Sept. 4, 1928.

E. THOMSON

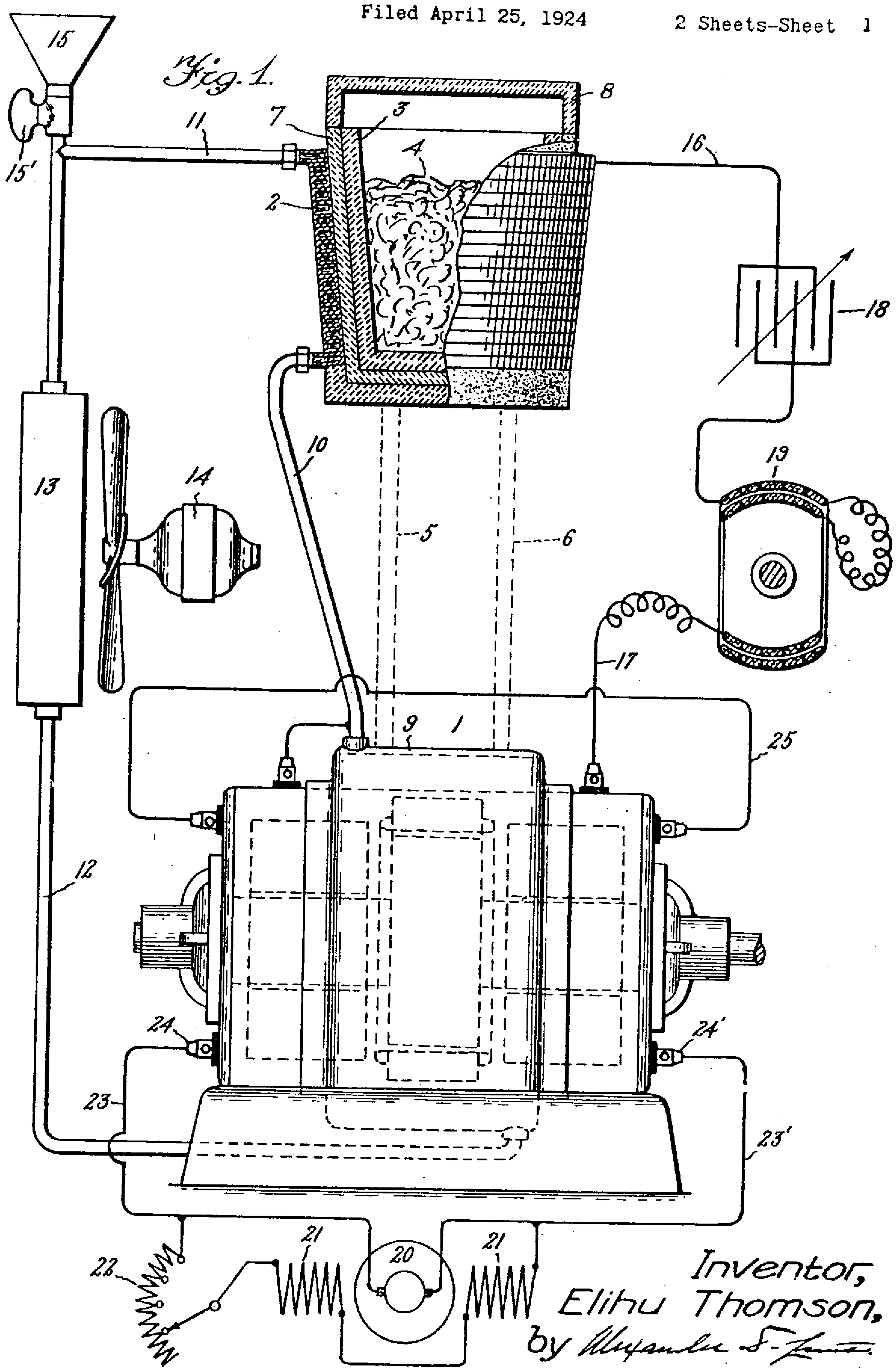
1,683,146

HIGH FREQUENCY INDUCTION APPARATUS

Filed April 25, 1924

2 Sheets-Sheet 1

Fig. 1.



Inventor,
Elihu Thomson,
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His Attorney.

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2 Sheets-Sheet 2

Fig. 2.

