

April 23, 1940.

A. WINTHER

2,197,990

ELECTROMAGNETIC APPARATUS

Original Filed July 29, 1936

2 Sheets-Sheet 1

FIG. 1.

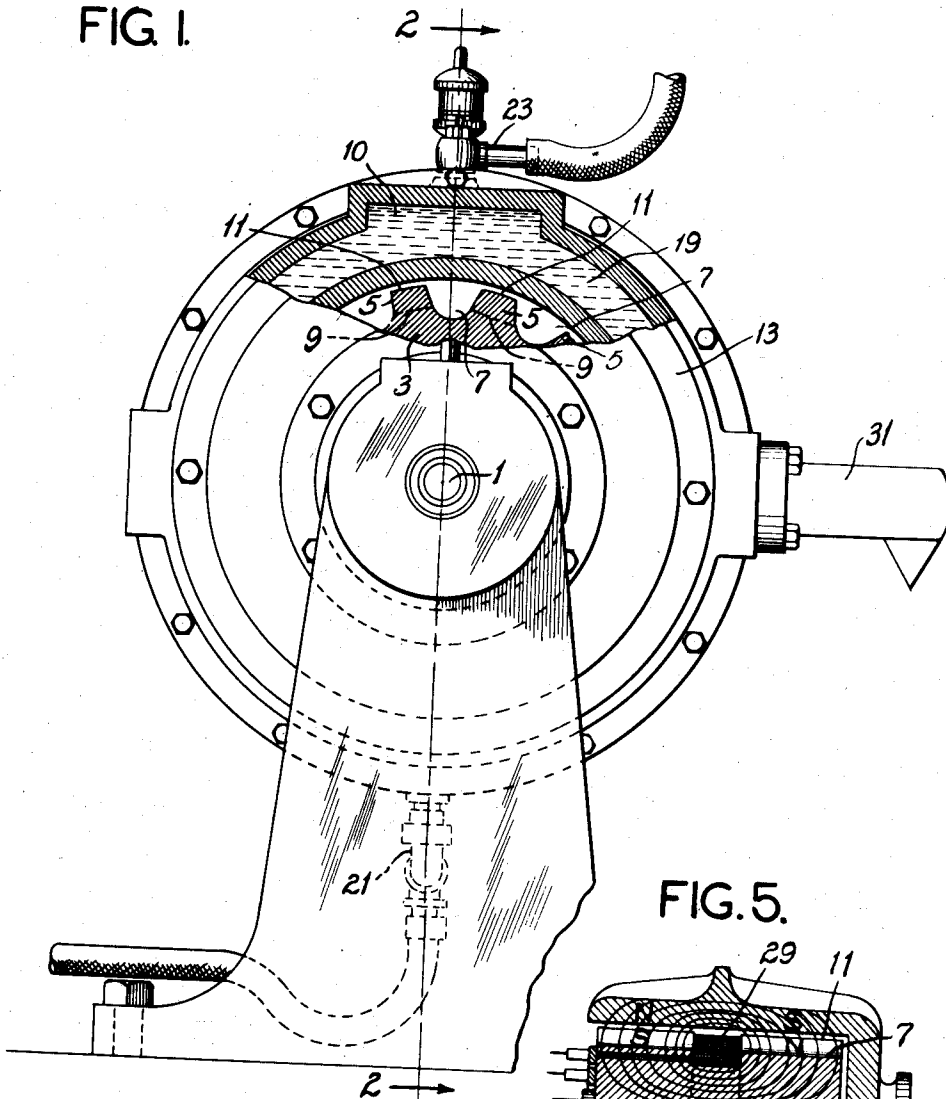


FIG. 5.

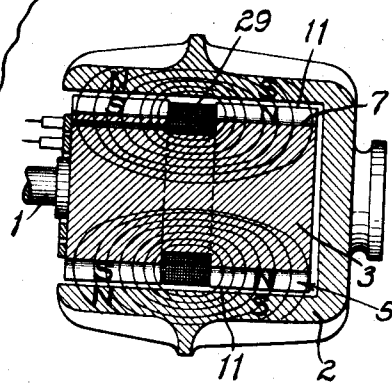
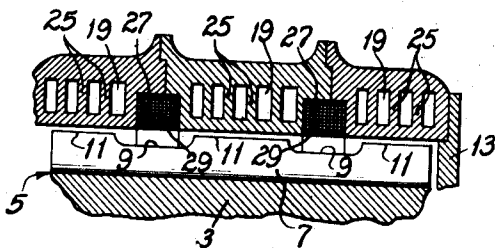


FIG. 3.



