Apr. 17, 1923.

1,452,327

M. E. THOMPSON

POWER TRANSMISSION ARRANGEMENT

Filed Dec. 20, 1919 3 Sheets-Sheet 1

Fig. 1

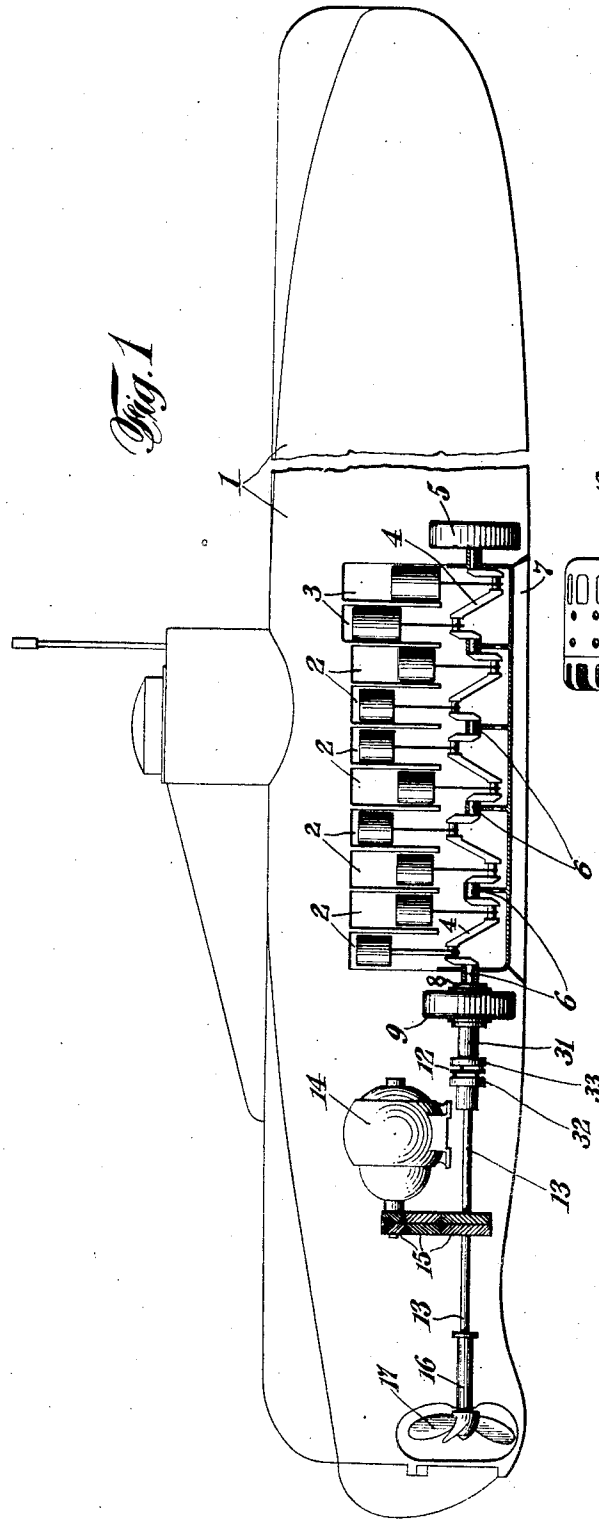
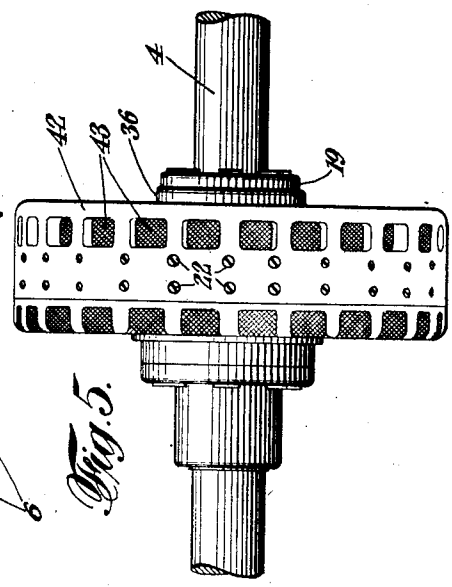


Fig. 5.



