

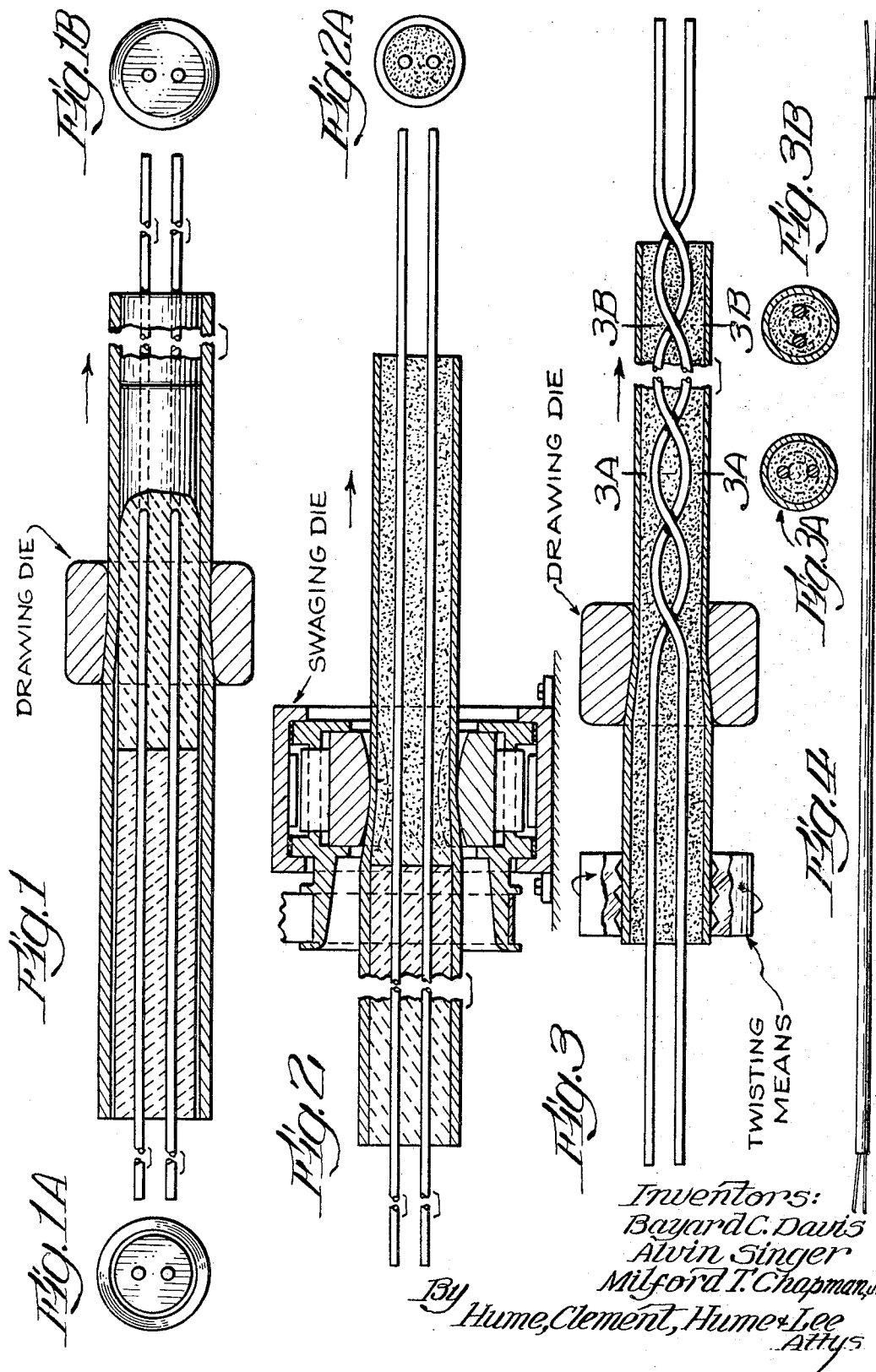
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METHOD OF MAKING SHIELDED CONDUCTORS

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METHOD OF MAKING SHIELDED CONDUCTORS
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This invention relates to a method of making shielded conductors and more particularly to an improved process for making metal sheathed thermocouples.

