the tuning of the entire group of notes associated with a particular oscillator relative to the rest of the organ. Tuning between the notes associated with any given oscillator is fixed; this is controlled by the selection of resistance values used in the key switches for that oscillator.

The two keyboards of the Model 6221 are constructed so that they may be pulled forward from the front of the console, away from the generator modules (after loosening the two securing screws under the keyboards). The upper keyboard may then be tilted upward to gain access to the key switch contacts, wiring, or front panel controls. The lower keyboard may also be tilted upward to gain access to the key switches located there by removing the two screws. The filter components for the lower keyboard tone colors are located underneath the left key cheek of the upper keyboard together with the front panel controls and associated wiring.

Access to the underside of the upper keyboard of the Model 6215 is gained by removing the three screws visible from the top of the console. The entire keyboard can then be pulled forward and tilted upward for servicing. The contacts of the lower keyboard may be serviced after first removing the panel from the underside of the lower keyboard.

The pedal keyboard is secured to the underside of the floor of the organ console. It can be easily removed for servicing as required. It is connected to the generators by means of two multi-contact connectors so that it can be removed in its entirety with ease.



The Model 6220 is identical in all respects to the Model 6221 described above except that it has no reverberation unit or reverberation transducer or panel control. Reference to the schematic for the Models 6220 and 6221 will reveal that the normal input and output connections to the reverberation preamplifier are simply jumpered across.

The Model 6215 differs from the Model 6221 in several important respects. The lowest seven notes of the lower keyboard, the lower half of the "frequency-keyed" generators, is not present. The top half of the "frequency-keyed" generators and the 12 complete "output-keyed" generators are identical to those in the 6221. There is no chord system on the 6215, hence all switches on the lower keyboard are of the single contact set type. The Model 6215 incorporates a fixed tone color filter network for the lower keyboard output therefore eliminating the need for tone switches for this manual. The vibrato signal is controlled entirely by a single console front panel potentiometer which adjusts the amount of the vibrato depth from completely off to full on. In all other respects the Model 6215 is identical to the Model 6220; or to the Model 6221 without reverberation.

#### Installation

Installation of the Models 6215, 6220 and 6221 is primarily a matter of selecting the location and plugging the power cord into any convenient wall outlet. This is covered in the Owner's Manual and does not require the services of a technician. For maximum stability of the generator circuits and for protection of the console finish it is highly recommended that the instrument be protected from extremes of temperature and humidity and that the instrument not be installed near any heating duct, radiator, or exposed to the direct rays of the sun.

#### External Speaker Systems

An external speaker may be connected to the organ to enhance reproduction. To do this, make a two-wire cable, one end connected to the terminals of the speaker system to be used and the other terminating in a standard 1/4 inch single-circuit phone (not phono) plug. When the plug is inserted into the jack under the keyboards of the organ, the internal speaker will be inoperative.

If either an external speaker or amplifier is to be permanently attached to the organ, it may be desirable to make the connection directly to the terminals of the console speaker rather than by means of the phone plug; in such a case the use of headphones as described below will cause both the console speaker and the external speaker or amplifier to be inoperative.

Any good speaker system will work well though the same treble response as required for a good high-fidelity system is not required. Any external speaker system should be reasonably efficient; in general "bookshelf" type speakers will produce a lower maximum level than that obtained from a built-in speaker.

Ideal impedance is eight ohms, but other impedances cause no harm except to induce some loss of efficiency.

The organ output may be connected to a high-fidelity system to take advantage of its amplification and speaker system, or for distribution of the sound to other rooms or throughout large areas. A cable is required; it may be but does not have to be shielded. However, if it is not shielded, the two wires should be readily identifiable so that the external amplifier ground may be connected to the organ ground.

(The amplifier end of the cable should be terminated in a connector appropriate for the amplifier and plugged into the "auxiliary" input existing on most system preamplifier-control units, or directly to the input of the power amplifier if no preamplifier is used. The selection of this type of input is dictated by the requirement that no amplification be interposed between organ output and power amplifier input as the organ output signal is large and would cause overloading.

To retain a correct load on the built-in organ amplifier and to reduce the large organ output signal to proper level, a simple resistor network must be placed at the organ end of the cable. This is diagrammed in Figure 11. Note carefully the identifications in the diagrams of the tip and barrel plug connections and the "hot" and grounded connections to the amplifier and observe these polarities. Reversing them may cause slight hum.

The volume control on the amplifier or preamplifier must be used to set maximum sound level with the volume of the organ set at maximum. On preamplifiers having "loudness" controls, see that the owner realizes that setting it lower than maximum will alter the tone of the organ by boosting the bass. There is no harm, however, in doing this deliberately or even in using the preamplifier's tone controls to alter the overall tone of the organ at will.

No electronic organ sounds at its best when the speaker points directly at the listener. To take best advantage of the superiority of an external speaker, the speaker should face away from the organ or even directly at a wall or ceiling so as to diffuse the sound before it reaches the listener. As this may be difficult to do with an established high-fidelity system, it may be considered as a factor when locating the organ within the room.

No normally available headphones have sufficient bass response to sound as well with an organ as a speaker; in addition, the sound reaches the ears too directly, there being no opportunity for the sound to diffuse.

Headphones are often used, however, for practicing without disturbing other members of a household, and in a family situation where it is appropriate, the dealer and service technician should recommend the purchase of as good a pair of headphones as possible without representing that the sound will be equal to the built-in loudspeaker in quality.

Headphones of any impedance can be used only if a 10-ohm resistor is included on high impedance phones; however, the lower-impedance units, down to eight ohms, are desirable as they match the organ output more closely. If, as is probable, the sound in the headphones is too loud, the organist can simply lower the expression pedal setting. However, this reduces the range of control while playing and the technician should be ready to install within the headphone plug a resistor network equivalent to that shown in Figure 11, substituting for the 470-ohm resistor a value which yields comfortably loud volume with the expression pedal set at maximum.

### Preliminary Service Checks

Always check the following items for much time can often be saved which would ordinarily be wasted by overlooking a very simple but obvious item. Refer to the Owner's Manual to identify controls.

The line cord must be plugged into a working outlet furnishing a nominal 117 volts of 60-cycle AC. The organ will draw no more than 75 watts when operating normally.

The top of the expression pedal should be pushed toward the rear of the organ.

The keys of the upper keyboard will not sound unless the bottom of at least one of the six white voicing switches at the right of the control panel is pushed all the way in.

The keys of the lower keyboard will not sound unless the bottom of at least one of the four white voicing switches at the left of the control panel is pushed all the way in (except the Model 6215 on which the "ACC" control should be turned fully clockwise).

If headphones, high-fidelity system, or external speaker is plugged into the jack on the organ, the built-in speaker will not sound and failure to play is probably the fault of the external equipment.

Remove the fuse from the side of the power supply chassis and examine the fuse wire inside the glass tube; if it is severed, replace it with a 1 1/2 ampere type 3AG unit only. CAUTION: Insure that the power cord is removed from the power supply chassis before touching the fuse since it is connected to one side of the 117-volt line at all times.

Examine the large multi-pin connectors to make sure that they are properly seated. There are two of these on the amplifier-power supply chassis, two on the bottom of the organ generator tray (for connection to the pedal board). In addition check the small, round four-pin connector on the reverberation unit and the many small push-on type pin connectors on all generator modules and on the amplifier etched-circuit board. CAUTION: Insure that the power

cord is removed from the power supply chassis before performing this check; power supply voltages in excess of 250 volts are present at some connectors.

### Component Removal and Replacement

The back of the organ console may be removed by withdrawing the 12 screws. Two small brackets are located on the lower edge of the console floor to assist in guiding replacement of the back. A safety interlock is permanently installed on the organ back which interrupts power from the line cord to the power supply when the back is removed. CAUTION: High voltages exist at several of the connectors and within the modules of the generators and amplifier-power supply. The safety interlock was installed for a purpose. **DO NOT DEFEAT THIS PURPOSE BY INTERFERING WITH THE NORMAL OPERATION OF THE INTERLOCK OR BY REMOVING IT.**

Power may be supplied to the organ for service purposes through the use of a standard TV "cheater" cord. The above caution notice should be clearly understood, however, and care taken in all movements with the power applied.

Once the back is removed, access may be gained to any component module. The sections following explain just how these modules may be removed for servicing or inspection. Assembly is usually just the reverse of the disassembly procedure except where special notes are indicated.

Amplifier-Power Supply: To remove the amplifier-power supply completely, open the expression pedal fully; then withdraw the screw securing the expression pedal linkage to the chassis-mounted potentiometer. MAKE SURE THAT THE POWER CORD HAS BEEN DISCONNECTED. Withdraw the two large multi-pin connectors; these are of two different sizes and are polarized to prevent wrong reconnection. Refer to Figure 21 for references to the top of the amplifier-power supply chassis connections. The six wires connecting the reverberation unit to the amplifier-power supply chassis should be disconnected (Model 6221 only). Remove the four screws holding the chassis to the console floor, slide the unit to the right until the potentiometer clears the expression pedal linkage; then lift carefully.

When replacing the amplifier-power supply unit, first place the chassis on the console floor to the right of its normal position; then slide to the left until the potentiometer fits into the linkage and the apron holes are positioned over the threaded inserts. Make sure that the securing screw on the expression pedal linkage is tightened against the flat side of the control before tightening. Replace all connectors and cables according to the diagram of Figure 21. Ensure that the braided ground straps (three on the Model 6221; two on all other models) are located beneath the apron over the threaded inserts before inserting the securing screws.

Reverberation Unit (Model 6221 only): Disconnect the three wires of the shielded cable from the amplifier-power supply unit; disconnect the three wires of the

unshielded cable from the amplifier-power supply unit. Remove the plug attached to the wires leading to the reverberation transducer. Free the shielded cable running to the front panel controls; then carefully unsolder the three wires in this shield from the reverberation potentiometer located on the front panel. Withdraw the four screws securing the reverberation unit to the console floor and remove the unit. The reverberation transducer may now be removed by withdrawing the two screws securing it to the wall of the console.

Replacement of these components is simply a reversal of the above steps. Figure 12 indicates the correct rewiring of the reverberation control. Make sure that the braided ground strap from the amplifier-power supply is in place beneath the reverberation unit before the securing screws are tightened. Figure 21 indicates the correct connection of this unit to the amplifier-power supply.

"Output-keyed" Generator Modules: Disconnect carefully all connectors from the module. Withdraw the screw or screws from the module. Lifting the module slightly in the front, slide it carefully from the securing slot or connector in the back rail. All modules are identified as to the notes which they generate except the low-C divider board which is the only module with no vacuum tube. Ensure that this designation matches that appearing on the back rail before replacement. The correct connections for replacement are shown in Figure 18.

"Frequency-keyed" Generator Module: Carefully disconnect all connectors from the module. Withdraw the two screws from each end of the module. Lift the module carefully from the generator tray. On replacement, ensure that the tuning potentiometers are toward the rear of the organ. Figures 20A and 20B indicate the correct wiring and placement of this module.

Keyswitches: Access to the keyboard switches of the Model 6221 may be had by withdrawing the two screws (and washers) located underneath the keybed. If only the upper keyboard and/or front panel controls require access, these two screws may merely be loosened to the point that both keyboards can be pulled forward together, then the upper keyboard tilted upward. If access to both keyboards is required, the screws must be removed completely. Then both keyboards may be pulled forward just sufficiently to tilt either one or both keyboards upward. Care should be taken to ensure that the keyboards are not pulled too far forward. Switch adjustment details are given in Figure 5A and 5B.

The contacts of the keyswitches on the Model 6215 may be reached either by removing the three screws appearing at the top of the console, pulling the upper manula outward and tilting it upward, or by removing the protective plate beneath the lower manual.

Front Panel Controls: The rocking tablet tone switch assemblies are held in place by a flat tension clip. To remove these switch assemblies, unsolder all of the wires leading to the switch contacts, then carefully apply pressure from the bottom of the assembly. The assembly will come out through the escutcheon plate.

Should it be necessary to service any of the potentiometers located on the front panel, the assembly plate must be removed. Pull the potentiometer knobs off from the front. Three screws may then be removed to allow access to the potentiometer mounting nuts. Unsolder the control to be replaced, remove the control nut and associated hardware. Be careful with the assembly plate. Inadvertent flexing of the plate may result in broken wires. Assembly is simply the reverse procedure. See Figure 14 for the Model 6221 and Figure 17 for the Model 6215 for wiring details.

Pedal Switch Assembly: Place the console on its back. Remove the eight hex screws, holding the assembly with one hand. Each assembly is provided with sufficient cable to permit servicing of the pedal switches with the cable in place. Details of pedal switch adjustment are given in Figure 6.

Loudspeaker: Unsolder the two wires from the speaker terminal strip. Remove the four hex nuts holding the speaker frame in place and carefully withdraw the speaker.

Expression Pedal: Loosen the pedal linkage from the potentiometer by slackening the bolt. Place the console on its back and withdraw the three screws and carefully remove the pedal.

### Tuning and Synchronization

In the discussion that follows all references should be made to Figure 15 for the Model 6221 and Figure 16 for the Model 6215 which show the layout of the keyboards and their relation to the generator module controls, as well as the nomenclature of the notes. This nomenclature includes the note name, such as C or G#, as well as the numbering of the octave in which that note appears. These octave numbers vary from 0 to 4 beginning at the low end of the lower keyboard. Thus the low-end notes of the "frequency-keyed" generators are all in octave 0 and the high-end notes are all in octave 4. All "output-keyed" generators produce notes falling in octaves 1, 2 and 3 (plus C<sub>4</sub>). Thus the higher the octave number, the higher the note. Always be sure to allow the organ to warm up for at least one-half hour before tuning or synchronizing.

Two kinds of adjustments may be required for the tone generators. Like almost all musical instruments, the organ may eventually need tuning. Tuning is a precision adjustment of the frequencies of the notes. In Electro-Voice organs, there are sixteen such adjustments (fourteen on the Model 6215): twelve are made by turning the screw which locates the slug in one of the "output-keyed" oscillator coils; the remaining four (or two, on the Model 6215) are accomplished by turning the blue potentiometer knobs on the "frequency-keyed" module. Adjustment of the tuning slug for a particular oscillator in the "output-keyed" generator adjusts simultaneously the tuning of all octaves for that note within the range of that generator. Adjustment of the tuning potentiometer for a particular oscillator in the "frequency-keyed" generator adjusts simultaneously the tuning of all adjacent notes using that oscillator.

The second type of generator adjustment is octave synchronization and is required only by the "output-keyed" generators. The three stages of each of the twelve oscillators in this generator are "locked" together electronically so that in each case generator output 2 must always be exactly an octave below output 3, and output 1 an octave below output 2. In each case the lower octave is half the frequency of the one above it. These frequency relationships will occur, however, only if the free-running frequency of a neon-tube stage is somewhere within the range over which the signal it receives from the master oscillator can "catch" it and force it to exactly the correct frequency. This free-running frequency is determined by the R-C values in the neon stage. The C is fixed, but the R may be varied by rotating the small blue knobs associated with this generator.

