This is not really a demonstration. It is simply a description of essential features of a DC amplifier which is to be used with a thermocouple or thermopile to display a temperature difference on the digital voltmeter. The amplifier and a typical thermocouple are described here. For a description of the digital voltmeter, see demonstration EC-4.

**General Description:** Thermocouples used will always be of the iron-constantin type unless otherwise specified. A typical couple consists of a "test" junction (always indicated by red) and a "reference" function (always indicated by black), with a connector which fits onto the input of the amplifier. The DC amplifier has the following controls: (1) An off-on switch with associated pilot light. (2) Input and output terminals. (3) A toggle switch which either shorts the amplifier input or connects the thermocouple (or the thermopile) to the input. (4) A toggle, reversing switch which determines the polarity of the input, and indicates which of the two junctions is at the higher temperature. (5) A rotary control for balancing the amplifier, normally while the input is either shorted or connected to a thermocouple the junctions of which are definitely at the same temperature. (6) A rotary control which allows one to select an amplification factor of 10, 19, 100 or 1000.

**Calibration of the Amplifier:** When an iron-constantin thermocouple is used with an amplification factor of 19, the temperature difference between junctions is displayed directly on the digital voltmeter to which the output of the amplifier is connected. Assuming that the amplifier is properly balanced, the difference is displayed directly to the nearest 1°C on the 999-mv scale of the voltmeter, or to the nearest 0.1°C on the 99.9-mv scale. If the reference junction is maintained at 0°C, the actual temperature of the test junction is displayed. Negative temperatures can be displayed directly by reversing the proper switch. Amplification factors other than 19 are intended primarily for use with a thermopile, or with a thermocouple when greater sensitivity is desired but when direct readings are not important. Knowing that for an amplification of 19 the voltmeter displays the temperature difference directly, one can calculate, if desired, the temperature difference corresponding to the display when any other amplification is used.
Remarks Regarding Balance:— The amplifier must always be balanced for the readings of the voltmeter to have significance. Unfortunately, the digital voltmeter will read only when the applied potential is of the proper polarity. This fact makes balancing the amplifier somewhat more awkward than it would otherwise be. To balance, proceed as follows:— With the input shorted, or connected to a thermocouple the junctions of which are definitely at the same temperature, turn the balance control clockwise until the digital voltmeter reads an unbalanced potential. Then gradually rotate the control counterclockwise until the reading is reduced to zero, care being taken not to go beyond this point. The balance should be checked occasionally if accuracy is required.

Occasionally it is suggested that, for a particular demonstration, the amplifier is to be balanced with a thermocouple or thermopile connected to the input, rather than with the input shorted. This is done when it seems wise to compensate for any temperature difference that might exist between the two junctions of a thermocouple, or between the two groups of junctions in a thermopile. When balanced in this manner, the balance can of course not be checked during a demonstration.

Accuracy:— Response of the amplifier is essentially linear. The accuracy of temperature readings therefore depends largely upon the linearity of response of the thermocouple and the accuracy of the digital voltmeter. The response of the thermocouple is very close to linear between 0° C and 100° C, as shown by the chart on the amplifier, and reasonably close to linear up to 200° C. Below 0° C, however, the response quickly deviates from linearity, becoming far from linear at low temperatures. At low temperatures the actual temperature represented by a given display must be evaluated from the chart.

Note Regarding Service:— There is little chance that the amplification factor will ever change unless some critical part of the amplifier is replaced. However, there is an internal, continuous adjustment for the amplification factor of 19. If adjustment is ever necessary, place the reference junction of the thermocouple in a cracked-ice-water mixture, place the test junction in boiling water, and adjust the control until the display indicates the boiling point of water. (A display of 99.5 to 100° is sufficiently accurate.)

Note Regarding Storing Thermocouple A:— Thermocouple A is to be stored with the lead wires doubled loosely in about 8-inch lengths, and held against the two prods with a rubber band.