May 24, 1938. A. G. CARPENTER, JR 2,118,589

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Fig. 1

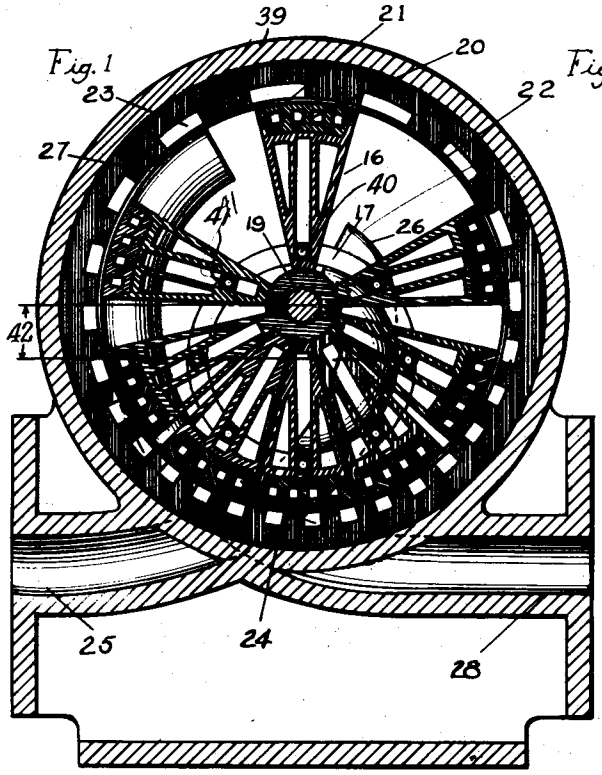


Fig. 2.

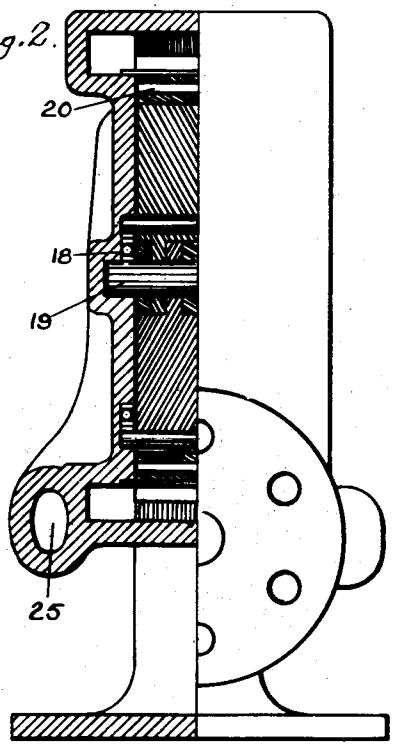


Fig. 4

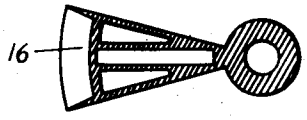


Fig. 3.

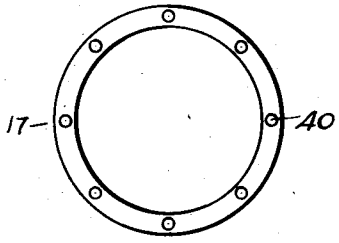
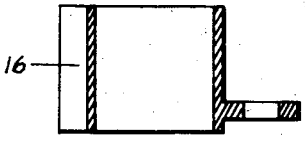


Fig. 5



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Fig 1A

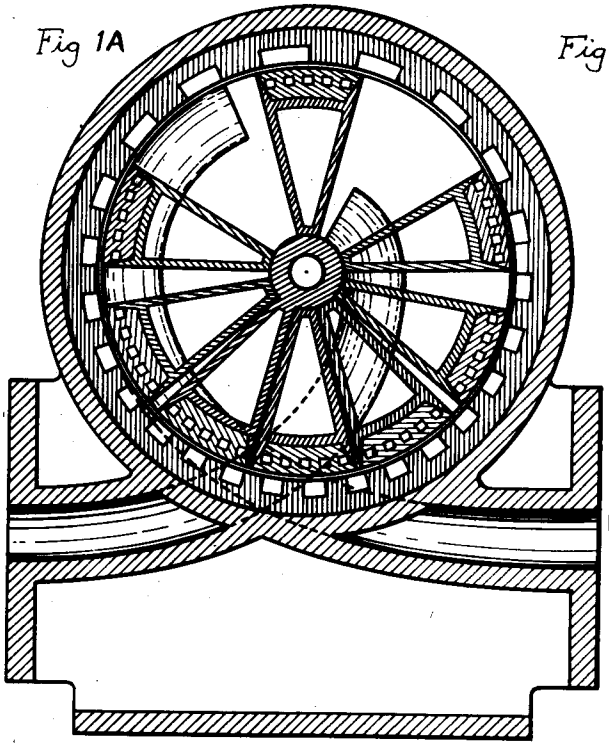
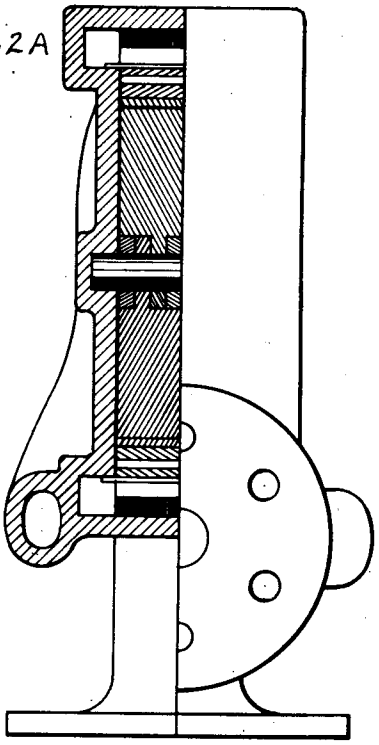