The effect of synchronization is exactly like the synchronization of the horizontal and vertical scanning generators in a television receiver. When the picture is moving up or down in the frame or is flopped over on its side, it is because the scanning generator within the receiver is not adjusted so that it can be forced to the proper frequency by the synchronization signal sent out by the station transmitter. When you rotate the "hold" control, you are adjusting a timing element in the scanning generator. At some point in the adjustment, the generator characteristics come within the range where the station's sync pulses can "catch" it and force it to the correct frequency--and the picture suddenly stops rolling or straightens up.

In the organ, this sudden reversion to correct operation is identical. As you rotate a sync knob, the tone abruptly jumps into place at the correct frequency. **THE VIBRATO MUST BE ON FULL.** This is not a precision adjustment; it is either entirely correct or entirely wrong. It is, therefore, easily made by ear. When a key other than one of those in octaves O, 3, or 4 sounds at the wrong pitch (not an octave below the same key an octave higher) or when its sound is garbled and not of one clean, definite pitch, sync must be readjusted.

Note carefully that no key can produce a sound almost an octave below the same key an octave higher; if, therefore, the tone is clean and seems just slightly different from an exact octave, you can conclude that your ear is at fault. To be out of sync, a note must either sound very "dirty" or, if clean, must sound several notes higher or lower than it should. **BE SURE THE VIBRATO IS FULLY ON WHEN MAKING SYNC ADJUSTMENTS, OFF FOR TUNING FOR CORRECT FREQUENCY.**

When you determine that a note is out of sync, first check the same note in the 3rd octave to see that it is at a pitch somewhere between those of the next higher and lower keys. This indicates that the master oscillator is working properly. (This note may have a little "dirt" in the background, simply due to a back-coupling from the lower note which is out of sync.) Assuming that this is the case, play the same note in the 2nd octave. Holding the key down, adjust the blue knob for that note (it has a small "2" beside it; see Figure 6). As you turn the control from one extreme to the other, you will hear the note, first fuzzy and out of tune, then clear and exactly one octave below the corresponding note in octave 3, then

fuzzy again but at a different pitch, still out of tune. Note the settings of the control where the note just comes into tune and is clear; then set the control exactly half-way between these two points.

Now repeat exactly the same procedure with the same note exactly one octave lower--in octave 1. Use the blue control corresponding to that note but with a small "1" beside it. Now check octave 3 again, then repeat the setting of octave 2, then octave 1 and the synchronization for this particular set of notes is complete. If the stable sync range is less than 20 degrees of control rotation, replace that generator module to avoid further service problems.

The entire procedure should be repeated for each of the notes in octave 3. First, check the note in octave 3, then sync octave 2, then octave 1; check octave 3 again, check sync in octave 2, finally check sync in octave 1; repeat with another note. Once all twelve notes in octave 3 have been checked and the corresponding sync controls in octaves 2 and 1 have been set, the synchronization is complete.

Sync adjustments can be made by any intelligent owner though he may call the service technician the first time just to be sure he has done it correctly. Depending on his judgment of the owner's abilities, the technician may teach him how to do it; this will avoid needless calls in the future.

We come next to the subject of tuning. Electro-Voice organs employ an L-C and R-C oscillator scheme for setting and stabilizing the exact tuning of each of the generators in octaves 0, 3 and 4. As is always true of such oscillators, they may drift away from the frequencies to which they were originally tuned after a period of time, even though the ones in the organ are of exceptionally stable design. They may eventually, therefore, require tuning. The time between tunings depends primarily on how good an "ear" the owner has; the typical person is relatively tolerant and does not recognize mistuning as such until it is bad enough to sound really sour.

Almost everyone, however, having become accustomed to an instrument that is somewhat out of tune, will unfailingly recognize the difference after it has been retuned correctly. Even though he may not know why, the organ will sound much more pleasant to him, with greater tonal life and vibrancy. It is recommended that every service or sales call include a tuning job. With the proper instrument, it will take less than five minutes, but it will leave an extremely good impression of the call. As no technical knowledge is required to tune an Electro-Voice organ with a suitable tuning device, the dealer may have his salesman make a courtesy call occasionally for this purpose, taking advantage of the opportunity to renew acquaintance and keep the dealer's name in the customer's mind.

The technician should keep in mind, of course, that Electro-Voice organs are fully as stable as the best all-electronic organs available anywhere, and should never have or give the impression that constant retuning is necessary; nothing could be farther from the truth. The simple facts, in summary, are these:



All electronic oscillators tend to change tuning after a time, simply due to the effects of age, even after a year or two. However, the change in tuning will never be such as to make the organ unmusical.

The very fact that Electro-Voice organs can be tuned means that they can be tuned to agree with other instruments, such as a piano for ensemble playing, even though this kind of tuning may not agree with the theoretical international standard.

Retuning an Electro-Voice organ is extremely simple--much easier and faster than tuning a piano or most other kinds of organs.

There is one recommended method of tuning. For all service technicians and others who habitually work on organs there are instruments especially made for the purpose. The Schober Autotuner and the Conn Strobotuner can be used by anyone to tune an Electro-Voice organ to the highest possible accuracy in five minutes or less. Both of these instruments are stroboscopic and should be used in accordance with the instructions accompanying them.

Here are the steps to be followed in completely tuning and synchronizing the Electro-Voice organ:

TURN THE VIBRATO OFF COMPLETELY WHILE TUNING. TURN THE VIBRATO ON FULLY WHEN CHECKING AND ADJUSTING SYNCHRONIZATION

Tune all the notes in octave 3 first. These may be tuned in any order, but must include all notes from  $C\#_3$  (554.4 cps) through and including  $C_4$  (1047 cps).

Synchronize all the notes in octave 2 and 1. Do not forget that  $C_3$  must also be synchronized; also the lowest C in octave 1. Thus all notes between  $C_1$  (130.8 cps) and  $C_3$  (523.3 cps) inclusive must be synchronized.

Tune  $G_0$  (98.0 cps) by adjusting the left-hand potentiometer on the "frequency-keyed" module (See Figure 20 for all "frequency-keyed" modules). This also tunes  $F_0$ ,  $F\#_0$ , and  $G\#_0$  automatically. (Unnecessary on the Model 6215.)

Tune  $A\#_0$  (116.5 cps) by adjusting the second potentiometer from the left on the "frequency-keyed" module. This also tunes  $A_0$  and  $B_0$  automatically. (Not necessary on the Model 6215.)

Tune  $F_4$  (1397 cps) by adjusting the right-hand potentiometer on the "frequency-keyed" module. This also tunes  $E_4$ .

Tune  $D_4$  (1175 cps) by adjusting the second potentiometer from the right on the "frequency-keyed" module. This also tunes  $C\#_4$  and  $D\#_4$ .

For a final test, play the lowest bass pedal note and the corresponding lowest note on the lower keyboard ( $C_1$ ) at the same time. Do this for each pedal note to determine accuracy of sync adjustment. Use only the 1st octave of the lower keyboard for comparison (plus  $C_2$  against the top pedal note). If the two corresponding notes played are not clean, readjust the sync control for the key depressed on the lower manual.

### Schematic Diagram

This manual contains a complete wiring diagram of the organ showing all individual wires and connections with wire colors needed for correct servicing. It should not ordinarily be necessary to use this diagram; where you remove a component it is always good practice to make your own sketch or list showing the connections removed so you can replace them the same way. However, the diagram may rescue you if you fail to do so or become confused for any reason.

### Trouble Shooting

The remaining pages of this Service Manual contain a list of typical service problems and their remedies. By simply running down the list and finding the symptom which matches the situation, you should be able to make the repair.

Be sure that what the customer believes is a fault is not a misunderstanding of how the organ works. A typical case of this would be an owner who calls in to say that when he plays chords on the lower manual of the Model 6220 or 6221, he gets terrible discords. The service technician may make the call and find the owner has the chord switch in the "on" position so that each key depressed produces three notes--and, of course, depressing the three keys of a normal chord produces as many as nine notes, making a discord. A similar lack of knowledge might cause the complaint of no pedal operation; the pedals may not be heard if the pedal balance control is not turned higher than its minimum position. It is, therefore, a good idea to get some preliminary information when the complaint is telephoned in; this may save a service call.

Do not confuse a "fault" found in mere testing with a normal situation that would not impair playability. For instance, if all stop tablets (tone switches) are in the "off" position, playing the upper or lower keyboards with the expression pedal all the way open will produce faint sound due to stray leakage of tones. This is common to almost all electronic organs. However, it is completely insignificant because it would be foolish to play on a manual without any stops on.

You will find that, like all electronic devices operated from house AC power lines, there will be a small amount of hum and background noise in the speaker when the expression pedal is open and no music being played. This is of no importance because when the organ is played the music will be so much louder than the back-

ground noise that the noise will not be apparent. Reverse the AC plug in its socket for minimum hum.

The Models 6215, 6220 and 6221 are somewhat different from "conventional" organs--witness the special chord feature, the modular construction, and so on. All persons connected with the dealer store should deliberately make themselves familiar with how the organ operates so that an inquiring customer can be quickly and authoritatively given answers to any questions involving operation and corrected if he believes a normal function to be a fault.

Electro-Voice is willing and anxious to receive suggestions and information from technicians in the field regarding all technical matters as well as to give full and prompt answers to any questions which any field technicians might encounter. A letter or telephone call to the Service Department at the Buchanan plant will bring complete cooperation.

The symptoms and remedies below are not listed in any particular order, since apparently related symptoms may relate to quite different parts of the organ. As time passes and additional information is acquired, service bulletins will be issued to owners of this Service Manual.

#### Common Service Problems and Their Remedies

Tones from one stop are intermittent or missing completely, but other stops work correctly.

Stop switch contact may be improperly adjusted. Gain access to rocking stop tablet assembly by tilting upper keyboard. Readjust contact separation for that stop as shown in Figure 6.

A note in octaves 1 or 2 (or C<sub>3</sub>) is very "dirty" or at incorrect pitch.

Improper synchronization of the frequency divider. See section on "Tuning and Synchronization". If the procedure given there will not correct the fault, replace the 12AX7 tube for that oscillator; retune and synchronize the generator if necessary. If the difficulty still persists, replace the entire module, retune and synchronize as necessary.

Tone not heard when a key is depressed or tone constantly heard even with its key not depressed.

Improper key switch contact adjustment so it is either not touching its bus bar when the key is depressed or it is touching the bus bar even when the key is not depressed. Gain access to keyswitches. Readjust key switch clearance according to Figure 5. Use care in bending the contact finger, bending only at the root of the blade. A silent note may also be caused by a broken wire at the rear of a key switch or at the front of a generator. Examine visually and

if necessary check with an ohmmeter to detect a wire broken within its insulation. If these results are negative, disconnect the appropriate wire from the generator and touch to another generator output. If the key then sounds (though it will be the wrong note) the generator is faulty. First check to see if a new 12AX7 tube corrects the difficulty. If not, replace the entire module.

Dead note or notes; one or more neon tubes not lit.

Refer to Figure 18 to see the path of the various signals between generators. Carefully trace for any broken or disconnected wire (s) and reconnect. If the power supply appears to be defective, try a new 5Y3 rectifier tube; if this does not correct the problem, replace the power supply.

If only one neon tube is out, the generator is defective and should be replaced. If more than one neon tube in the organ is out, but not all, a wire passing B plus voltage to the affected generators may be broken or disconnected. If all neon tubes are out, a wire from the B plus power supply may be broken or the power supply itself may be defective.

Dead note in 3rd octave (or C<sub>4</sub>) only. Lower octaves 2 or 1 (or C<sub>3</sub>) sound out of tune or "dirty".

Replace 12AX7 tube in affected generator, retune and synchronize.

No sound; the pilot light is not on; the neon tubes and tube filaments are not lit.

Check power cord. Inspect fuse and replace if necessary. Check power switch wiring on front panel. Replace power supply.

All notes (or a great majority) in octaves 1 and 2 (and C<sub>3</sub>) not on pitch and/or "dirty".

Check synchronization. Inspect OA2 and OB2 regulator tubes; if they are not glowing, replace them.

All pedal keys above a certain one are silent.

Examine pedal switches. Center blade of highest pedal which sounds is not touching upper blade when the pedal is released. See Figure 6 for adjustment clearances.

No pedal keys sound.

Make certain that the cables from the pedalboard are firmly inserted into their sockets. Check amplifier tubes V2 and V3.

No vibrato.

Check V2 tube in amplifier. Check connections to vibrato switches or controls to make sure that they are secure. Check vibrato switch contacts.

No sound from organ; neon tubes and all tubes except possibly V4 on amplifier are lit.

Try replacing V4 with a new 6AQ5. Make sure reverberation unit connections are secure. Check tubes V1, V8 and V9 by replacement. Check contacts on output jack to make sure that they are meeting properly. Check all multi-pin plugs. Check speaker by connecting headphones to output jack; if they work and speaker connections are good, replace speaker.

One pedal note is dead; all others play.

See that the center blade of the pedal switch contacts the lower blade when the pedal is depressed. Check the wire to the lower switch contact and the other end of this wire in the multi-pin plug. If the corresponding note in the 1st octave does not play (or C<sub>2</sub>), the generator concerned may be defective.

Noisy attack of note when key is depressed or intermittent note.

Work key rapidly 20 times or more. The wiping action of the contact blades will usually clean the switch. If not, cleaning is necessary; use small piece of cotton wound tight on a thin stick (like a Q-tip) moistened in non-residue contact cleaner such as alcohol. Use sparingly.

Noisy operation of expression pedal, vibrato control (Model 6215), or balance controls.

Replace appropriate potentiometer.

Crackling or popping noise even when organ is not being played, irrespective of expression pedal setting.

Replace 12AT7 tube (V8) in reverberation unit.

Audio howl. Volume is dependent upon expression pedal setting.

Check for proper closing of "frequency-keyed" generator keyswitches.

Reverberation not operative.

Check reverberation unit tubes 12AT7 and 6AV6 (V8 and V9). Check connections to transducer, amplifier-power supply, and front panel control. Remove transducer and check continuity of internal connections with ohmmeter.

