Repairing vibrators for DC to DC convertors

I have successfully repaired many H.V. vibrators so I thought that you might be interested in what I learned and how I did it. The theory of the two types of vibrators follows the repair instructions. I like to repair these devices as I like to hear these little hummers operating in older radios.

The first step is getting them open. The aluminum cans are usually rolled over the base but on occasion I have seen them crimped. I first used a screw driver to pry up the rolled edge but that made a mess of things. Now I use a Dremel tool with a cutting wheel and carefully cut a slit around the base as close to the rolled edge as possible. The reason being that I epoxy the can back onto the base so I leave something for the epoxy to adhere to. Now the guts should just slide out of the can. If not, sometimes they use that black sealant and you have to carefully pry the base loose from the can. Once you get the vibrator out of the can, you should find the vibrator itself encased in foam rubber. If the coil isn't fried, or the contacts badly burned, you have a chance at rebuilding it by cleaning the contacts.

Forget about a contact file or burnishing tool as the contacts are tungsten and are VERY hard. To clean these babies you're gonna have to disassemble the contact stacks and use a fine diamond hone. It's a tedious job but not to difficult, just take your time and make sketches as you go. If the contact sets are riveted together use several cutting wheels on the Dremel tool to grind off one end of the rivet so that you can take it apart. Sometime a little penetrating oil helps to slide the fiber separators off of the tubular insulators. As I take the point sets apart I lay them out in the order that I disassembled them so it's easier to get them together again.

In order to properly clean the contacts you have to file to the bottom of the pit marks. Place the contact on a solid surface so you can press down on the diamond hone evenly to produce a flat surface. I use a 10X jewelers loupe to check my progress as I work. After I have reached the bottom of the pitting I use crocus cloth to polish the contact. With a little elbow grease I can get the contacts to shine almost like a mirror. I remove as many of the hone scratches as I can so that the contacts won't burn as easily in the future. I tried using course, medium, and fine hones but then it was more work to remove the scratches.

After all the contacts have been cleaned, reassemble the contact stacks. If the stacks were riveted use small bolts to replace the rivets. Now all you have to do is adjust the gaps. This is a trial and error procedure until you find the right gaps. I find that usually I'm pretty close if I can just see light between the first set of contacts to make. The opposing contacts usually have a little wider gap.

Before you plug the unit into the P.S. replace the buffer capacitor, (.01Mfd or so) then check the filter capacitors (20 to 40 Mfd) for leakage. I have had some luck reforming the electrolytics with a capacitor tester but if they don't come back within 5 minutes or so I replace them.

Now plug the vibrator into the P.S. and turn on the power. If you're lucky it'll start vibrating, but more than likely nothing will happen. Sometimes, if the point gap is close, you can tweak the vibrating blade with a toothpick and it'll take off. But either way just keep adjusting the blades until it vibrates reliably on it's own. Now just put it back in the can and epoxy the base to the can and it's ready to go.

Additional information by Dennis Starkes.
The most common failure with vibrators is the contacts sticking closed. Before cutting it open, try tapping it a few times on the floor. This will often times free up it's guts, and it will then go ahead and work. Be careful not to dent the side of the can, as if you do, and down the road need to cut it open, the dents will prevent the can from sliding off over the internal contacts/coil. The aluminum used in the cans on these vibrators is very soft, and easily deformed. I have seen unused spare vibrators that had been stored inside equipment that were crushed by the spring clip that was there to hold them. PE-117, and PE-120 power supplies for the BC-620, & -659 are notorious for this. Vibrators are often times very hard to unplug from their respective power supplies. If it does not come out by grasping it with your fingers, no not use pliers! If at all possible fit the blade of a flat screw driver under it, and gently "twist" it up (do not let the screw driver contact the phenolic socket), as it too is very fragile, and might even break under normal extraction (typical of the PE-114/BC-1000). Great care must also be taken when placing the vibrator back in it's socket. The only index device used are the one or two pins that are larger than the rest. It's often difficult to tell just by looking which are the larger pins, especially in the socket. Even when it is easy to tell, it can still be a real chore getting the things lined up and maintaining this alignment while pressing down firmly. So it's a good idea to make your own index mark with a permanent marker along the edge of the vibrator and chassis before removing it. Lastly, once the vibrator is removed, spread the retaining fingers of the socket slightly so as not to be so tight when you go to put it back.
Dennis Starkes

