Aug. 29, 1933. W. ESMARCH 1,924,680

COIL FOR INDUCTION FURNACES

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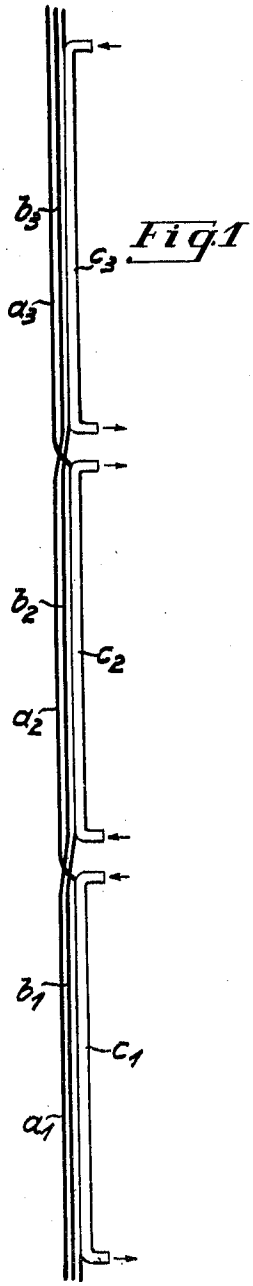


Fig. 1

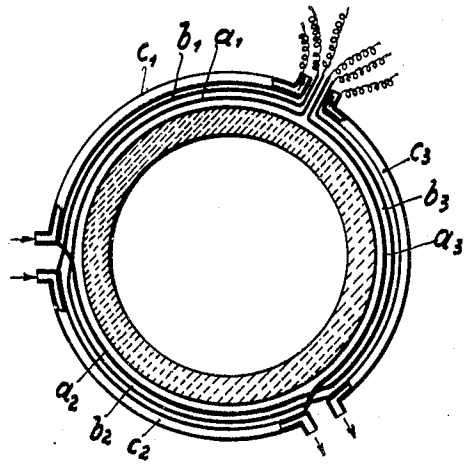


Fig. 2

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COIL FOR INDUCTION FURNACES

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2 Claims. (Cl. 219—47)

The invention relates to a novel construction of coil for induction furnaces, designed for high efficiency and low operating cost by combining in said coil the advantages of the water cooled tubular conductor and of the thin metal band conductor, the latter serving to substantially eliminate the skin effect and the former serving as the means for cooling.

The invention is illustrated in the accompanying drawing, in which:—

Fig. 1 is a developed view illustrating the elements of a coil in accordance with the invention.

Fig. 2 is a sectional plan view of a typical furnace with a coil constructed in accordance with the invention, associated therewith.

It has been customary to construct the coils of high frequency induction furnaces of a series of convolutions of water cooled copper tubing. Such construction possesses the advantage of effecting the intensive cooling of the coil and the consequent employment of a heavy current. On the other hand, in windings of this kind, the influence of the skin effect is highly detrimental, in that the current distribution throughout the cross section of the conductor is unequal and most of the current is crowded to the inside of the coil of the conductor and the major part of the conductor is practically free from current. Because of these conditions, the losses in furnaces of this character are high and the efficiency of the furnace is greatly impaired. In order to avoid the objections inherent in the water cooled coils, in furnaces of this type, and to insure a more efficient distribution of the current throughout the cross section of the conductors of which the coil is composed, it has been proposed to subdivide the conductor forming the coil into a series of relatively thin bands of metal, preferably copper, insulated from each other, the thickness of which bands is so regulated that the so-called skin effect is substantially eliminated. The individual copper bands are so disposed and interlaced that they are equivalent or alike in respect of the resistance, impedance and inductive action, so that all of them are traversed by equal currents. It has been found that furnaces equipped with coils so constructed and arranged have, in fact, attained a very high efficiency. However, coils constructed and arranged in this manner necessitate the application of air cooling, usually by subjecting the coils to the action of air currents. This type of cooling is cumbersome in arrangement, expensive in operation and, as a general rule, is not as effective as the water cooled tubular coils hereinbefore referred to.