INVENTOR,
Milton E. Thompson,
BY
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3 Sheets-Sheet 2

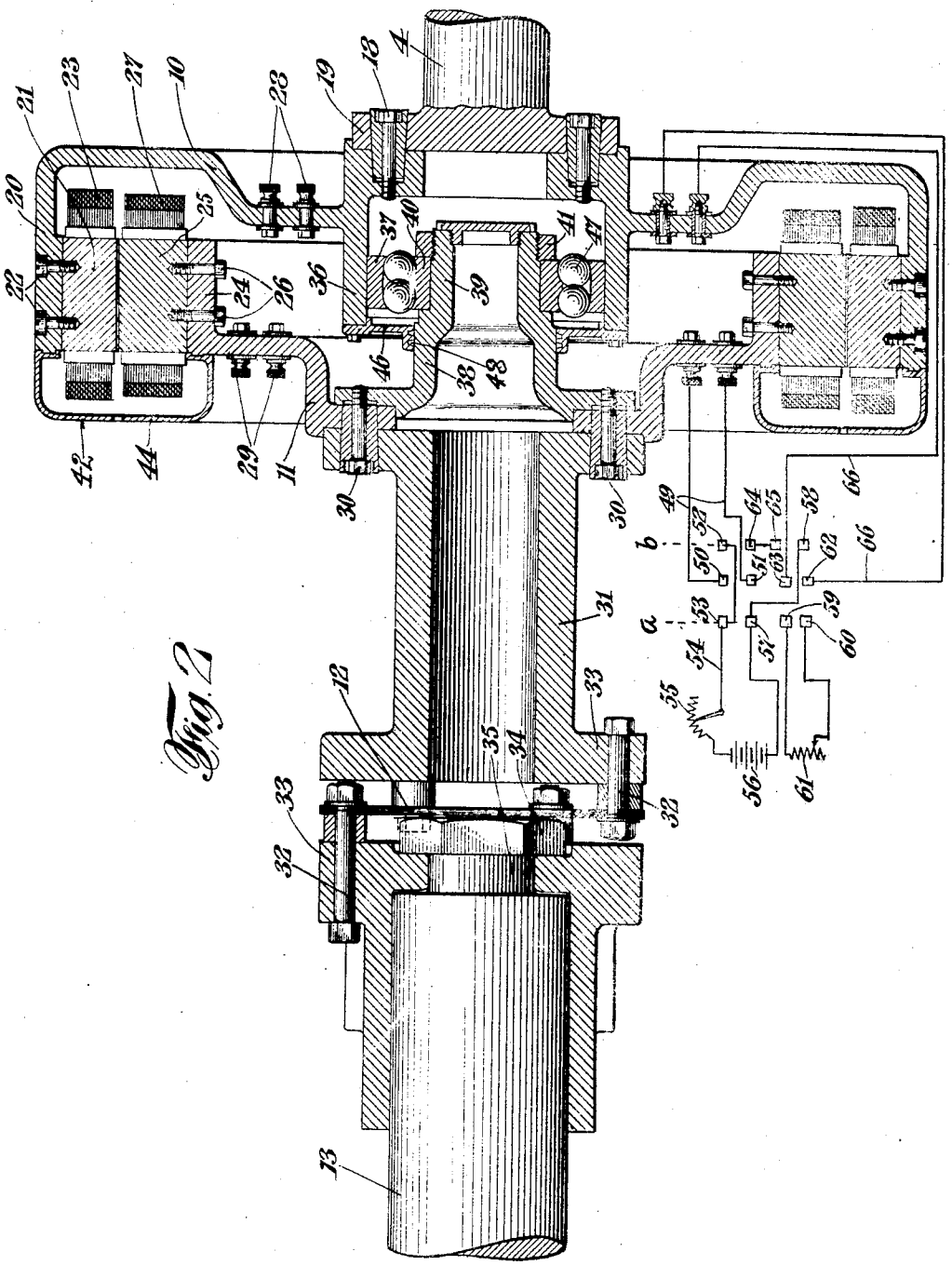


Fig. 2

Inventor,