THEORY of VIBRATOR POWER SUPPLIES

101 General

a. A vibrator power supply converts direct current from a low-voltage power sources, such as a vehicular storage battery, into alternating current that can be rectified and used for the higher d-c potentials required by the operating equipment. When vibrator power supply is used within its rated limits it will furnish the necessary potentials to low-power communications equipment.
b. The difference between a conventional power supply operating from a-c sources (or d-c power lines) and a vibrator power supply is the vibrating mechanism used to convert the low d-c voltages to high a-c voltages, and the special step-up power transformer. The vibrating mechanism is essentially a high-speed reversing switch, which automatically opens and closes sets of contacts by magnetic action when d-c power is applied to it. The vibrator unit is designed to operate at a predetermined frequency, usually between 60 and 250 cps, but for special applications, higher frequencies can be used.

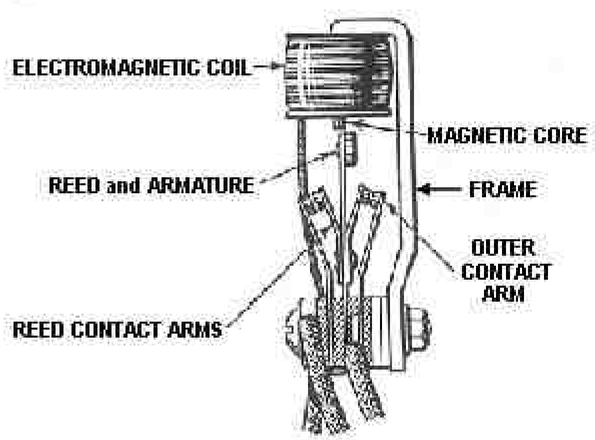

Figure 79. A simple vibrator mechanism.

c. The vibrator consists of five basic parts: a heavy frame, an electromagnetic coil and core, a flexible reed or armature, one or more contacts attached to the side of the armature, and one or more semifixed contacts mounted to each side of the armature. In construction, the electromagnetic coil is mounted on one end of the frame, and the armature is fastened rigidly to the opposite end of the frame. The armature contacts and the semifixed contacts are mounted on supporting arms on the sides of the armature. Figure 79 shows a simple vibrator mechanism in which the pole piece is attached to the electro-magnetic coil.

d. During construction, the whole vibrator assembly is sealed in a can and the leads from the contacts are brought out to metal prongs on the base of the can. The vibrator units are plugged into special sockets, which are wired permanently Into the input of the power supply circuits. This plug-in type of connection insures easy replacement of defective or worn-out vibrators. Since the life of a vibrator often is less than that of an ordinary electron tube, the plug-in method of replacement is convenient and time saving.

e. The vibrator is connected in the primary of the power transformer between the battery and the primary circuit. When the vibrator is actuated, the battery current through the transformer primary is interrupted at the vibrator frequency rate, resulting in sharp pulses of current through the transformer primary. These pulses of current flow in alternate directions through the transformer primary because of the action of the vibrator contacts which interrupt and reverse the current flow. These interruptions and reversals cause the current to give rise to a changing magnetic field, which induces an alternating voltage in the transformer secondary. Because of the step-up ratio of the transformer secondary, the induced a-c voltage in the secondary is many times greater than the primary voltage. This high value of a-c is then rectified, either by a separate rectifier device, or by additional sets of contacts on the vibrator unit. The rectified voltage then is filtered and regulated in the conventional manner to provide the required value of d-c voltage in the power-supply output.

f. The standard basic structure of two electrical vibrators is described in paragraphs 102 and 103. One of these is the interrupter, or the simply constructed nonsynchronous vibrator, which requires the use of some form of rectifying device. The other is the self-rectifying or synchronous vibrator; as the name implies, it performs the additional function of rectifying the a-c voltage, which it produces. The rectified voltage is feed from the output of the vibrator transformer circuit directly to the filter section of the power supply. (ed.) This version is usually found in military equipment.