MODEL Q20-21-22  
REPLACEMENT PARTS PRICE LIST

Part No.	Model	Schematic Ident.	Description	Retail Price		Dealer Cost	
				Exch.	New	Exch.	New
46293	6215	R68	Accompaniment Balance Control		1.00		.60
83205	6215	---	Amplifier-Power Supply Subassembly	25.00	95.00	15.00	57.00
83072	6221	---	Amplifier-Power Supply Subassembly	25.00	95.00	15.00	57.00
20681	both	---	Control Knobs		.25		.15
56027	6221	---	Chord Switch		1.00		.60
46166	6215	R83	Expression Pedal Control		1.15		.69
46166	6221	R113	Expression Pedal Control		1.15		.69
83201	6215	---	Frequency-Keyed Generator Subassembly	8.50	32.50	5.10	19.50
83112	6221	---	Frequency-Keyed Generator Subassembly	8.50	32.50	5.10	19.50
20519	both	---	Fuse 1-1/2 amp 3AG		.10		.06
75506	6215	C	Keyboard Actuator Pad (C) All Keys		.05		.03
74388	6221	A	Keyboard Actuator Pad (A) Chord Section through serial #8500		.05		.03
74389	6221	B	Keyboard Actuator Pad (B) All Keys except chord section and Frequency-Keyed section through serial #8500		.05		.03
75506	6221	C	Keyboard Actuator Pad (C) all Frequency-Keyed through Serial #8500 and all keys after serial #8500		.05		.03
75518	6215	---	Loudspeaker, 8-inch	recone 5.85	8.00	recone 3.50	4.80
75395	6221	---	Loudspeaker, 12-inch	recone 7.50	12.00	recone 4.50	7.20
83189	6215	---	Low "C" Frequency Divider Subassembly	2.50	8.00	1.50	4.80
8623	6221	---	Low "C" Frequency Divider Subassembly through serial #9000	2.50	8.00	1.50	4.80
83189	6221	---	Low "C" Frequency Divider Subassembly after serial #9000	2.50	8.00	1.50	4.80
83203	6215	---	Oscillator Subassembly (A-E)	7.50	27.50	4.50	16.50
83038	6221	---	Oscillator Subassembly (A-E) through serial #9000	7.50	27.50	4.50	16.50
83203	6221	---	Oscillator Subassembly (A-E) after serial #9000	7.50	27.50	4.50	16.50
A83203	6215	---	Oscillator Subassembly (B-D)	7.50	27.50	4.50	16.50
A83038	6221	---	Oscillator Subassembly (B-D) through serial #9000	7.50	27.50	4.50	16.50
A83203	6221	---	Oscillator Subassembly (B-D) after serial #9000	7.50	27.50	4.50	16.50
B83203	6215	---	Oscillator Subassembly (F#-C#)	7.50	27.50	4.50	16.50
B83038	6221	---	Oscillator Subassembly (F#-C#) through serial #9000	7.50	27.50	4.50	16.50
B83203	6221	---	Oscillator Subassembly (F#-C#) after serial #9000	7.50	27.50	4.50	16.50
C83203	6215	---	Oscillator Subassembly (G#-D#)	7.50	27.50	4.50	16.50
C83038	6221	---	Oscillator Subassembly (G#-D#) through serial #9000	7.50	27.50	4.50	16.50
C83203	6221	---	Oscillator Subassembly (G#-D#) after serial #9000	7.50	27.50	4.50	16.50
D83203	6215	---	Oscillator Subassembly (A#-F)	7.50	27.50	4.50	16.50
D83038	6221	---	Oscillator Subassembly (A#-F) through serial #9000	7.50	27.50	4.50	16.50
D83203	6221	---	Oscillator Subassembly (A#-F) after serial #9000	7.50	27.50	4.50	16.50
E83203	6215	---	Oscillator Subassembly (G-C)	7.50	27.50	4.50	16.50
E83038	6221	---	Oscillator Subassembly (G-C) through serial #9000	7.50	27.50	4.50	16.50
E83203	6221	---	Oscillator Subassembly (G-C) after serial #9000	7.50	27.50	4.50	16.50
46293	6215	R73	Pedal Balance Control		1.00		.60
46165	6221	R109	Pedal Balance Control and Power Switch		1.50		.90
46286	6221	R212	Reverberation Control		1.00		.60
83139	6221	---	Reverberation Transducer	4.50	7.50	2.70	4.50
83118	6221	---	Reverberation Unit (without transducer)	12.00	25.00	7.20	15.00
C8522	6221	A & B	Switch Blade through serial #8500		.25		.10
75328-cu	6215	C	Switch Wire		.05		.03
75328-cu	6221	C	Switch Wire after serial #8500		.05		.03
4330	both	---	Tube OA2		2.50		1.46
4390	both	---	Tube OB2		2.50		1.46
4314	both	---	Tube 5Y3		1.75		.98
4333	both	---	Tube 6AQ5		2.15		1.20
4344	6221	V9	Tube 6AV6		1.50		.90
4327	6221	V8	Tube 12AT7		3.00		1.80
4311	both	---	Tube 12AX7		2.55		1.43
46294	6215	R71	Vibrato Control and Power Switch		1.50		.90
74187	both	---	Switch Blade Adjusting Tool				.45
74178	both	---	Dampp-Chaser Model #5RE-10-EV		5.45		3.27