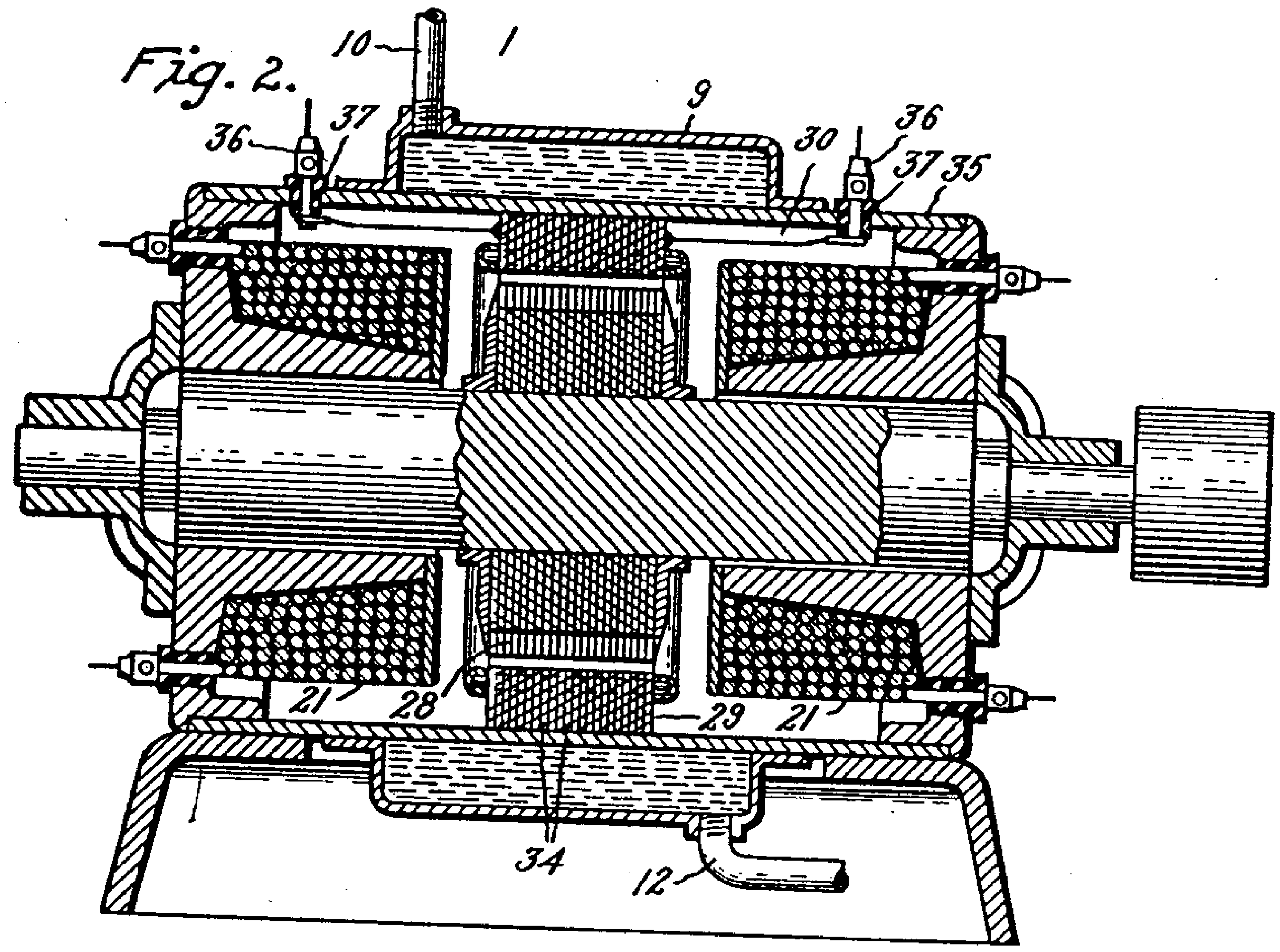


Fig. 3.

