No. 779,090. PATENTED JAN. 3, 1905.

A. L. MARSH.

THERMO ELECTRIC ELEMENT.

APPLICATION FILED JUNE 4, 1904.

2 SHEETS—SHEET 1.

Fig. 1.

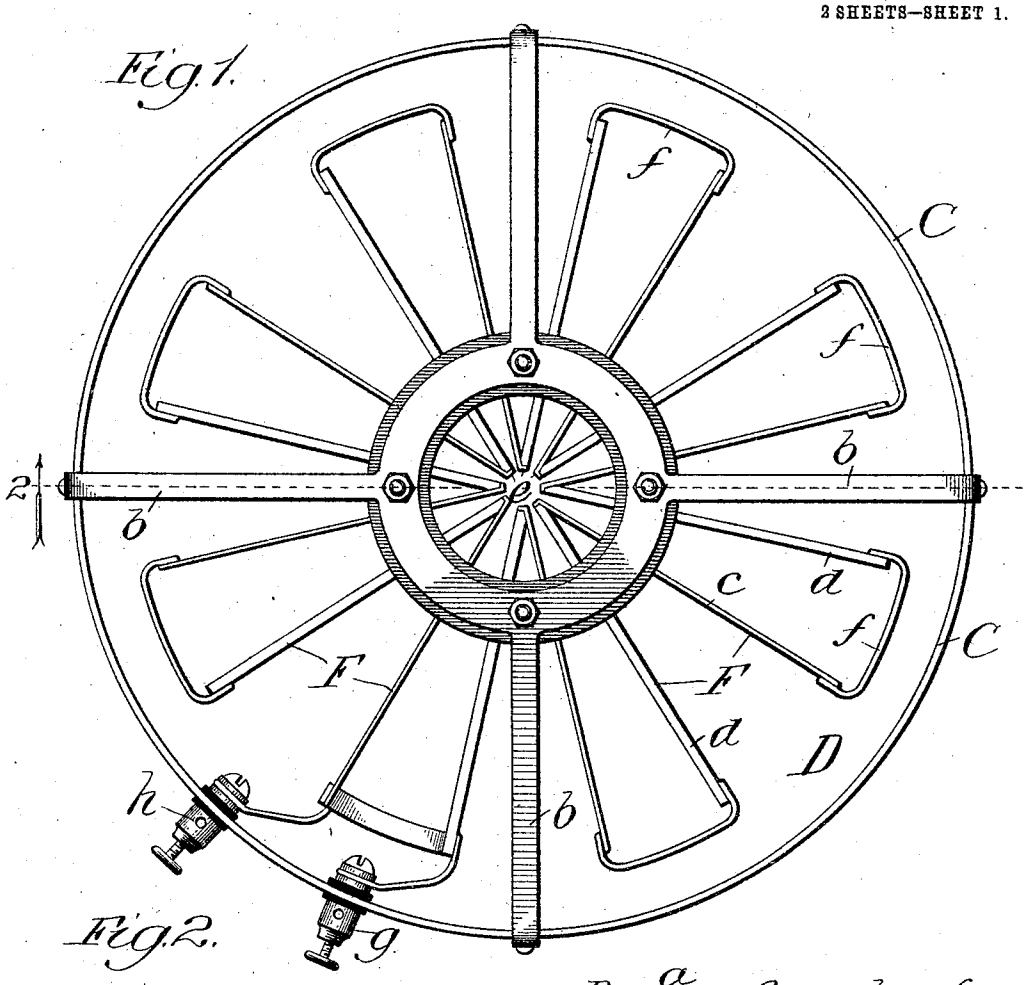
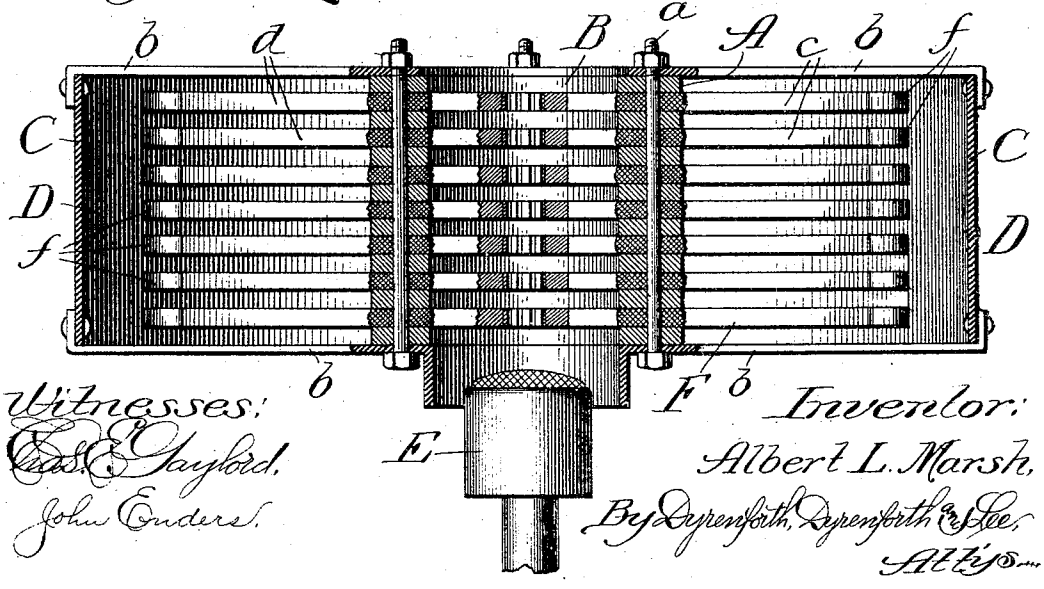


