The Solovox

Servicing this popular [illegible] can provide a new source of revenue to servicemen

The Solovox keyboard installed on a standard upright piano.

By PAUL M. MILLER

THE *Solovox* piano attachment is becoming more popular with piano owners every day. Many thrilling tones are produced by this versatile electronic musical instrument. Although the owners of these fine instruments are seldom acquainted with such technical terms as "oscillator drift" and "negative pulse," they do recognize that the tone is "flat" or "off-key" and look to a radio repairman for service. *Solovox* owners hesitate to entrust their instrument to just any radio serviceman that happens to be handy. They would rather (and who can blame them) be assured that the man who gets their *Solovox* to repair or adjust is thoroughly familiar with its operation and maintenance.

There are two models of the *Solovox* —the old and the new—the Model J and the Model K. Basically they are similar.

The Model K has a few circuit changes that eliminate some of the oscillator adjustments, and has a new family of clarinet-like woodwind tones, controlled by a "Mute" key.

The modern Model K will be discussed here.

The *Solovox* is essentially an oscillator, and it all starts out with the 6SJ7 oscillator tube. This one tube controls all the notes on the keyboard. The oscillator operates at the highest octave of the audio frequencies that the instrument features, from 2093 to 3951 cycles per second.

Fig. 1, the wiring diagram, shows the keyboard and the oscillator circuit. The keys are attached to the tuning condensers grouped in series at the extreme left of the diagram.

Pressing any key inserts a certain amount of capacity into the oscillator grid circuit and tunes the oscillator to a particular frequency. Note that all similar musical letters on the keyboard in the three octaves are paralleled and note also that the low, middle, and high octave sections of the keyboard are each attached to a separate tuning contact bar. The reason for this is immediately apparent realizing that all keys of the three octaves of the same letters are in parallel and would produce the same note when pushed down, if a tuning contact ba connected to a frequency divider wer not present.

The note "C" (the first key) is th lowest frequency of the oscillator; th note "B" (the last key in the octave is the highest frequency produced b the oscillator. The twelve condenser that tune the oscillator to the third o highest octave are all located in th "Vibrato box" attached to the key board. Examination of the diagram i Fig. 1 will reveal that in any octav on the keyboard there are twelve key but only eleven contacts.

Key "B" in each octave has no cor tact.

When any one of the three "B" key are depressed (or when no key is de pressed) the oscillator is tuned to th highest frequency (3951 c.p.s.). Th "C" keys tune the oscillator to it lowest frequency (2093 c.p.s.)

The oscillator tuning coil T_1 in Fi 1, is the main tuning control of th *Solovox*. A powdered iron slug moved in and out of the core of th coil, varying the inductance and there fore the frequency of the 6SJ7 osci lator. The only difference betwee this oscillator slug-tuned coil, and th oscillator coil in a receiver is that th slug has a long shaft and a knob c the end that extends to the outside the cabinet so that the owner ca "raise or lower the pitch" of th instrument. This is often necessa because few pianos are in perfect tun Age of the piano, condition of pia and other factors will cause a notic able difference between the piano a the *Solovox*—one of them will sou

(*Continued on page* 63)

Fig. 1. Wiring diagram of the Solovox showing the keyboard and the oscillator circuit. The keys are attached to tuning condensers shown at left of diagram.