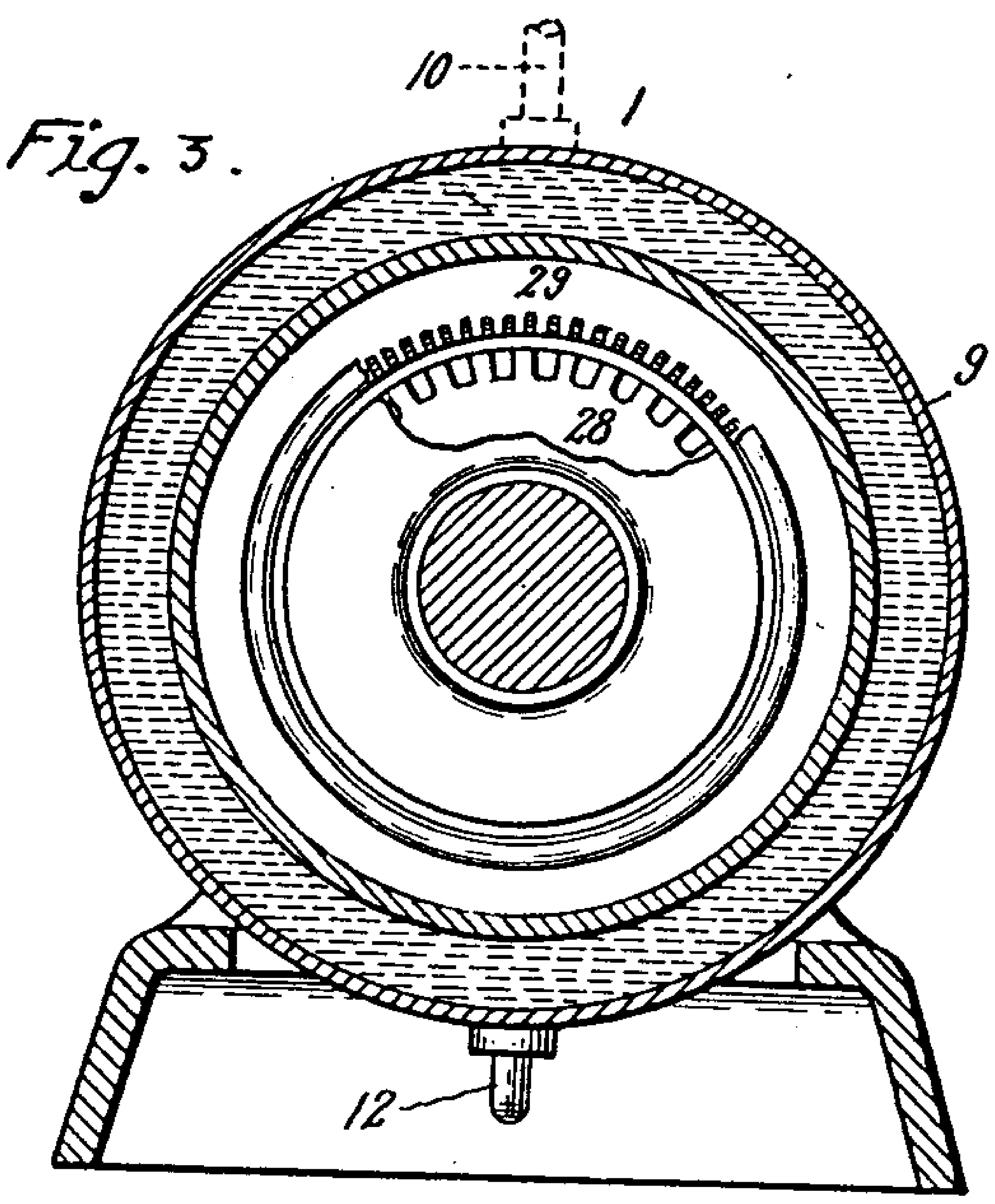
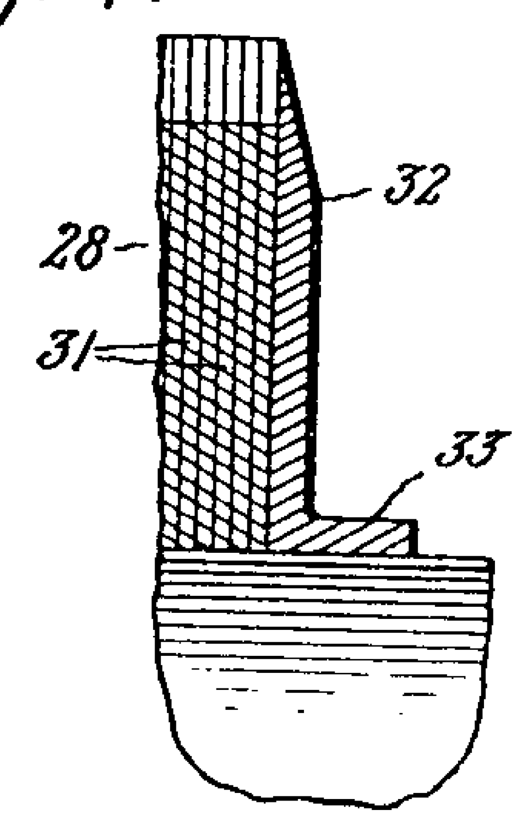