1 - 11 units  
3.02  
12 or  
more units

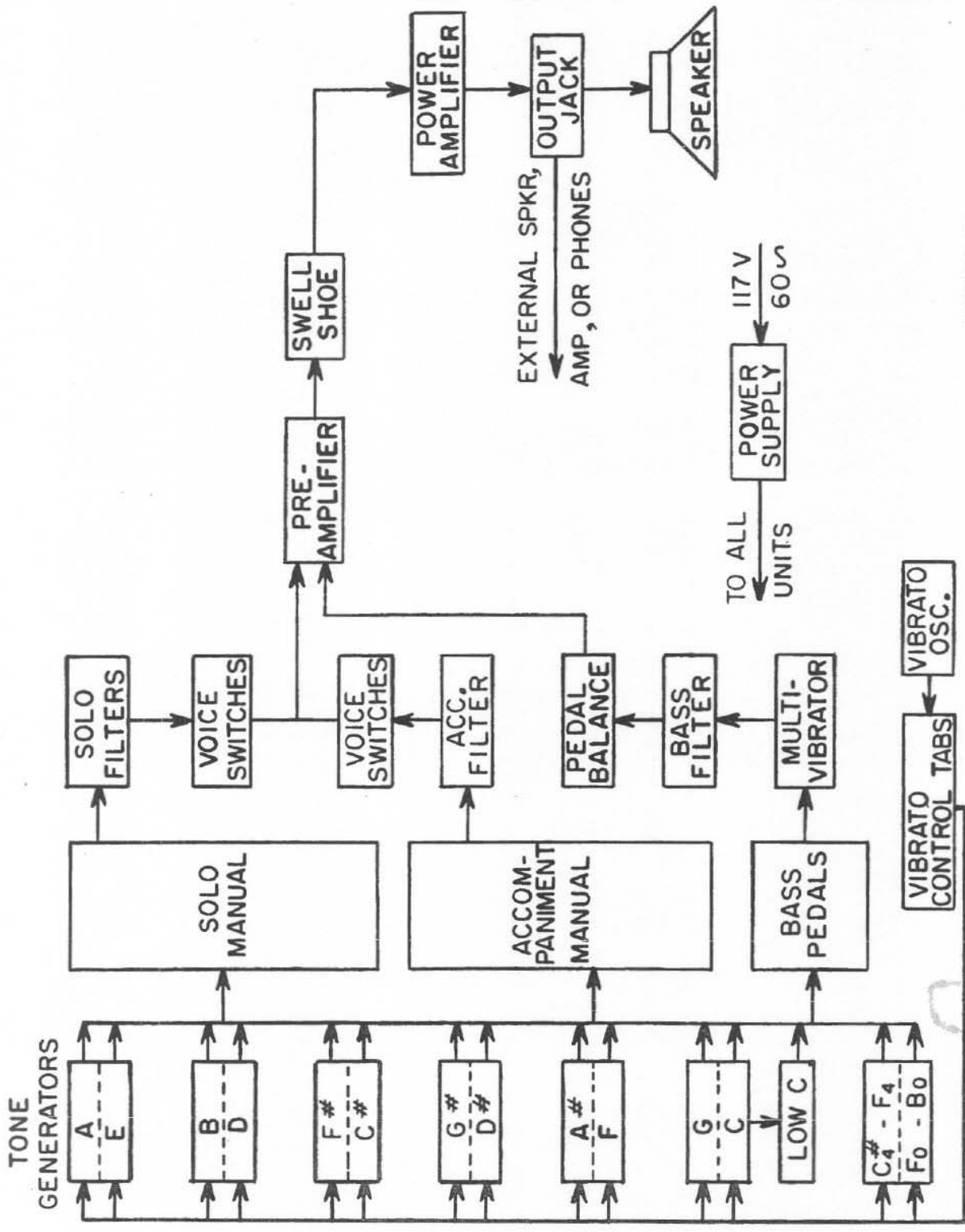


FIGURE 1A  
MODEL 6215 - BLOCK DIAGRAM

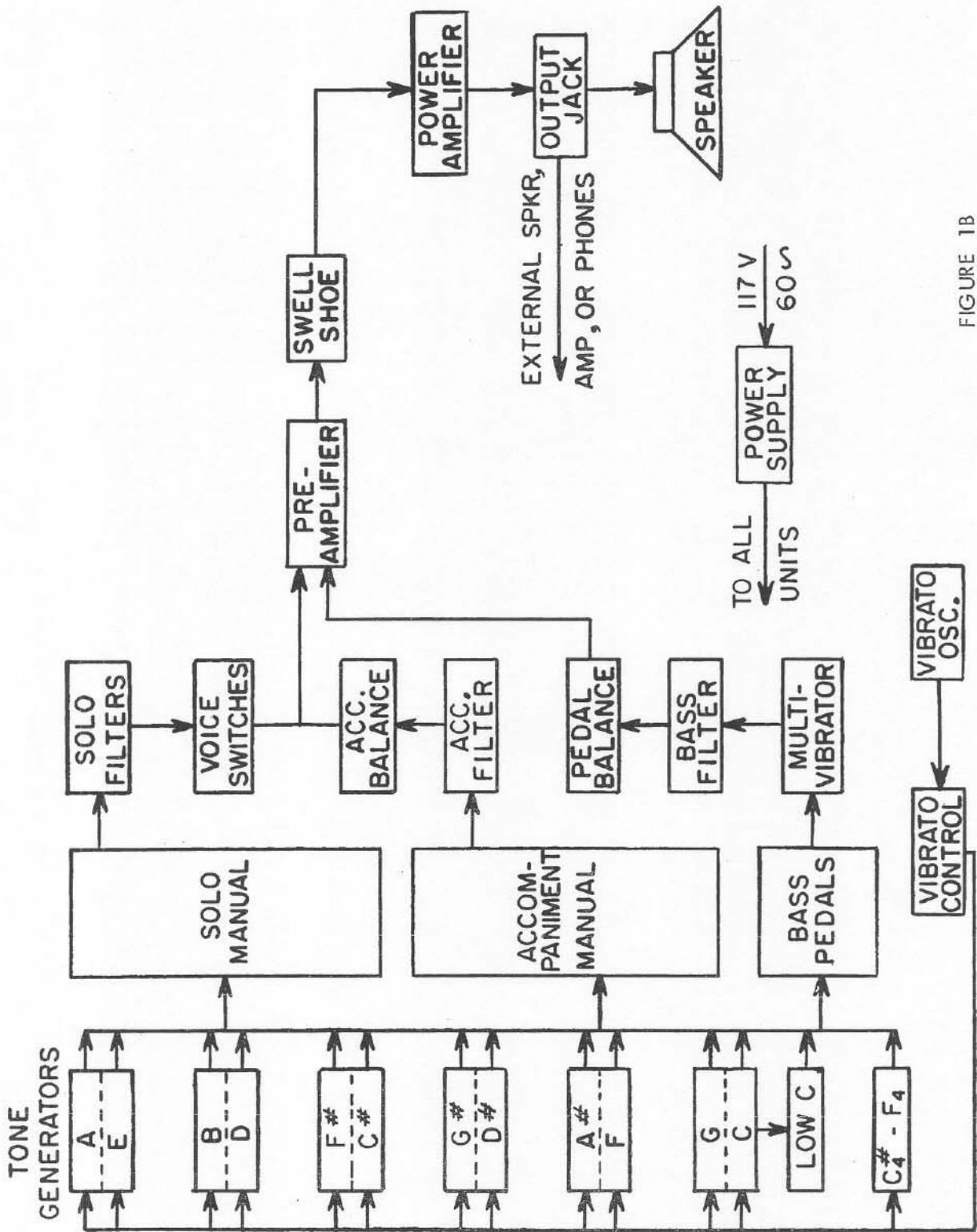


FIGURE 1B  
MODEL 6220 - BLOCK DIAGRAM



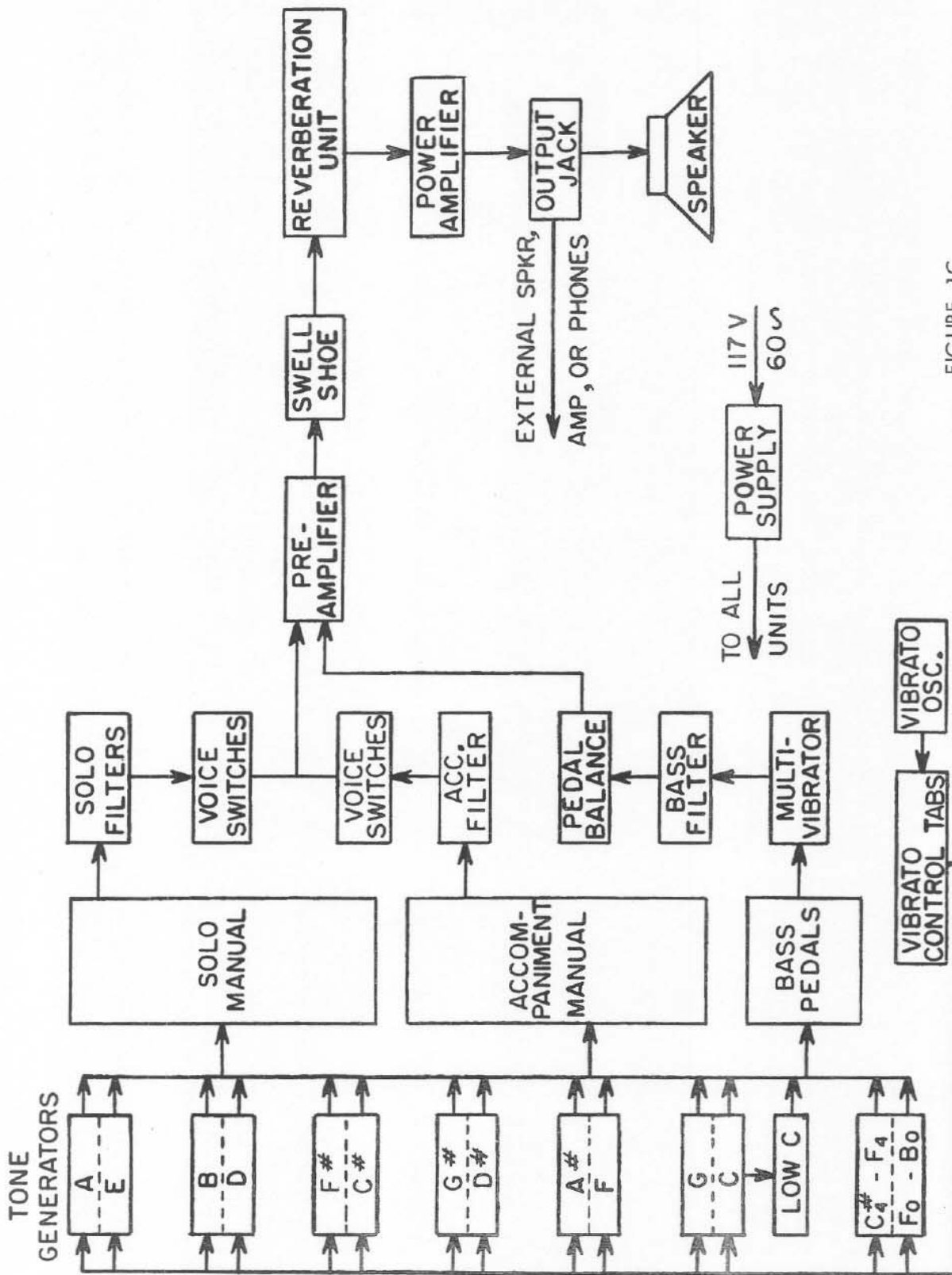
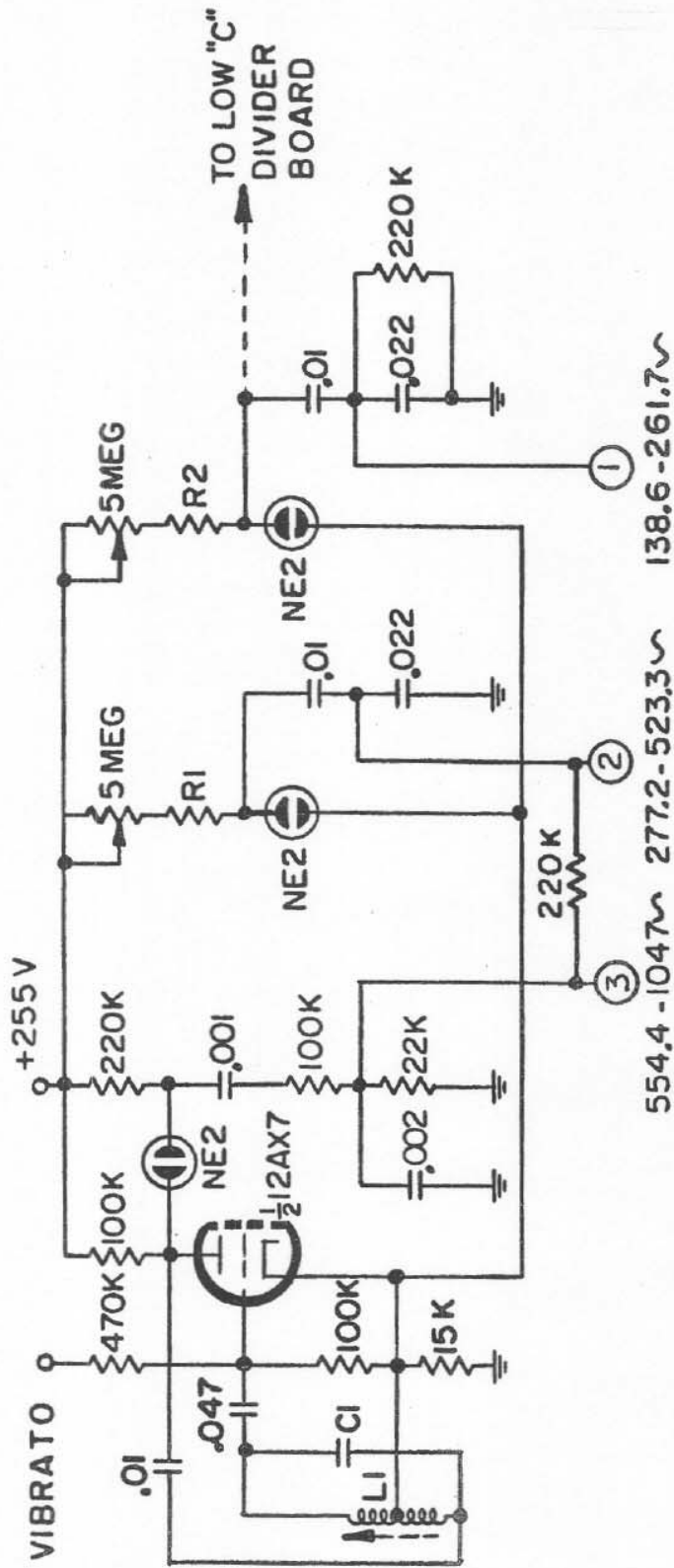


FIGURE 1C  
MODEL 6221 - BLOCK DIAGRAM



554.4 - 1047  $\sim$  277.2 - 523.3  $\sim$  138.6 - 261.7  $\sim$

NOTE	R1	R2	LI/CI PART NO.
C	1.2 M	1.8 M	C8538
A#	1.2 M	3.9 M	A8538
G#	1.2 M	4.7 M	F8538
B	1.2 M	3.3 M	B8538
A	1.2 M	3.9 M	8538
F	1.2 M	5.6 M	D8539
D	1.8 M	6.8 M	A8539
E	1.8 M	5.6 M	C8539
G	1.2 M	4.7 M	E8538
F#	1.2 M	5.6 M	D8538
D#	1.8 M	6.8 M	B8539
C#	2.2 M	6.8 M	8539

FIG. 2 TONE GENERATOR

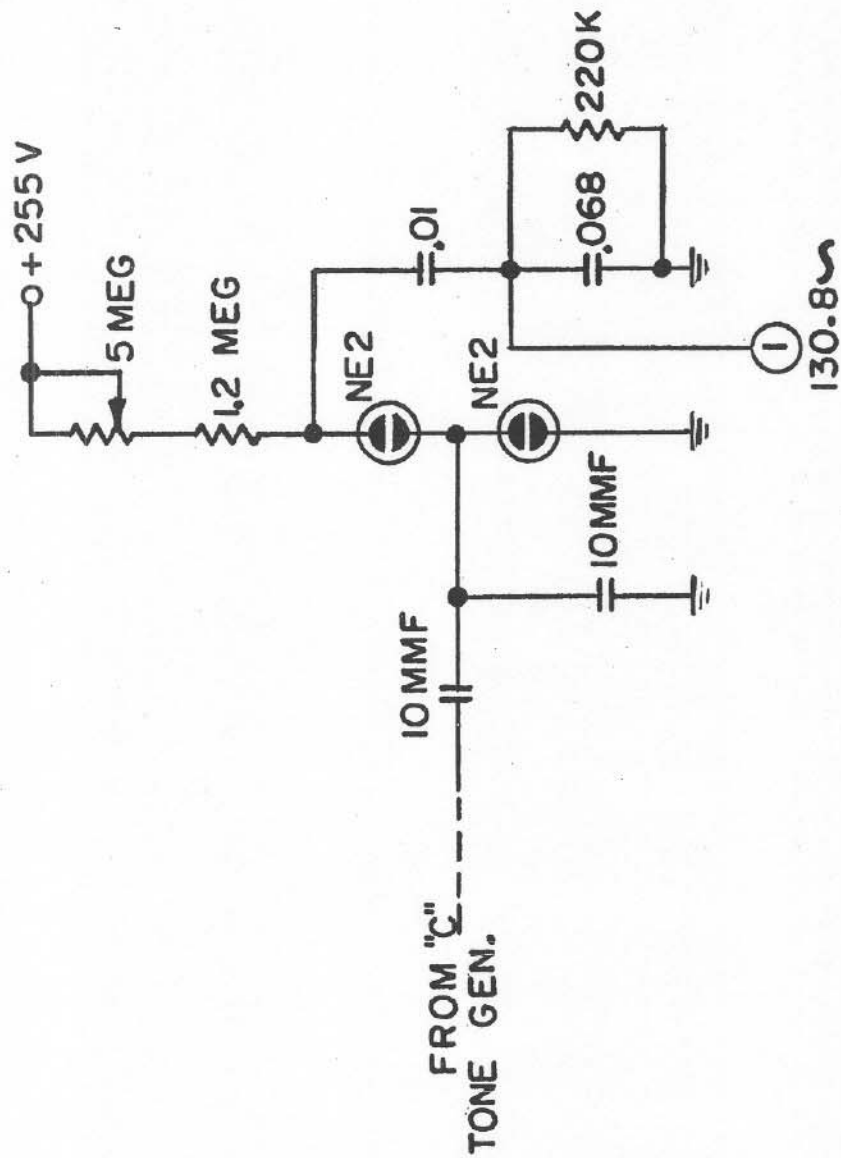
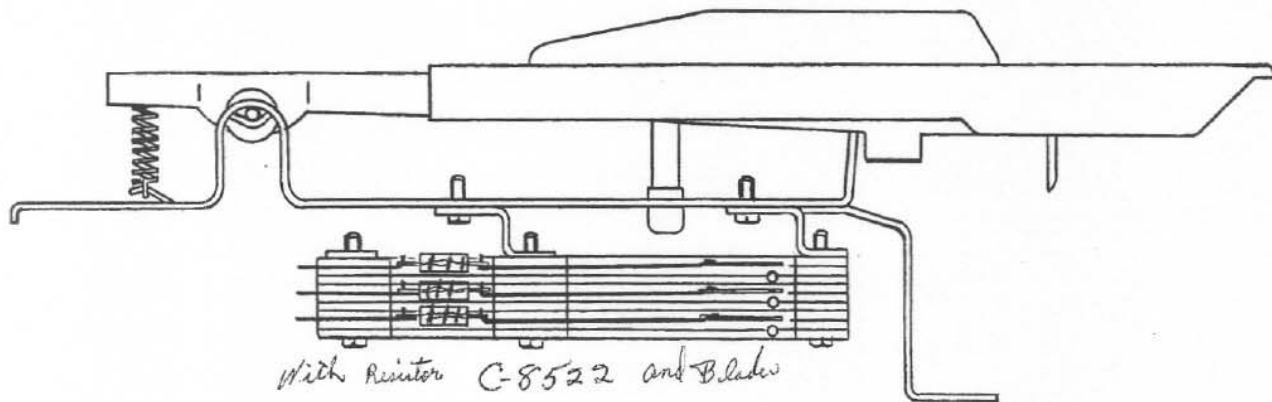
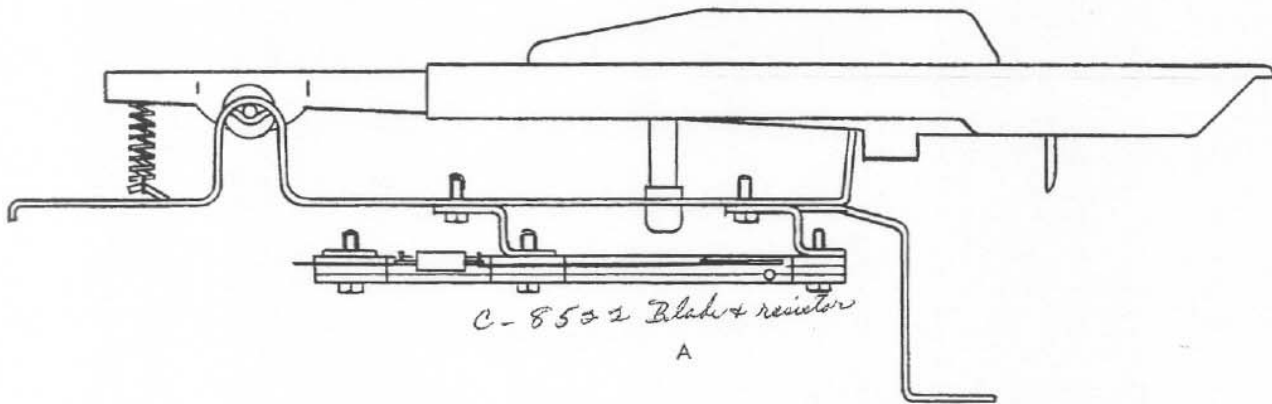


FIG. 3 LOW "C" DIVIDER BOARD





NOTE 8 SWITCHES SHOULD BE ADJUSTED TO BE CENTERED BETWEEN BUSS BARS WITH KEY IN UP POSITION & SHOULD TOUCH BUSS BARS WHEN KEY IS DEPRESSED APPROX.  $\frac{1}{3}$  TO  $\frac{1}{2}$  WAY DOWN.

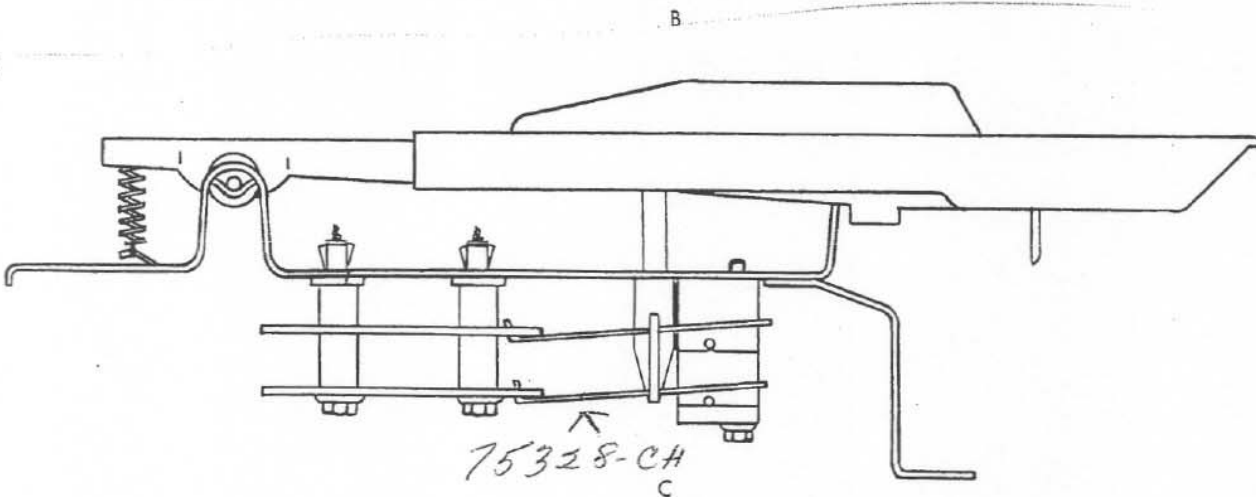
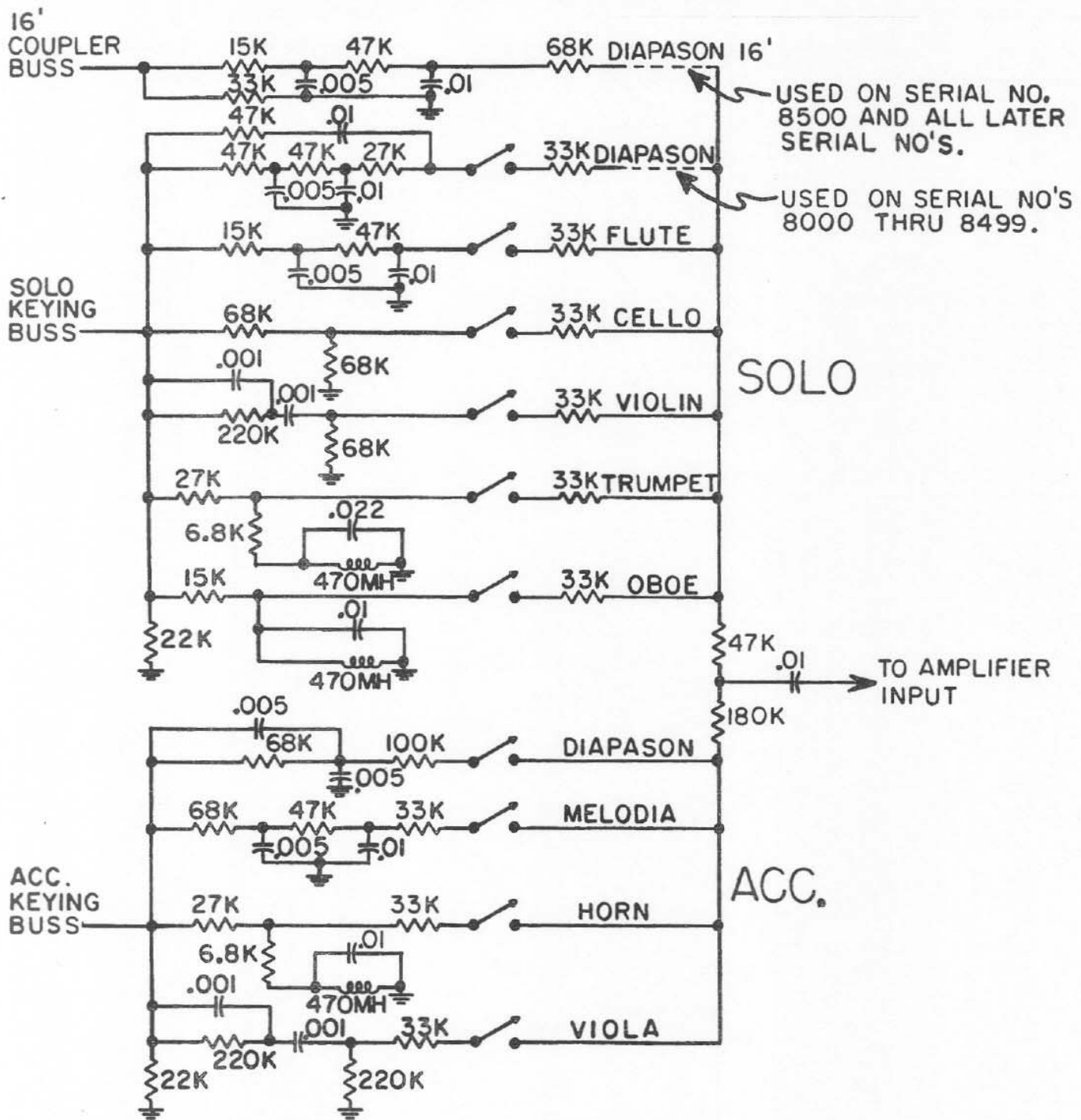