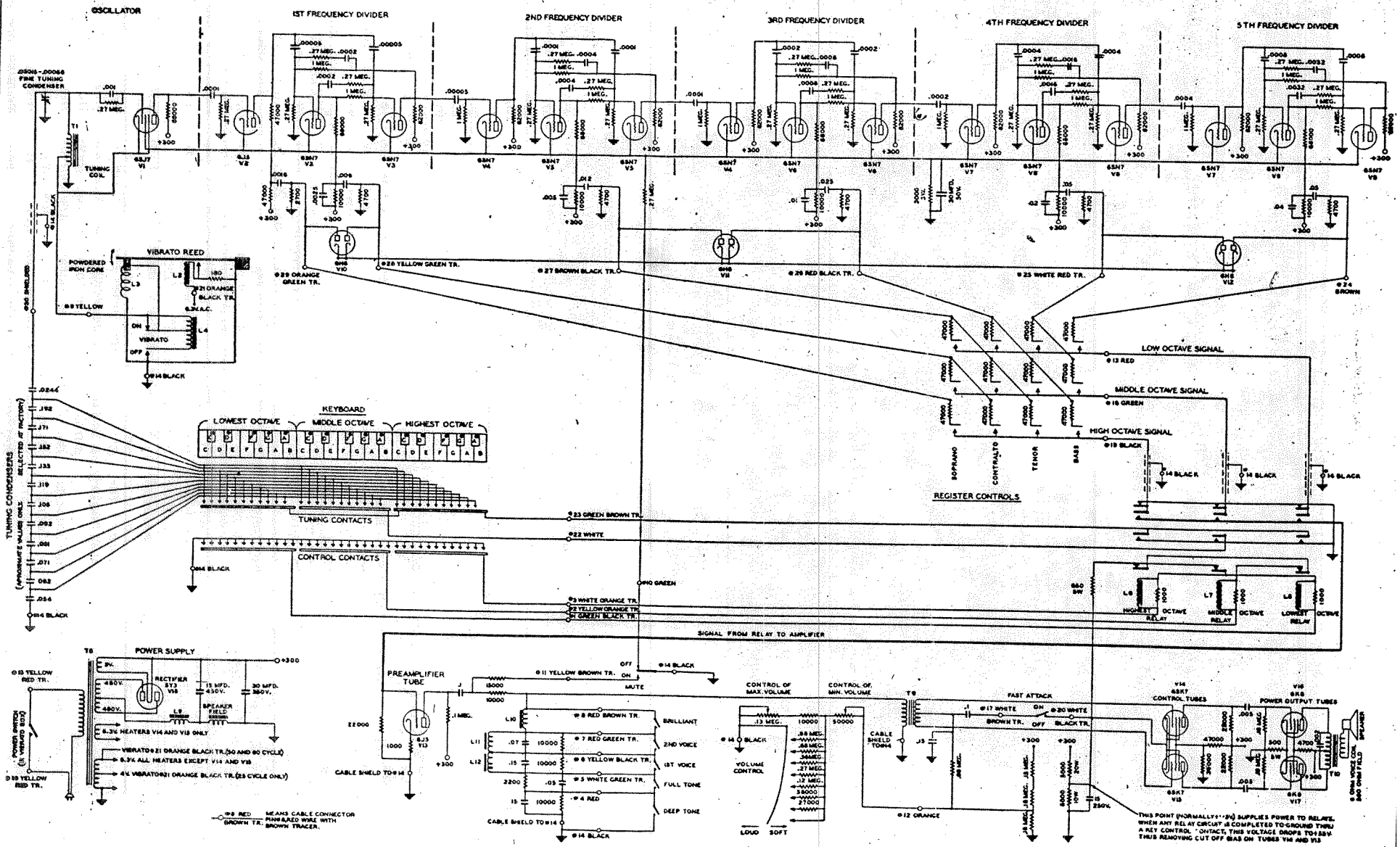
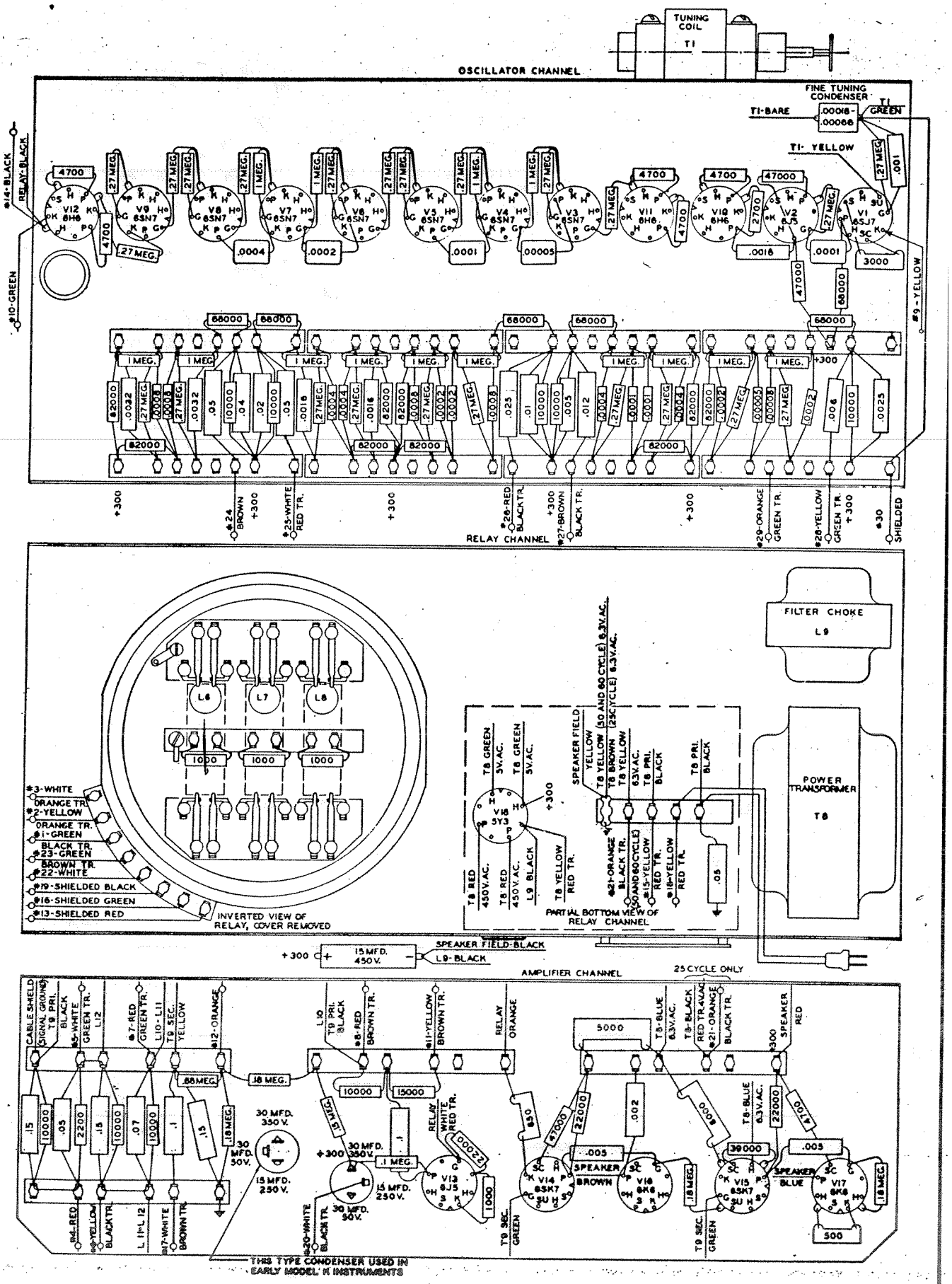