Fig. 2.



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2 SHEETS—SHEET 2

Fig. 3.

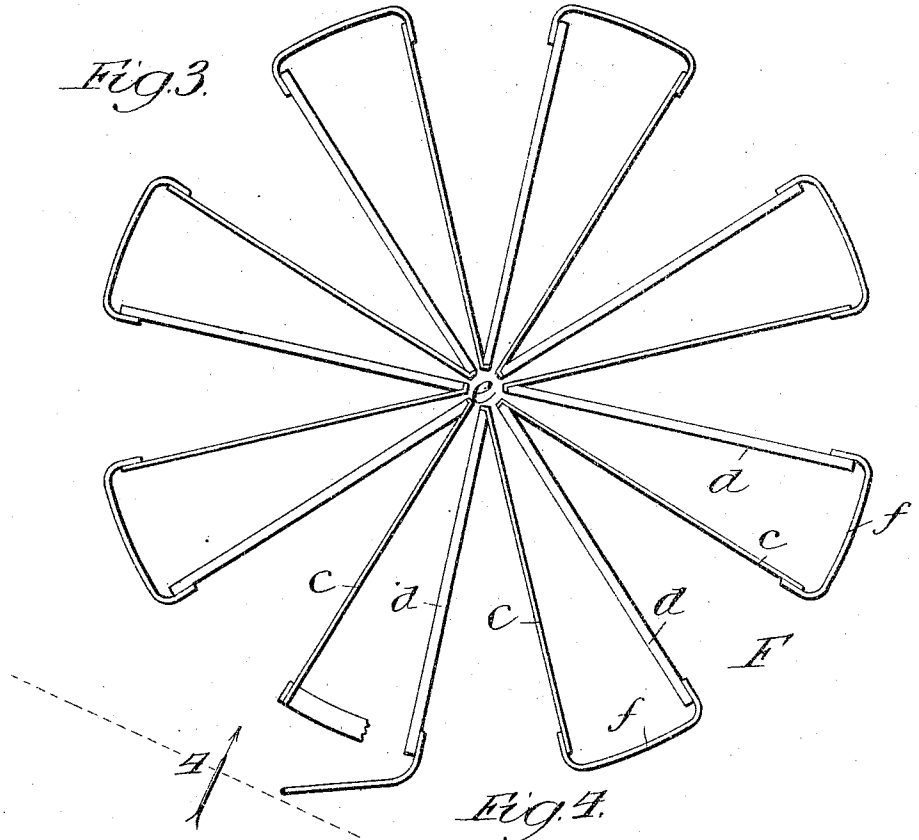
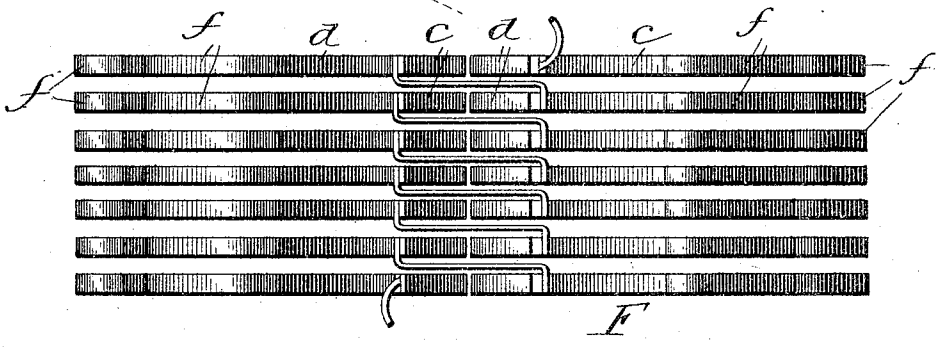


Fig. 4.