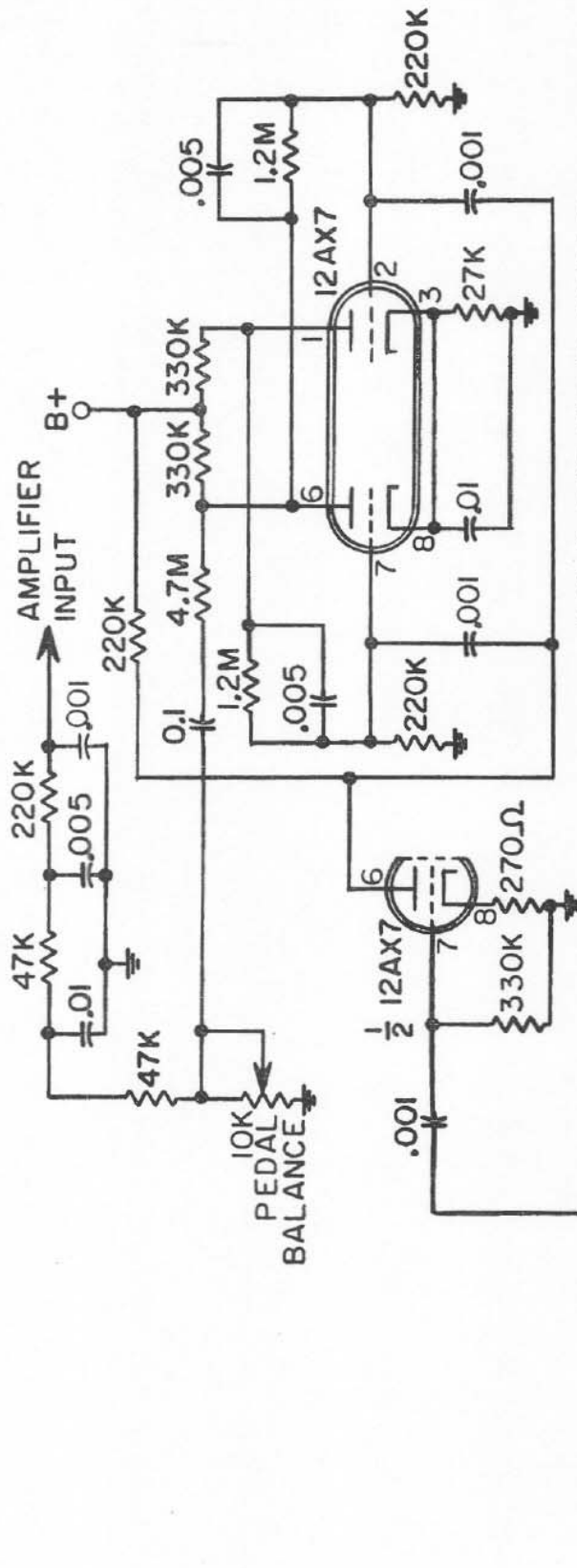
FIGURE 5  
KEY SWITCH CONTACT ADJUSTMENTS





