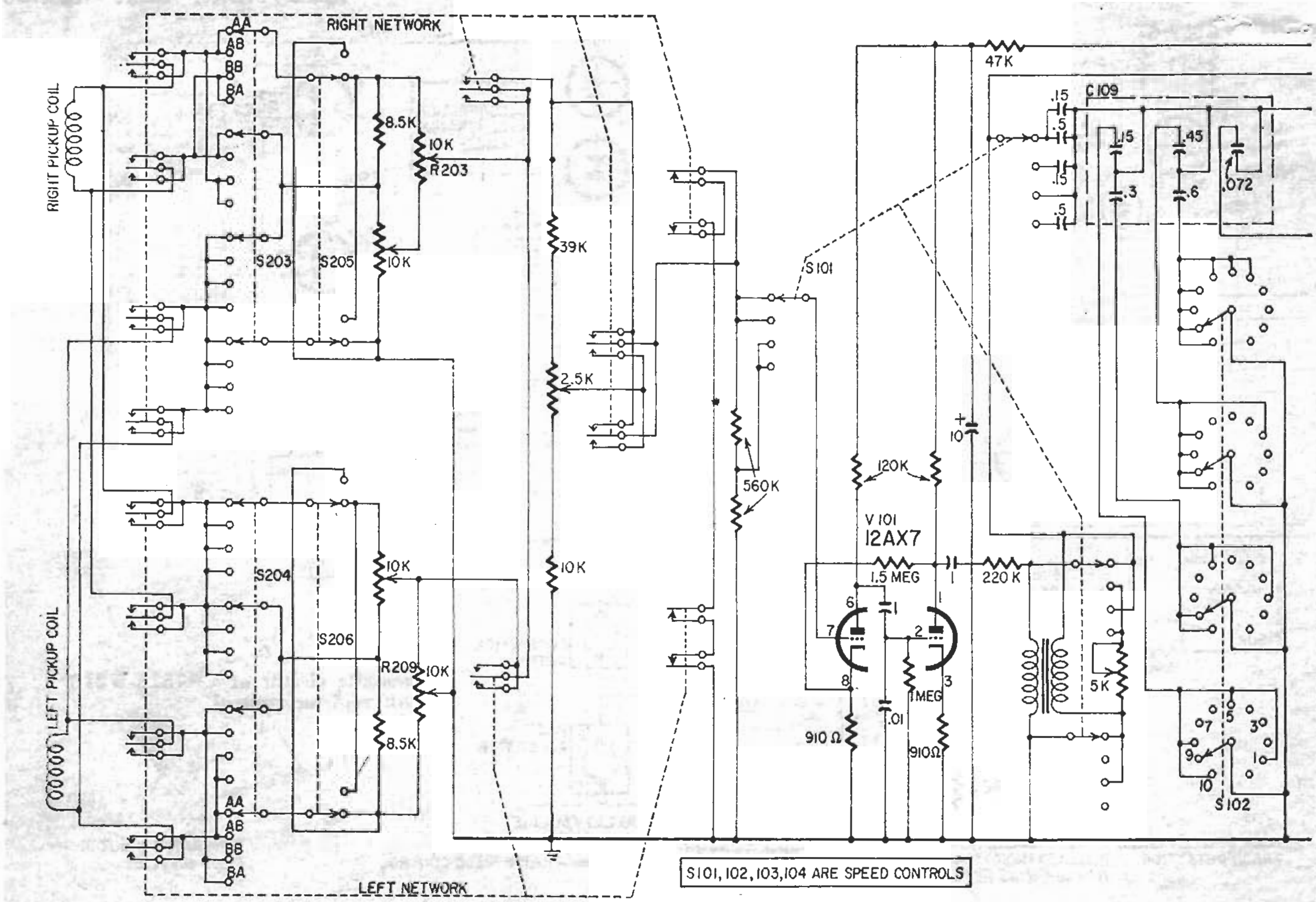


ELECTRONIC BALANCING for BETTER MOTORS

Balance the rotor of a fractional-horsepower motor and you increase efficiency, and reduce wear and vibration. One way to do this is with an electronic dynamic balancer

By J. W. ESSEX*

SMALL electric motors are in constant use wherever you turn—phonographs, drills, saws, typewriters and mixers. The heart of these fractional horsepower motors is the rotor, which turns at speeds as high as 3,400 rpm. If the rotor is balanced, there are no problems; if it isn't, the motor will be noisy and vibrate. It will also wear excessively and be inefficient. Such vibration can even make a motor shake itself to pieces—holding nuts work loose, tie rods fall out and the whole works comes apart.