Fig 2A



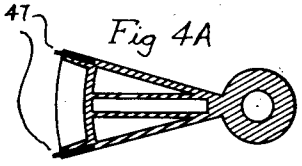
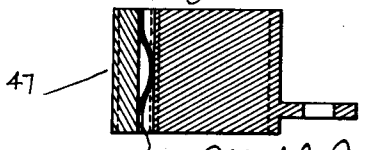


Fig 4A

Fig 5A



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Fig.3A



Fig.3B



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Fig 1B

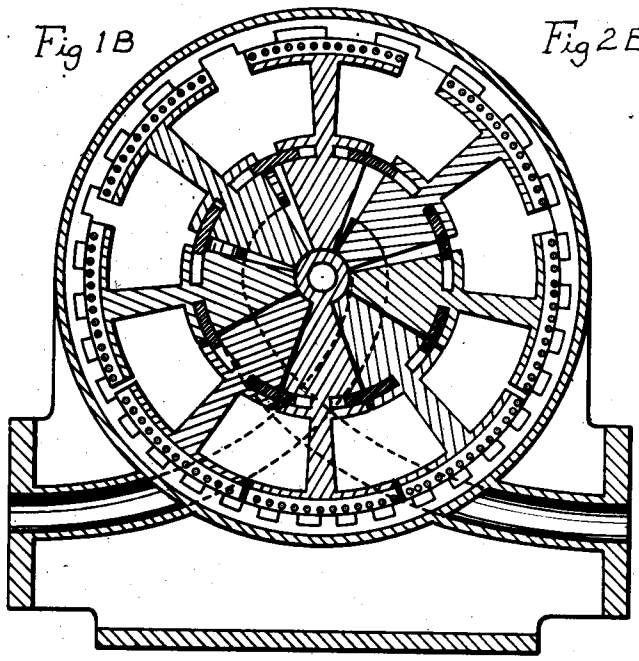


Fig 2B

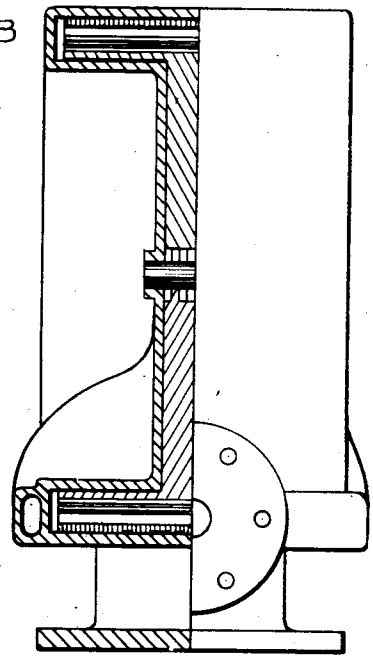


Fig 15

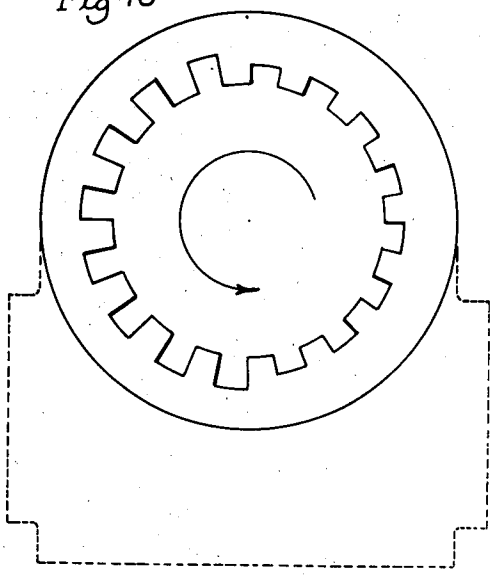
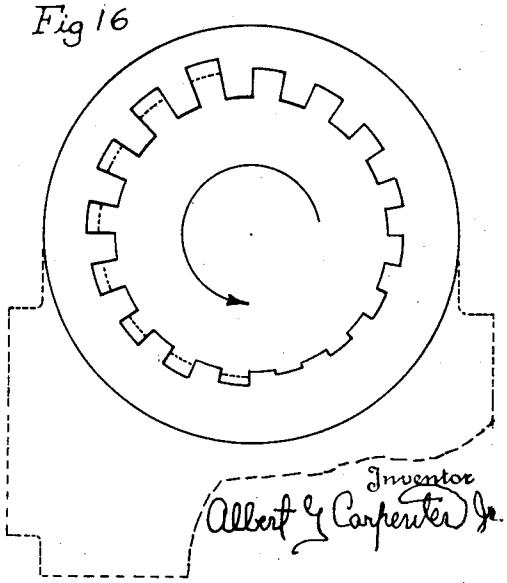