Anthony Winther
Inventor.
Delos S. Hayne
Attorney.

April 23, 1940.

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2 Sheets-Sheet 2

FIG. 2.

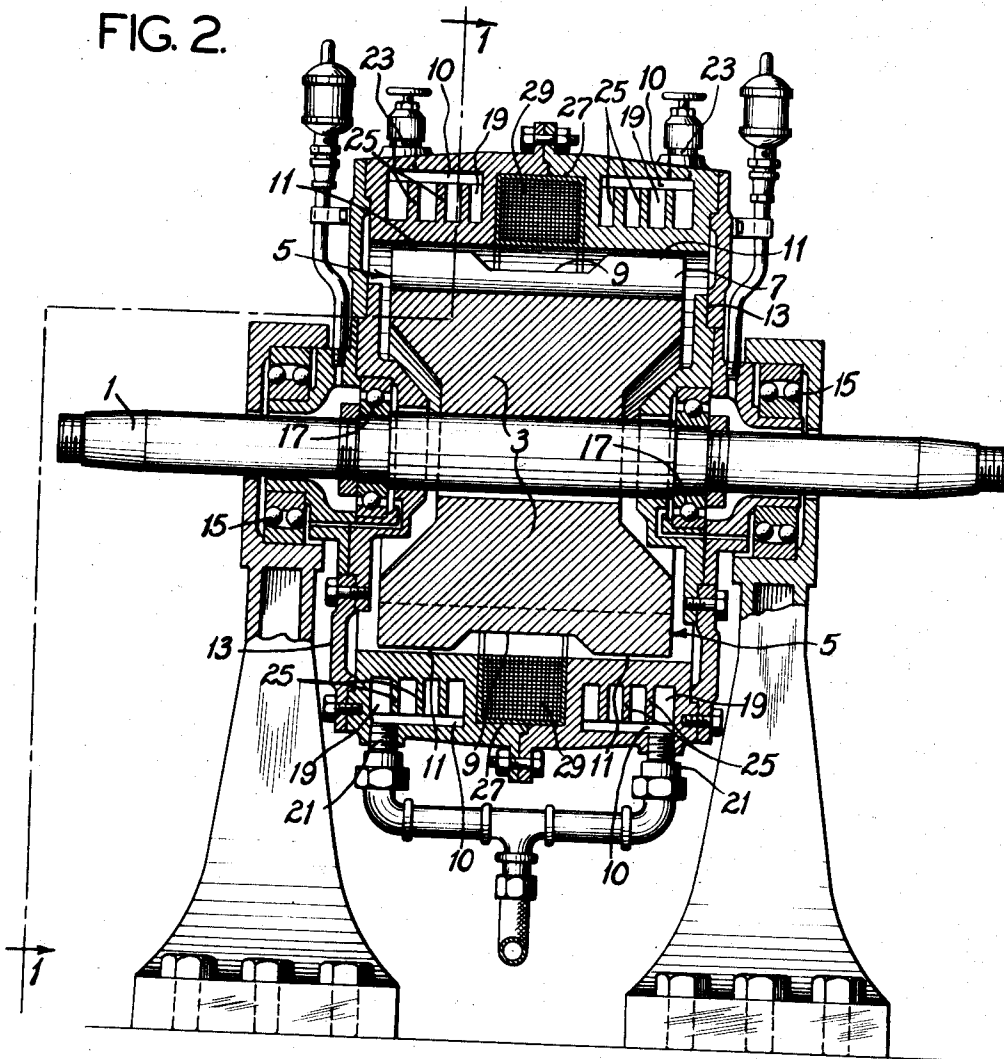
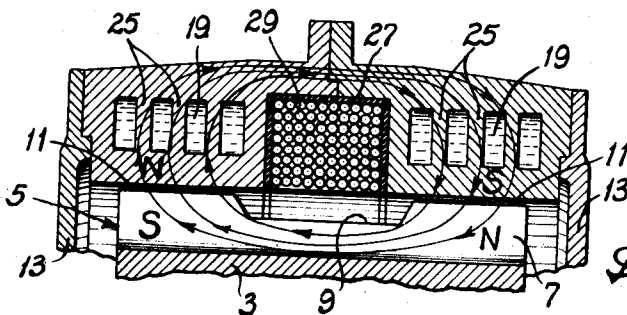


FIG. 4.