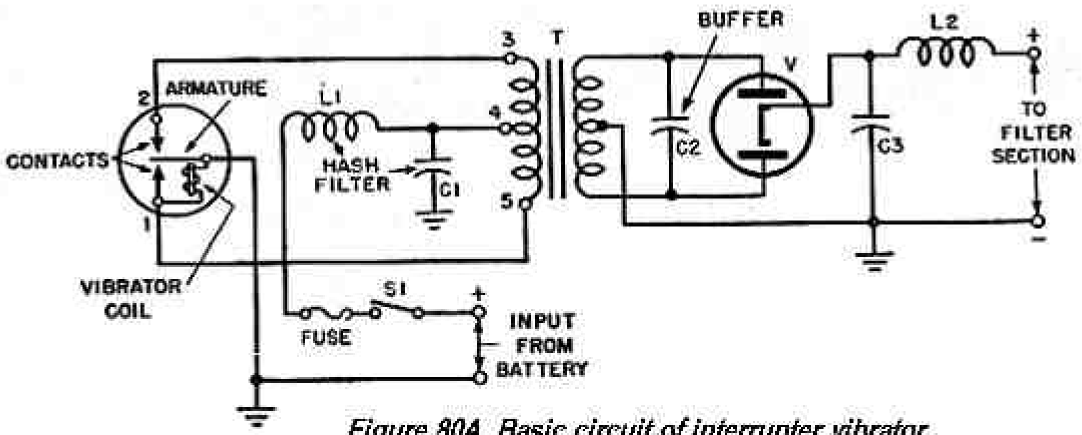

Figure 80A. Basic circuit of interrupter vibrator.

102. Interrupter-Vibrator

a. The circuit of a simple interrupter-vibrator power supply is shown in figure 80A. With switch S1 open, the armature rests midway between the two fixed contact points, 1 and 2, and no contact is made between them. When switch S1 is closed, current flows from the negative terminal of the battery through the vibrator coil and to the bottom of the transformer primary at 5. The current continues to flow through the primary ,winding to the center tap, through the r-f choke L1, and back to the positive terminal of the battery. As the current flows through the vibrator coil, a magnetic field is built up which pulls the armature against contact 1. This causes a short circuit across the vibrator coil and deenergizes it. During this time, the pulse of current through the primary, between 4 and 5, is at a maximum, making 5 negative with relation to 4; no current flows through 3 and 4 at this time. The armature, being no longer attracted springs upward and inertia forces it against the upper contact 2. The current through 5 and 4 of the transformer primary abruptly ceases to flow, but 3 and 4 complete the circuit to the battery. Current now flows from the negative terminal of the battery, through vibrator contact 2, and through 3 and 4 of the primary. It continues through choke L1 and flows back to the positive terminal of the battery. During this time, the pulse of current through the primary, between 3 and 4, is at a maximum, making 3 negative with relation to point 4; no current flows through 4 and 5 at this time. The successive closing of contacts I and 2 on the vibrator corresponds to one complete cycle of the, vibrating frequency and two pulses of current flow in alternate directions through each half of the transformer primary. The magnetic field created by these alternate current pulses induces a voltage in the transformer secondary, which has a waveform similar to a square wave (Fig. 80B).

b. As the armature, in A, makes contact with 2, the field of the coil builds up and attracts the armature back to 1. The coil is short-circuited again and the armature springs upward against the top contact, 2, and another cycle is completed. This action continues at a rate dependent on the inherent frequency of the vibrator. Continuous alternating voltages are induced in the transformer secondary and applied to the

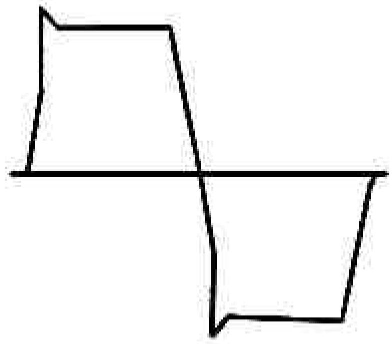

Figure 80B. Interrupter waveform.

plates of the full-wave rectifier tube, V.
c. Since the making and breaking of the vibrator contacts occur at a comparatively high rate of speed, a small amount of sparking occurs at the contacts. This sparking causes r-f interference and, unless filtered out, it appears in the output of the operating equipment. To minimize this interference, called vibrator hash, special r-f filters are used. These filters consist of r-f choke L1 and capacitor C1 in the primary of the transformer and r-f choke L2 and capacitor C3 in the output of the rectifier tube.
d. Capacitor C2 connected across the entire secondary winding is called the buffer capacitor and it's EXACT CAPACITANCE IS CRITICAL. It's function is to absorb the surges that occur when the current is interrupted in the primary. The collapse of the magnetic field is practically instantaneous and causes very high voltages to be induced in the secondary. As a result, if C2 is not present excessive sparking occurs at the vibrator contacts which shortens the life of the vibrator. Typical values of capacitors used as buffers are between 0.03 and 0.005 mfd. A resistor of approximately 5,000 ohms sometimes is connected in series with the buffer capacitor to limit the secondary current in case the buffer capacitor shorts out. The buffer capacitor should be rated at 1,500 to 2,000 working volts in power supplies delivering voltages of 250 volts or higher.