Fig 16



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Fig. 6

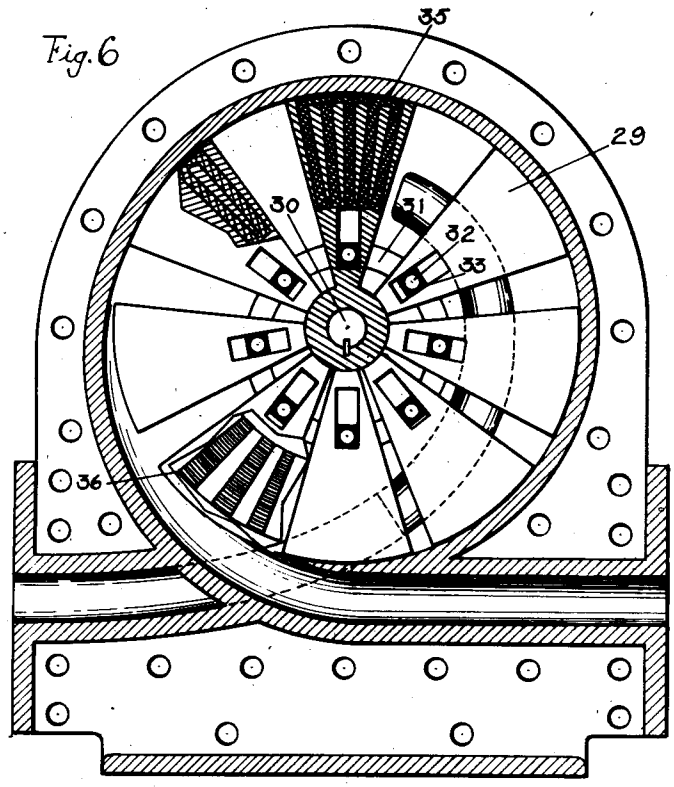


Fig. 7

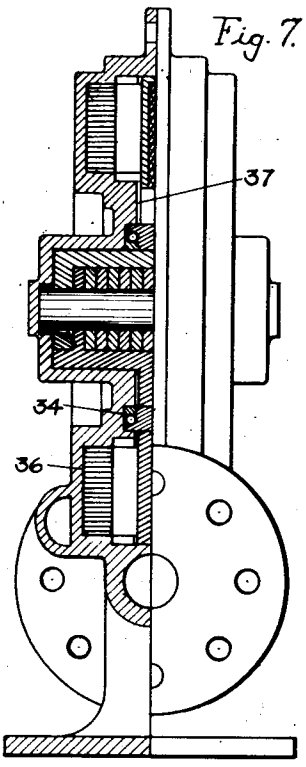


Fig. 8

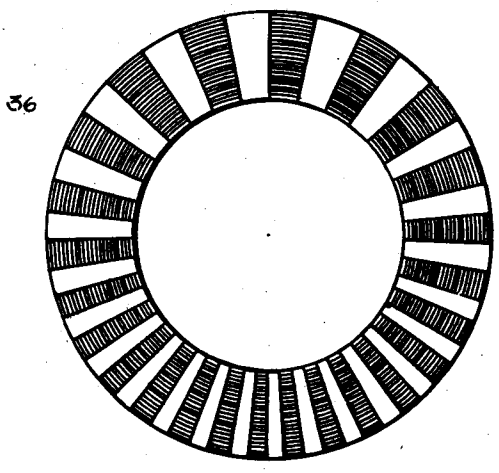


Fig. 9

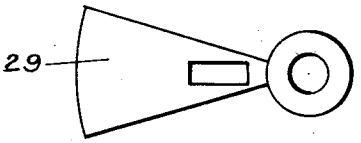
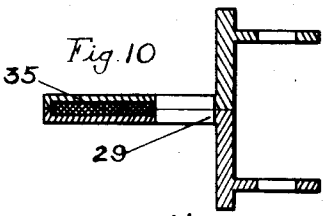