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3 Sheets-Sheet 3

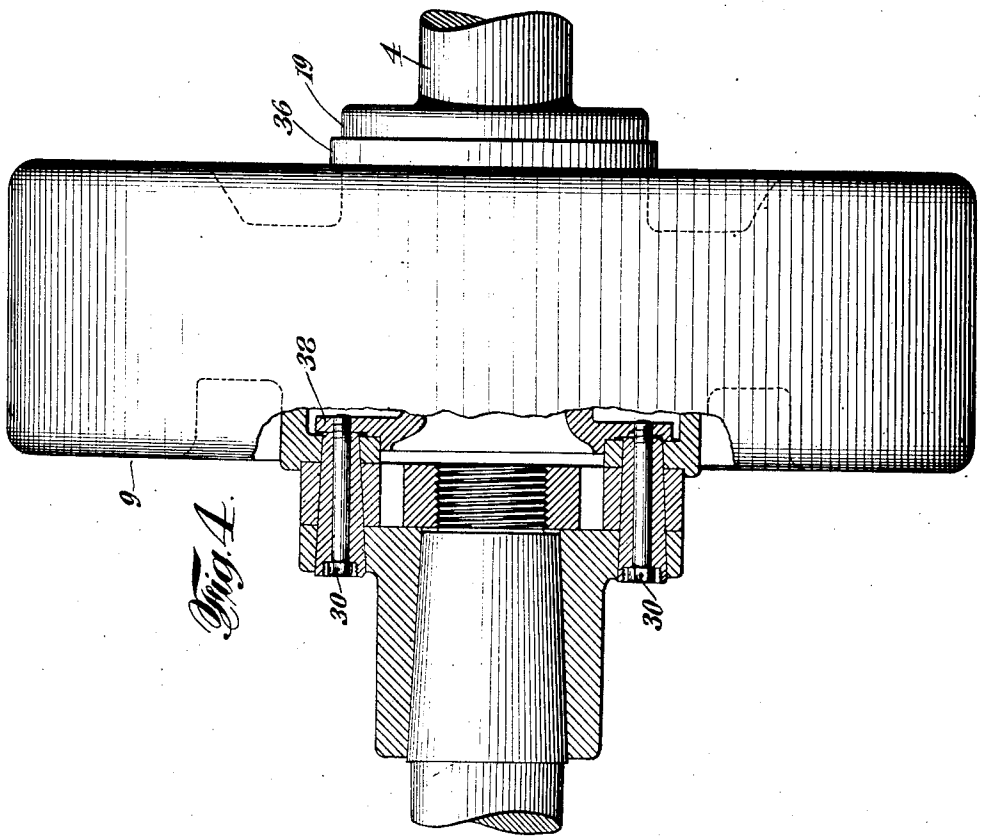


Fig. 4.

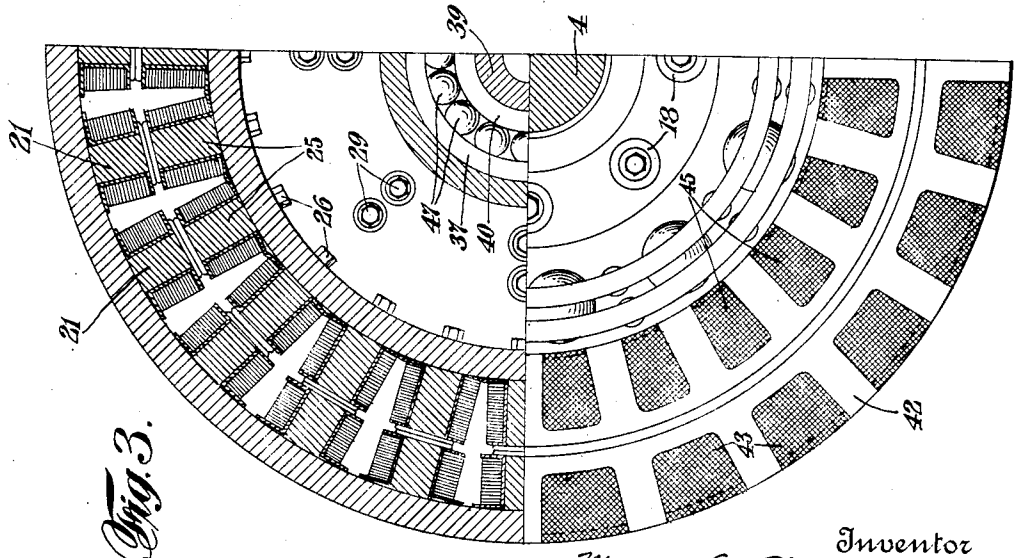


Fig. 3.