As is well known, metal sheathed thermocouples are generally comprised of three basic components, namely an outer metallic sheath, suitable insulating material, and one or more sensing wires that are surrounded and suitably maintained in spaced relation by the insulating material and confined within the sheath. For some time a conflict has existed between those skilled in the art as to which of several techniques provides the best answer to the manufacture of such thermocouples in any desired length. The basic problem to be faced in connection with the production of metal sheathed thermocouples is the provision of a thermocouple structure which is characterized by good thermal and electrical characteristics, relatively unaffected by moisture penetration, free from gas residue and possessing a metallic sheath which is structurally strong and not prone to rupture.

It is a prime object of the present invention to provide an improved method of making shielded conductors.

It is a further object of the present invention to provide an improved process for manufacturing metal sheathed thermocouples in any desirable length, which thermocouples possess excellent thermal and electrical properties.

An additional object of the present invention is to provide a process for manufacturing metal sheathed thermocouples whereby the resulting product is substantially unaffected by adverse environmental conditions, is characterized by substantially uniform insulation density throughout the length of the thermocouple, and possesses a metallic sheath which is neither rendered susceptible to rupture nor otherwise structurally weakened as a result of the manufacturing process.

Still another object of the present invention is to provide an improved method of making metal sheathed thermocouples whereby and as an additional step of the basic process the sensing wires surrounded by the densely compacted insulating material and confined within the structurally stable sheath are selectively twisted to provide a thermocouple that effectively eliminates the problem of extraneous signal pickup which has heretofore severely limited the utility of thermocouples under various operating conditions.

Other objects and advantages of the present invention will become apparent from the following description wherein a general presentation of the overall process is followed by a detailed description of the preferred steps and a preferred sequence of performing the steps of the process as reflected in the accompanying drawing wherein:

FIGURE 1 depicts the first drawing step involved in the process of the present invention;

FIGURE 1A is a left end view of the assembly being processed as shown in FIGURE 1;

FIGURE 1B is a right end view of the assembly being processed as shown in FIGURE 1;

FIGURE 2 illustrates the swaging step involved in the process of the present invention which follows the drawing step depicted in FIGURE 1;

FIGURE 2A is a right end view of the assembly being processed as shown in FIGURE 2;

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FIGURE 3 illustrates the second drawing step involved in the process of the present invention and further illustrates means for effecting a twisting operation in accordance with one preferred embodiment of the invention;

FIGURE 3A is a cross-sectional view taken along the line 3A—3A in FIGURE 3;

FIGURE 3B is a cross-sectional view taken along the line 3B—3B in FIGURE 3; and

FIGURE 4 depicts a metal sheathed thermocouple structure processed in accordance with the present invention.

In general, the improved process of the present invention is initiated by operations which yield a thermocouple assembly of the desired length. In this assembly, the sensing wires as surrounded and held in place by the insulating material, and this subassembly is in turn relatively loosely fitted within a tubular metallic element that serves as the sheath for the completed thermocouple. This thermocouple assembly is then subjected to a suitable number of drawing and swaging operations until the thermocouple has been formed.

As a result of these sequentially performed operations, the insulating material is densely and uniformly compacted about the sensing wires, but not so as to damage or otherwise harm the wires. The metallic sheath is worked so that it intimately engages and confines the insulating material wherein the sensing wires are maintained in uniform spaced relation. As a result, a substantially uniform insulation pack density is realized within the thermocouple, and the exterior sheath has a substantially uniform cross section and is not susceptible to structural failure such as rupturing.

It is often desired to produce a metal sheathed thermocouple wherein the sensing wires are suitably twisted so as to effectively eliminate the pickup of extraneous signals which are encountered under certain operating conditions. To this end and in accordance with the present invention, the thermocouple can, if desired, be further worked during at least one of the drawing operations to uniformly twist the sensing wires about each other and in spaced apart relation along the entire length of the thermocouple.