Fig. 10



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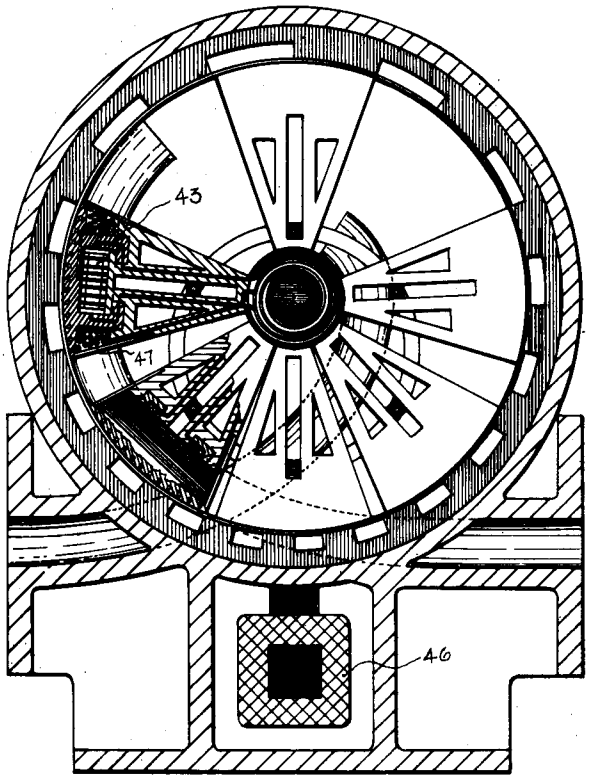


Fig. 11.

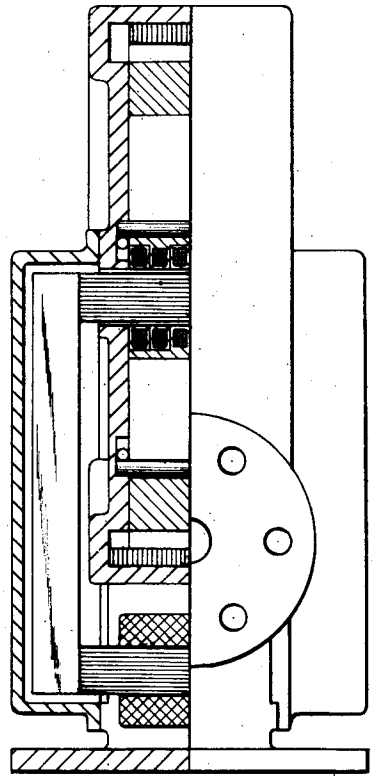


Fig. 12.

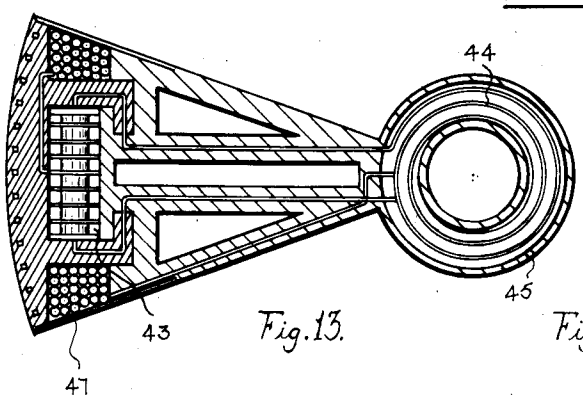


Fig. 13.

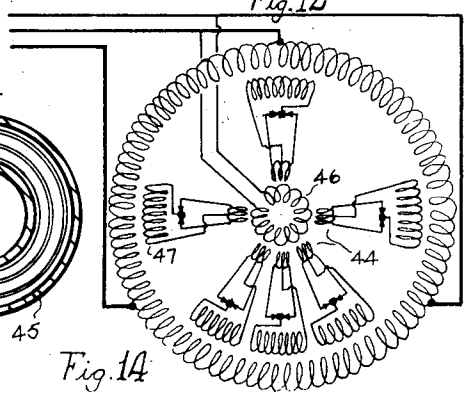


Fig. 14.

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Patented May 24, 1938 2,118,589

UNITED STATES PATENT OFFICE

2,118,589

PUMP

Albert Guy Carpenter, Jr., Yonkers, N. Y.

Application June 11, 1934, Serial No. 730,047

14 Claims. (Cl. 103—118)

My invention relates to an electromagnetic means in pump mechanisms for actuating pumps or parts of pumps requiring progressively varying speed or which are subject to progressively varying load during a cycle of operation.

An object of my invention is to construct a pump having the characteristics of a centrifugal pump, such as unrestrained flow by means of a volute and pressure variations corresponding to the square of the speed, yet retaining those characteristics of a rotary pump such as self-priming against a suction head and positive displacement and including within the pump itself a means of progressively driving each impeller individually and independently without mechanical connection to same in such a way as to relieve the pump of any stress or strain which might occur if direct mechanical driving means were used to affect the pumping action.

Another object is to simplify the construction of devices of this character.

A further object is to cheapen the construction of a combined motor and pump.

A further object is to increase the life and efficiency of such devices.

Fig. 1 is a transverse sectional view of one embodiment of applicant's electrically driven pump where the electromagnetic driving force is progressively applied at the periphery of the rotating impellers.

Fig. 2 is a longitudinal semi-sectional view of the pump of Fig. 1.