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Patented Apr. 17, 1923. 1,452,327

UNITED STATES PATENT OFFICE.

MILTON E. THOMPSON, OF RIDGWAY, PENNSYLVANIA.

POWER-TRANSMISSION ARRANGEMENT.

Application filed December 20, 1919. Serial No. 346,292.

To all whom it may concern:

Be it known that I, MILTON E. THOMPSON, a citizen of the United States, and a resident of Ridgway, Elk County, State of Pennsylvania (whose post-office address is c/o Ridgway Dynamo & Engine Co., same place), have invented certain new and useful Improvements in Power-Transmission Arrangements, of which the following is a specification.

My invention relates to power transmission systems and is particularly useful where the power from one shaft is transmitted to another shaft under circumstances such that said shafts may or may not be in accurate alignment, and in fact where such alignment is not under control. My invention has special usefulness also in such arrangements as above described wherein it is desired that a certain torsional flexibility or cushioning effect be provided.

My invention is especially applicable to the problems arising in connection with the propulsion of submarines, but is, of course, not limited to use in submarines, reference being made to submarines because they illustrate the nature of the problem which my invention solves. In the following description reference will be made to the use of my invention in submarines for the purpose of illustration of the problem which my invention solves and not in any way as limiting the invention to use in that particular instrument.

A submarine, as is well known, is driven while submerged by an electric motor from storage batteries and when the submarine is running on the surface it is desired that it be driven by an internal combustion engine for two reasons, first, to save the battery; and second, because usually the engine drives the boat at a higher speed than the motor does. Another problem arising in the operation of submarines is that of starting the engine when the boat comes to the surface without stopping the boat. This problem is solved by my invention as will appear in detail later by reason of the torsional flexibility between the driving elements of the coupling between the engine shaft and motor and propeller shaft. This feature allows the motor while driving the boat to also start the engine from rest without injuring the coupling or any other part of the driving mechanism. When the engine has been started and is capable of operating under its own power, the motor is then disconnected from the batteries and the boat driven by the engine alone, although it may be assisted by the motor if occasion demands.

By reason of the nature of a submarine, it is found to be practically impossible to maintain the engine shaft and the motor and propeller shaft in alignment. This is due primarily to the fact that the boat being of a comparatively slender design and light construction, is subject to changes of temperature. These changes of temperature for instance cause the boat to change its longitudinal axis in such a way as frequently to throw the engine shaft and the motor and propeller shaft considerably out of alignment. Since these changes occur in accordance with the difference in temperature of the different parts of the boat, the alignment is likely to be off in any direction and is, therefore, totally beyond control and provision must be made for driving the motor and propeller shaft from the engine or vice versa regardless of alignment of the shafts.

In the latest design of submarine boats the engine shaft is about 24 feet long, the engine having eight individual cylinders and there being bearings between each two adjacent cylinders. When these engines are of the Diesel type the crank shaft is also connected with two air compressor cylinders for well known reasons. This construction makes it necessary, therefore, to accurately align ten or twelve bearings in order that the engine crank shaft shall operate properly and without undue strain. Taking up as it does, therefore, some twenty-four feet of length of the boat, a slight deflection of one part of the boat with respect to another might cause relatively large deflection of the end of the shaft.

The motor and propeller shaft which is a single continuous unit is in the latest type of submarine about thirty-six feet long. This shaft extends through a long stuffing-box to the propeller and has several bearings including the motor bearings which must be accurately aligned and such alignment maintained, and this shaft taking up as it does thirty-six feet of the length of the boat, may be relatively largely affected by changes of the axis of the boat due to temperature changes, whereby it is likely to cause a considerable deflection of the cou-

pling end of this shaft with respect to that of the engine shaft. If the deflection of the engine shaft and that of the motor and propeller shaft happen, as they not infrequently do, to be in opposite directions, the total deflection would be the sum of the two and a deflection of this character must be provided against since it may occur in all directions.

