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 bar connected to a frequency divider were not present.

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

Key "B" in each octave has no contact.

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

The oscillator tuning coil T1 in Fig. 1, is the main tuning control of the Solovox. A powdered iron slug moved in and out of the core of this coil, varying the inductance and therefore the frequency of the 6SJ7 oscillator. The only difference between this oscillator slug-tuned coil and the oscillator coil in a receiver is that the slug has a long shaft and a knob at the end that extends to the outside of the cabinet so that the owner can "raise or lower the pitch" of the instrument. This is often necessary because few pianos are in perfect tune. Age of the piano, condition of piaf and other factors will cause a noticeable difference between the piano and the Solovox—one of them will sour. (Continued on page 63.)
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.

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)
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**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 assure a cut-off condition until the next cycle.

The next input 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, but 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 .024 µuf condenser in the strip of the relay to 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 tone 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 the "C" key by the capacitance that is thrown into the grid circuit of the 6S7T 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...
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6DQ5A, 6F8A, Full ratings. (66 watts output) up to 250 mW. 250 ma. vol. 10000 volts. Red. $2.49 ea. or $4.40 for 2. HOLD #1300, Full ratings. (66 watts output) up to 250 mW. 250 ma. vol. 10000 volts. Red. $2.49 ea. or $4.40 for 2.

RCA 6012 VHF Triode. Tantalum plate and tantalum grid. 35 watts plate dissipation. Used as osc, or exp, in full grid output (66 volts) up to 250 mW. Double plate and grid disconnection allow balanced circuit design. High “Q” lines provides maximum neutralization. C.T. 6.3 volts. Filament reduces filament life. Excellent 4 meter tubes. All tubes BRAND NEW. Reg. price $14.50. Supplies areeady had, buy now or sell out of stock. $2.49 ea. or $4.40 for 2.

WE316A VHF Triode. Brand NEW! Completely new “brass knocker” tube. This tube is outstanding for your high power dissipation. Used to oscillate to 1000 volts. Also used in 500-600 volts. 80 ma. 75 watts output at 5800 MHz. Reg. price $14.50. Supplies areeady had, buy now or sell out of stock. $2.49 ea. or $4.40 for 2.

32B TWIN BEAM TETRODE.

This well known tube is ideal for applications at VHF. Full output (72 watts) up to 250 mW. 200 ma. 12 volts, 6 volts, or 5 volts. BRAND NEW. Reg. price $27.95. Supplies areeady had, buy now or sell out of stock. $13.50 ea. or 4 for $48.00.

CHEROMIC SOCKET for 398, 392 etc. 49c ea.

357 TWIN BEAM TETRODE. (Not pictured) 24 watts output up to 150 volts. 45 volts. 6.3 volts. 6.6 volts. 12 volts. 15 volts. BRAND NEW. Reg. price $55.95. Supplies areeady had, buy now or sell out of stock. $13.50 ea. or 4 for $48.00.

OTHER TUBES NOT PICTURED

607 Beam Tetrode. This popular tube hardly requires any explanation. One of the most used tubes for R.F. applications. $1.12 ea. or 4 for $3.95. 819 Power Triode. This tube is a real powerhouse. 575 watts output up to 30 mW! Carbon types. Grid out of scale for use in high k.t. efficiency. BRAND NEW! Only $5.95 ea. or 4 for $23.80.

815 Twin Beam Tetrode. Full ratings (65 watts output) up to 150 mW. Requires only 11.5 vol. grid driving power for full range. A very versatile tube for most any h.f. application. (Brand new. Only $2.50 ea. or 4 for $9.80.

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tes, miniature transistors, oil de-
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Tubes, 2 Type 6K6, 1 Type 6K14, EVERYTHING BRAND NEW. VERY FEW ON HAND. Mail order on your order.

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SIGMA HERMETICALLY SEALED 7000 OHM SPD RELAYS

Operates on 12 volt change. This relay requires no maintenance as all moving parts & actuator parts are in a VACUUM! Manufactured by SIGMA, this relay sells TOPS in performance and Contact ratings. 1 amp. Used in photostatic systems, automatic controls, relays, etc. Heavy wire lead connections. Solid mold(nombre, simplification of a 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 circuit. The grounding capacitor to G.E. cathodes. Switching the switch 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 that control labeled "Deep Tone," etc., that insert various combinations of resistance, capacity, and inductance into the line to change the characteristics of the sound going to the power amplifiers. For instance; the Full Tone control 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 F.M. 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 75 volts positive cut-off.