Fig. 2. Wiring diagram of the tone cabinet of the Solovox Model K.



flat. This oscillator adjustment permits the user to tune both to a harmonious balance.

The "Vibrato" effect is one of the outstanding features that make the *Solovox* a musical instrument instead of merely a multi-toned oscillator. Any audio oscillator operating at a fixed frequency produces a pure solid note. In the *Solovox* the individual notes seem to quiver or vibrate, producing a musical note that is pleasing to the ear. The vibrato effect is incorporated in the *Solovox* by means of a coil with a movable iron core connected to a reed that is driven back and forth rapidly, like an automobile vibrator reed. This varies the inductance of the coil in regular and even amounts. This coil is connected to the tap on the master oscillator coil and thus varies the frequency of the oscillator.

The reed is started automatically, that is, when the volume control is pulled out to start the instrument operating, it starts the reed vibrating and the magnetic drive keeps it going. It is a silent mechanism. The vibrato reed and its associated circuit can be seen in Figs. 1 and 3.

The Frequency Dividers

The output (2093-3951 c.p.s.) of the master oscillator is fed to a series of frequency dividers connected in cascade fashion.

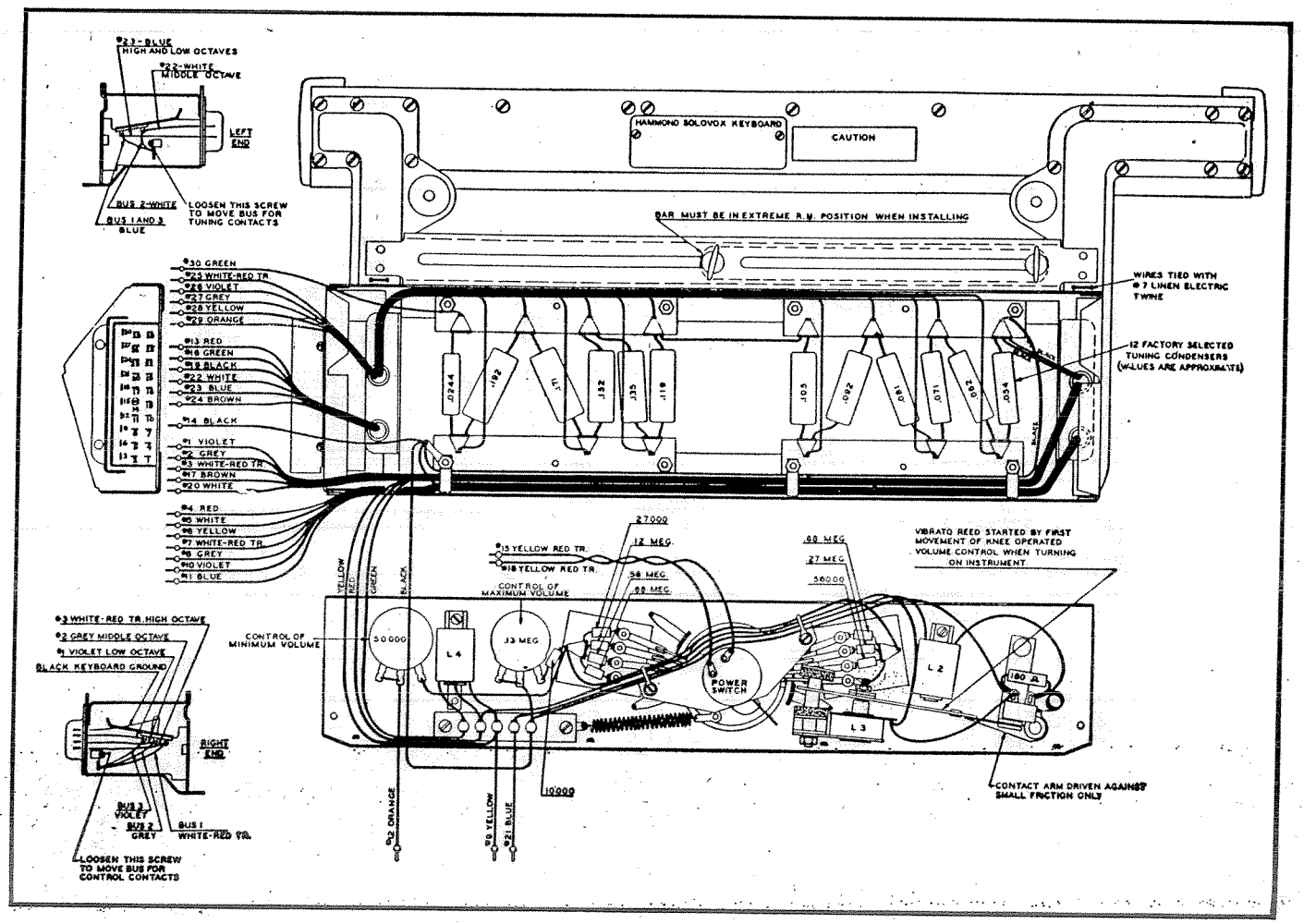
Close-up view of the Solovox keyboard as it is attached to the piano.