More specifically, the process for making metallic sheathed thermocouples in accordance with the present invention is initiated by selectively feeding, for example, two or more sensing wires through suitable apertures in structurally stable ceramic insulator strips. In effect, the insulator strips, which may be of variable length and formed of substantially pure ceramic materials such as alumina and magnesia held together by a suitable bonding agent, are strung onto the sensing wires so that the entire lengths of the wires are substantially encompassed by the strips. Inasmuch as the sensing wires, which may be formed of Alumel and Chromel, are confined within apertures provided in the insulator strips, these wires are maintained in substantially uniform spaced apart parallel relationship.

This "stringing" of the insulator strips onto the sensing wires yields a subassembly which is then ready for insertion into a metallic tube (e.g. surgically clean stainless steel) that will serve as the sheath for the completed thermocouple. In this connection, the insulator strips, which are susceptible to handling without breaking and further susceptible to being returned to a powdered condition upon the application of force thereto, have an outside diameter which is somewhat less than the inside diameter of the tubular element that is formed into the metallic sheath (FIG. 1A). Accordingly, the strung strips and sensing wires are readily insertable within the metallic tube. When the assembly has been inserted, a first of the actual thermocouple working operations is commenced.

The initial working operation performed on the subassembly is the drawing of the subassembly through a suitable die arrangement (FIG. 1). This step of the process is effected by engaging one end of the assembly after it has been initially inserted in a stationary die structure and thereafter advancing the remaining portion of the assembly through the die at a preselected rate.

As a result of this operation, the sheath is drawn into contact with the strung insulator strips so that the strips are confined in generally fixed relation within the sheath (FIG. 1B), although the forces imparted to the sensing wires confined within the insulator strips are minimal and although the cross section of the sheath is only slightly reduced. Moreover, this initial drawing operation insures that all of the strips are brought into mating contact with those adjacent thereto so that a continuous covering of insulation is provided for the sensing wires. As hereinafter described in detail, this leads to substantially uniform pack density in the resultant thermocouple subsequent to the other forming operations.

After this initial drawing operation is completed, the partially worked assembly is advanced through a second, swaging die structure in a manner similar to that described above (FIG. 2). This second die structure effects a swaging operation to within approximately .001 inch of the desired size of the finished thermocouple. As a result of the swaging operation, the cross section of the assembly is reduced although little axial elongation is experienced.

Since the initial drawing operation caused the adjacent insulator strips to be drawn into a continuous fixed array, the compacting of the insulator strips caused by the swaging yields a powdered insulating material having a substantially uniform pack density throughout the length of the thermocouple (FIG. 2A). The compacting of the insulator strips and the reduction of the cross section of the sheath does not disturb the substantially uniform spaced apart relation of the sensing wires that are, as a result of this operation, surrounded by the powdered insulation.

Any discontinuities, indentations and the like left in the exterior sheath of the thermocouple as a result of the swaging operation are eliminated as a result of the next step of the process of the present invention. That is, the once-drawn and once-swaged thermocouple is similarly advanced through still another die structure, and the entire thermocouple is drawn so that the outside diameter is reduced to the desired finished size (FIG. 3). This finishing operation eliminates any indentations and/or bulges present in the assemblies and the resulting thermocouple has a diameter which is substantially free of variance from end to end, notwithstanding length.

In a copending application of Messrs. Davis, Singer, and Chapman, Ser. No. 282,406, which was filed on May 22, 1963 (now United States Letters Patent No. 3,205,296), a metallic sheathed thermocouple is disclosed and claimed wherein the sensing wires are suitably twisted so that the pickup of extraneous signals thereby is substantially eliminated. A thermocouple structure as contemplated by this copending application can be readily fabricated pursuant to the process described above. However, incident to the final drawing operation, the entire assembly is further worked to yield the desired twisted and spaced apart sensing wires.

