Effects of Humidity on

Moisture absorption decreases leakage resistance and changes dielectric constant of a terminal strip. Resulting adverse effects on circuit operation can be avoided by the design and layout techniques which are discussed and illustrated

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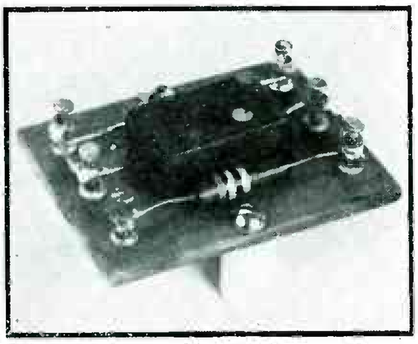
DEPENDABLE and accurate operation of radio and other electronic equipment under extreme conditions of high temperature (+50 deg C) and relative humidity (95 percent) requires, among other factors, careful consideration of terminal-strip design. Most failures experienced during tests conducted on a variety of equipment under these extreme conditions have been traced to faults either in the design or dielectric material of terminal strips. If an analysis is made of the circuit and the particular terminal strip in question, it is possible to develop a good design and so considerably reduce failures of this type.

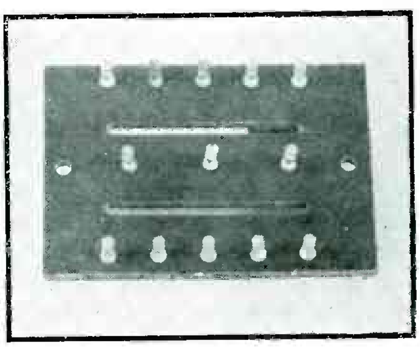
Effects of Leakage

Leakage resistance may be decreased by moisture absorption in the material itself or by a moisture film on its surface. Capacitance changes are also present since the dielectric constant of the material will also change with moisture content. This will disturb the frequency stability of a tuned circuit. For example, the resulting equivalent circuit of a parallel *LC* circuit is shown in Fig. 1, *L* and *C* being shunted by the capacitance C_1 in series with the leakage resistance R_1. Thus the circuit *Q* and the resonant frequency will be subject to change.

In the case of a terminal strip upon which are mounted resistors and fixed capacitors, leakage may exist not only to ground but from lug to lug. The effect upon circuit operation in the presence of leakage in a strip upon which these components are mounted is frequently serious. For example, the time constant of an *RC* network can be materially changed.



Mounting terminal strip on half-inch standoff insulators prevents leakage to ground



Although the moisture absorption of this material is high, slotting the strip provides satisfactorily low leakage

A variation in time constant can upset the desired circuit operation by affecting frequency response and phase shift. If the circuit is to pass a square wave, the leakage may actually differentiate it. The reverse condition may also occur in an integrating circuit.

Figure 2(a) shows examples of leakage paths that can exist in a resistance-coupled amplifier. Low leakage resistance from plate to ground will limit the positive plate-voltage swings and cause distortion if the plate load resistance is high. A voltage divider is formed by the plate load resistance R_L and the leakage resistance R_1 in parallel with R_2, so that the maximum voltage applied to the plate depends upon the relative values of these resistances. For instance, with the values shown, the plate voltage cannot exceed 150 volts.

It is also evident that if leakage exists between plate and grid, a d-c potential will be applied to the grid by the voltage-divider action of the leakage resistance R_3 and the grid resistor R_g. Again, its magnitude will depend upon the relative values of these resistances. A small amount of leakage at this point can, of course, greatly disturb the grid bias and cause improper operation. Similar action can take place between the plate and screen grid when the tube is a pentode.

Moisture Increases Leakage

The amount of moisture absorption by a terminal strip varies with the material used. Wax impregnation of the strip will reduce absorption, but it must be remembered that it is not by any means a cure-all. None of the commonly used impregnating agents afford 100 percent protection; they merely retard the process of absorption, and once moisture is absorbed the impregnation tends to retain it.

When equipment is subjected to high temperature and humidity conditions for long periods of time, say two months, the amount of absorption may be considerable. While it is true that when the equipment is operated heat dissipated within the unit will tend to dry it, the time