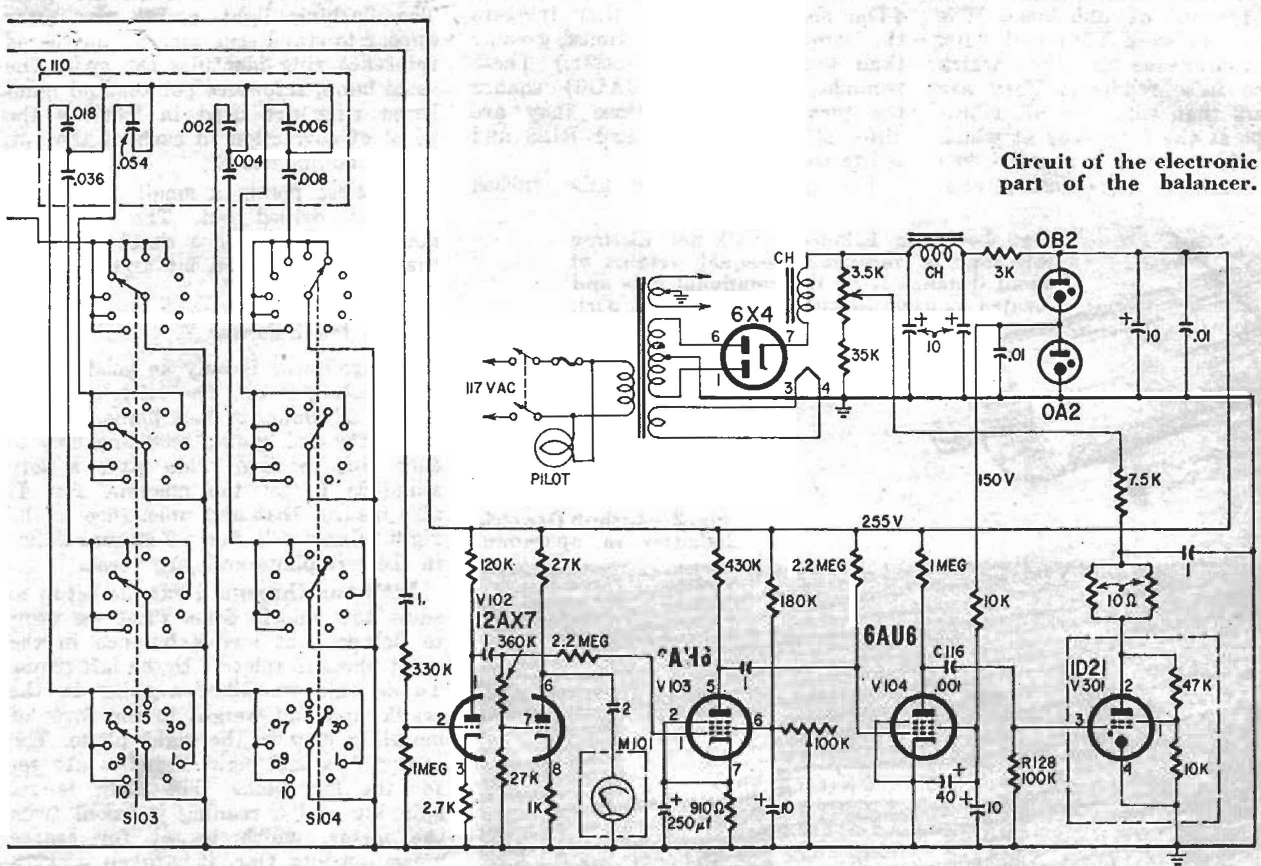
How are rotors balanced? The old method called for taking the completed rotor and placing it on a set of two steel rails. If unbalanced it would roll along the track until the heavier weight of one side would bring it to rest. Then the operator would remove the rotor and place it in a drill press. After drilling out some of the mass from the heavy side, the rotor would go back to the rails for another check, and so on until it was balanced properly.

The process works well, but is too slow. Using this method, two men could run off only 150 rotors a day, far short of a desired target of 700 a day. Also, static balancing does not reveal dynamic unbalance caused by two equal weights at equal distance from the rotational axis and located on opposite ends of the rotating part (Fig. 1).

Electronic balancing

The solution to the problem came in the form of an electronic balancing machine. It has proved itself by turning out more, better-balanced rotors per day. The result is

*Former inspector, quality control, Small Motor Div., Canadian Westinghouse, Hamilton, Canada.



Circuit of the electronic part of the balancer.

higher quality at lower cost, a survival prerequisite in this mechanical age.

The time-consuming part of rotor balancing is in finding the unbalance point and the amount of mass that must be removed to balance the rotor. Here's how this problem is handled by the Gisholt Dynetric balancer, a machine with which the author is familiar.