Figure 1A is a transverse sectional view of the electrically driven pump of Figure 1, but with the mechanical aligning cage in the pump of Figure 1 omitted.

Figure 2A is a longitudinal semi-sectional view of the pump of Figure 1A.

Figure 1B is a transverse sectional view of an electrically driven pump of the type of Figure 1A where the electromagnetic driving force is progressively applied at the periphery of an extension of the impellers, the pumping section at the center of the structure.

Figure 2B is a longitudinal semi-sectional view of an electrically driven pump of the type shown in Figure 2A where the width of the electrical windings is considerably greater than the impeller width.

Fig. 3 is a side view of the mechanical aligning cage which is shown in the pump of Figs. 1 and 2.

Fig. 4 is a radial sectional view of one of the segmental impellers used in the pump of Figs. 1 and 2.

Figure 3A shows an axial view of a grooved crosshead member as used in the aligning cage of Figure 3.

Figure 3B shows a longitudinal view of the crosshead member of Figure 3A.

Fig. 5 is an axial sectional view of the impeller of Fig. 4.

Figure 4A is a radial sectional view of a segmental impeller with sealing vanes also applicable to the pump of Figures 1 and 2.

Figure 5A is an axial sectional view of the impeller of Figure 4A.

Fig. 6 is a transverse sectional view of another embodiment of applicant's electrically driven pump where the electromagnetic driving force is applied at the sides of the rotating impellers.

Fig. 7 is a longitudinal semi-sectional view of the pump of Fig. 6.

Fig. 8 is a view along the axis of the special radial induction field structure used in the pump of Figs. 6 and 7.

Fig. 9 is a radial view of one of the segmental impellers used in the pump of Fig. 6.

Fig. 10 is an axial view of the impeller of Fig. 9.

Fig. 11 is a transverse sectional view of a further embodiment of applicant's electrically driven pump where synchronous operation is obtained by providing the impellers with magnetic excitation of fixed polarity.

Fig. 12 is a longitudinal semi-sectional view of the pump of Fig. 11.

Fig. 13 is a radial sectional view of one of the impellers used in the pump of Figs. 11 and 12.

Fig. 14 is the circuit wiring diagram of the pump of Figs. 11 and 12.

Figure 15 is a transverse view of a special induction field structure applicable to the pump of Figures 1 and 2 with all poles equally spaced, but with the magnetic strength of poles varying in one revolution according to the pumping force required.

Figure 16 is a transverse view of a special induction field structure applicable to the pump of Figures 1 and 2 with all poles equally spaced, but with the strength of poles designed for minimum slip loss in addition to the variation in strength per revolution according to the pumping force required.

In drawings: Figs. 1 and 2 show the end elevation and side view, respectively, of the pump which consists of a casing or housing, **39**, a plurality of impellers, **16**, each mounted to pivot concentrically with the pump housing; each impeller is free to move relative to any other impeller about the pump center but is constrained from doing so by eccentrically mounted auxiliary

aligning discs or rings, 17, imbedded in the pump casing and running on low friction bearings, 18. The aligning disc, 17, has pins or lugs, 40, protruding from its surface and riding in cross-head bushings, 41, these pins are equi-distant about a circle concentric with the disc circle, the latter is eccentric to the impeller circle or casing by an amount, 42. In the pump shown the two eccentric discs and their connecting pins form a cage, Fig. 3, which holds the impellers in their correct positions as they rotate within the casing.

The disc, 17, does not constitute a major driving member driven externally by some mechanical means, but in the case of this pump the disc is allowed to remain free, merely acting as a spacing member, while the impellers are driven by separate means. The pumping action desired is obtained by the spreading apart and closing in of the impellers, which are guided in their motion by the eccentric control members and also by the special driving means to be described, in such a way that as the impellers, 16, pass by the suction opening, 26, they start to spread apart in a uniformly progressive manner, creating a displacement between adjacent impellers drawing fluid through the suction inlet, 25, and trapping said fluid between them, carrying fluid around the pump casing until the impellers converge at the discharge opening and expelling the fluid by a combined centrifugal and squeezing action between impellers causing the fluid to pass out of the pump through the discharge volute, 28.

The impellers, 16, of the pump are constructed essentially as illustrated in the drawings and are wedge shaped members, although this shape is not necessary to operation. It is advisable to make these impellers as light as possible and of skeleton design. Sealing vanes 47, not shown in pump of Figures 1 and 2 but illustrated in the modified vane of Figures 4A and 5A, applicable to this type of pump may be placed in the periphery, obtaining their sealing action through centrifugal force, or by springs 48, but the large surface afforded along the outer section of each impeller provides a highly efficient seal especially if fluid works its way into the impeller casing and remains there during operation. A by-pass 49 to allow any trapped fluid to pass by the oscillating cross-heads Figures 3A and 3B in the form of grooves cut into same should be provided to obviate jamming if the fluid is incompressible.