The problem, therefore, of driving one of these shafts by the other under the conditions above outlined, and which conditions are subject to change while one shaft is driving the other or vice versa is not by any means an easy one. This problem has been met in a measure by many devices heretofore devised, but I am advised by those in authority that no device to date has been devised which is entirely satisfactory.

By reason of the enormous power transmitted the devices in ordinary use cause much annoyance and the surfaces of the coupling are quickly worn and soon destroyed if relative rotation of the coupling members occurs. It not infrequently happens that with such devices one or both shafts are bent or broken and the coupling destroyed and the boat consequently entirely disabled.

I have solved the above complicated problem by providing a coupling which allows flexibility both laterally and torsionally with respect to the general axis of the co-operating shaft, that is to say, I mean by lateral flexibility that quality which permits a certain part of the coupling to move in any direction with respect to the axis of the shaft with which it is connected, thereby compensating for the changes in alignment in a manner somewhat similar to a universal coupling. I have provided for the necessary torsional elasticity or flexibility by driving one member by the other through members, which, as far as the power transmitting functions are concerned, are mechanically totally independent and separate, the driving being accomplished by magnetic means. It is necessary, however, that these drive members should be maintained in a substantially concentric relation in order that they may be, when desired, connected together magnetically. At the same time they must be so related that the changes of the position of the two shafts will not cause the driving portions of said members to come into mechanical contact, that is to say, a substantially constant air gap must be maintained between the driving portions of the two members and the air-gap between them must be of substantially constant length in order that an acceptable efficiency may be secured.

Another difficulty which has been overcome by my invention is that the pulsations due to the individual explosions in the cylinders of the engine are so cushioned when transmitted through the magnetic coupling, that they are not felt beyond the magnetic coupling, that is to say, by reason of the torsional flexibility or cushioning effect resulting from the absence of mechanical contact of the driving members, the vibrations which are inherent in the Diesel type of engine are entirely eliminated from the driving system on the propeller side of the coupling.

My invention is illustrated by the accompanying drawings forming a part hereof and in which,

Fig. 1 is a diagrammatic illustration of the arrangement of the engine coupling showing the general layout of the supports of bearings for these elements.

Fig. 2 shows a longitudinal section of the coupling and also diagrammatically the electrical connections for exciting the windings.

Fig. 3 shows an end elevation viewed from the engine side of the coupling partly in section.

Fig. 4 shows a front elevation, partly in section, of a modification of my invention; and

Fig. 5 shows a front outside elevation of the coupling.

Referring to Fig. 1, the general form of the submarine is shown by the hull 1; inside is shown in section a diagrammatic representation of an engine of the Diesel type. This engine usually has eight cylinders, all in a line, the same being represented by the numeral 2. Mounted in alignment with the cylinder 2 are air compressor cylinders 3 for supplying the air to the engine in the well-known way. Mounted on the crank shaft 4 of the engine is a fly-wheel 5. The crank-shaft 4 is supported at desired points by bearings 6, which bearings are supported by a suitable bed-plate 7 or in any other desired manner. Attached directly to the crank-shaft by means of a suitable connection 8, is the magnetic coupling 9, comprising members 10, 11 and 12, as will be explained more in detail later. Connected to the other end of the coupling are the motor and propeller-shaft 13 which may be supported by suitable bearings. The armature of the motor 14 is connected to this shaft 13 by suitable gearing 15. The shaft 13 extends through a stuffing-box 16 and on the end of the shaft is mounted a propeller 17. From the foregoing the general arrangement of the engine, coupling, motor, propeller and their shafts, and the bearings therefor, will be apparent. By referring to Figs. 2 to 5 the detailed construction of the coupling will be better understood. Referring to Fig. 2, the engine shaft 4 is directly connected to one of the coupling members 10 by means of bolts 18 extending through an integral flange 19 and into the

member 10. The member 10 is of a general disk shape, having preferably a portion 20 extending substantially parallel with the axis of the shaft 4. Attached to the portion 20 of the member 10 is a series of magnetic pole-pieces 21 of any well-known or desired form, usually composed of soft iron, there being usually about twenty-four of such pole-pieces attached to the member 10, the same being attached by bolts 22. Each of the pole-pieces 21 has wound therearound a winding 23.