Each frequency divider divides its input frequency in half, producing a note one octave lower than its input note. Looking at Fig. 1 it is seen that each frequency divider stage is comprised of three triodes. In the first stage the 6J5 triode acts as a driver and pulse rectifier, supplying sharp and narrow negative pulses to actuate a symmetrical feedback tripping circuit made up of two triodes in one envelope (6SN7). The driver of the balance of the stages is one half of a 6SN7.

Either section of the twin triode can

(*Continued on page* 136)

Fig. 3. Wiring diagram of the Solovox keyboard unit.



The Solovox

(*Continued from page 63*)

be conducting at any one particular moment. When one triode is conducting, it is drawing plate current and the resulting voltage drop across the plate load resistor biases the other triode to cut-off and holds it there until the driver sends another negative pulse to the grids of the twin triode. Since one triode is already in a cut-off condition, this negative pulse will have no effect on it, but it will drive the other triode to cut-off condition. When this triode suddenly stops conducting and therefore stops drawing plate current, a positive pulse is produced at the plate terminal of this triode.

This positive pulse appears at the grid of the second triode and it starts to conduct. The instant it starts to conduct and draw plate current, a negative pulse is produced at its plate and this negative pulse is fed back to the grid of the first tube to insure a cut-off condition until the next cycle.

The next input pulse from the driver will have no effect on the first triode (this time) but drives the second triode to cut-off and then starts the first triode conducting. From this it can be seen that two input cycles are necessary to produce one output cycle. This looks rather complicated as it is written in a lot of words, but following the action on the diagram makes it very simple.

The output of the second triode in any divider stage is fed to the grid of the driver of the next stage. Note that the coupling condenser values are doubled in the progressive stages as the frequency is halved.

Now we press a key on the keyboard, a "C" key for instance. Any one of the "C" keys we push down will tune the oscillator to the same frequency by inserting the .0244 μfd. condenser in the strip of twelve, and tuning the oscillator. The oscillator is oscillating and activating all of the frequency divider stages. Let us assume that the audio system is silent for a moment—waiting for the system to select one note out of many that are ready to be admitted, while we follow the path of the note that we chose.

Underneath the keyboard tuning contacts on the diagram are the "Control Contacts." If we depressed the "C" key in the lowest octave, the No. 3 or lowest octave relay is actuated, and all of the frequency dividers are tuned to "C" by the capacitance that is thrown into the grid circuit of the 6SJ7 oscillator tube.

Off the plate of the second frequency divider comes the signal and down to the low octave section of the "Register Controls" through a 47,000 ohm resistor and through the relay to the grid of the preamplifier tube and on into the control tubes to the audio output 6K6's. At the same moment we pressed the key the low octave relay went

into operation and removed the cut-off bias from the control tubes—permitting the signal to enter. This action is described in detail later in the article.

Sound Effects

That note we just released through the *Solovox* was a single note (for purposes of explanation). Now how do we get those beautiful organ tones and other sound effects that create depth and fine tone qualities? When we depressed the key to send our "C" note on its way through the circuit, we also tuned all of the frequency dividers, as noted before, to "C"—but in different octaves. The output of the rest of these dividers is not used at♦present but if we want the above effects all we have to do is to add the output of one or more of these dividers to the preamplifier input by pressing the "Contralto," "Tenor," "Bass" buttons, and the signals (an octave apart) come through the 47,000 ohm resistor, mix with the original signal, and the composite signal goes on into the preamplifier input grid.