Each impeller, however, in its periphery has imbedded in it a suitable electrical winding, 20, generally taking the form of rotor bars as used in a standard induction motor, these bars being placed in laminations, 21, to increase the electrical efficiency, and short-circuited at each end.

Outside of these impellers and separated from same by a suitably thin wall of non-magnetic high resistance material, 22, which may take the form of a glass compound, a stainless steel or steel alloy, a composition insulating compound molded in between the poles, or any other suitable substance which will not be reacted upon by the fluid pumped, not to be unduly affected by heat and having high non-abrasive qualities, lies a second winding, 23, taking the form of the stator or stationary winding of this electrical pump, the electrical poles of which may be completely separated from the rotating impellers by the separating substance, or may be protruding through same in suitable slots formed for the purpose; nevertheless, the windings being completely sealed by close fits and by the use of sealing compounds from the impeller casing.

It is essential that the separation between the rotor windings, 20, and the stator windings, 23, be an absolute minimum.

The unique and fundamentally new principle involved in this device is the non-symmetrical placing of the poles which are staggered about the periphery to conform essentially with the geometric motion of the impellers, and the fact that the winding reacts on each impeller individually instead of driving all impellers at once, as is done in most other combination motor-pumping devices of this nature.

The operation of this device is as follows: If the stator winding, 23, is of such a nature, that is, capable of producing a rotating magnetic field either by split-phase or multiphase currents or their equivalent, this field when current is flowing through the windings will set up currents in the rotor windings, 20, within the impellers, 16, the reaction of which will serve to drag the latter around in the direction of field rotation. Since the electrical field rotation with a constant frequency source is constant in speed it is necessary to make the distance traversed by the electrical field conform to the distance traversed by the impellers during their motion, or else there will be great positive and negative rotor slippage. That is, at some points the electrical field would be going considerably faster than the rotor sectors at those points, while at other points the rotor sectors would be going faster than the electrical field. This of course would be the result of the fact that the rotors are tied together mechanically by the cage, 17. Under heavy load conditions of pumping there would, of course, just be positive slippage, or no impellers would ever lead the field.

To obviate any great difference in motion between the impellers and the field, the pole spacing of the field, as mentioned above, is made to conform with the geometric motion of the impellers. That is, where the impellers come together there also are the poles placed closer together and where the impellers spread apart, there also are the poles separated to correspond.

From the nature of the device it is obvious that the greatest load will occur where the impellers are concentrated during the discharge half of the revolution, at the point, 24, in the discharge volute. The windings may therefore themselves be increased in strength during the discharge half so as to produce a maximum torque at discharge; or else they may be uniformly distributed, taking advantage of the eccentric spacing cage to transmit power from one section of the device to where it will do the most good at some other section; in fact, various constructions of electrical strength of windings may be resorted to, to relieve the cage of a non-uniform load.

If a very powerful electromagnetic field is used and the pump is not required to work against an appreciable head, the guiding cage may be dispensed with entirely. Such a modification is illustrated in Figures 1A and 1B showing a pump, identical in construction, element for element with the pump of Figures 1 and 2, but with the mechanical aligning cage and guide members merely omitted.

Figs. 6 and 7 show another method of construction of this pump, with the electrical windings placed upon the sides. With such construction very high torques may be obtained and consequently higher pressures in operation.

The operation of this pump is essentially the

same as the afore-described electrically driven pump having windings placed at the periphery.

The impellers, **29**, also shown separately in Fig. 9, supported on the shaft, **30**, and constrained in their motion of rotation by the eccentric ring, **31**, imbedded in the walls of the pump and riding on suitable bearings, **34**, through the pins, **32**, protruding from the rings and acting on the cross-head bushings, **33**, are constructed of a highly magnetic material, or else have magnetic laminations placed within their shells. Also imbedded in the impellers are radial rotor bars, **35**, short-circuited at their ends.

Imbedded in the walls of the pump adjacent to the electrical windings in the impellers is a stationary or stator magnetic field winding, **36**, also shown in Fig. 8, of eccentric pole construction, that is, having an irregular pole pitch designed to conform essentially with the geometric motion of the impellers, **29**. The poles of this stator winding are either separated from the impellers by a very thin separating wall, **37**, of high resistance non-magnetic material having a high anti-abrasive quality adequately resisting heat and being impervious to chemical attack by the pumped fluid or else these poles protrude through suitable slots cut within the wall of this material so as to make the distance between stator poles and impellers a minimum.

Split phase or multiphase currents flowing through the windings of the stator set up currents, the fields of which oppose the stator field and cause the impellers to be dragged around in the direction of and after the rotating stator field. Thus the impellers are each individually driven by the electrical field and the load of pumping is uniformly distributed, greatly relieving the strain upon the guiding ring cage, **31**.

It is possible to stage this pump very easily so that enormous pressures may be obtained in the final stage. If the fluid is compressible, the various stages may be decreased in size the proper amount to insure complete displacement with or without intercoolers.