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PHOTO-LITHOGRAPHED BY SACKETT & WILHELMS LITHO. & PTG. CO. NEW YORK.

No. 779,090. Patented January 3, 1905.

UNITED STATES PATENT OFFICE.

ALBERT L. MARSH, OF LAKE BLUFF, ILLINOIS, ASSIGNOR TO WILLIAM A. SPINKS AND CO., OF CHICAGO, ILLINOIS, A COPARTNERSHIP.

THERMO-ELECTRIC ELEMENT.

SPECIFICATION forming part of Letters Patent No. 779,090, dated January 3, 1905.

Application filed June 4, 1904. Serial No. 211,125.

To all whom it may concern:

Be it known that I, ALBERT L. MARSH, a citizen of the United States, residing at Lake Bluff, in the county of Lake and State of Illinois, have invented a new and useful Thermo-Electric Element, of which the following is a specification.

My object is to provide a thermo-electric couple of an improved construction rendering it particularly strong, durable, non-oxidizable, efficient, and capable of use in connections where as heretofore provided thermo-electric couples have been considered impracticable.

My invention consists, broadly stated, in the discovery that certain metals possessing very high melting-points and metallurgical characteristics in common may, particularly when alloyed with nickel, be employed as thermo-electric elements electronegative to nickel-copper elements. Such negative alloys render it possible to construct thermo-electric couples of comparatively great efficiency, which may be subjected at their junctions to very intense heat without danger of injury. They are inherently tough, will not fracture under changes in temperature or severe jarring, and will endure indefinitely. Furthermore, they may be readily formed into strips of a thinness which insures sufficiently rapid heat radiation by air-cooling and dispense with any necessity of water-cooling or artificial refrigeration.

By the term "negative element" in the present connection is meant, as usually defined in this country, the element of a pair to which the electric current flows from the other, or positive, element, through the junction of the pair which is subjected to heat.

This invention is the result of experiments carried on with a view to discovering a readily-available metal having a melting-point exceeding that of pure copper and which, either alone or when alloyed with other metal or metals, would be either electropositive or electronegative to another highly-refractory metal or alloy with which it could be joined in a thermo-electric couple and possess the characteristics above set forth as my object. I have found that what is termed the "chromium group" of metals may when alloyed with nickel be formed into thermo-electric elements strongly electronegative to elements formed of an alloy of nickel and copper. Both the said negative and positive elements have melting-points much higher than that of pure copper and may be subjected without danger to intense heat, and thereby establish a difference of electric potential at least equal to any other practical couple of which I am aware without the drawbacks incident to such other couples. The chromium group referred to is defined in *Watt's Dictionary of Chemistry* and consists of the metallic elements of group No. VI (indicated by the even-numbered series) according to what is generally known as "Mendeléeff's table." (See page 212, *Remsen's Chemistry*, fifth edition, Henry Holt & Co., New York, 1898.) The metals of this group are chromium, molybdenum, tungsten, and uranium, and when suitably alloyed with nickel they effect results which in many respects are equally desirable in this connection. In constructing my improved thermo-electric battery I prefer to provide the positive element of an alloy of nickel (about thirty-five per cent.) and copper, (about sixty-five per cent.) This element has a fusing-point much above 1,050° centigrade, the approximate fusing-point of pure copper. I form the negative element of one or another of the following alloys: first, chromium and nickel; second, molybdenum and nickel; third, tungsten and nickel; fourth, uranium and nickel. For various reasons I prefer to employ for the negative element an alloy of chromium and nickel or molybdenum and nickel, the nickel predominating in each case. Two or more metals of the said chromium group may be alloyed together with nickel and produce desirable results. Any of the said alloys of nickel and a metal of the said chromium group is electronegative to the alloy of nickel and copper mentioned, and a bar of either may be readily welded to a bar of the other to form a highly-

refractory, non-oxidizable, tough, durable, and efficient couple which may be subjected without danger of injury to a concentrated flame of great intensity.