# TONE FILTERS

FIGURE 7



MULTIVIBRATOR

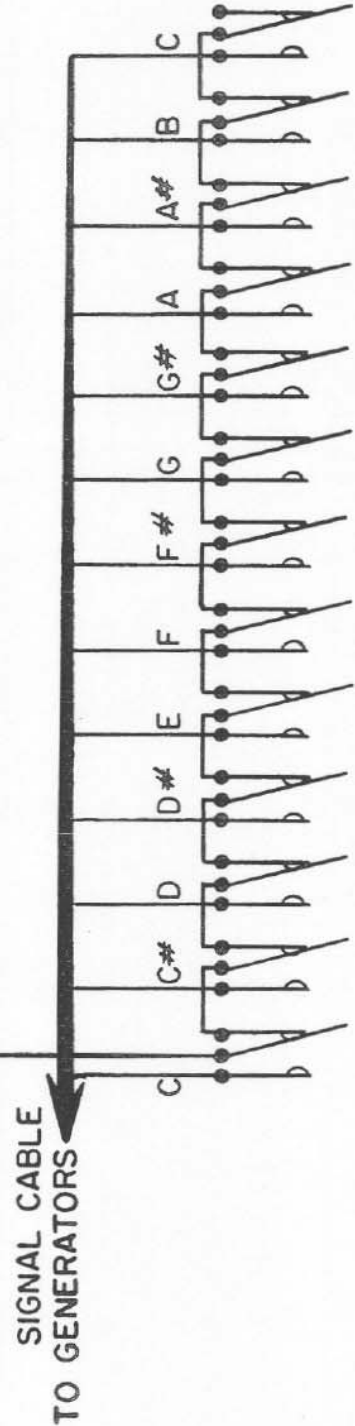


FIGURE 8



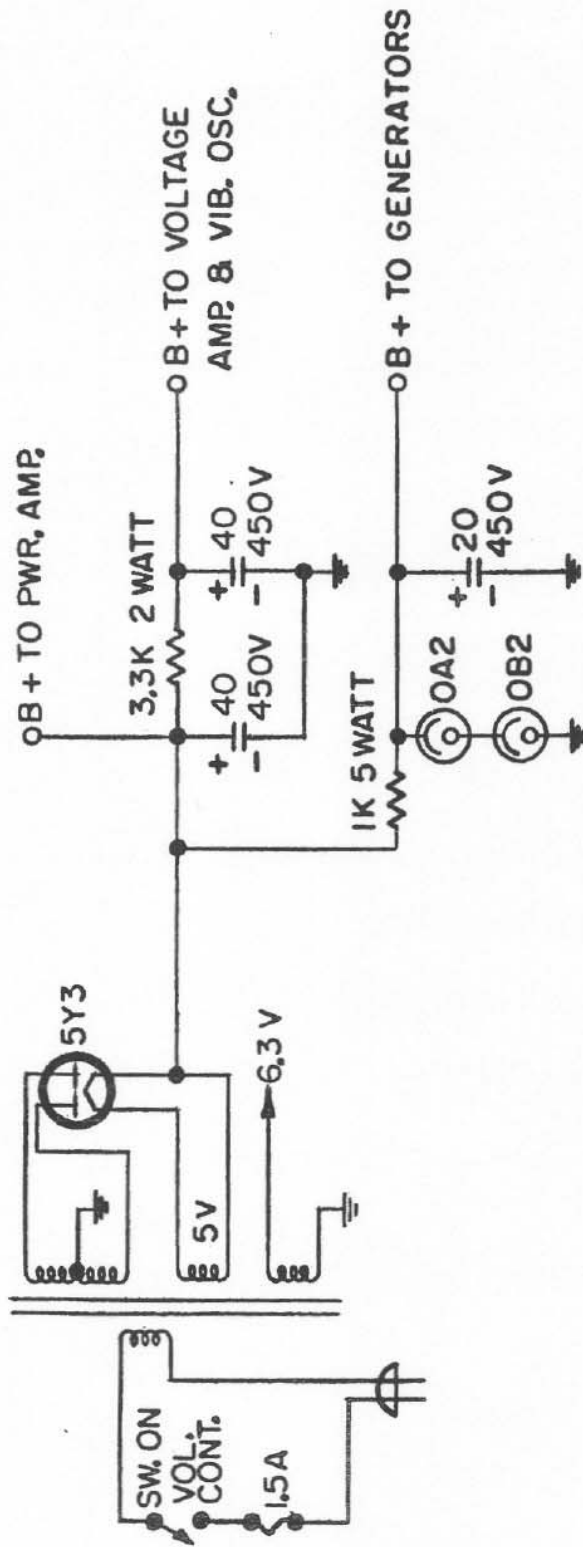


FIG. 9 POWER SUPPLY

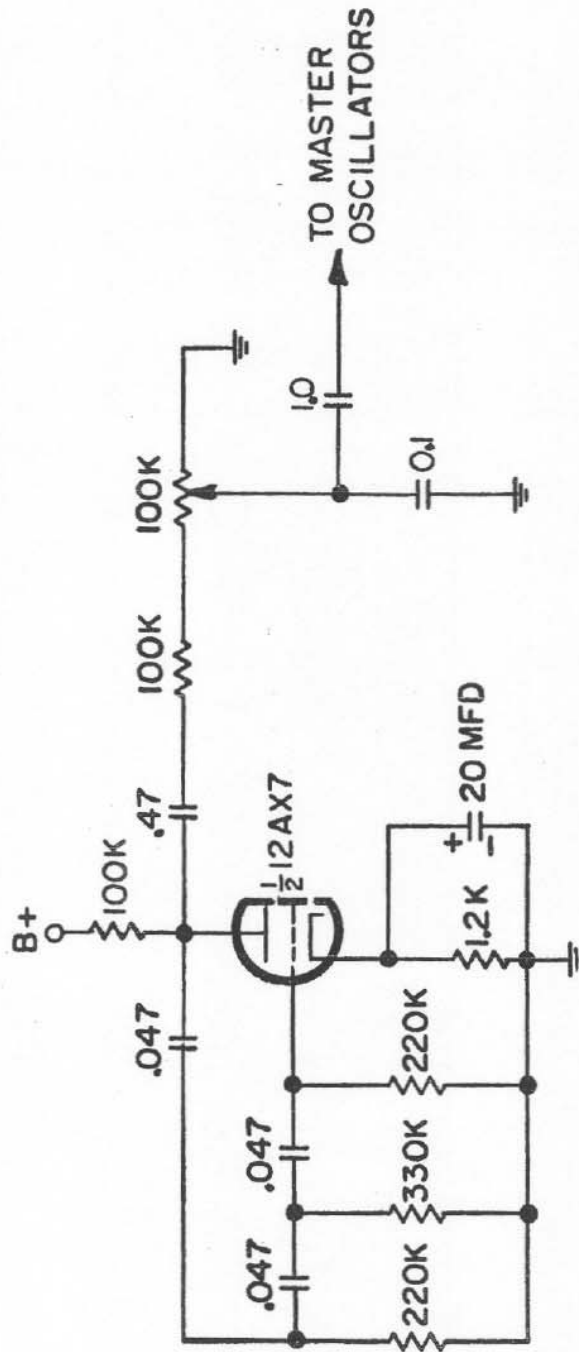


FIG.10 VIBRATO CIRCUIT

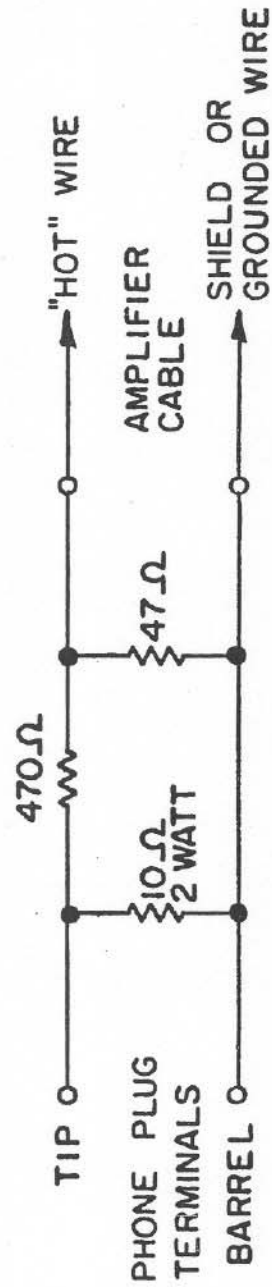
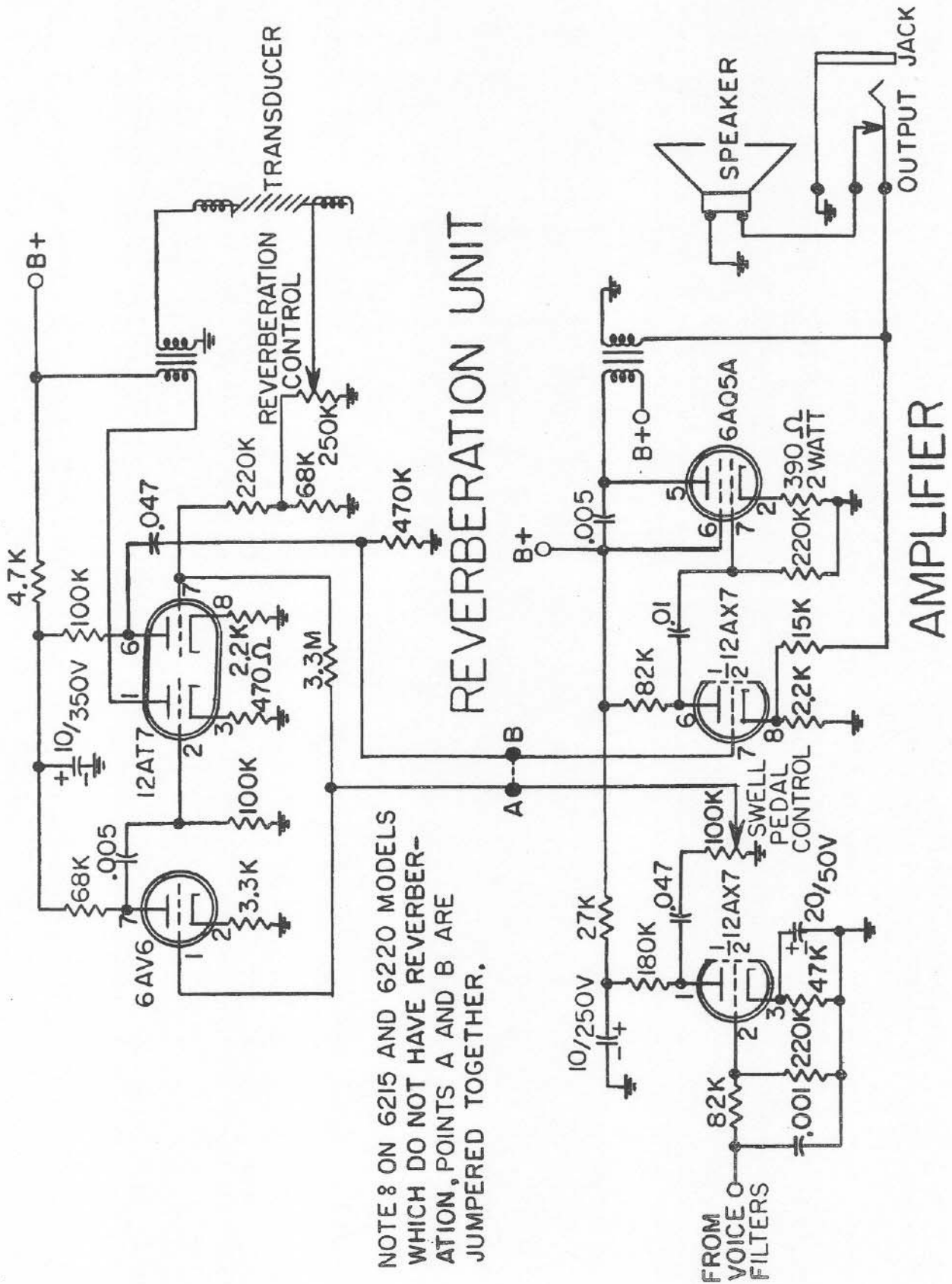


FIG. 11 ATTENUATOR FOR EXTERNAL HI-FI AMPLIFIER



NOTE 8 ON 6215 AND 6220 MODELS WHICH DO NOT HAVE REVERBERATION, POINTS A AND B ARE JUMPERED TOGETHER.