Terminal-Strip Design

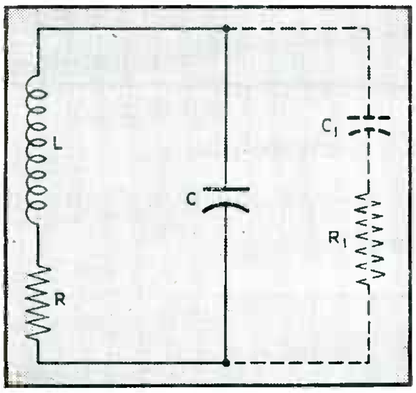


FIG. 1—Leakage can change both the Q and f_0 of a resonant circuit

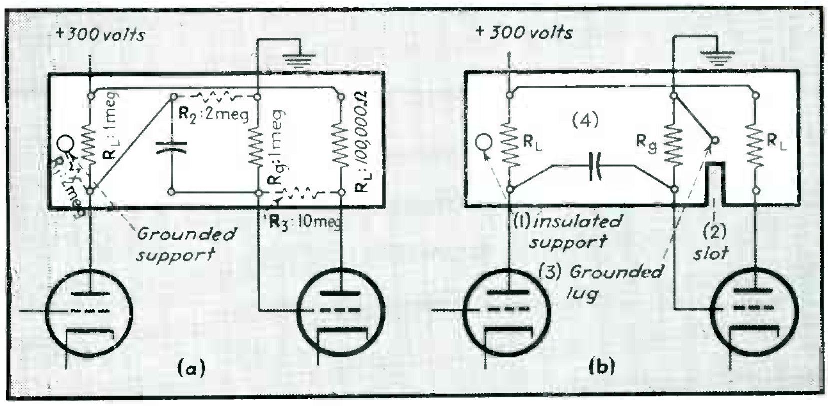


FIG. 2—Leakage paths to ground supports and between mounting lugs, shown dotted at (a), can be minimized by rearranging and changing as indicated at (b)

required for this process can be excessively long, sometimes a matter of hours. Selection of a material possessing high resistance to moisture absorption is therefore of prime importance.

Surface leakage will also be present regardless of the strip material. This type of leakage results from a film of moisture on the surface of the strip and is aided in formation and maintained by the accumulation of dust particles.

Layout Reduces Leakage

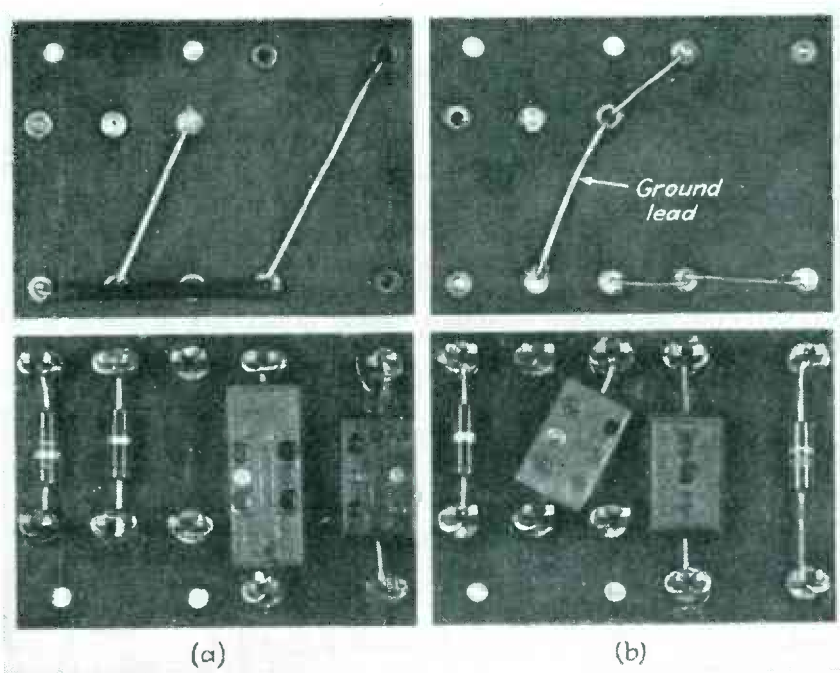
Figure 2(b) shows means that may be used in combating leakages. Obviously, if the spacing between lugs is increased, less leakage may be expected. Slotting of the strip will provide long paths between lugs and at the same time enable the terminal-strip size to be maintained within reasonable proportions. Leakage to grounded terminal-strip supports may be eliminated by using small stand-off insulators for mounting. Another method sometimes used to prevent d-c leakage from plate to grid is the insertion of a grounded lug between these two points. Any leakage existing in that path will then be to ground instead of to the grid. Care must be taken with this application, however, since leakage from grid to ground may be introduced, which may or may not interfere with correct circuit operation, depending upon the circuit.

When designing a terminal strip it is advisable to keep high-impedance points on it removed as far as possible from low-impedance points as well as grounds. The same precaution should also be taken with points of high d-c potential differences. In this way the possibility of a voltage breakdown due to leakage, may be prevented or at least reduced.

Also, leads from high impedance circuits should be dressed. The insulation on the lead itself can provide a leakage path between two adjacent points. When leads are cabled together, leakage through the insulation to other leads can occur if they are not satisfactorily protected against humidity. If insulation is not protected against moisture, leads to the affected circuit should be run directly instead of by cabling.

The effect of leakage in a terminal strip can easily be observed by simulating leakage resistance with fixed resistors of one or more megohms and connecting them between points on the strip where leakage is suspected or probable.

In any event, if impedances are kept as low as can be tolerated in the circuit design, effects of extreme conditions of high temperature and humidity may be dealt with more easily.



Direct-current leakage with the arrangement at (a) is prevented by rearranging components to interpose a ground lead as at (b) between high and low-voltage lugs