The member 11 is of the same general shape as the member 10, having a portion 24, preferably parallel with the axis of the shaft 4, although as it will appear hereinafter, the relative position of the member 11 to the shaft 4 may change. Mounted on the portion 24 of the member 11 is a series of pole-pieces 25, twenty-four such pole pieces being shown in the drawings, the same being arranged uniformly and symmetrically around the member 11 and attached to the portion 24 by bolts 26. The pole-pieces 25, like pole-pieces 21, are provided with electrical windings 27. The windings of the pole-pieces 21 are connected to the slip-rings 28, and the windings of the pole-pieces 25 are connected with the slip-rings 29. Rigidly connected with the member 11 by bolts 30 is an extension 31. In the form of my invention shown in Fig. 2, the member 31 is connected with a flexible ring 12, composed of a number of steel laminæ. This ring 12 is connected to the member 31 and shaft 13 by bolts 32 through flanges 33, one of which flanges is rigidly connected to the propeller-shaft 13 by means of a nut 34 screwed onto the reduced end-portion 35 of the shaft 13 and the other of which flanges is integral with member 31.

The member 10 has a second portion 36 which is tubular in shape and extending preferably parallel with the axis of the shaft 4. Arranged to fit snugly within the member 36 is a ball-race 37, which, however, is, by reason of its construction, permitted to have a slight movement in a direction parallel to the axis of the shaft 4. Mounted rigidly onto the member 11 is a member 38, which has a portion 39 parallel to the portion 36 of the member 10. Mounted on the portion 39 is a ball-race 40 which is held rigidly thereon by means of a nut 41 screwed onto the screw-threaded portion of the member 38. The ball-race 37, in addition to being arranged to have a movement longitudinally of the axis of shaft 4, has its interior face curved for reasons which will appear later.

Attached to the circumference of the member 10 is a member 42, preferably of non-magnetic material, which is provided at intervals with openings, in which openings are placed suitable screens 43, as shown in Fig. 3, for the purpose of allowing a circulation of air. Similarly the member 11 is provided with a member 44 having openings therein, in which are placed screens 45, as shown in Fig. 3.

The member 10 is also provided on its portion 36 with a member 46, which acts as a guard to retain the lubricant within the ball-bearing, composed of the members 37, 40, and balls 47. The opening in the member 46, which accomodates the member 38, is made sufficiently loose fitting to allow for a certain relative movement of the axis of the shaft 4 and of the member 31. The member 46 also carries at 48 a suitable packing material, which is resilient enough to retain the lubricant in the bearing and at the same time permit the relative movement above mentioned.

The windings 23 of the pole-piece 21 are preferably connected in series and one end connected to one end of the slip-rings 28 and the other to the other ring 28. Likewise the windings of the pole-pieces 25 are connected in series and to the slip-rings 29. The slip-rings 29 are connected by conductors 49 with the middle contacts 50 and 51 of the four-pole double-throw switch. The contacts 52 and 53 of the switch are connected by conductor 54 through adjustable resistance 55 to the battery 56. The contacts 57 and 58 are also connected to the battery 56. The contacts 59 and 60 are connected with a resistance 61. Contacts 62 and 63 are connected with the slip-rings 28. The contacts 64 and 65 are connected together.

The operation of my device is as follows: Assuming that the submarine is submerged, it will be propelled by the motor 14. the same being supplied with energy from storage batteries in the usual way. At that time, the windings of the coupling will be deenergized and the member 11 will rotate with the shaft 13 without communicating any motion to the shaft 4, the engine at that time being dormant. When the submarine comes to the surface, it is desired to propel the same by the engine so as to save the batteries and for other obvious reasons. It is desired also to be able to start the engine by the electric motor from the batteries, and this is accomplished as follows: The member 11 is rotating with the motor shaft 13. The double-throw switch is thrown to position *a*, thereby connecting the slip-bearings 29 with the battery 56 through conductors 49, contacts 50, 53, conductor 54, resistance 55, battery 56, contact 57, contact 51. This energizes the pole-pieces 25 and at the same time the slip-rings 28 are connected, through conductors 66 contacts 62 and 63, 60 and 59, with the resistance 61. This therefore puts the windings of the rotating element across the battery with the resistance 55 in series therewith and connects the windings 23 in series