This electric driven pump may also be constructed as a synchronous device having synchronous windings with pole facings in each impeller and receiving their D. C. excitation by making the shaft contain the primary winding of a transformer, the pivot ringlets containing the secondary windings and each impeller containing a small copper oxide rectifying unit to convert the alternating current to direct current from whence it is fed into the field poles of the rotor in each impeller.

This scheme is illustrated in Figs. 11 and 12 showing the copper oxide rectifier units, **43**, placed in each impeller member, the coils, **44**, in the pivot ringlets, **45**, through which the flux from the external alternating exciting field, **46**, flows and which sets up currents which flow through the copper oxide rectifiers and the field pole coils imbedded in each impeller member, Fig. 13. The circuit diagram of the hook-up of this particular drive is shown in drawings, Fig. 14, with the numbers corresponding to those above.

With such an arrangement as above, the power factor of the combination motor and pump may be controlled at will by varying the excitation on the rotating impeller field poles.

There are other methods of constructing this pump to obtain high torques, such as placing the windings an extreme distance from the impellers, that is, having the pumping section of pump at center with the windings at a considerable distance from same to increase the torque arm as illustrated in Figure 1B.

In the case of the pump described in Figs. 1 and 2, the width of the impellers may be made small, while the width of the windings may be made much greater as shown in Figure 2B.

The important advantages of the electrical pump drive are these: The use of the windings which are completely sealed from the fluid pumping section of the pump, place the driving force of the pump in the exact positions most suitable for same, namely, upon each individual impeller.

The nature of the electric drive also tends to remove the strain upon the pump since each impeller is driven ifidividually and the electrical field tends to smooth out the shock resulting from the accelerations and decelerations of the impellers for the same reason that amortisseur windings are placed in synchronous electrical machines to prevent hunting of the same; the electrical field not only drives the impellers but produces a drag upon them which greatly smooths out operation.

The use of electrical windings also eliminates the necessity for any driving mechanism external to the pump casing. Hence the pump may be sealed up tight, having only an inlet and an outlet, eliminating all stuffing boxes and relying upon the pumped fluid for lubrication, although some auxiliary means for lubricating may be resorted to.

This feature of being able to seal the pump completely is a decided advantage, especially in the pumping of volatile substances such as ammonia in refrigerating machines.

In cheap, low pressure small volume pumps, it is not necessary to use staggered electrical poles, especially if the stroke per impeller is kept low, nor is it even necessary to use laminations or rotor bars in the impellers, especially if the latter are made of a magnetic and electrical conducting material.

Since a small torque is applied during the suction period on the impellers it is even possible to construct this pump with all poles equally spaced but making the magnetic strength of the poles along the suction sector of less strength than those along the pumping sector, with the poles along the latter designed for minimum slip, thus the effect of great negative slip along the suction sector will not be felt greatly in the machine. Two variations of such a field winding applicable to the mechanically spaced impeller-type of pump of Figures 1 and 2 is shown in Figures 15 and 16.

Having described my invention, I claim:

1. In combination a pump comprising a casing with inlet and outlet, impeller members rotatably mounted in the same plane on a shaft but movable with respect to one another in such a way that a progressively periodic variation in their spacing during rotation creates a displacement between adjacent impellers and an electromagnetic field adjacent the impellers and adapted to drive and control the same, said field having the same center as the axis of rotation of the impeller members and having poles the spacing or pitch of which varies progressively about the field to correspond to the spacing and motion of the impellers.

2. A pump comprising a casing with inlet and outlet, a support, impellers rotatably mounted upon the support and movable with respect to one another, an electromagnetic field adjacent

the impellers and adapted to drive the same, said field comprising poles the spacing of which varies progressively with the required spacing of the impellers during rotation, positive auxiliary means for controlling the spacing of adjacent impellers progressively from minimum to maximum during rotation of the impellers.

3. A pump comprising a casing with inlet and outlet, impellers rotatably mounted and movable with respect to one another, an electromagnetic means for applying a variable driving and controlling force individually to each impeller in proportion to the spacing from each adjacent impeller, auxiliary means for positively controlling the impellers so that the spacing of adjacent impellers varies progressively from minimum to maximum during any one rotation, and said auxiliary means being independent of the previously mentioned driving and controlling means.

4. A pump of the type in which flow is produced by progressive variation in the spacing of impellers, comprising a casing with inlet and outlet passages for fluid impellers rotatably supported within the casing, and movable with respect to one another, and an electromagnetic means to drive and control each impeller individually at a speed proportional to the spacing of said impeller from each adjacent impeller, and an auxiliary means for constraining the spacing of each adjacent pair of impellers from a certain minimum to a certain maximum during each rotation and to a certain amount at any one point in the rotation, the progressive increasing of the spacing between impellers drawing the fluid into the pump and the progressive decreasing of the spacing forcing the fluid out of the pump.