FIGURE 12

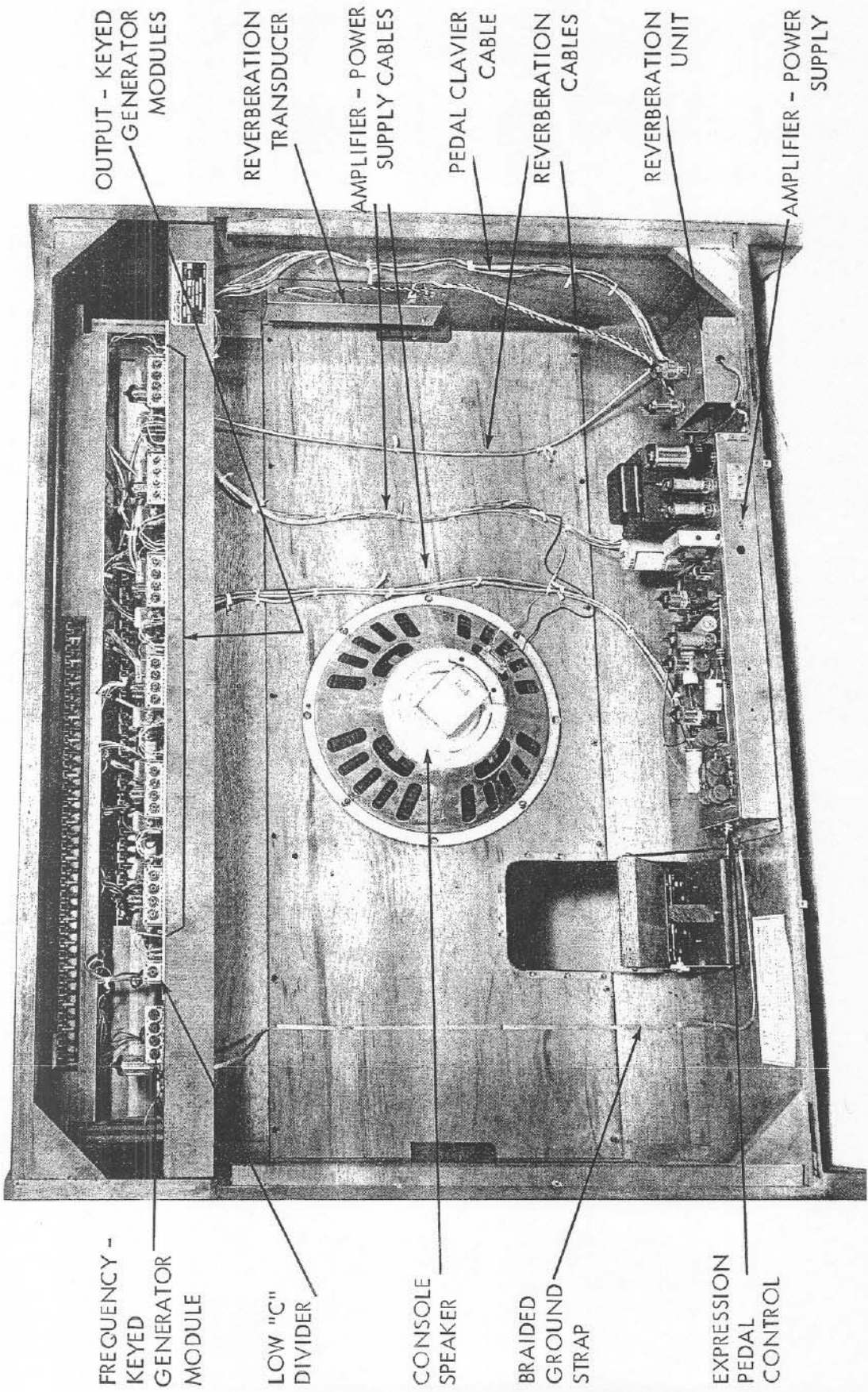


FIGURE 13  
 MODEL 6221 - BACK REMOVED

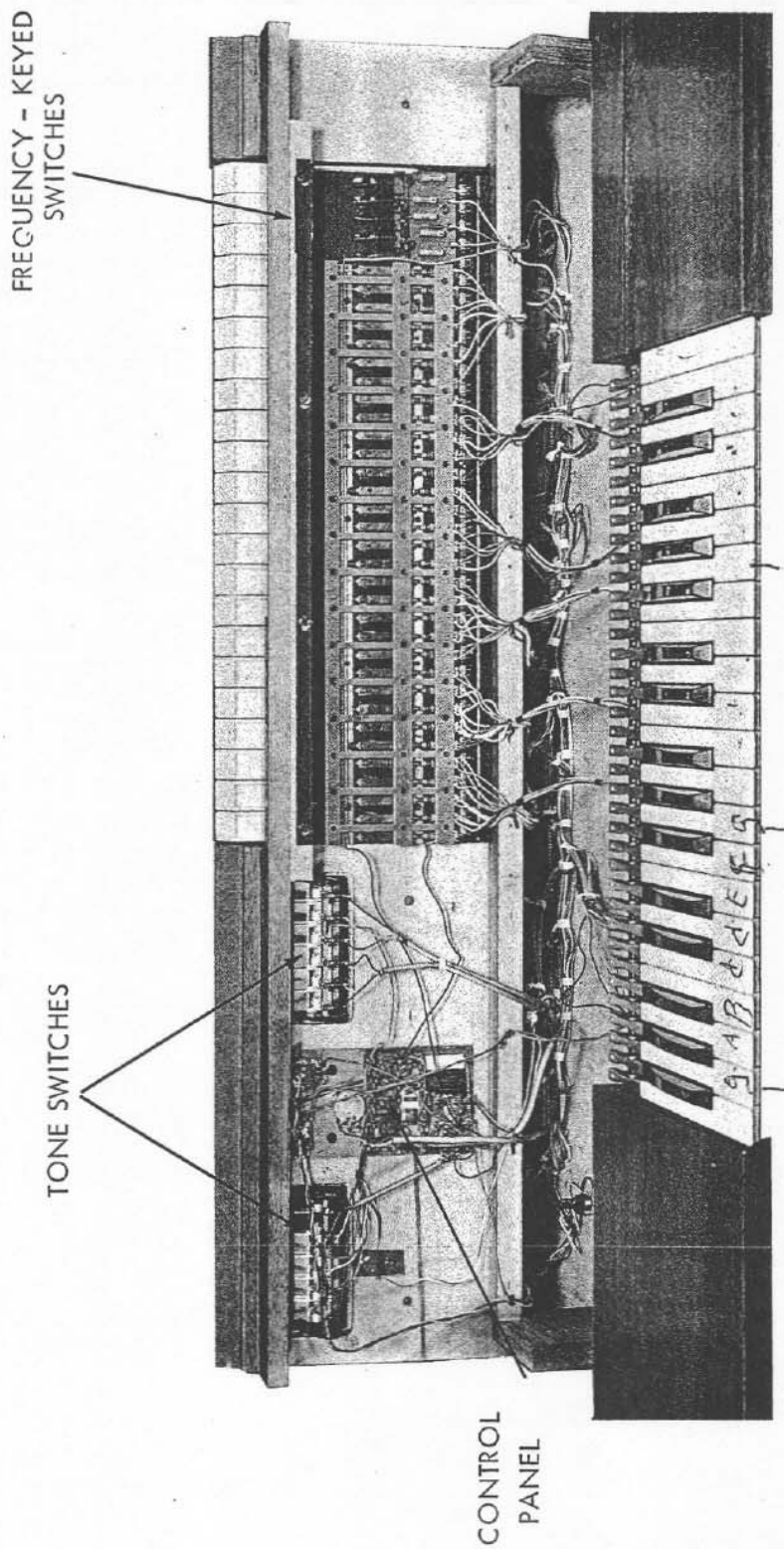


FIGURE 14  
MODEL 6221 KEYBOARDS IN SERVICE POSITION

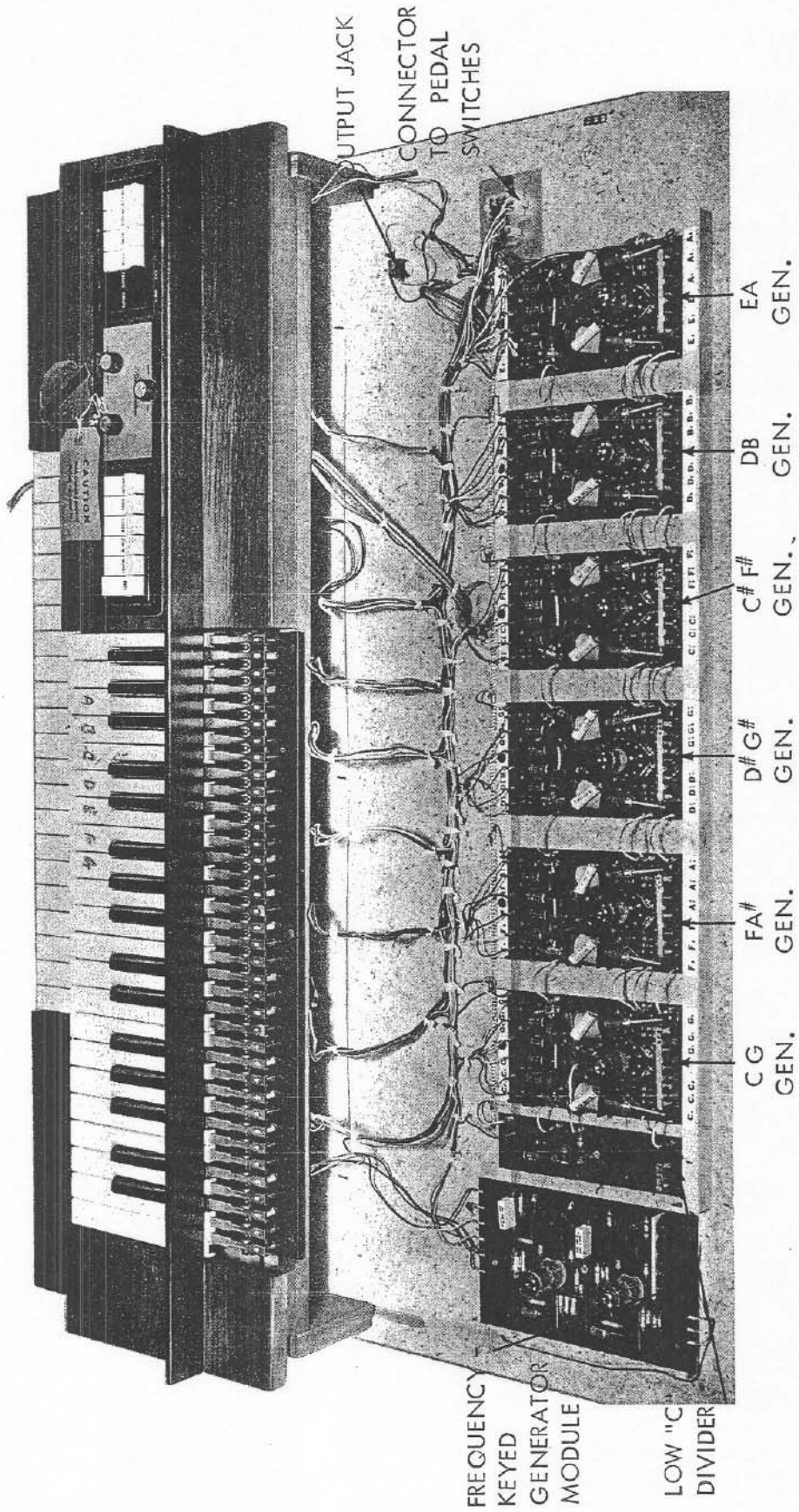


FIGURE 15

MODEL 6221 KEYBOARD/GENERATOR LAYOUT

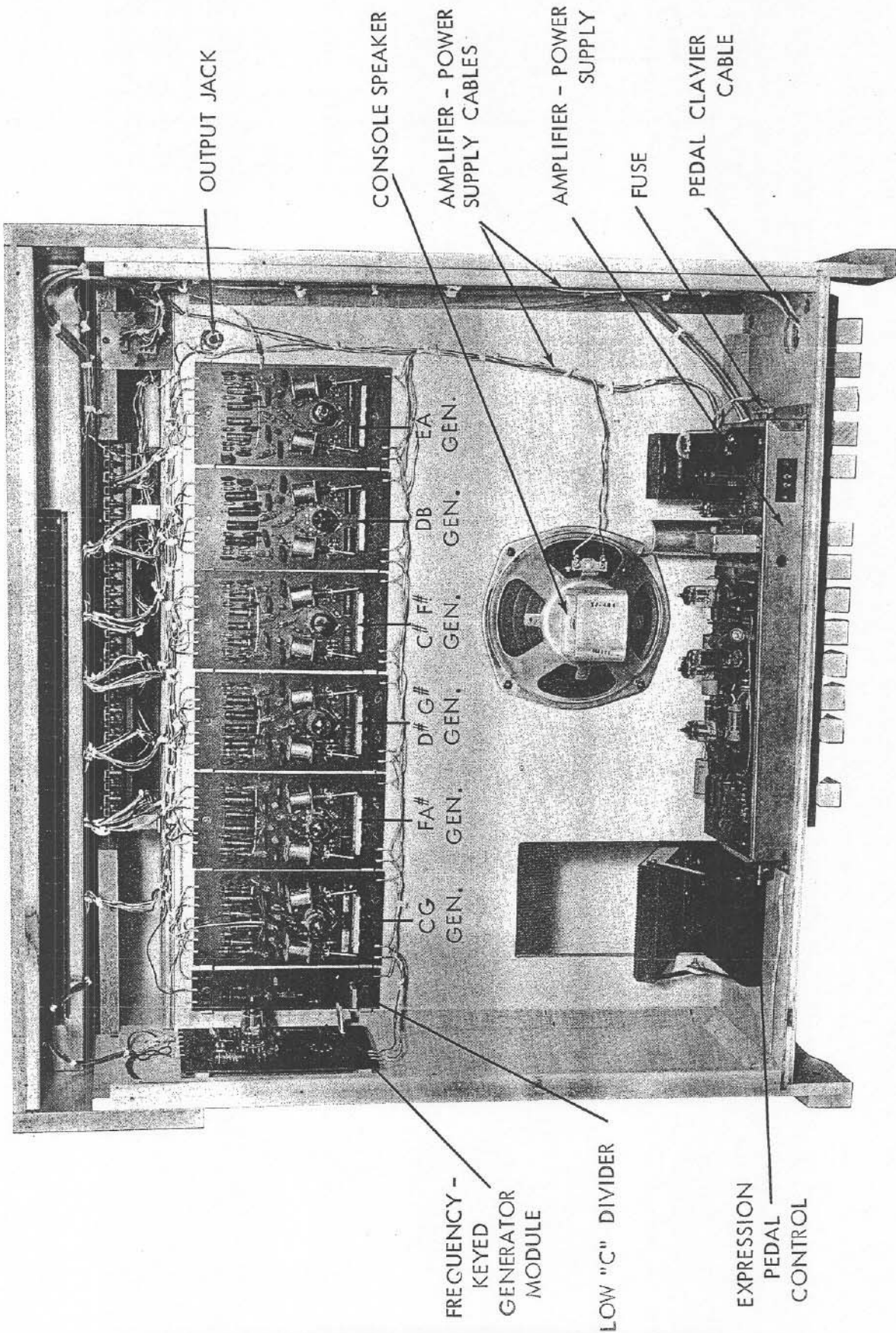


FIGURE 16  
 MODEL 6215 - BACK REMOVED



FREQUENCY - KEYED  
SWITCHES

TONE SWITCHES

CONTROL PANEL

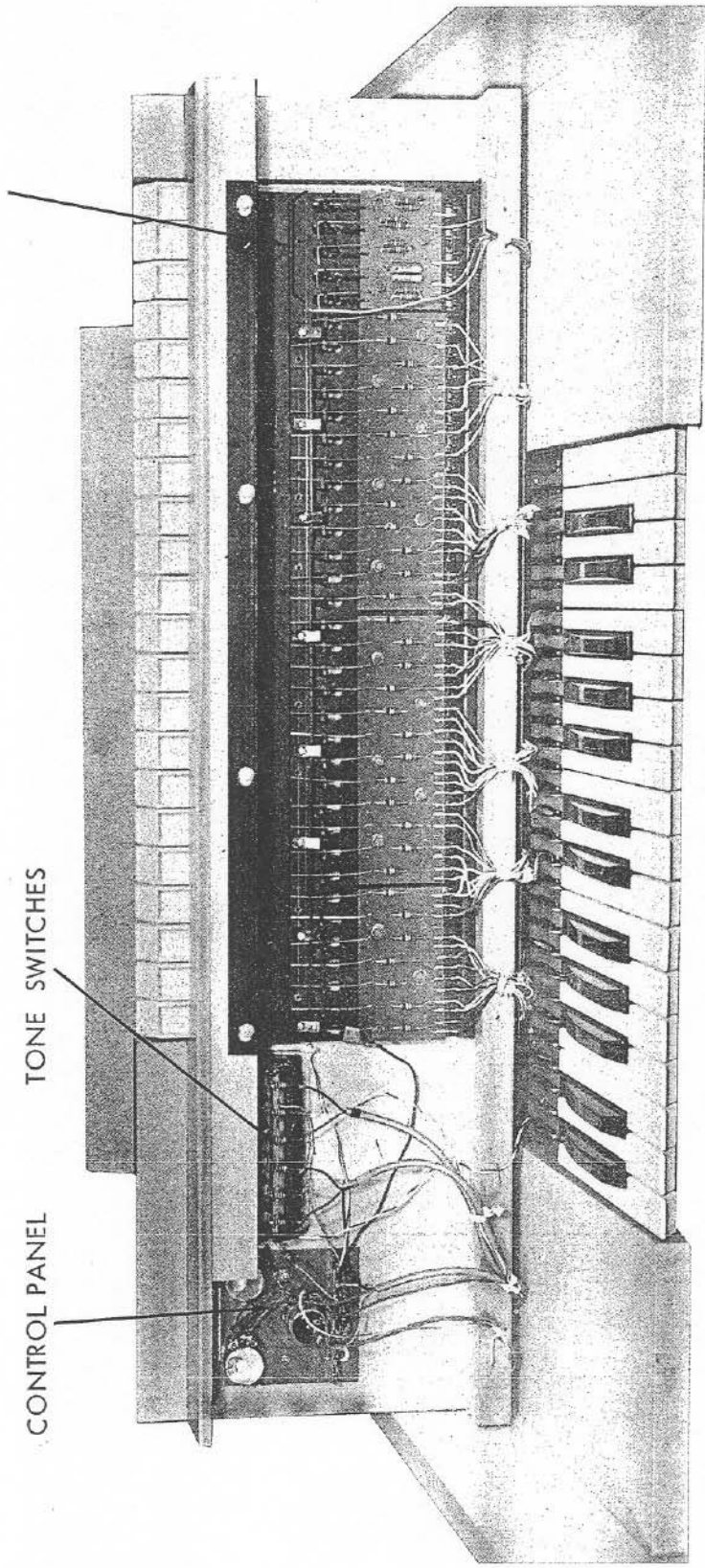


FIGURE 17

MODEL 6215 KEYBOARDS IN SERVICE POSITION

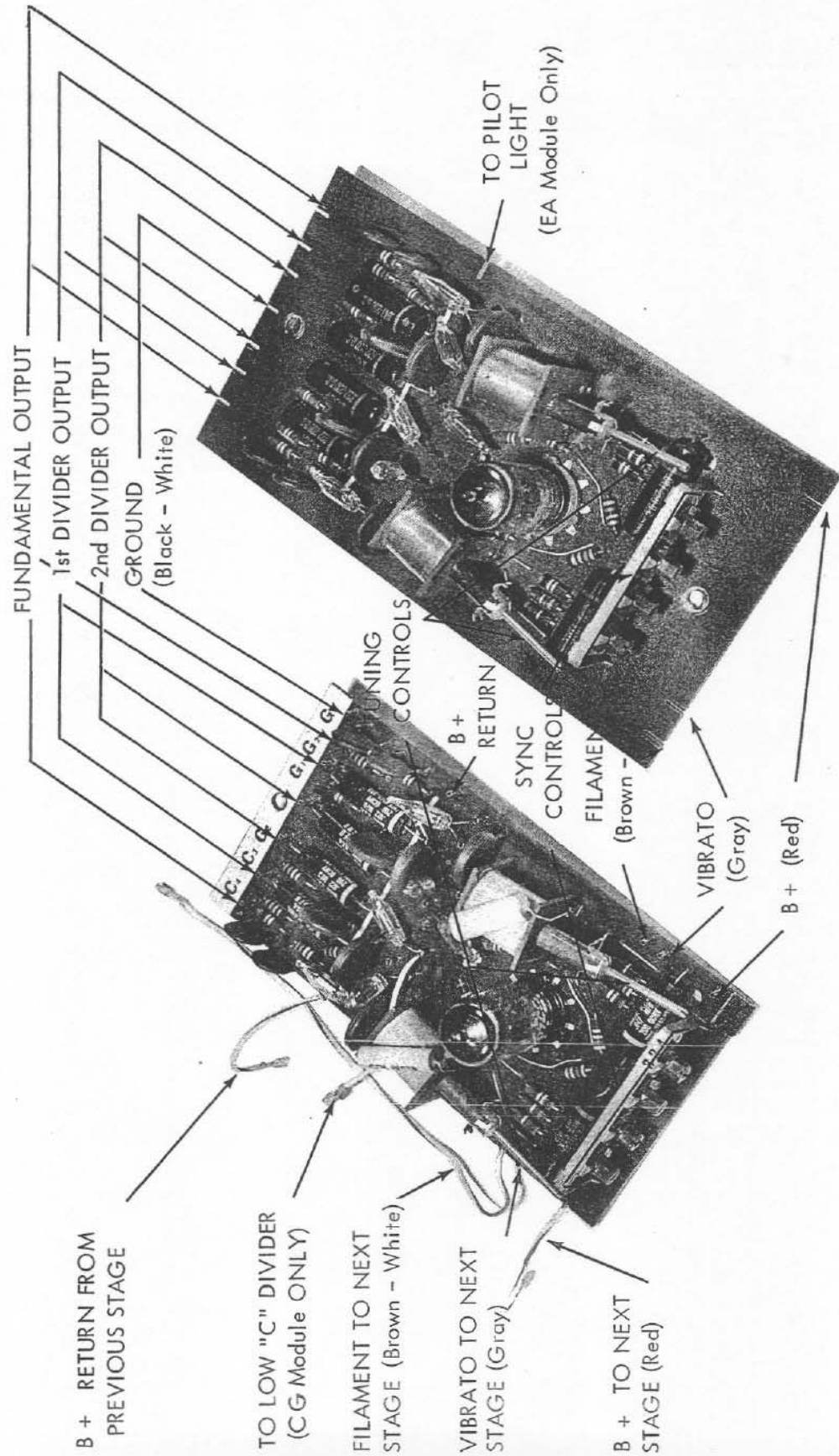