with the resistance 61. The resistance 55 is then gradually cut out of the circuit of the windings 27, whereby the magnetic strength of the pole-pieces is increased and the magnetic effect causes the member 10 to rotate, slowly turning over the engine crank shaft 4. The speed of the member 10 with respect to that of the member 11 will depend upon the effect of the battery and the amount of the resistance 61. After the engine has begun to rotate under its own power, the switch is thrown to the position *b*, which connects the battery 56 directly to one of the slip-rings 29 and also connects the battery direct with one of the slip-rings 28 through contacts 62, 58 and 57. In this position of the switch the other slip-ring 29 and the other slip-ring 28 are connected together through contacts 51, 64, 65 and 63, thereby placing the windings 23 and 27 in series with each other across the battery. This connection causes the members 10 and 11 to rotate synchronously. The motor may then be disconnected from the batteries and the boat propelled by the engine through the members 10, 11 and 12, the coupling then rotating as a unit and transmitting the revolutions of the shaft 4 to the shaft 13.

It not infrequently happens that, due to temperature or other causes, the shafts 4 and 13, while normally substantially aligned, are thrown actually out of alignment with each other, and in that event it becomes necessary to drive the shaft 13 from the shaft 4, although those two shafts are out of alignment. This is provided for in my device as follows: By reason of the connection through the member 12, the member 31 is permitted to have a certain lateral flexibility with respect to the shaft 13, that is to say, the right-hand end of the member 31 as shown in Fig. 2, may take a position in any direction substantially out of alignment with the axis of the shaft 13; at the same time the member 31 is at all times torsionally rigidly connected with the shaft 13. By reason of the bearing between the portions 36 and 39 of the members 10 and 11 respectively, the members 10 and 11 are permitted to rotate in parallel or non-parallel planes, depending upon whether or not the shafts 13 and 4 are in alignment with each other. If the members 10 and 11 are in parallel planes, the relation of members will be as shown in Fig. 2. If, however, by reason of the change of alignment of the shafts 4 and 13, a movement is given to one of these members, they are thrown in non-parallel planes but are held in concentric relation relatively to each other by reason of the bearing between the portions 36 and 39, so that the air-gap between the pole-pieces 21 and 25 is always maintained substantially constant, although the members 10 and 11 may be rotating in non-parallel planes. The curved portion of the member 37, as well as the fact that it is permitted to move longitudinally of the member 36, permits the bearing to adjust itself automatically to the various requirements brought about by the alignment and (or) non-alignment of the shafts 4 and 13.

It may be desirable to form the faces of the pole-pieces 21 and 25 so that they are concentric with the center of the bearing between the members 10 and 11, which arrangement would maintain the air-gap constant at all relative positions of the members 10 and 11, but that arrangement is not usually necessary because the air-gap is normally of sufficient length to permit of the necessary relative movement without any possibility of mechanical contact between the members 10 and 11.

From the foregoing it will be seen that I have devised a simple and effective means of transmitting power from the motor to the engine to start the same, and from the engine to the motor and propeller-shaft for driving the boat, this transmission of power being equally effective whether or not the shafts 4 and 13 are in alignment and the said power being transmitted without any mechanical contact between the driving surfaces and the coupling providing both lateral and torsional flexiblity, the former acting to permit an efficient operation with the shafts out of alignment and the latter preventing the transmission of the impulses due to the explosion in the cylinders of the engine, to the motor and propeller shaft, thereby materially decreasing vibration and lessening the wear and tear on the parts due to the operation of the submarine under the power of the engine.

My arrangement also provides a system of power transmission where the work is sometimes done by one power motor directly as in this case by the electric motor and sometimes by another power motor indirectly, as the engine, through a coupling having its driving parts mechanically independent and separate, but adapted to connect the motor shaft and the engine shaft together magnetically to cause them to rotate synchronously so that when the engine is doing the work a certain amount of tortional flexibility is interposed between the engine and the work.