Naturally if two keys are pressed on the keyboard in any octave, some undesirable notes would be created if it were not for a section of the relay that prevents this by selecting only the lower pitched note in such cases.

Between the preamplifier tube and the volume control on the diagram is a switch labeled "Mute." It is shown in the normal position in the diagram, grounding the 6H6 cathodes. Throwing the switch on disconnects the diodes. The odd harmonics of the frequency dividers, which sound like a clarinet, are then produced.

Following the preamplifier is a group of condensers, resistors, and chokes and the controls labeled "Deep Tone," etc., that insert various combinations of resistance, capacity, and inductance into the line to change the characteristics of the signal going to the power amplifiers. For instance; the "Full Tone" contact attenuates some of the high frequencies but does not affect the low or medium frequencies. Other combinations affect the "curve" of the note in other sections. Similar to the tone and treble controls in a radio or public address system, the effects are very pleasing to the ear.

Remembering the "vibrato," magnetically driven reed, we can readily appreciate the range and tone of the *Solovox*. This vibrato reed might be compared to an FM sweep generator, but mechanical in operation and in the audio frequency range.

Control Tubes

Almost any amplifier will pick up and amplify hum, microphonics, and other noises of an undesirable nature, but in the *Solovox*, a unique circuit arrangement prevents any such disturbances from sounding through the speaker—when no key is pressed the *Solovox* is perfectly silent. The normal cathode voltage on the 6SK7 control tubes is 175 volts positive cut-off.

This bias voltage is obtained from the resistors forming the voltage divider attached to the cathodes, the 5000 and 6000 ohm resistors.

When a key is pressed, the relay shunts the 6000 ohm resistor with the resistance of the relay coil, reducing the bias voltage to about 55 volts and the control tubes are no longer cut off, and the "gate is open" for the note to pass through.

The 15 μfd. condenser in parallel with the divider prevents surges, plops, and clicks and makes the entry and departure of the note into the control grids smooth. Fast attack and slow attack is obtained by throwing the .1 μfd. condenser in series with the cathode in or out of the circuit.

Although the depressing of any key throws this cut-off bias off the control tubes, it determines only the matter of signal or no signal, and not *how much* signal. This is taken care of by the volume control which is also part of the voltage divider furnishing bias to the control tubes. This group of resistors in parallel determines how much operating bias and therefore regulates the gain. It is not an ordinary volume control and not subject to the vagaries of such.

A variable control of minimum volume and maximum volume is incorporated in series with this master volume control and is set for the customer's preference. They will vary according to the customer and the location of the instrument. These adjustments may require setting (resetting) if the *Solovox* is moved, for instance, from the living room of a private home to a large auditorium with quite different acoustics.

Full understanding of "How It Works" will enable most servicemen to satisfy many of the customer complaints that will arise—by making a few simple adjustments that the customer does not know about, or has forgotten. Often the instruction book gets lost or mislaid and the owner brings the instrument in for service rather than trust to memory.

Any serviceman who plans on going out after *Solovox* business, and there is plenty of it, should have *all* the dope before attempting any repairs or adjustments.

—30—

Radio Service

(*Continued from page* 57)

Television service will tie-in perfectly with your regular work, provided you have the equipment and knowledge necessary. Charges for this type of service will be high, in accordance with the high cost of the sets. Installation of television antenna arrays is a business by itself!

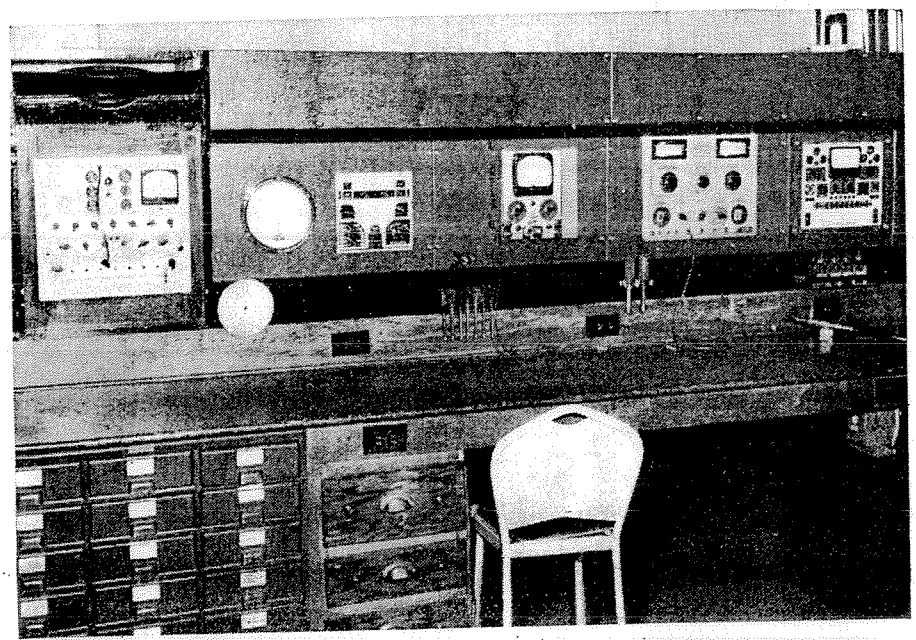
Test instruments are all expensive. Some of them are out of sight for most of us—but—please select the best you can. Stay away from these bargain testers, the pretty but cheaply made ones. A good instrument, though costly, will be accurate and last longer, and will add to your prestige as a radioman.