Fig. 4.



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Patented Sept. 4, 1928. 1,683,146

UNITED STATES PATENT OFFICE.

ELIHU THOMSON, OF SWAMPSCOTT, MASSACHUSETTS, ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

HIGH-FREQUENCY INDUCTION APPARATUS.

Application filed April 25, 1924. Serial No. 709,045.

The present invention relates to the utilization of alternating current of relatively high frequency for electric heating. It is the object of my invention to extend the range of usefulness of this form of heating.

Heating by high frequency electric induction is now being used advantageously especially when the inaccessibility or shape of the work to be heated renders impracticable inductive heating which involves interlinkage with a magnetic core of iron, as is the case when currents of commercial frequencies are employed. Heretofore, high frequency currents for heating purposes have been generated by apparatus containing resonant or oscillating circuits and the frequencies employed have been of the order of one hundred kilocycles or higher. The generation of these very high frequencies has involved the use of spark discharge gaps or vacuum tubes.

Vacuum tubes are relatively fragile and subject to deterioration with continued use. Dynamo electric machines on the other hand are rugged and capable of continued use with little depreciation. For relatively large power outputs vacuum tube outfits occupy far more space than dynamo electric machines.

In accordance with my invention the advantages of the ruggedness, dependability and compactness of a mechanically operated source of power are secured for high frequency heating devices.

The accompanying drawings illustrate an embodiment of my invention. Fig. 1 is a somewhat diagrammatic representation of a complete heating outfit; Figs. 2 and 3 respectively are longitudinal and cross sections taken vertically through a dynamo which is suited for the purposes of my invention and Fig. 4 is a view illustrating a detail of the dynamo structure.

Fig. 1 shows a dynamo electrical machine 1 combined in operative relation with a high frequency primary inducing coil 2, within which is arranged a refractory crucible 3 containing a charge 4 of materials to be heated. This crucible may be supported upon the dynamo electric machine by pedestals 5, 6. The crucible 3 may consist of conducting material, as for example carbon or tungsten. Between the crucible 3 and the coil 2 a refractory insulating layer 7 is provided. A refractory, non-conducting cover 8 reduces heat losses. The construction of the dynamo electrical machine 1 will be more fully described in connection with Figs. 2, 3 and 4. In general the dynamo is of the type described in my prior Patent No. 432,655 of July 22, 1890. A dynamo of this construction is shown in Fig. 1 surrounded by a jacket 9, through which water or other cooling fluid may be circulated. Preferably the same cooling fluid is also circulated through the primary winding 2 which consists of convolutions of a hollow conductor such as flattened copper, formed into a helix as shown. This helix is connected by conduit 10, 11 and 12 in series with a radiator 13 to the water jacket 9 of the dynamo. A fan 14 serves to carry heat away from the radiator 13 in the manner well understood in automobile practice. The cooling fluid may be introduced by a funnel 15 provided with a stop cock 15′.

The closed system for circulating the cooling fluid in series around the furnace through a radiator and then through the primary coil is of advantage where a continuous flow of water is not easily available. The closed system of course can be replaced by separate supply pipes for the cooling water and an overflow or discharge pipe for the warmed water.

The conduit 10 also serves as one of the electrical conductors, for sake of convenience, the circuit being completed by the conductors 16 and 17. A variable condenser 18 and a variable inductance 19 preferably is included in the circuit. The variable inductance 19 is composed of two hollow single layer coils, one within the other, so that the position of the coils may be arranged to get a variable self-induction. When the current of both helices is in the same direction the reactance is a maximum and when the inner coil is reversed in position so that its turns have current in the opposite direction to the current in the outer coil, the reactance is of minimum value. The condenser 18 need not be of unusual high capacity, as it is used for regulating purposes.