FIGURE 18  
OUTPUT - KEYED GENERATOR MCDULE

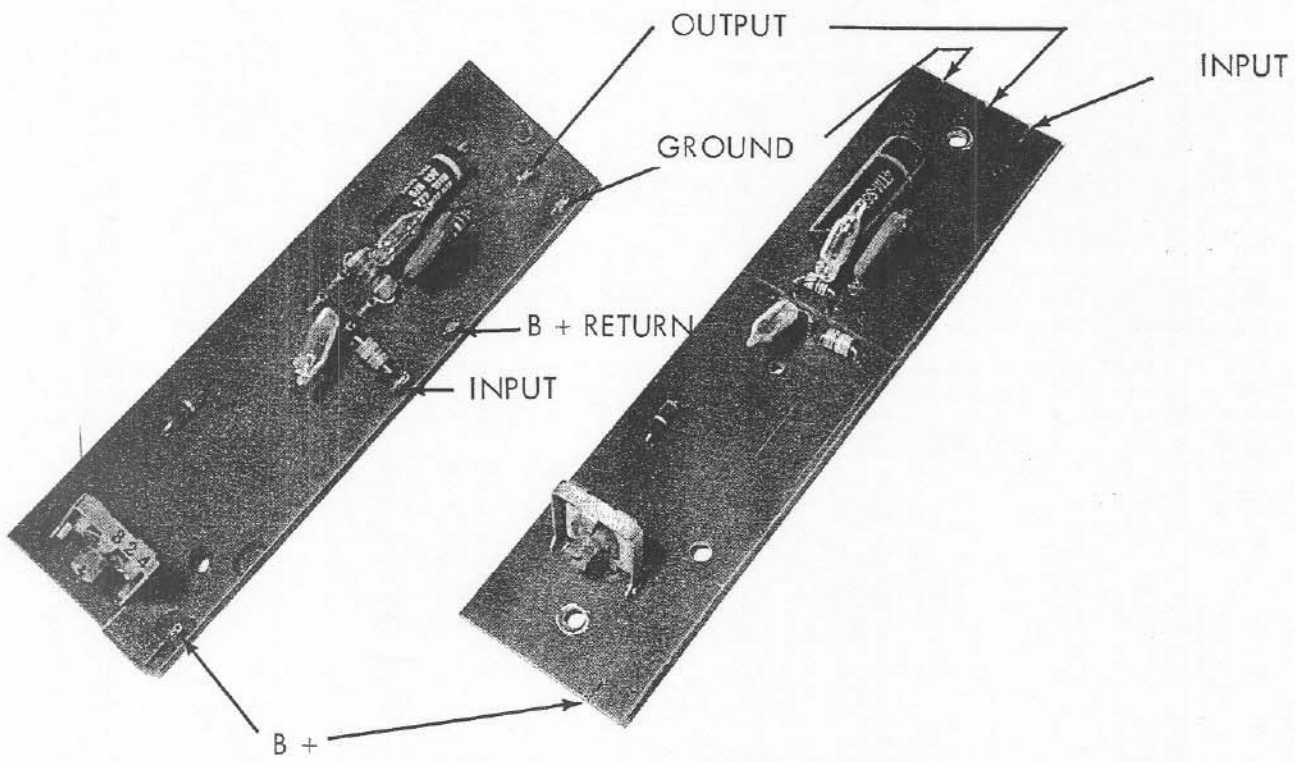


FIGURE 19  
LOW "C" FREQUENCY - DIVIDER MODULE

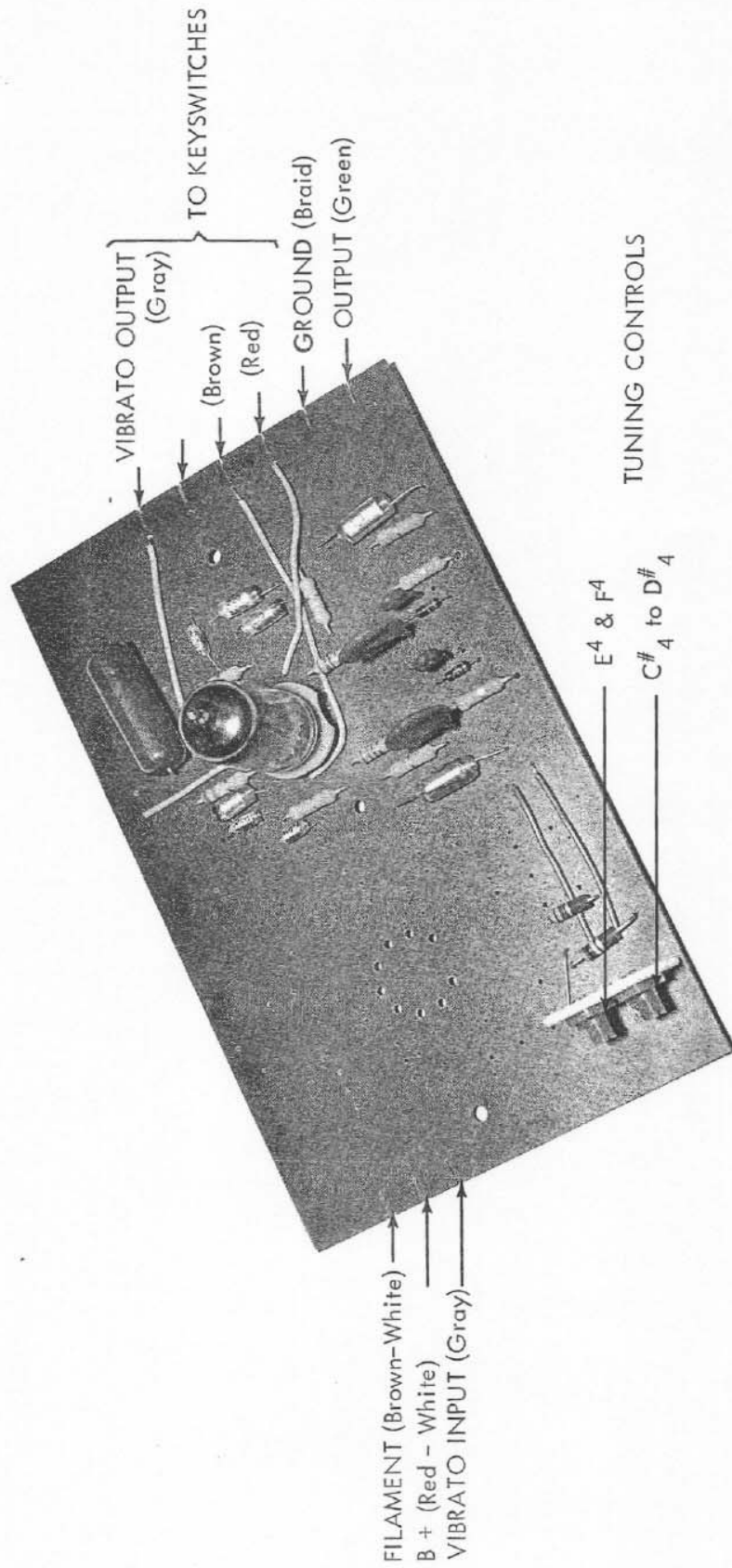


FIGURE 20 A  
 FREQUENCY-KEYED GENERATOR MODULE  
 MODEL 6215

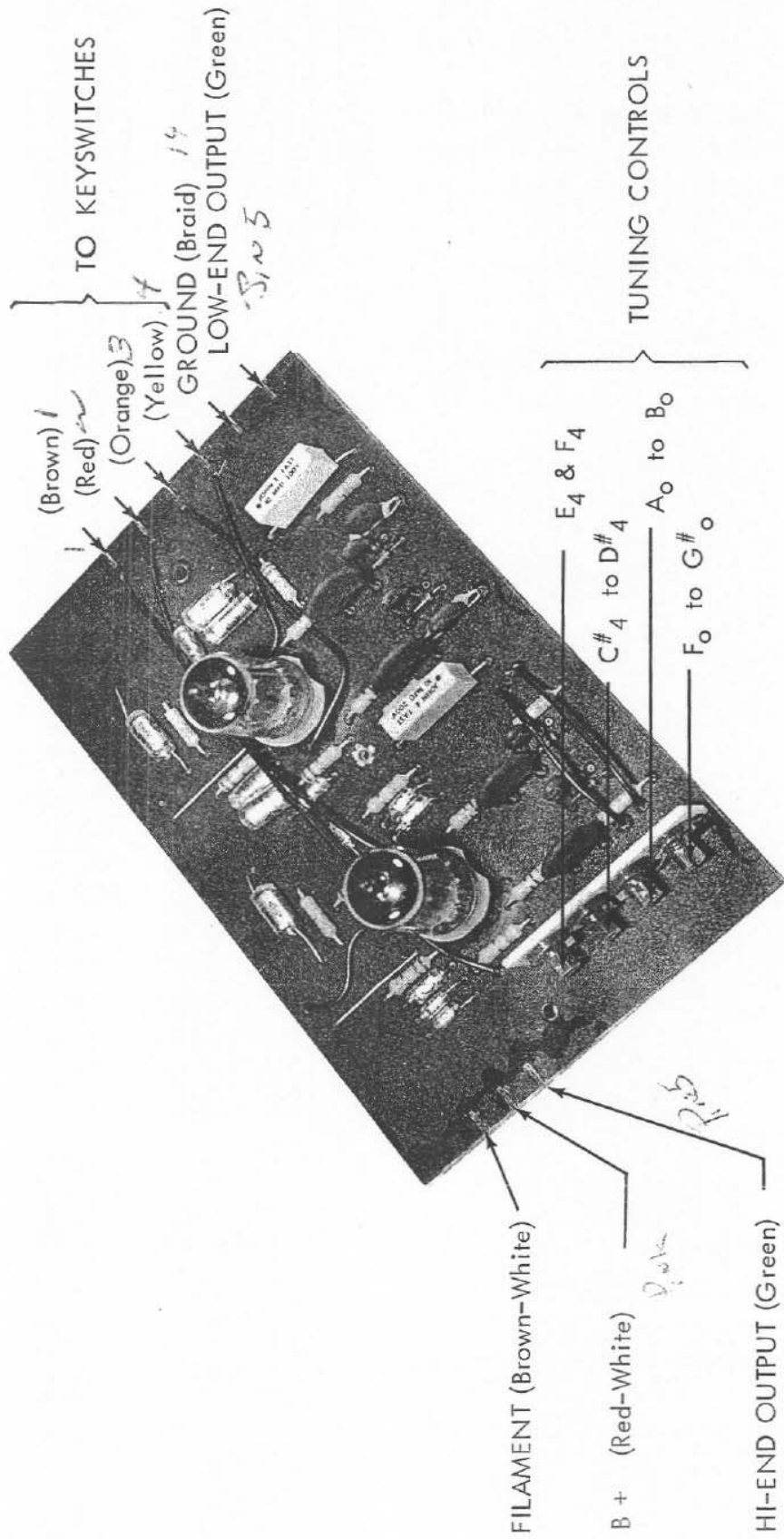


FIGURE 20 B  
 FREQUENCY - KEYED GENERATOR MODULE,  
 MODEL 6220-6221

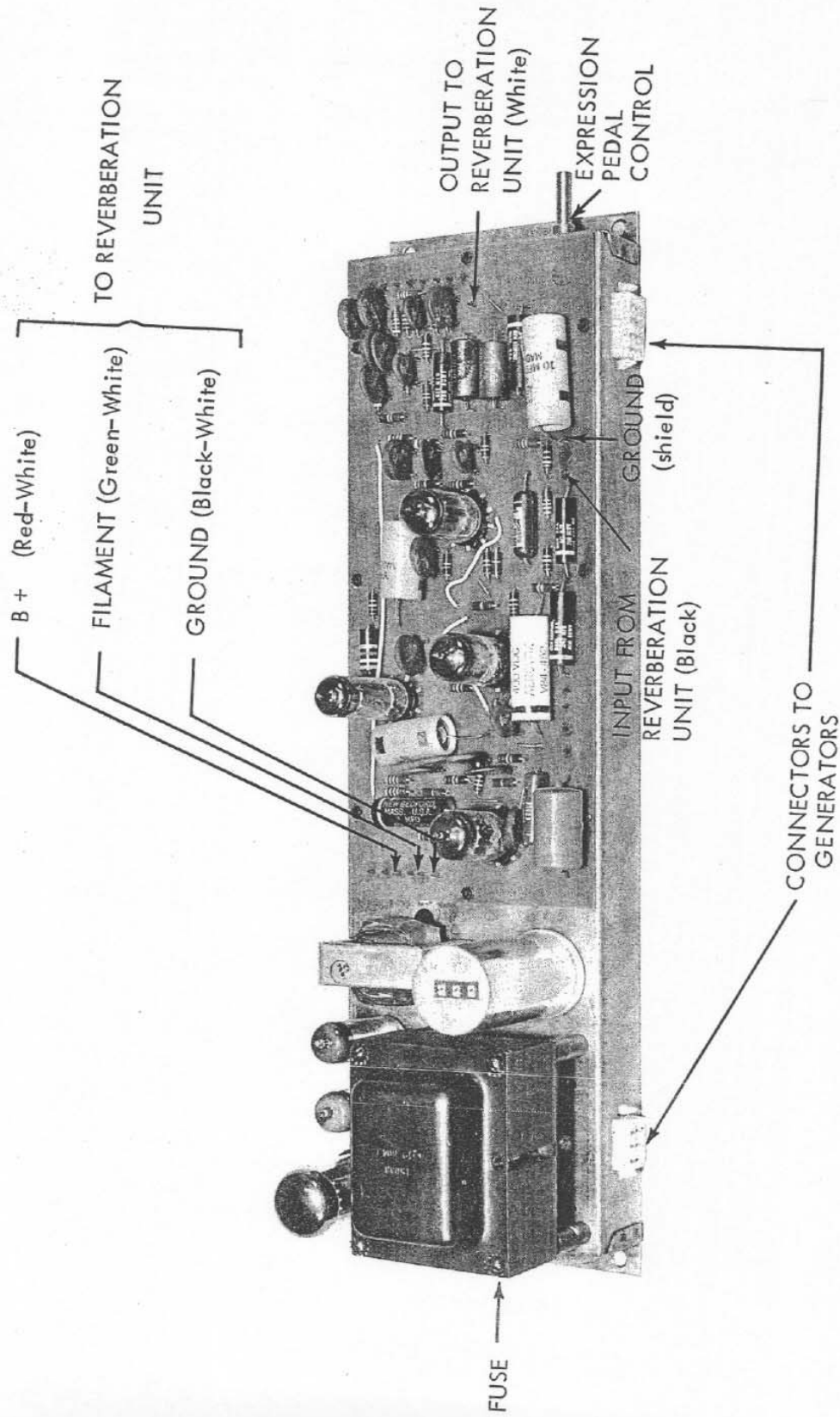


FIGURE 2I  
 AMPLIFIER - POWER SUPPLY

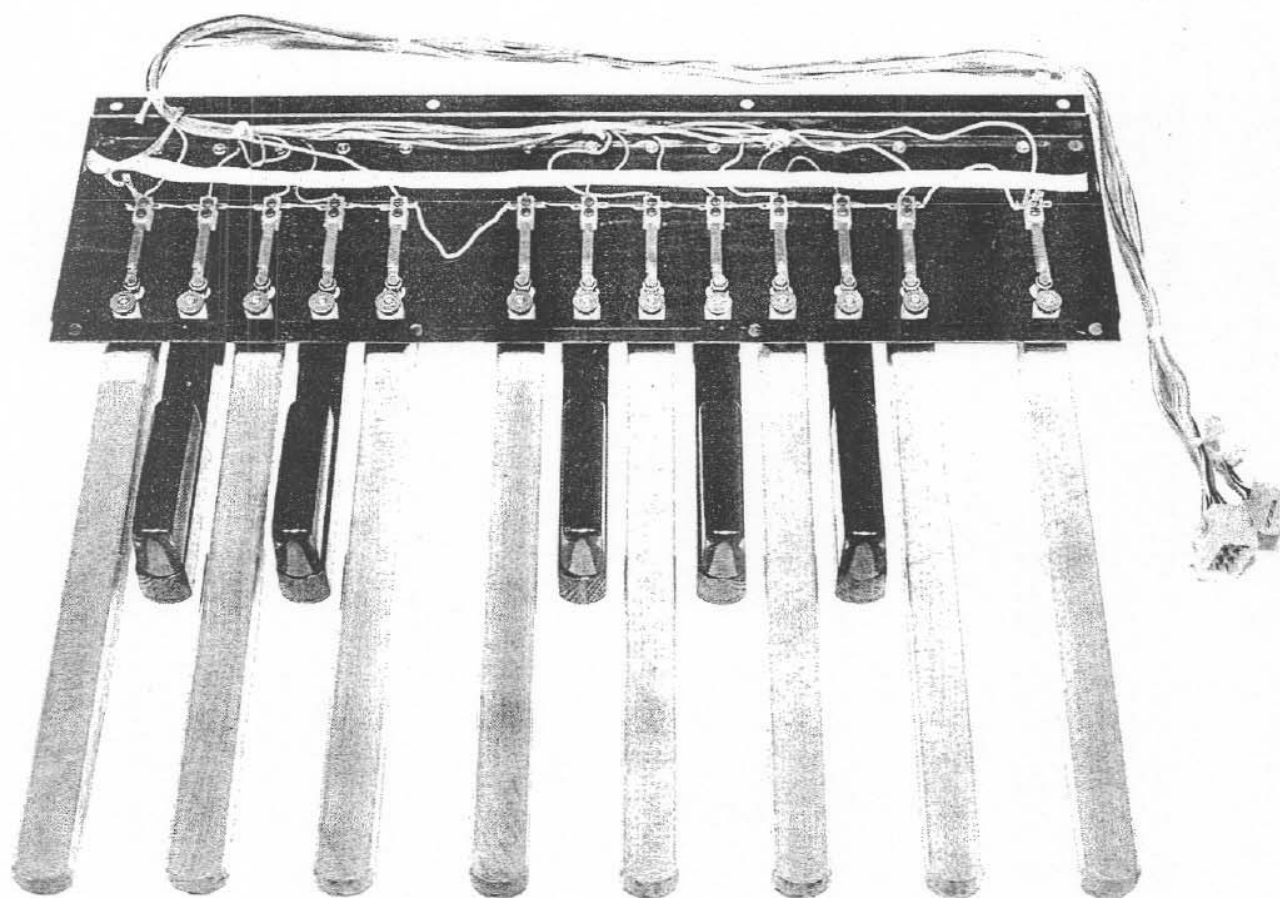


FIGURE 22  
PEDAL CLAVIER - SWITCHES EXPOSED