The following is a list of instruments for the up-to-date service shop. They are suggested as a means of fast, accurate and profitable work. The well equipped shop should have; a test speaker, a v.t.v.m., a signal generator, oscillograph, tube tester, and a sweep signal generator (for television).

In addition to these instruments, the shop should have a portable tube checker and multimeter. These can be of the cheaper variety as they are used for outside work and are subjected to much abuse.

—30—

Fig. 5. Another view of the test bench. By panel-mounting all test instruments the workbench surface is kept clear and the servicing work is expedited.



The following article describes the new and remarkably ingenious Solovox, invented by Laurens Hammond who created the Hammond Organ and the Novachord, and tells how this 14-tube device may be used as an electronic musical supplement to any piano.

← The photos at left illustrate various elements of the Solovox. At A, the attachment in use on a grand piano, a set of 12 control tablets giving any piano an indefinite variety of tone colors that simulate the organ (Note individual volume control.); B, close-up of upper portion of the Solovox showing how the control tablet add-on device is tilted to produce a desired effect; C, the Solovox keyboard being attached to the piano keyboard by thumbscrews.

THE ELECTRONIC "SOLOVOX"

Latest Radio-Musical Adjunct to the Piano

THE Solovox is a new 14-tube instrument —invented by Laurens Hammond, creator of the Hammond Organ and the *Novachord, and expressly designed as a musical supplement to the piano—that even a child can play perfectly. Operated entirely by electricity, the Solovox is a 3-octave keyboard which is attached to the piano so that the fingers of one hand can easily span the 2 keyboards. A total of 12 control tablets give the Solovox a 6-octave range as well as an indefinite variety of tone colors, and being smooth, sustained and capable of "swell," its tone colors make an effective contrast to the percussive brilliance of the piano. A knee lever controls the volume. A slim tone cabinet containing the electrical equipment, including the loudspeaker, is set alongside a vertical piano or *underneath a grand piano.*

This instrument represents a new source of income for Servicemen and Servicemen-dealers.

MODUS OPERANDI

All the notes of the Solovox are controlled by a single radio vacuum tube *master oscillator* (see diagram) operating at one of the 12 audio frequencies in the highest octave of the instrument (2,093 to 3,951 cycles). Each time a key is depressed, a switch under it tunes this oscillator to the pitch associated with the key in this highest-octave range. This occurs regardless of whereabouts on the keyboard the playing key is depressed. Thus, whenever any one of the "C" keys is depressed, this oscillator is tuned to 2,093 cycles, which is its lowest frequency. If any "B" key is depressed, its frequency will be 3,951 cycles, which is its highest frequency.

The output of this master oscillator controls the frequency of another oscillator called the *buffer oscillator* which operates at the same frequency as the master oscillator. The output of this first controlled (buffer) oscillator in turn controls the frequency of a second controlled oscillator, so interconnected with the first as to oscillate at one-half the frequency of the first oscillator. This new frequency corresponds to a note of pitch one octave lower than the first controlled oscillator.

Similar cascaded oscillators provide pitches of 2, 3, 4 and 5 octaves below that of the master oscillator. In this way, each time the master oscillator is tuned to some one of its 12 possible frequencies (one for each note of the scale), each of these 6 controlled oscillators immediately follows it to produce outputs which are the lower octaves of this pitch, to form a series of 6 frequencies in exact octave relationships. Now the particular oscillator outputs desired for passing through the amplifier and speaker, depend upon the particular playing key depressed (for instance on which one of the 3 "C" keys) and also, upon which of the "BASS-TENOR-CONTRALTO-SOPRANO" controls are employed.

The selection of the desired oscillator occurs when a second contact under each key closes. This second contact operates an electrical relay having contacts to make the desired oscillator selection. It is to be noted that there are 3 relays, one of which is common to each of the 3 octave groups of keys. Thus, we see that a playing key functions in 2 ways—first, it tunes all of the oscillators to the pitch of the key being depressed, and then selects the output of the particular sub-octave frequency controlled oscillator desired.

A further function of the second key contact is to transmit the signal to the speakers with a controlled rate of attack, so as not to be musically abrupt. Tuned electrical circuits and tone controls follow, which control the quality of tone over a very wide range.

The effect of the "MUTE" is produced by passing the signal through a vacuum tube operated non-linearly so as to suppress the sharp curvature of its input wave, and thus render the tone more mellow.