Anthony Winther,
Inventor.
Delos G. Hayes,
Attorney.

UNITED STATES PATENT OFFICE

2,197,990

ELECTROMAGNETIC APPARATUS

Anthony Winther, Kenosha, Wis., assignor to
Martin P. Winther, as trustee, Waukegan, Ill.

Original application July 29, 1936, Serial No.
93,176. Divided and this application January
21, 1938, Serial No. 186,138

5 Claims. (Cl. 188-104)

This invention relates to improvements upon electromagnetic apparatus of the general class shown in my United States Patent 1,977,600, dated October 16, 1934, reissued December 29, 1936 as No. 20,225.

This application is a division of the application which resulted in my Patent No. 2,106,542.

Among the several objects of the invention may be noted the provision of an improved arrangement of magnetic circuits and the provision of certain flux concentrating or distorting means, and method of moving the latter, whereby a steadily rising torque may be delivered from an output member, as the velocity of an input member increases; the provision of apparatus of the class described which will avoid the heretofore undesirable drooping of the torque curve after a predetermined speed is reached; the provision of apparatus of the class described in which the exciting current for operation is materially reduced; the provision of apparatus of the class described in which the increased amount of heat which has been converted from its form as work may efficiently be carried away; and the provision of apparatus which is lighter and simpler than prior corresponding apparatus. Other objects will be in part obvious and in part pointed out hereinafter.

The invention accordingly comprises the elements and combinations of elements, features of construction, and arrangements of parts which will be exemplified in the structures hereinafter described, and the scope of the application of which will be indicated in the following claims.

In the accompanying drawings, in which are illustrated several of various possible embodiments of the invention,

Fig. 1 is an end view on line 1-1 of Fig. 2, showing one form of energy absorption apparatus to which the invention applies, parts being broken away to show a section;

Fig. 2 is a vertical section taken on line 2-2 of Fig. 1;

Fig. 3 is a fragmentary section, similar to parts of Fig. 2, showing an alternative form to that shown in Fig. 2;

Fig. 4 is an enlarged detail section of a part of Fig. 2; and,

Fig. 5 is a view illustrating another form of the invention.

Similar reference characters indicate corresponding parts throughout the several views of the drawings.

The electromagnetic apparatus shown in my said United States Patent 1,977,600, and in its

Reissue 20,225, while it sets forth improvements in pole shapes, has in common with other old apparatus, the method of inducing eddy-currents by sweeping successive electromagnetic poles of opposite polarities past given points on the member in which the eddy-currents are induced. Such apparatus, efficient as it may be at low relative sweep rates of the electromagnetic poles, has the disadvantage that above the relatively low sweep rates, the torque delivered from driving to driven member drops off.

By means of the present invention, the conditions are obtained in which there is continuous rise in the torque transmitted with increase in speed of the pole sweep.

Referring now more particularly to Figures 1 and 2, these show the invention as applied to an absorption dynamometer. Numeral 1 shows the drive shaft, driven from a suitable source of power. Fastened to the drive shaft 1 is a rotor 3 which is simply made of solid magnetic material, such as iron or steel and which carries peripheral teeth 5 with spaces 7 therebetween. Each tooth 5, by means of a central depression 9 is formed with two working faces or end areas 11 which, as will be seen later, form magnetic concentrators or distorters.

Mounted around the shaft 1 is a swinging case 13 supported in bearings 15. The shaft 1 is supported within the case on bearings 17. This case 13 constitutes the energy absorption member which is to receive energy from the shaft 1 and rotor 3, convert it into heat, and being forced to apply the resulting torque or moment to a suitable measuring device. For the purpose of carrying away generated heat, the periphery of the case 13 has four peripheral water circulating channels 19 leading from inlets 23 to outlets 21 respectively. Between the channels 19 are peripheral walls 25 serving purposes to be described. Adjacent the inlets 23 and outlets 21 are cross passages 10 joining the respective sets of four passages 19 with said inlets or outlets, as the case may be. Thus water may flow from the inlets 23, through the upper cross passages 10, around passages 19, through the lower passages 10 and to the respective outlets 21. At all peripheral points, except at said cross passages 10, the peripheral walls 25 completely separate the channels 19.

