Series and Parallel Thermocouple Measurements

Questions as to the definition and use of thermocouples in series or parallel come up on occasion. In an attempt to generally clarify most of these questions, the following information is offered.

SERIES - Frequently referred to as a Thermopile (see Sketch No. 1).

Thermocouples connected in series produce an emf signal that is additive. That is, the output from a number of thermocouples are added together to produce a total output of all the thermocouples.

With reference to Sketch No. 1, we will assume that A is iron and B is constantan. We will further assume the reference junctions are at 32°F and the measuring junctions are at 200°F. From our catalog thermocouple temperature millivolt tables, we see that the output of a single thermocouple at 200°F is 4.906 millivolts. With four couples in a series, as in Sketch No. 1, we add 4.906 millivolts four times to get a final millivolt output of 19.624 millivolts. The formula for working this out is:

$$E = ET_1 + ET_2 + ET_3 + ET_4$$

Two common applications are:

1. Measuring temperature where a very minute change is critical to the application. By blowing up the signal, these small changes can be detected more easily on simple instruments.

2. Working a voltage sensitive relay where a small change is not sufficient to trip the contact. Care must be taken in this case so that you do not exceed a workable external resistance factor.

PARALLEL - Frequently referred to as averaging thermocouples (see Sketch No. 2).

Thermocouples connected in parallel produce an emf the same as for a single thermocouple. If all the thermocouples are of **equal resistance** and their measuring junctions are at various temperatures, then the emf generated will correspond to the average of the temperatures of the individual junctions.

Looking at Sketch No. 2, let us again assume that A is iron and B is constantan. Let us also assume the reference temperature T_1 is at 32°F. If T_2 is 200°F, T_3 is at 205°F, T_4 is 210°F, and T_5 is 215°F, and all couples are of equal resistance, we will get an output of 207-1/2°F which is the average temperature. The formula which applies is:

$$EMF = \frac{T_2 + T_3 + T_4 + T_5}{4}$$

It is not always posible to make all parallel couples of equal resistance. When this presents a problem we can add swamping resistors in series with each couple. If we have four couples varying between 8 and 12 ohms and add a 200 ohm swamping resistor in series with each, we reduce the differences to insignificant fractions of the total resistance.

Two common applications are:

1. Aircraft harness assemblies where a group of couples are placed in a ring around the exhaust system and lead back to a single cockpit indicator.

2. An inexpensive method of high temperature alarm using a single instrument for alarm indication. This would be a good application for our "900" Series Monitor which is sensitive enough to sense small changes in emf signals.

Grounds which introduce cross connections between either the series or parallel combination of thermocouples are not permissible.

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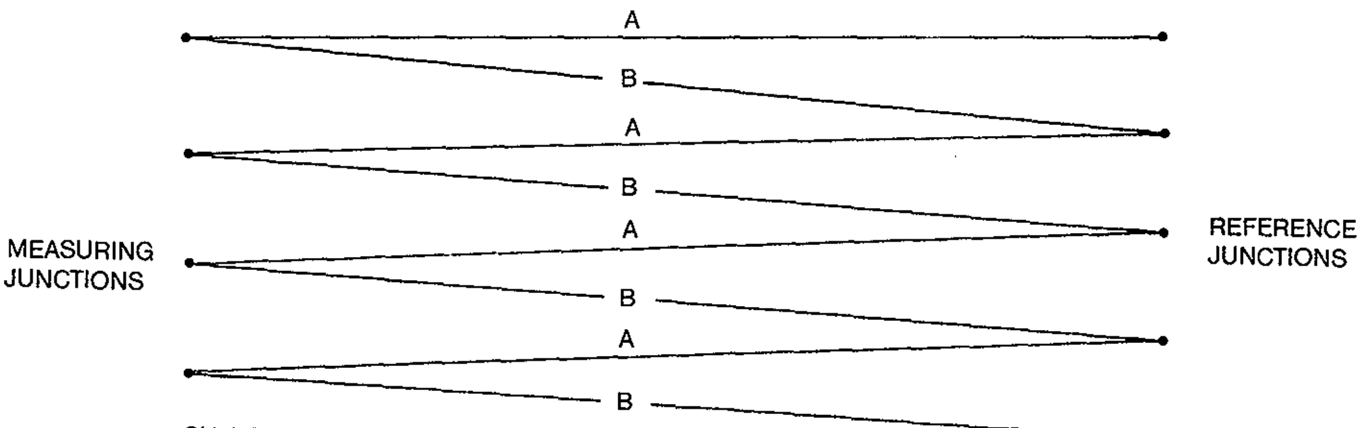
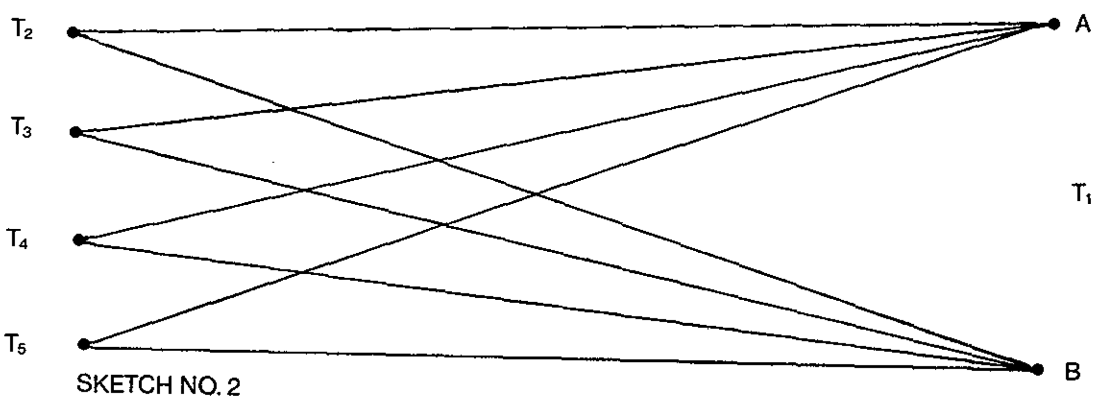
SERIES WIRING



SKETCH NO. 1

PARALLEL WIRING



SKETCH NO. 2