PERMEABILITY TUNED

The "VIBRATO" effect is produced by a vibrating reed (which is put into motion when the volume control lever is brought forward in starting the instrument) which *intermittently changes the pitch of the master-oscillator by varying the inductance of a small coil* (L1 in diagram) *connected across it.*

The volume of sound from the speaker is controlled by a knee-operated rheostat which acts to control the amount of amplification.

The Solovox will remain in tune indefinitely. However, as the pitch of the piano with which it is to be played will vary considerably, a tuning adjustment knob at the top of the tone cabinet has been provided with which the instrument may be easily tuned by the pianist in 10 seconds' time, to the piano. It is not necessary to tune each note—the single tuning knob provided simultaneously tunes them all *by varying the inductance* (L2 in diagram) *that resonates the master-oscillator circuit.*

USES

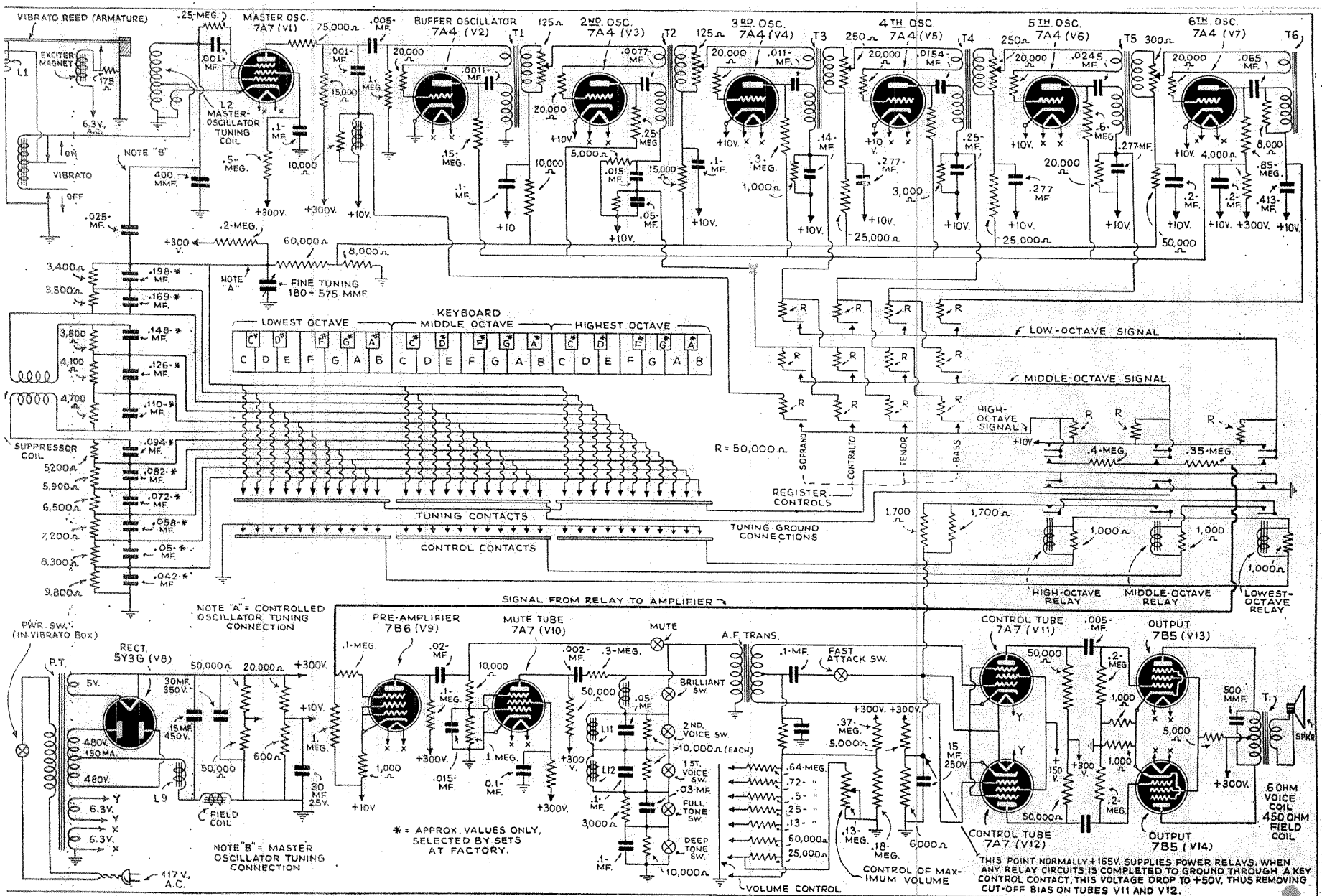
The Solovox, which can be played by even the self-made pianist without any special instruction, adds singing voices like orchestral instruments to the tones of the piano. The player carries the melody on the Solovox with the right hand and the left hand accompanies on the piano. The right hand can easily encompass notes on the Solovox and piano keyboards simultaneously, considerably enlarging the pianist's scope.