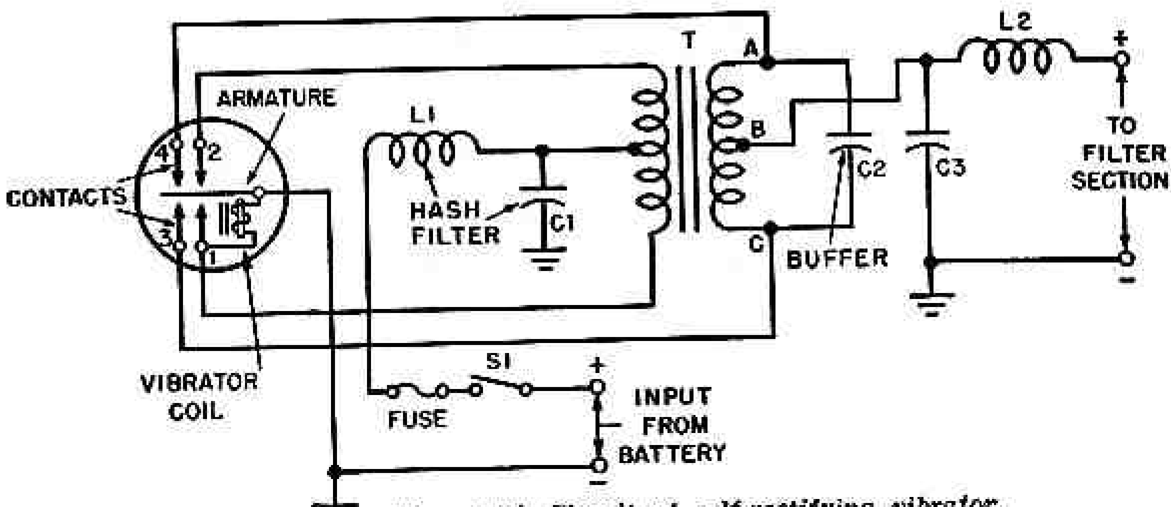

Figure 81. Circuit of self-rectifying vibrator.

103. Self-Rectifying Vibrator
a. Figure 81 shows the circuit of a self-rectifying or synchronous vibrator power supply.' A rectifier tube is not used in this circuit and rectification is accomplished by means of an extra set of contacts, 3 and 4, on the vibrator. These contacts are connected to points A and C on the transformer secondary. A positive rectified d-c voltage is obtained from center tap B on the secondary winding.
b. When S1 is closed, the action of the primary of T and contacts 1 and 2 are identical with that of the interrupter vibrator previously described. A different condition exists in the secondary circuit because of the presence of additional contacts and 4 on the vibrator. A pulsating d-c similar to that obtained from any rectifier exists between point B of the secondary winding and ground. This rectified output is fed to a filter section and appears as the required value of d-c voltage in the output. This action takes place as follows:
c. Ground or B-minus is the lowest point of potential for the circuit, and all

other points are positive with relation to ground. When the vibrator coil is energized and the armature is pulled against contact 1, contact 3 also is closed by the armature. This places C, on the bottom of the secondary winding, at ground potential since the armature is grounded and it becomes the common B minus for the power supply momentarily. The center tap, B on the secondary winding, is positive with relation to C and the voltage across the output terminals is positive in polarity. When the vibrator coil is de-energized, the armature springs against contacts 2 and 4. A on the transformer secondary then is placed at ground potential and becomes B minus. Since B still is positive with relation to A, and the voltage existing across the output terminals has the, same positive polarity as before. Since the pulsating current through the power supply always flows in the same direction, the current at B is the same as that obtained from a full-wave rectifier. The reversal of the B-minus point from A to C and then from C to A on the transformer secondary occurs at such a rapid rate that the output of the power supply is a pulsating d-c voltage. (If the battery polarity is reversed, the synchronous vibrator will not have the output voltage shown unless the transformer primary or secondary connections also are reversed.)

d. R-f chokes L1 and L2 and capacitors C1 and C3 in the primary and secondary circuits of the transformer are filtering networks to filter out the vibrator hash. To help eliminate r-f interference, center-tapped resistors sometimes are connected across the transformer primary, or a capacitor is connected across the entire primary winding. The power supply should be well shielded to prevent radiation of the r-f interference caused by sparking at the vibrator contacts.