I claim:

1. A magnetic coupler comprising magnetic members whose power transmitting faces are separated by an air gap, and a spherical journal supporting one of said members upon the other.

2. A magnetic coupler comprising magnetic members whose power transmitting faces are separated by an annular air gap, and means mounting one of said members upon the other for relative universal move-

ment about a point located in a plane cutting the center of the annular air gap.

3. In a magnetic coupler and power transmission mechanism for connecting power and work shafts, comprising magnetic clutch members with their working faces separated by an air gap, spherical journals supporting one of the clutch members from the other, and power transmitting connections between each shaft and one of the clutch members, one of said connections being flexible to permit the connected parts to be out of alignment.

4. A magnetic coupler and power mechanism for connecting power and work shafts, comprising electro-magnets separated by an air gap, mountings therefor journaled together by a spherical bearing, one of said mountings being a stub shaft, a flexible driving connection between the stub shaft and the power or work shaft, and a driving connection between the other clutch member and the other power or work shaft.

5. A coupler including separated electro-magnets mounted for relative universal movement about the same center and driving connections from the electro-magnets to power and work shafts, one of said driving connections including a stub shaft connected to the electro-magnet and a flexible connection therefrom to the power or work shaft.

6. A driving shaft, a driven shaft, a coupling having two members connected to rotate one with each shaft and each comprising a plurality of pole pieces with windings thereon, circuits for said windings, and means for shifting circuit connections to cause said members to rotate relatively or synchronously, as desired.

7. A magnetic coupling comprising rotary electro-magnets having pole surfaces separated by an air gap, means for exciting the winding of one electro-magnet and closing the circuit of the winding of the other electro-magnet to produce relative rotation inductively and means for exciting both sets of windings to produce synchronous rotation.

8. A driving shaft, a driven shaft, a magnetic coupling having two members connected to rotate one with each shaft and each comprising a plurality of pole pieces with windings thereon, and a ball bearing supporting one of said coupling members from the other and having a spherical ball race to permit change of angular relation of the two clutch members.

9. The combination of an internal combustion engine, a shaft connected directly to the engine crank shaft and in line therewith, an electric motor, a shaft connected to the motor armature and having a propeller on one end thereof, independent supports for said shafts, a coupling for connecting said shafts together, means between the motor and the coupling for allowing lateral flexibility between the motor shaft and the coupling, said coupling having one member connected to the motor shaft through said flexible means and another member connected to the engine shaft and a bearing inside the coupling for holding the members in concentric relation, but allowing one of them to rotate at various angles to the axis of the engine shaft and propeller shaft.

10. In a power transmission system, the combination of a driving shaft and a driven shaft, a two-part magnetic coupling, one member being rigidly connected to one shaft and the other member being connected to the other shaft so as to give lateral flexibility, said second member being also supported by the first member so as to maintain the air gap between the members substantially constant.

11. In a power system of the class wherein the work is sometimes driven by one power motor directly, and sometimes by another power motor indirectly through a coupling, two rotary magnets constituting such coupling, a flexible mounting supporting one of said magnets upon the other and a flexible power connection between one of them and the work.

12. A magnetic shaft coupling comprising two electro-magnetic members and a bearing supporting one of said members upon the other and holding said members out of actual contact, said bearing permitting said members to rotate in planes parallel or non-parallel.

13. A magnetic coupling comprising two members each having a set of field poles concentrically arranged, a bearing supporting one of said members upon the other and holding them out of actual contact and maintaining an air gap between them, said bearing also permitting said members to rotate in planes parallel or non-parallel.

14. A magnetic coupling comprising a flange having a plurality of pole pieces arranged symmetrically radially on the interior of the circumference thereof, a flange having a similar set of pole pieces arranged on the exterior of the circumference thereof, one set of pole pieces being arranged interiorly of the other with an air gap between the poles, means for exciting said poles and a ball bearing between said flanges having a race on one flange and a curved race on the other flange for permitting said flanges to rotate concentrically but in non-parallel planes.

In testimony whereof, I have signed my name to this specification.

MILTON E. THOMPSON.