On the front of the Solovox are the previously-mentioned, tablet-shaped tone selectors and all that the player must do is to push them in various combinations to extend the range of the instrument to 6 octaves and create hundreds of exciting new tone-colors. Some of these tones resemble flutes, strings, brasses or woodwinds, *while others have never been heard before!*

The exceptional versatility of the Solovox makes it a flexible addition to the studio equipment of any radio station. With the Solovox attached to the piano, ensembles are heightened and dramatized by its smooth attack. The rich variety of its tones ranging from a brilliant, string-like effect to a deep and penetratingly organ-like quality make it a new and different instrument for music lovers to hear and enjoy.

For a vocalist, the Solovox provides a

*See "Announcing the 'Novachord'—Electronic Music's New 163-Tube 'Baby'", Radio-Craft, April 1939.



Diagram, model J Solovox. Following are circuit notations, including omissions, not located in time for inclusion in the diagram, Tube V9 (7B6): consider the grids, connected to the cathode, as diode plates. A movable iron core tunes L2. Missing component values: V3 plate R.F. load resistor, shunted by 0.05-mf. condenser, 4,000 ohms; V5 plate D.C. load resistor, 0.4-meg.; V10 S.-G. filter resistor, 0.5-meg.; connected to center-tap of "A.F. trans." is a 0.72-meg. unit shunted by 0.15-mf.; V12-V14 coupling unit, 0.005-mf. Note that contacts shown normally open, nearest to Highest-, Middle-, and Lowest-Octave relay magnets, should be shown closed; ditto, the 3 pairs of contacts, at top, contacting the +10 V. bus.

SERVICING TELECEIVERS

SERVICE work on television receivers can be divided into 2 parts: 95% can be done with the conventional instruments which every Serviceman has already, plus an ultra-frequency oscillation; 5% requires instruments that individual Servicemen and most dealers would not be justified in buying, Andrea Radio Corp. has found.

It appears, therefore, that the jobbers will have to take upon themselves the investment in instruments required for the 5% part of service problems. Dealers and Servicemen will handle all this very small part of the work, and when a condition arises which they cannot meet, they will have to deliver the set to the jobber's service shop, since the equipment needed in such cases is hardly portable, nor would it be wise to do the work in the customer's home.

95% Are Simple Cases—As you will discover when you become acquainted with television receivers, they are quite different, electrically and mechanically, from broadcast sets. Since the slightest deviation from extremely high standards of precision design shows up in the "picture" tube, such compromises in specifications and tolerances as have been adopted widely in sound receivers cannot be made in television circuits.

The use of high voltage exerts an important influence in television set design. If parts break down in sound equipment, it is easy to replace whatever has gone wrong, but when several thousand volts get loose, expensive damage may result. Finally, cheap materials and inferior designs are not suitable for ultra-frequency circuits.

Thus, the superior materials and construction necessary for television equipment eliminate the source of many failures common to the average sound receiver. There is a sufficient background of experience already to indicate that service work on an average good television receiver is almost entirely a matter of tube failures.

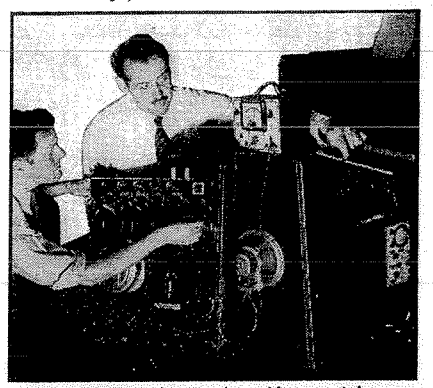
From the foregoing, you can see that there is no high-voltage hazard involved in 95% of the television service work. The 5% to be done by the jobber's service department may require special tests to be made with the current on, but the Serviceman who makes the conventional tests for which he is equipped does not need to take any risk whatever. He can do his work with the power switched off.

ELECTRONIC SOLOVOX

(Continued from page 290)

full, well-rounded background. The fact that all the technical difficulties, such as perfect pitch intonation, smooth vibrato, smooth tonal attack, and quality control are all taken care of in the design of the instrument makes the Solovox the easiest of all orchestral instruments to play. No special training is necessary, for anyone who can pick out a tune by ear on the piano can play it effectively.

In the studio where space is precious, the Solovox is especially adaptable, for it takes up no extra room. It is entirely electrical in operation and by means of 1 tuning knob can be tuned to the piano with which it has been assembled. The 14 standard, inexpensive radio tubes—the heart of the instrument—may need replacement only in the course of several years' playing time. Radio men will note that the comparatively low cost of the Solovox (under $200) places it within the range of small as well as large radio stations. (Dealers give to purchasers, without charge, what little instruction may be necessary.)



Laurens Hammond at work on his newest invention, the 14-tube Solovox, which was recently introduced simultaneously in Chicago to the National Music Merchants Association convention and in New York to music notables and to members of the press.