According to the present invention, the advantages of water cooling the coils or the individual convolutions thereof may be effected by making the conductors of the coil in part of water cooled tubing and in part of the relatively thin bands of copper or the like, the tubular conductors with the circulating cooling water being disposed to the outside of the coil, so that the heat developed in the bands will be transferred to the water in the tubular sections. All of the conducting elements, including the bands and the tubular sections, are electrically insulated from each other either by suitable lacquer coatings, or, if necessary, by means of interposed strips or bands of insulation. The tests have shown that thin layers of insulation are no obstacle to an efficient exchange of heat between the bands and the water cooled tubing and that this cooling action may be effected with as great a degree of intensiveness and efficiency as in the case of the coils formed entirely of the water cooled copper tubing. On the other hand, the coil constructed in accordance with the invention has the additional advantage of involving a minimum loss of current. Further, the manufacture of such a coil is considerably cheaper than that of the subdivided coils made of thin conductor strips, as heretofore proposed, because the coil of the present invention avoids the expense of the air cooling system associated with the strip coils and because, in most instances, a smaller number of conductors are required in the new form of coil to produce the same effect.

The drawing illustrates an exemplary arrangement of furnace and coil generally similar to that shown in United States Patent No. 1,721,073, dated July 16, 1929, except that each convolution of the coil includes a tubular water cooled section and two strip sections. According to the patent, the high frequency induction furnaces employ for the primary winding flat wound bands of conducting material insulated from each other, the bands being relatively so thin that the skin effect is substantially eliminated and the individual convolutions of the coil being so disposed as to be identical in respect of resistance, impedance and inductive effect on the furnace charge. As stated, the present invention involves the application of the water cooling effect by tubular conductors and the elimination of the losses due to skin effect, by employing the thin band-like conductors.

As shown in the figures of the drawing, three separate convolutions of the coil are connected in parallel with the supply mains, each convolu-

tion consisting of a tubular conductor having connections at each end for circulating water therethrough and two sections or lengths of the thin strip conductor. The relation of the conductors is indicated in the development in Fig. 1 and also in the plan view of the coil as applied to the furnace in Fig. 2. Each section of the coil constitutes a complete convolution, the portions a_1, a_2 and a_3 of the respective coils being located adjacent the outer wall of the furnace and next thereto on the outside are the respective coil sections b_1, b_2 and b_3 and outside these are the tubular conductors c_1, c_2 and c_3, which are water cooled by suitable connections with a water supply and exhaust system, whereby the water is supplied. The individual tubular conductors c_1, c_2 and c_3 are insulated from each other and are substantially equal in respect of resistance, impedance and inductive action with the individual coil parts a_1, a_3 and b_1, b_3. The elements of each convolution are connected up in the following order: Strip conductor sections a_1 and b_2 and tubular conductor c_3; strip conductor b_1, tubular conductor c_2 and strip conductor a_3; and tubular conductor c_1, strip conductors a_2 and b_3. By this arrangement, the three convolutions, constituting the separate coils, are superposed one on the other, the parts being in the relation hereinbefore described. It will be understood, of course, that, while three separate convolutions, connected in parallel, are shown and described, any desired number of convolutions may be employed, depending upon the conditions of operation.

Experience has demonstrated that the cooling of the outside of the coils by means of the tubular water cooled sections is of particular importance in the operation of high frequency induction furnaces. Furnaces which are fed with low frequency current may, if desired, be arranged in such a manner that the cooling tube or tubes, constituting elements of the coil, may be disposed between the individual strip conductors forming the coil or the convolutions of the latter, but it has been found, as a general proposition, that better results were obtained by locating the tubular conductor members with the water circulation on the outside of the coils, as far as possible, so that the heat generated by the other coil elements will be rapidly transmitted to the circulating water and thus dissipated.

What I claim is:

1. An induction furnace coil having multiple convolutions, each including a tubular water cooled section and a metallic band in series, the tubular sections being disposed on the outside of the coil and arranged to substantially surround the furnace.

2. An induction furnace coil, including metal band conductors and tubular water cooled conductors in series, the latter being disposed on the outside of the coil and overlying the band conductors.

WILHELM ESMARCH.