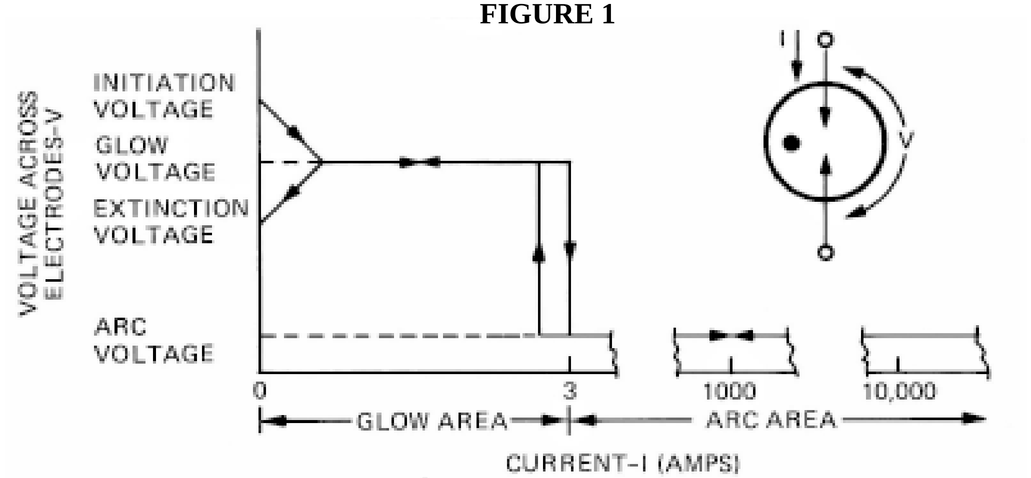
Gas tubes (gas filled spark gaps) are basically high energy voltage controlled switching devices. They are unique in their ability to repeatedly switch currents of thousands of amperes, which leads to their most common usage as transient protectors for applications where high energy transient electrical surges are anticipated.

The basic design and operation of a gas tube spark gap is simple. If two metal electrodes are separated by a suitable insulator and a gas placed between the electrodes at a specific pressure, an electrical breakdown occurs between the electrodes following the application of sufficient voltage across the electrodes. Once formed, this electrical *arc* is capable of carrying currents of many thousands of amperes while the voltage developed between the electrodes during the arc state remains relatively independent of this arc current. Typically this arc related voltage is in the range of twenty to thirty volts once the breakdown has been initiated.

GAS DISCHARGE TUBE CURRENT-VOLTAGE CHARACTERISITICS
FIGURE 1



To initiate the arc in a gas tube, a voltage considerably higher than the arc voltage must be applied. Figure I illustrates the *current-voltage characteristic* of a typical gas tube.

As a voltage is applied across the electrodes of the tube this voltage must be raised until it reaches the initiation point before current begins to flow. This initiation voltage is both a function of the device design and the rate at which the input voltage is applied. Characteristically gas tubes require higher initiation voltages the more rapidly the input voltage is applied. The first current that flows following initiation is the *glow current.* Over a narrow band of low amperage currents an associated glow voltage occurs across the electrodes which is essentially independent of current. This low amperage area is called the *glow region* and it is the normal operational region of the voltage regulator type of gas tube.

Most spark gap protection devices are not designed for operation in this glow region due to the current limitations of the region, but are intended for use in the arc area which occurs as current is provided beyond the glow region.

In the application of spark gap gas tubes, two fundamentals from Figure I are of importance. First, the applied voltage must reach the initiation voltage before breakdown can occur and second, in order for the arc to extinguish following the initiation of the breakdown, the voltage curve must be retraced back through the glow area.

Figure IL-A shows a basic application for a gas tube used as a protective device. The gas tube is placed across the input terminals of the circuit load to be protected. Because of its high inherent impedance the gas tube is essentially undetected by the normal signal voltages, however with the arrival of a transient voltage of sufficient magnitude the gas tube goes into its arc state, thus placing a very low impedance across the load for the duration of the transient.

Figure lI-B illustrates the same basic application except for a three electrode gas tube on a balanced pair line.

It is apparent from the current-voltage characteristics of Figure I that a breakdown or initiation voltage selected for the gas tube must be above the normal signal voltage to prevent unwanted breakdown of the protector. In addition, if the incoming lines include a D.C. voltage, consideration must be given to the current-voltage requirements of the gas tube to allow it to *extinguish* following initiation of the tube by a transient voltage. Extinction of the are where the source is an AC voltage is relatively direct due to the zero voltage crossover point which occurs with each polarity reversal.

For all but simple communication and data lines, application of gas tubes involves the combination of the gas tube with other circuit devices to fulfill the requirements of the current-voltage relations of the gas tube. For all applications, selection of a gas tube device with the proper current capacity, coordinated with the expected transient, is required.

Examples of the combination of gas tubes with other circuit devices are as follows. These coordinated circuit protectors are hybrids and may be specified and packaged as a complete system.
For D.C. systems whose normal voltage and power supply short circuit current are adequate to hold the gas tube in the arc or glow area, a series resistance must be provided with the gas tube. Either a resistor having a high current capability or a varistor may be used. The resistance element must drop sufficient system voltage to bring the across -the -electrode voltage below the glow voltage curve for the gas tube once the transient voltage has passed. Several resistance-gas tube combinations may be placed in parallel to lower the transient voltage developed across the resistance elements.
For AC systems with a large source power capability, a resistance element may be placed in series with the gas tube to lessen the current duty required of the gas tube until the next current zero is reached and extinction occurs.

BASIC CIRCUIT APPLICATION OF A GAS DISCHARGE TUBE
FIGURE II.

For solid state systems having a low voltage damage threshold, a second stage of protection using a device whose current capability is less than the gas tube, but which has a lower initiation voltage may be used. An example of such a device is the hybrid combination of a zener diode and a gas tube shown in Figure III for a balanced pair line. The resistances, R1 ad R2, limit the current through each zener diode until the gas tube discharges.
There are many combinations of circuit elements which may be used with the gas tubes for specific applications. Reynolds Industries offers the assistance of their Application Engineering Group to provide technical help with specific applications. Complete hybrid packages designed specifically for your application can also be supplied.

BALANCED PAIR HYBRID PROTECTOR
FIGURE III.