Electrical Noise In Sliding. The idealized performance of a sliding electrical contact system would be such that it would transfer both d-c and a-c signals from the moving contact member to the stationary member (or vice versa) with no change in amplitude. Thus in Fig. 1-25, where there is relative motion between members **A** and **B**, the outputs would be the same as if $\mathbf{R}_L$ were moved to the phantom position R'_L i.e., I_o and E_{out} would be the same as I'_o and E'_o. The fact that this idealized performance is approached but never attained will now be explained.

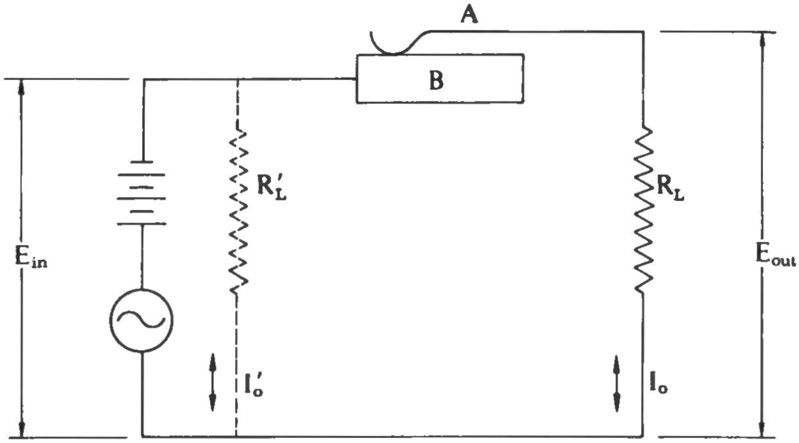

Fig. 1-25.

One deviation from idealized performance is due to the fact that the ring and brush materials have resistances which are in series with the load. The current passing through these resistances causes a slight loss in the voltage that appears across R_L. The loss is simply $\mathbf{I} \times \mathbf{R}_B$ where $\mathbf{R}_B$ is the bulk resistance of the members. This bulk resistance can be computed from the resistivities and dimensions of the members by using equation 1.3 or 1.3a.

In long conduction paths or where the cross-sectional area of the members is small, the bulk resistance may be significant, but for small currents (high values of R_L) the effect is usually negligible.

Another possible deviation from ideal performance is caused by the frictional heat generated by the sliding. The interface then acts as a thermocouple producing small voltages dependent on the interface temperature. The magnitude of this voltage is a function of the relative thermal emf characteristic of the two members, and is not constant since localized temperature varies from moment to moment. Contacts operating at just a few grams force and at surface speeds below 50 inches/sec. (~125 cm/sec) are seldom troubled with this type of spurious voltage. One exception is that in which the sliding contacts are expected to transmit thermocouple signals.

Variation in the instantaneous contact resistance is called electrical *noise*. Any factor that would affect stationary contact resistance will, if it changes, have an effect on sliding or dynamic contact resistance. Thus changes in the instantaneous force, a-spot shape, number of a-spots, hardness, proportion of mechanical load that is supported by films and the momentary film thickness can cause noise. Because of the microscopic roughness, wear debris and sliding motion, a-spots are continually being created, obliterated and changed in size, shape and number; the same applies to load bearing areas and the proportion of them that are supported by films. We recall that minor films are always present to some extent except in a hard vacuum.

In the case of stick-slip motion, contact resistance is momentarily low during stick and high during slip—even to the extent of the whole source voltage appearing across the contact surfaces, since they may be physically separated. This is appropriately termed "open circuit noise." Of course, thick non-conducting films and contact bounce are other sources of "open-circuit noise."

The simplified concept of the ohmic nature of noise leads one to expect that its magnitude is directly proportional to current. This has been verified for currents up to several hundred milliamperes.

Except for "frictional polymer," which will be covered in a later section, the major sources of noise are :

1. Tarnish or corrosion films
2. Imbedment or compaction of foreign matter
3. Stick-slip motion
4. Contact bounce
5. Variation in size and number of a-spots

By using precious metal alloys and with careful mechanical design, the noise of moderate speed instrument slip rings can be kept to a typical maximum value of 10 microvolts/milliampere, or an equivalent noise resistance of 10 milliohms in an ideal environment. Multiple points of contact are used to good advantage in all cases where noise requirements are stringent.