The rotor to be balanced is placed on the Dynetric balancer as shown in Fig. 2. A numbered reference ring is attached around the rotor and a belt drive placed around the center of the rotor. When the balancer is turned on, the rotor is spun at about 800 rpm. If it is unbalanced, it will vibrate in its cradle, move a couple of coils in a magnetic field, producing a sine-wave output. The output is amplified and shaped to produce pulses that fire a strobe light. The vibrations appear at the same time during each revolution, so the light flashes at the same time each revolution. The operator notes the reference number that appears in the strobe light over the reference pointer. This identifies the off-balance point. The meter tells the operator how much weight must be taken off or added. (The more common practice is to drill out the necessary material.) After this is done, another check is made and if the rotor passes, the job is done.

Balance a rotor

Now let's take a closer look at the electronics side of the operation. How is the vibration picked up and changed to a pulse that triggers the strobe light?

A rotor to be balanced is placed in a cradle (Fig. 3) that consists of two supports attached to coils which move in strong magnetic fields. The more the coils move in the magnetic fields the greater their voltage output. The coils' outputs are fed to a common meter which indicates a voltage when either end of the rotor moves up and down.

When the rotor is unbalanced, represented by weight W on the right side, and is rotated, it vibrates between lines Y–Y and Z–Z. As the right side swings more than the left side, the voltage induced in coil A is greater than that in coil B. The coils are arranged so the voltages fed to the meter buck each other and the meter reads only the difference.

By adjusting coil A's output with the potentiometer, the meter can be zeroed. In this way the effect of weight W in the right plane is balanced out. If a weight is placed on the left end of the rotor, the meter would measure the unbalance in the left plane. This is how the two planes of the rotor are separated for balancing.

In use, the pickup coils are followed by somewhat complicated networks and level or volume controls. They can be seen in the main diagram at the head of this article, the complete electronic circuit of the Gisholt balancer.

Of course, the weak vibrations set up by the rotor must be amplified before they can be used, and this is where electronics comes in. The amplifier uses four tubes (in addition to the strobotron, rectifier and voltage regulators) to provide amplification in the order of 1,600,000 times. The output from the coils is fed to a 12AX7 (V101) for impedance matching and early amplification. The signal then goes to V102, another 12AX7 used as a resistance-coupled amplifier to drive meter M101, which indicates the amount of unbalance. The filter network between V101 and V102 cuts down extraneous vibrations which could cause false readings. They are tuned filters that eliminate all vibrations except at the frequency at which the rotor is turning (usually 800 cycles). To trigger the 1D21 stroboton two additional amplifiers are used. (The signal amplitude that triggers the strobe light is 15 times greater than that fed to the meter.) These pentodes (6AH6 and 6AU6) square the pickup voltage before they are differentiated by C116 and R128 and fed to the strobe tube.

The gas-filled strobe tube flashes each time a pulse reaches its grid. The flashing light makes the rotor appear to stand still, and the numbered reference ring identifies the spot. The same lamp, reference pointer and numbered ring are used in locating the point of correction in each of the two correction planes.

At these points a small amount of mass is drilled out. The necessary amount is shown on a chart that lists the size of the drill bit and depth to use.

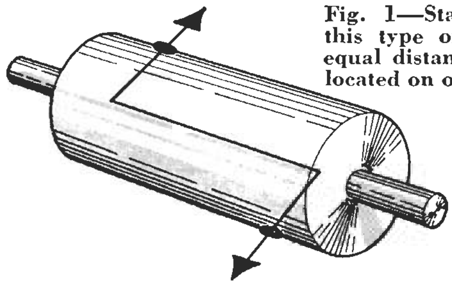
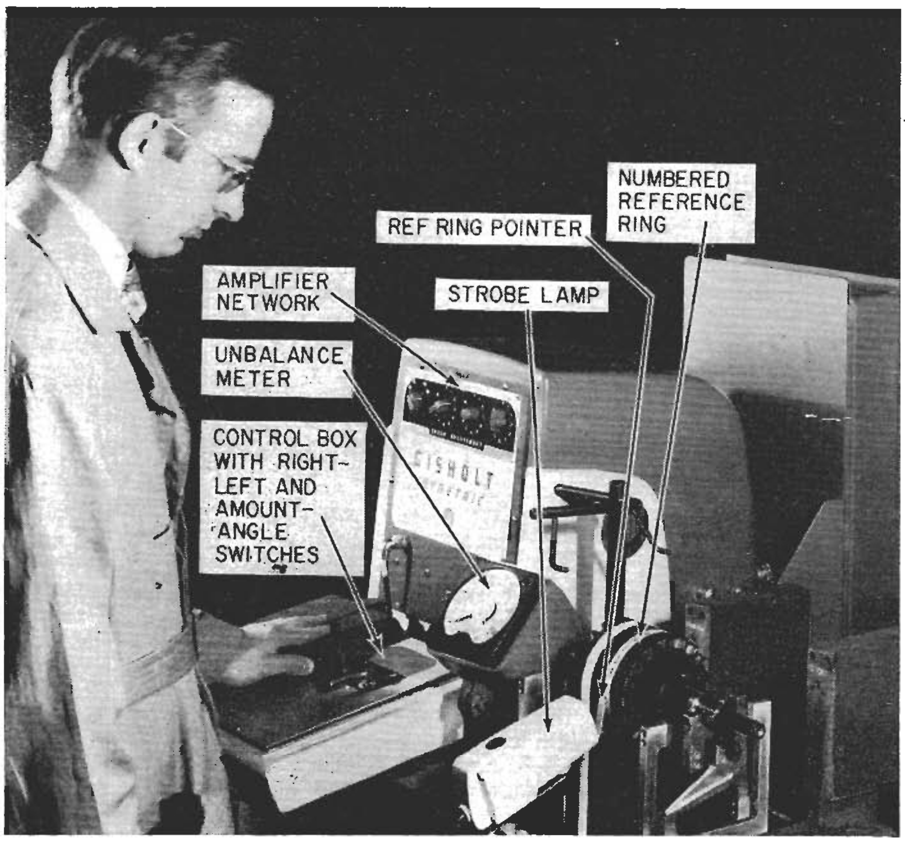