104. Application

a. Vibrator power supplies axe designed and constructed to meet specific requirements. In military applications, vehicular storage batteries having voltage values of 6, 12, or 24 volts are used to operate this type of supply. This is accomplished by using a power transformer having a number of taps on its primary winding to accommodate the different battery voltages. Since the primary winding always is tapped in the center, the additional taps must be placed in pairs at corresponding points on the two halves of the winding. Two switches are ganged together to transfer simultaneously the two corresponding taps on the two sections of the primary winding; this adjusts the primary to the particular battery voltage being applied to the power supply.

b. Combination vibrator power supplies are constructed to operate on both an a-c and a battery power source as required. Use of a power transformer having an additional primary winding for use with a-c voltages is one method of accomplishing this. The primary winding used for the vibrator is tapped and can be used as the source of filament power when operating on a-c. This circuit requires a separate rectifying device, since the same high-voltage secondary is used for both a-c and d-c operation.

c. Another combination power-supply design uses two separate power transformers, with independent rectifiers, in the vibrator or the a-c input circuit. These two independent input circuits are connected in parallel across a common filter circuit. Either of the two input circuits can be selected at will by connecting the proper source of power and closing the switch.

d. The use of selenium rectifiers simplifies the design of this combination power supply since no filament power is required. An input circuit consisting

of an interrupter vibrator and its associated power transformer is used for d-c operation, the stepped-up voltage on the transformer secondary being rectified by the selenium rectifier(s). A-c input voltage is applied through a switch directly to the selenium rectifiers and in shunt with the transformer secondary winding. The voltage induced in a tapped section of the vibrator transformer primary provides filament power for the tubes in the operating equipment being supplied.

e. Although there are still a number of circuit arrangements for providing combined operation from both a-c and d-c input sources, the examples given here will suffice for general purposes. Other forms of combination vibrator power supplies include circuits operating from the same input source, but providing two or more entirely different power-supply output voltages to operate different equipments. By proper circuit arrangement, the outputs of these combined supplies can be either positive or negative, or both, and of varying values of output voltages.

f. Any of the conventional rectifier circuits, such as half-wave, full-wave, bridge rectification, and voltage multiplication, can be used in vibrator power supplies. Other power-supply features, such as voltage, regulation and voltage division, are equally applicable to this circuit. Vibrator power supplies are used widely in transportable communications equipment and in mobile installations.

105. Summary

a. Vibrator power supplies convert direct current, from a d-c prime power source, to alternating current, which can be used to furnish operating potentials for low-power equipment.

b. The vibrator consists of a magnetically actuated vibrating mechanism which causes the d-c input current to flow in pulses through alternate halves of a special power transformer.

c. The rising and falling magnetic field caused by the current pulses in the transformer primary induces an alternating square wave in the secondary.

d. Two basic vibrators are used widely one the nonsynchronous, interrupter vibrator, the other the synchronous, self-rectifying vibrator.

e. A separate rectifier is required with the nonsynchronous vibrator.

f. Rectification is accomplished with the synchronous vibrator by connecting an added pair of contacts to each end of the secondary winding. The voltage obtained from the center tap on the secondary winding then is always positive with relation to ground.

g. The frequency range of the vibrating mechanism is approximately 115 to 250 cps.

h. The purpose of the buffer capacitor is to absorb the high current surges occurring in the secondary. It's value is critical.

i. Several types of vibrator power supply operate from both low voltage d-c sources and standard a-c sources simply by throwing a switch to the required input circuit.

j. Vibrator power supplies find widest application in mobile and transportable equipment.

106 Review Questions

a. What is the purpose of a vibrator power supply?

b. What are the five basic parts of the vibrating mechanism?

c. Where is the vibrator connected in the power supply circuit?

d. What are the two basic types of vibrators?
e. How is rectification obtained in the synchronous vibrator?
f. What kind of voltage waveform does the vibrator produce in the secondary of the power transformer?
g. What is vibrator hash?
h. How is it minimized?
i. What is the purpose of the buffer capacitor?
j. Where is the vibrator power supply used most widely?

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If you have any questions please CLICK HERE to email me.

73, Buzz

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