Between the pair of members which form the channels 19 is provided a peripheral recess 27 in which is peripherally wound a coil or electromagnet 29 which is connected into a suitable electric circuit. A torque arm 31 on the case 55

serves to impress force on a scale balance or the like. It is to be understood that the water inlets 23 and outlets 21 have suitable flexible hose connections, so that the case 13 may freely swing to the degree required by the measuring apparatus with which the torque arm 31 contacts.

In view of the above, it will be seen that if the circuit is closed through the coil 29 the resulting excitation will result in a magnetic field being established of generally toric form around the coil 29 and along the general lines indicated by the arrows in Fig. 4. This induces two north and south magnetic poles axially arranged in the periphery of the case, as indicated. These north and south poles in the case will induce opposite polarities in the adjacent faces 11 of the teeth 5, the magnetic circuit passing through the case, and the various teeth 5. The teeth function as distorters of the magnetic field. All teeth at one end of the rotor 3 are of one polarity. Thus all adjacent teeth peripherally considered are of one polarity.

If the shaft 1 be rotated, it will be seen that the effect of the teeth 5, as their faces 11 pass a given point on the inner face of the case 13, is to concentrate the lines of flux from the adjacent areas into areas approximating the areas of the faces 11 of the teeth.

In the present improvement the successive concentrator poles are of the same polarity. Where the successive poles are of different polarities, and themselves cause in the inductor the magnetic field, said field must necessarily be reversed throughout as the successive reverse poles pass the given point. With the present apparatus, the lines of the magnetic circuit are never reversed in the inductor. Furthermore, the magnetic field in the inductor is due as a whole to the coil in the inductor or in a stationary member, as in the drawings, and is not induced therein as a whole by adjacent and moving poles in the toothed member as heretofore, and the effect of the adjacent and moving poles is merely to distort without inducing the movement of this field completely or reversing it.

An advantage of electric dynamometers of the class shown in Figures 1 and 2 is that they are infinitely adjustable to various values of power. This is in contrast with the great difficulty encountered in adjusting the regulation of a load on such dynamometers as water brakes, rope brakes, and the like. Furthermore, the present type of dynamometer has a much lower cost than the old generator type. For example, electric dynamometers required to be operated at very high speeds must have very expensive armatures, while in the case of the present invention, the rotor is nothing more than a small, solid toothed steel member.

It will at this time be seen that the walls 25 are flatwise peripherally and are thus best adapted to accommodate there-through the magnetic lines of force, and therebetween the circulating water. Thus the cooling water jacket is formed to carry the flux. However, the flux path thus formed is only imperfect at best, and the advantage gained by the present scheme is that the flux is unchanging through said imperfect path. Obviously, it would be difficult to pass rapidly changing flux through such an imperfect magnetic path, improved as it is.

I have carefully investigated the proper form of tooth to use to obtain the highest efficiency out of the new type of machine. To do this I have built a large number of rotors of varying

tooth form, as to width, depth, spacing, tapering, etc., and in general can say that it is advantageous to taper the teeth from their bases to their faces, and to make their width such that the pole tooth end width will be between 25 and 50 percent (say 35 percent as an average) of the total peripheral distance from the edge of one tooth to the corresponding edge of the next one. This can be stated in another way by saying that the width of an open space should be (for highest torque) about twice that of the width of a tooth.

The tooth depth may vary from one-fourth to twice the tooth width; it being best to make it about the latter for the reason that as little leakage as possible is desired between teeth. As disclosed in Patent 1,977,600 (Reissue 20,225), it is important to taper the tooth edges so as to effect flux saturation at the tooth faces or ends.

In the case of Patent 1,977,600 (Reissue 20,225), it was shown that if the pole end areas were about thirty percent less than the sectional area of the pole which is needed to carry all the flux including leakage flux which did not go through the end area, then highest efficiency of transmission was obtained. The same rule applies in the present circumstances, except that the areas to be considered are the superficial or radially disposed end areas of the teeth at either end portion of the rotor (exclusive of those at the other end), as compared to the cross-sectional area of the rotor through the waist within the loop of the coil 29 including the areas of the depressed connecting portions 9. Thus the total of the superficial end areas of the teeth at one end of the rotor should be about thirty percent less than the central cross-sectional area of the rotor. This is for the same reason given in said patent, namely, that the cross-sectional area of the rotor needs to carry all of the flux which is to pass out through the ends of the teeth, plus leakage flux. In order to cause a maximum concentration at the tooth ends, the metal of the tooth ends should be worked at flux saturation. Since there is about thirty percent leakage of flux aside from that which goes through the tooth end areas, it follows that, to saturate said tooth end areas with seventy percent of the flux, said areas must be thirty percent or so less than the rotor waist area. The rotor is in effect an axial pole, the waist of which must carry all flux, and the superficial end areas of the flux-distorting teeth which carry only working flux, the remainder of the flux being leakage flux.