An alloy of nickel and copper in substantially the proportions mentioned above has been employed as one of the elements of a thermo-electric couple; but the other element has hitherto consisted of a much more readily fusible metal or alloy. The best results, so far as I am aware, so far as current-producing efficiency is concerned, have been obtained by employing with the copper-nickel electrode an electrode consisting of an alloy of zinc and antimony, which fuses at a comparatively low temperature. This last-named alloy is inherently brittle, fractures readily under changes of temperature, and great care is necessary in its use to prevent the temperature from becoming excessive. For use in many connections it is impracticable, first, because great care must be employed to keep down the temperature of the heating medium; second, because it cannot be subjected to jarring or the like rough usage without danger of fracture, and, third, because to give it the strength and conductivity necessary for practical use it must be formed in a bar comparatively large in cross-section, which cannot be air-cooled, but must be subjected along the outer end to water-cooling or equivalent artificial refrigeration.

The main advantages of the thermo-electric couple constructed in accordance with my invention lie, first, in the increased strength and durability; second, in the fact that as it may be subjected to heat of great intensity care in heat regulation is unnecessary; third, in the fact that the elements may be as thin as desired for rapid heat radiation under the influence of cool air alone, and, fourth, in the fact that the elements may be welded together to produce a joint equally heat-resistant with the body portions of the elements.

In the accompanying drawings I show a thermopile of one desirable and convenient form constructed with thermo-electric couples in accordance with my present invention.

Referring to the drawings, Figure 1 is a plan view of the thermopile; Fig. 2, a section on line 2 in Fig. 1; Fig. 3, a plan view of a set of thermo-electric couples connected together in series; and Fig. 4, a broken side view showing a nest of the couples, the view being taken from line 4 in Fig. 3.

A tube or cylinder A is constructed of asbestos rings fastened together by bolts *a*, surrounding a central chamber or passage B. An outer cylindrical wall C is held to the tube A by radial arms *b* in the manner shown to form an open annular chamber D about the tube.

E is a Bunsen burner capable of discharging a flame of great intensity through the tube A.

F F indicate thermo-electric couples, each comprising a positive element in the form of a strip *c* of the nickel-copper alloy mentioned and a negative element in the form of a strip *d* of the alloy of nickel and a metal of the said chromium group, as described. The elements of each couple are preferably electrically welded together to form a joint *e*, and they pass through the material of the tube A to extend at their joints near the center of the tube and at their opposite ends near the wall C. The thermo-electric couples are connected in a common manner by means of strips *f*, which may be of copper, in series, and the thermopile is provided with the usual terminals *g* and *h*, one of which would be positive and the other negative.

I have found in practice that while a thermo-electric couple of my improved construction when subjected to a direct blast of the greatest possible heat intensity from a Bunsen burner in the manner indicated generates an electric current of a voltage comparatively little in excess of that which may be generated by the most efficient couples hitherto constructed and of which I am aware, my improved couples may be subjected to a heat at one end and a cooling action at the other, which maintains them at approximately their greatest efficiency for an indefinite time without affecting their durability to any appreciable extent. This cannot be done with any degree of safety with the said couples heretofore devised, because if subjected to a temperature at their joints just below the melting-point to give the greatest efficiency they are soon destroyed. This makes it necessary in the case of the last-named couples to maintain the temperature materially below that which would produce the maximum voltage. For the reasons just stated my improved couples may in practice generate a current of materially greater efficiency while operating in a practical way than any previously-constructed thermo-electric couples of which I am aware.

While I have described my invention as a thermo-electric element electrically negative to an alloy of copper and nickel, I do not thereby wish to limit the invention to the use of the latter alloy as the positive element. Any other suitable element electropositive to the first said element may be employed therewith without departing from the spirit of my invention as defined by the claims.

What I claim as new, and desire to secure by Letters Patent, is—

1. In a thermo-electric couple, a metallic element formed of an alloy electronegative to an alloy of copper and nickel and having a melting-point in excess of the melting-point of pure copper.

2. In a thermo-electric couple, an element

electronegative to an alloy of copper and nickel and formed with a metal of the chromium group to have a melting-point exceeding that of pure copper.

3. In a thermo-electric couple, an element electronegative to an alloy of copper and nickel formed of an alloy of nickel and one or more metals of the chromium group, and having a melting-point exceeding that of pure copper.

ALBERT L. MARSH.

In presence of—
WALTER N. WINBERG,
ALMA N. THORIEN.