December, 1948
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, looks, 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 bias divider furnishing bias out 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. —96—

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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 radio technician.

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. —96—

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 is in use on a grand piano; a set of 12 control tablets giving any piano an indefinite variety of tone colors that simulate the organs. 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 humbrellas.

**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 the 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 tuning 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 “C” keys) and also, upon which of the “BASS-TENOR-CONTRALTO-SOLOVOX” 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 variable coil (L1 in diagram) connected across it.

The volume of sound from the speaker is controlled by a knob 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 as this 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 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 richness of its tones ranging from a brilliant, string-like effect to a deep and penetrating organ-like quality make it a new and different instrument for music lovers to hear and enjoy.

For a vocalist, the Solovox provides a...
Model 549 is the result of a long period of research and planning in the development of a multimeter which will fulfill the servicer's needs of today and tomorrow at a price he can afford to pay. The instrument will take care of all the servicer's multimeter requirements since it has standard provisions for A.C. and output voltages, direct current measurements, etc., in addition to the electronic circuit for D.C. voltage and resistance measurements.

0.1 TO 600 D.C. VOLTS—covered by six overlapping ranges of 0.2/5/20/50/100/600 volts. These ranges may be extended to 600 volts, at small extra cost, by use of a SUPREME Type 445 Probe. The input impedance of all ranges up to and including 600 volt range is 1,000,000 ohms. The input impedance of the 600 volt range is 1,000,000 ohms. Both probes for measuring D.C. voltages have a built-in resistance so that the D.C. values developed across oscillator grid leak can be measured without materially affecting the oscillator. Also all plate, screen and A.C., and A.C. voltages can be measured without upsetting the operation of the receiver. Voltages of either negative or positive polarity with respect to chassis or ground may be measured by setting the circuit-selector switch to "0" volts or "+" volts. The low range of 2 volt full scale gives a sensitive meter necessary in measuring small control voltages.

0.5 OHMS TO 1000 MEGOHMS—covered by 5 overlapping ranges of 0.001/0.01/0.1/1/10/100/1000 megohms. This electronic circuit permits all resistance ranges, including the 1000 megohm range, to be operated by the self-contained 5 volt battery. Features incorporated are the extreme accuracy achieved by adjusting the ohmmeter at "zero" position and "full-scale" position. After this is done, there are no adjustments to be made between ranges. The low range has a center scale resistance of 150,000 ohms which gives a good deflection in checking resistances of radio frequency coils. You will like this type of ohmmeter for its speed and accuracy. Being of an electronic type, the meter is fully protected and a sectional application of the voltage to the ohmmeter will not injure the instrument.

0.1 VOLT TO 500 A.C. VOLTS—covered by 5 overlapping ranges of 0.05/0.5/5/50/500 volts in a circuit whose calibration is guaranteed to ±5%. A cosine meter, fully protected and carries the same guarantee as all other parts of the instrument. Temperature error of rectifier is corrected over a working range of °F to °F.

10 MICROAMPERES TO 15 AMPERES D.C. CURRENT—covered by 7 direct ranges of 0.5/5/50/500 microamperes; 1,000,000 mA; and 0.15 amperes. Such a wide selection of ranges was incorporated to meet all current measurements necessary—from the few microamperes found in control circuits to the ampere drain of automobile receivers.

0.1 TO 500 OUTPUT VOLTS—can be used with any good (SUPREME Model 571 or 561) for receiver alignment. Covered by five ranges of 0.05/0.5/1/5/50/500 volts.

The Model 549 is also available in beautifu1 oak case as a four cash and 3 monthly payments of $5.00 each or $30.00 cash and 10 monthly payments of $1.00.

Laurens Hammond on his newest invention, the 14-kube Solovox, which was recently introduced simultaneously in Chicago to the National Music Merchants Association convention and in New York to the Phonograph Dealers and to members of the press.

wise to do the work in the customer's home. 99% 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, each component is checked in specifications and tolerances as if it were adopted widely in sound receivers. The quality of visible sound receivers, therefore, is almost entirely a matter of good design and workmanship.

The use of high voltage excites 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, else there is no sufficient background of experience already ready to indicate that service work on an average good television receiver is almost entirely a matter of luck.

From the foregoing, you can see that there is no high-voltage hazard involved in 99% 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 service man who makes the conventional tests for all of his customers will not find them to be any risk whatever. He can do his work with the power switched off.

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