rheostat mode must be limited to the maximum allowable wiper current for the particular potentiometer being used.

100ma is a common maximum wiper current rating for most wirewound and cermet type units. The manufacturer's data sheet, for the particular unit being considered, should be consulted to ascertain the limiting value of wiper current for rheostat applications.

Once again, refer to the circuit and response curve of Fig. 3-18. The function of the potentiometer is to vary the current through load resistor R_L. When the potentiometer is adjusted fully counterclockwise, the only resistance remaining in the circuit will be that of the load resistor. This is the lowest total circuit resistance condition, hence the high current condition of the circuit. In this state, the total current in the circuit must be limited to the maximum value explained in the previous paragraph. Relating this limitation to circuit voltage and load resistance:

$$\frac{E_I}{R_L} = \sqrt{\frac{P}{R_T}} \quad \text{(100 ma, absolute maximum)}$$

As the wiper is caused to move clockwise, more resistance will be added into the circuit and, therefore, the total current will decrease remaining below the maximum allowable magnitude. The current flowing through the wiper and, hence through the load resistor, is graphically represented in Fig. 3-18B. Applying this maximum current limitation to a rheostat design will insure that the maximum power rating of the potentiometer will never be exceeded.

Using the maximum current limit is only slightly conservative for potentiometers which have rather poor thermal characteristics. For those units which have a good thermal path in the element structure, the maximum power which can safely be dissipated is somewhat larger than that limited by the maximum current calculation. Potentiometers designed specifically for power control or other high power operations have elements wound on an insulated metal core which aids in the distribution of heat. Such potentiometers can have a maximum power limit in the 20 to 30 percent travel range that is twice the 20 to 30 percent of the value indicated by the maximum current calculation.

Some cermet potentiometer designs also have good thermal characteristics, and hence a higher permissible power for limited element applications. Do not assume that the potentiometer will never be adjusted to a particular setting. Always assume that any position is possible and design for that possibility.

Controlling the Adjustment Range. The potentiometer, when used in the rheostat mode, provides a range of resistance from the absolute minimum resistance to the TR. Fixed resistors may be added to alter the adjustment range. Fig. 3-21 shows five basic arrangements and gives formulas for the resulting resistance ranges. Note that the effects of absolute minimum resistance need only be considered in conjunction with minimum settings.

A single series resistor R_1 as shown in Fig. 3-21B, provides an effective offset (equal to its value) to the resistance parameters. The resulting output function is still a linear function of relative wiper travel. The effect of R_1 is most pronounced at the minimum resistance setting and is often necessary to prevent excess current flow. In all instances, analogous to Figs. 3-21A and B, the total circuit current passes through the potentiometer's wiper circuit.

Placing a fixed resistor in parallel with the potentiometer's element as in Fig. 3-21C, has its most significant effect when the wiper is positioned fully clockwise. The resulting output function is a nonlinear function of travel as illustrated by Fig. 3-22. At the minimum resistance setting, the absolute minimum resistance of the potentiometer is shunted by R_2 resulting in a resistance effectively lower than the minimum resistance. This condition is indicated as approximately R_M ($\sim R_M$) on the chart of Fig. 3-21.

Adding a second resistor in the manner shown in Fig. 3-21D, provides the same type of output function shown in Fig. 3-22, but all resistance values are increased by an amount equal to R_1. Note that in Fig. 3-21, circuit D is simply the combination of circuits B and C.

In the final arrangement shown in Fig. 3-21E, the shunt resistor R_2 is placed in parallel with the series string of the potentiometer TR and R_1. The minimum resistance becomes the parallel equivalent of R_1 and R_2. The maximum terminal resistance is the parallel equivalent of R_2 and the sum of R_1 and R_T. This configuration permits the control of currents higher than the device's maximum current rating. When the ratio of R_1 to R_2 is large, most of the total circuit current flows through R_2, and only a small portion flows through the potentiometer.

The circuit arrangement of Fig. 3-21E is frequently used where the potentiometer is to provide some small fractional adjustment in the equivalent resistance of a fixed resistor. For example, assume that R_1 is equal to $10R_2$. Fig. 3-23 shows the resulting output functions obtained for two values of R_T. When $R_T = 10R_2$, the total effective circuit resistance varies from about $0.91R_2$ to a little over $0.95R_2$.