Fig. 1—Static balancing will not disclose this type of misbalance—equal weights at equal distance from the rotational axis and located on opposite ends of the rotating part.

Fig. 2—Gisholt Dynetric balancer in operation.



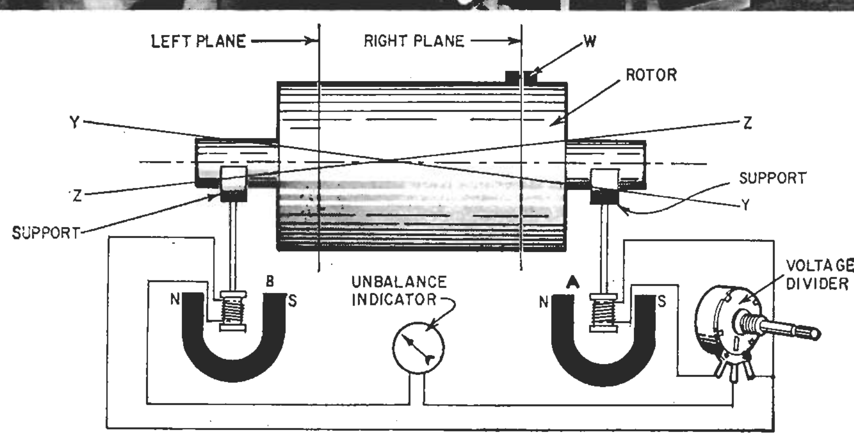


Fig. 3—How rotor vibration is transformed into an electronic signal.

Set up the balancer

The balancer is only as good as the man setting it up. The trick is to get a good minimum in each plane, using a test rotor and adding modeling clay to each side in turn. This gives a zero standard to set the machine for. It also insures that any unbalance in the right plane will not affect unbalance in the left plane and vice versa.

Let's run through a sample setup to show how this is done. First we want to balance out any unbalance in the right plane in relation to the left plane. To do this we place a rotor in the cradle and add weight in the form of modeling clay in the right plane. The control box left/right switches are set for the left plane. The rotor is set spinning and a reading is taken from the meter, which is set for coarse measurements. Once it is taken, a small amount of clay is added and the rotor is spun once again. If this causes an increase in the meter reading, reverse the input switch before continuing. As the operator proceeds, adjusting controls as he goes along, the meter reading drops each time clay is added. As the readings get low, the operator switches to the fine reading and continues adding clay and rechecking. When readings get low once again, the operator keeps adding clay and checks the settings of switches S204 and S206 and potentiometer R209 (only one combination of these controls will give a zero reading). This continues until a zero reading is obtained. Now that the left side is balanced the operator sets the left/right switch to right and repeats the process, this time adding clay to the left side of the rotor. When doing final balancing on this side, switches S203, S205 and potentiometer R203 are adjusted.

Once established, settings are recorded so that for successive rotors of the same type approximate settings can be made without all the preliminaries given here. In our plant we eventually got a list of figures for all the rotors we make. It simplifies the job considerably when switching from one rotor to another.

Now the angle/amount switch is set to angle and the strobe light flashes, indicating the point of the unbalance. In this way electronics gives us a machine that makes low-cost, high-quality fractional-horsepower motors possible. END