In this connection, as the once-drawn and once-swaged thermocouple assembly is advanced through the final die structure (FIG. 3), a suitable rotary means is brought into engagement with a trailing end portion of the assembly (i.e., a portion of the assembly on the side of the die structure away from the path of advancing travel). This suitable rotary means travels with the advancing thermocouple and imparts rotary or twisting motion thereto. The rotary or twisting rate is dictated in part by the speed at which the assembly is passed through the final die structure and by the number of twists per inch required in the completed thermocouple to achieve the elimination of extraneous signals.

The rotary or twisting motion imparted to the thermocouple produces a coaction of forces at the die structure which results in the sensing wires being uniformly twisted and yet maintained in suitable spaced apart relation within the surrounding compacted insulating material (FIGS. 3A and 3B). However, the coaction of forces produced at the die structure and the sheath working operation carried out by the die structure are such that the sheathed thermocouple emanating from the die does not possess any unusual surface abnormalities, notwithstanding the twisting of the sensing wires which is concomitantly effected.

It should be understood that the foregoing steps of the process can be effected by employing any number of suitable cooperating die and assembly advancing instrumentalities. However, the details of such structures do not form a part of the invention and will not be dealt with. Suffice it to say that one skilled in the art can conceive of any number of suitable arrangements for effecting the operations to achieve the production of a metal sheathed thermocouple which is relatively free from any undesirable structural, thermal, or electrical defects and which may or may not include one or more pairs of twisted sensing wires.

It should be further understood that the foregoing is merely illustrative of one preferred embodiment of the process of the present invention. Various modifications of the preferred steps described above can be effected without deviating from the invention, various features of which are set forth in the accompanying claims.

What is claimed is:

1. A process for producing metal sheathed thermocouple conductors in any desired length; which process comprises the sequential steps of

preparing an assembly of sensing wires, insulation material, and metallic sheathing whereby said sensing wires are supported within discrete strips of said insulation material and are arranged in substantially uniform spaced relation along the entire length of the assembly and whereby said wires and surrounding insulation material are loosely supported within said sheath;

urging said strips into contacting relation with each other and said sheath by subjecting said assembly to an initial drawing operation through a stationary reducing die means;

reducing the cross section of the drawn assembly to approximately the desired cross section of the completed thermocouple conductor but substantially without elongation of said assembly, and at the same time crushing the insulator strips and loosely compacting the insulation material about said spaced apart sensing wires supported therein by passing the assembly through a swaging die means;

and finally drawing said drawn and swaged assembly through a second stationary die means to uniformly reduce the cross section of the assembly to the desired final cross section and further compact said insulation material about said wires so that said wires are fixedly maintained in suitably spaced relation throughout the entire length of the completed thermocouple conductor.

2. The process defined in claim 1 wherein rotary motion is imparted to said assembly concomitantly with said final drawing operation so that said sensing wires are twisted about each other in uniform spaced-apart relation throughout the entire length of the completed thermocouple conductor.

3. A process for producing metal sheathed thermocouple conductors in any desired length by working an assembly of sensing wires, strips of insulation material, and metallic sheathing wherein said sensing wires are supported within the discrete strips of insulation material in substantially uniform spaced-apart relation and said wires and strips of insulation material are loosely supported within said sheath;

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which process comprises urging said strips into contacting relation with each other and said sheath by subjecting said assembly to an initial drawing operation through a stationary reducing die means;

reducing the cross section of the drawn assembly to approximately the desired cross section of the completed thermocouple conductor but substantially without elongation of said assembly, and at the same time crushing the insulator strips and loosely compacting the insulating material about said spaced apart sensing wires supported therein by passing the assembly through a swaging die means;

and finally drawing said drawn and swaged assembly through a second stationary die means to uniformly reduce the cross section of the assembly to the desired final cross section and further compact said insulation material about said wires so that said wires are fixedly maintained in suitably spaced relation throughout the entire length of the completed thermocouple conductor.

4. The process defined in claim 3 wherein rotary motion is imparted to said assembly concomitantly with said final drawing operation so that said sensing wires

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are twisted about each other in uniform spaced-apart relation throughout the entire length of the completed thermocouple conductor.

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