In Fig. 3 is shown how in a single unit, the elements of the invention may be compounded. This figure is inserted to show that the new principle can be carried out by the use of more than two poles per tooth. This compound device is in effect several units in tandem and having several waist sections, one each of which waist sections is within a coil 29. On each side of each waist section is enough superficial, radial tooth end area 11 to fulfill the relationships above specified. As in Figs. 1-4 the areas of the depressed connecting portions 9 are included in considering the cross-sectional area of the waist. It will be understood that Fig. 3 is diagrammatic and not to scale.

An advantage of the invention is that the flux-carrying walls are arranged for efficient carriage of the flux, and these are the parts in which the resulting eddy-currents are also generated. Thus these parts are arranged (1) for carriage of flux, (2) for production of eddy-currents and (2) for the transmission of heat at a high rate

into the cooling water. Much trouble heretofore with dynamometer apparatus has been not only the inability to convert work into heat, but quickly to transmit and carry off the heat when generated. In the present invention, all three functions of efficient flux carriage, work-heat conversion, and heat transmission are facilitated by the simple form of the apparatus described.

In Fig. 5 is shown an alternative form of the invention. In this case, the electromagnetic coil 29 is wound around the driving member 3 instead of around the driven member 2 which is forced by the driving member. If desired, in Fig. 5 energy may be applied to member 2 to rotate it, in which case member 3 is forced and may be driven, or function against a dynamometer scale. The theory is in general the same, there being no reversal of flux field in any member but merely a distortion of uni-directional field.

While the heat absorption features have not been shown on the apparatus of Fig. 5, it will be understood that they may readily be applied thereto. Furthermore, no connecting portions 9 are shown, these being simply desirable in the other forms of the invention and not absolutely necessary.

In view of the above, it will be seen that the several objects of the invention are achieved and other advantageous results attained.

As many changes could be made in carrying out the above constructions without departing from the scope of the invention, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

I claim:

1. In apparatus of the class described, a magnetic driving member having an axis, a magnetic member which is forced and being coaxial, relatively movable and spaced faces on said members one of which faces is smooth and the other having teeth, the toothed member having a waist in a plane perpendicular to said axis, an electromagnet wound at said waist and movably carried by said toothed member, the electromagnet forming a field all of which passes through the waist of the driving member and a substantial por-

tion of which passes through said teeth, the total radial end areas of the teeth on one side of the waist being so related to the cross section of the waist that the flux which actually emanates from said teeth effects substantial flux saturation at the radial ends of said teeth.

2. Apparatus of the class described according to claim 1 in which the smooth-faced member is located exteriorly of the toothed member.

3. Apparatus of the class described according to claim 1 in which the smooth-faced member is located exteriorly of the toothed member and in which the electromagnet comprises a single closed coil.

4. In apparatus of the class described, a magnetic driving member having an axis, a magnetic member which is forced and being coaxial, relatively movable and spaced faces on said members one of which faces is smooth and the other having teeth, the toothed member having a waist in a plane perpendicular to said axis, an electromagnet wound at said waist and carried by said toothed member, the electromagnet forming a field all of which passes through the waist of the driving member and a substantial portion of which passes through said teeth, the total of the radial end areas of the teeth on one side of the waist being substantially 30% less than the cross-sectional area of said waist.

5. In apparatus of the class described, a magnetic driving member having an axis, a magnetic member which is forced and being coaxial, relatively movable and spaced faces on said members one of which faces is smooth and the other having at least two peripheral rows of teeth, the toothed member having a waist and at least one electromagnet at said waist and lying between the two rows of teeth, the electromagnet forming a field all of which passes through the waist of the driving member and a substantial portion of which passes through said teeth, the total radial end areas of the teeth on one side of the waist being so related to the cross section of the waist that the flux which actually emanates from said last-named teeth effects substantial flux saturation at the radial ends of said teeth.

ANTHONY WINTHER.