The dynamo is excited by a shunt wound generator 20, the field coils 21 of which are connected in series with the variable resistance 22. The exciter circuit 23, 23′ is connected to the field terminals 24, 24′. A conductor 25 completes the field circuit. If desired the exciter 20 may be regulated to over excite the generator 1 so as to assist the condenser 18 to secure the desired high power factor. The dynamo 1 may be driven by turbine, motor or any suitable sort of power which will give it a periodicity suitable to the furnace desired which ordinarily will be within the range of 10 to 20 kilocycles, although for some purposes the frequency may be somewhat below or above this range.

The type of dynamo outlined in Fig. 1 shows the greater detail in Figs. 2 and 3 and is particularly adapted to be made the means for generating efficiently high frequency currents, particularly of such frequencies as are suitable for the operation of high frequency induction furnaces. The revolving structure 28 preferably is given many poles, for example about 100 or more. The stationary structure 29 has its conductors 30 placed in slots which are double the number of the poles, that is 200 or more, the clearance being made as small as possible between these two structures. The armature conductors 30 are connected in series, in multiple, in multiple series groups or other desired relation depending on the voltage required in accordance with the well understood practice.

A part of the revolving middle polar portion 28 is represented in cross section in Fig. 3 with the polar notches partly exposed. Fig. 4 shows an element of the laminated polar iron portion 31 and the supporting plate outside thereof indicated at 32. This plate 32 is made of high resistance metal, such as chrome steel, nichrome or the like and forms a flange 33 which extends outward to the edge of the revolving part and is not broken or toothed but complete in outline. This construction prevents extreme air agitation and reduces the noise. The plate 32 may be replaced by a more massive plate of highly conducting material, such as copper, in which case slight variations of the magnetic field nearby are smoothed out without being the cause of much loss of energy. The revolving structure is surrounded by the armature laminations 34. These laminations are mounted on the inner periphery of the casing 35 which is closed except for openings for the terminals 36 which are sealed therein as indicated by insulating bushings 37. Thus the machine becomes a relatively noiseless, self-contained, high frequency dynamo of good efficiency capable of producing current of such frequencies as are required for the operation of furnaces of the type shown for example, in Northrup Patent No. 1,286,395.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. An electric heating apparatus comprising the combination of a dynamo-electric machine capable of delivering alternating current of a periodicity of about ten to twenty kilocycles per second, a primary inducing winding connected to said source and constructed to permit electromagnetic interlinkage with a load to be heated without interlinkage with a magnetic core, a variable reactance connected in the electric circuit in series with said dynamo-electric machine and said winding, and common cooling means for said dynamo-electric machine and said winding.

2. An electric heating apparatus comprising the combination of a dynamo-electric machine capable of delivering alternating current of a periodicity of at least about ten kilocycles per second, an air core transformer winding operatively connected thereto whereby energy from said machine may be induced in a load to be heated, a variable reactance connected in the electric circuit in series with said dynamo-electric machine and said winding, and common cooling means for said dynamo-electric machine and said winding.

3. An electric heating apparatus comprising the combination of a dynamo electric machine which is capable of delivering alternating current at a periodicity of about ten to twenty kilocycles per second, a jacket therefor wherein a cooling fluid may be circulated, a primary inducing coil comprising hollow conductors, conduits connecting said inducing coil to said jacket to permit the intercirculation of a cooling fluid, a radiator included in series with said conduits, electric conductors electrically connecting said inducing coil to said machine, and a variable condenser included in said connections.

4. An induction furnace heating system comprising a dynamo-electric machine, a heating coil free from interlinkage of transformer iron, electrical connections between said dynamo-electric machine and said coil, and a variable condenser included in said connections in series with said coil and said dynamo-electric machine.

5. An induction furnace heating system comprising a dynamo-electric machine, a heating coil free from interlinkage of transformer iron, electrical connections between said dynamo-electric machine and said coil, a variable condenser included in said connections, and a variable inductance included in said connections.

In witness whereof, I have hereunto set my hand this twenty first day of April, 1924.

ELIHU THOMSON.