5. A pump comprising a casing with inlet and outlet passages, impellers rotatable within the casing and movable with respect to one another, and an electromagnetic field comprising progressively variably spaced poles about the impellers, adapted to drive the same individually at speeds corresponding to the spacing of the poles to which they are adjacent, so as to maintain the progressive spacing above specified, auxiliary means for controlling the spacing of the impellers so that the spacing between each adjacent pair of impellers varies from a definite minimum to a definite maximum and is a definite amount at any one point in each rotation, the progressive increase and decrease in the spacing of the impellers causing fluid to be drawn into and forced out of the pump.

6. In combination, a pump casing with inlet and outlet, impellers rotatably supported and movable with respect to one another in the same plane of rotation and electromagnetic field, comprising progressively variably spaced poles, devoid of mechanical connection with the impellers to drive the same individually at varying speeds so that the speed of each impeller varies progressively from a definite minimum to a definite maximum during each rotation and is the same for any given point in each rotation.

7. A pump comprising a casing with inlet and outlet passages, impellers rotatably supported in the casing and movable with respect to one another in the same plane of rotation and electromagnetic field comprising progressively variably spaced poles, devoid of mechanical connection with the impellers to drive the same individually at varying speeds so that the spacing of adjacent impellers varies progressively from a minimum to a maximum during each rotation and is the same for any given point in each rotation, the progressive increasing and decreasing of the spacing drawing fluid into and pushing it out of the pump.

8. In combination, a pump casing with inlet and outlet, impeller members rotatably mounted in the same plane on a supporting member and movable with respect to one another, and electromagnetic field comprising progressively variably spaced poles, devoid of mechanical connection with the members, to drive the same individually at varying speeds so that the spacing of each pair of adjacent impellers varies progressively from a minimum to a maximum during each rotation and is a given amount for any particular point of rotation.

9. A pump comprising a casing with inlet and outlet openings, a stator structure fixedly mounted in the casing and comprising progressively variably spaced poles, impeller members rotatably mounted within the casing adjacent the stator structure and movable with respect to one another, the said impellers being so driven by the electromagnetic field set up by the poles of the stator structure that speed of any one impeller and its spacing from each adjacent impeller are proportional to the spacing of the poles which it is adjacent; auxiliary means also mounted within the casing to constrain the movement of the impellers so that the spacing between each adjacent pair of impellers varies from a minimum to a maximum in each rotation and is a fixed amount during any one point of the rotation.

10. A pump comprising a casing with inlet and outlet, impellers rotatably mounted within the casing and movable with respect to one another, a stator structure comprising a series of progressively unequally spaced poles about the impellers, the impellers being driven by an electromagnetic field set up by the stator structure in such a way that the speed of any one impeller and its spacing from each adjacent impeller is proportional to the spacing of the poles to which the particular propeller is adjacent.

11. A pump comprising a casing with inlet and outlet openings, impeller members mounted for rotation within the pump, means to control the volume contained by each pair of adjacent impellers and the casing from a definite minimum to a definite maximum during each rotation and to a definite amount at any given point of rotation, and an electromagnetic field having poles about the impellers to drive the same, the spacing of said poles varying progressively in proportion with the volume contained between each adjacent pair of impellers immediately opposite the poles and the casing, the progressive increasing and decreasing of the volume between impellers and casing causing fluid to be drawn into and forced out of the pump.

12. A pump comprising a casing with inlet and outlet openings, impeller members mounted for rotation within the pump, and electromagnetic field comprising progressively variably spaced poles to drive the impellers with varying forces in the amount required by the changes in volume between each adjacent pair of impellers and the casing, auxiliary means to control the volume contained by each pair of adjacent impellers and the casing from a definite minimum to a definite maximum during each rotation and to a definite amount at any given point of rotation, the progressive increasing and decreasing of the volume between impellers and casing causing fluid to be drawn into and forced out of the pump.

13. A pump of the type in which flow is produced by progressive variation in the spacing of rotating impellers, comprising a casing with inlet and outlet passages for fluid impellers rotatably supported within the casing, and movable with respect to one another, said impellers comprising poles of a synchronous electrical machine arranged to receive excitation electromagnetically from an external source through coils and rectifiers imbedded within said impeller shells and a separate electromagnetic constraining means to drive and control each impeller individually at a speed proportional to the spacing of said impeller from each adjacent impeller, and an auxiliary means for constraining the spacing of each adjacent pair of impellers from a certain minimum to a certain maximum during each rotation and to a certain amount at any one point in the rotation, the progressive increasing of the spacing between impellers drawing the fluid into the pump and the progressive decreasing of the spacing forcing the fluid out of the pump.

14. A pump comprising a casing with inlet and outlet passages, impellers rotatably supported in the casing and movable with respect to one another, in the same plane of rotation, said impellers comprising poles of a synchronous electrical machine, arranged to receive excitation electromagnetically from an external source through coils and rectifiers imbedded within said impeller shells and a separate electromagnetic means devoid of mechanical connection with the impellers to drive the same individually at varying speeds so that the spacing of adjacent impellers varies progressively from a minimum to a maximum during each rotation and is the same for any given point in each rotation, the progressive increasing and decreasing of the spacing drawing fluid into and forcing it out of the pump.

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