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April 18, 1961 J. F. McCARTHY 2,980,022

CONDUCTIVE FLUID PUMP

Filed Oct. 23, 1956 2 Sheets-Sheet 1

FIG. 1

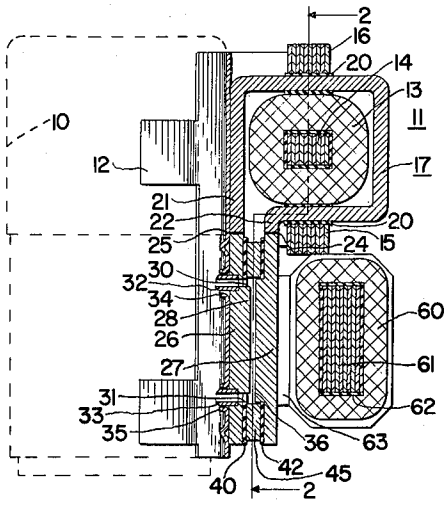
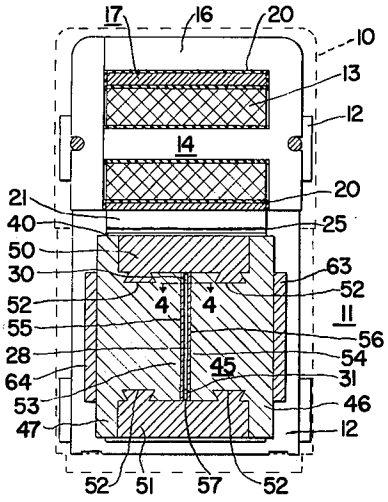


FIG. 2



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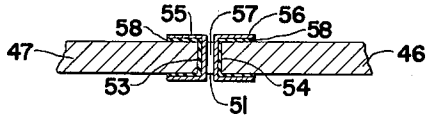
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FIG. 4



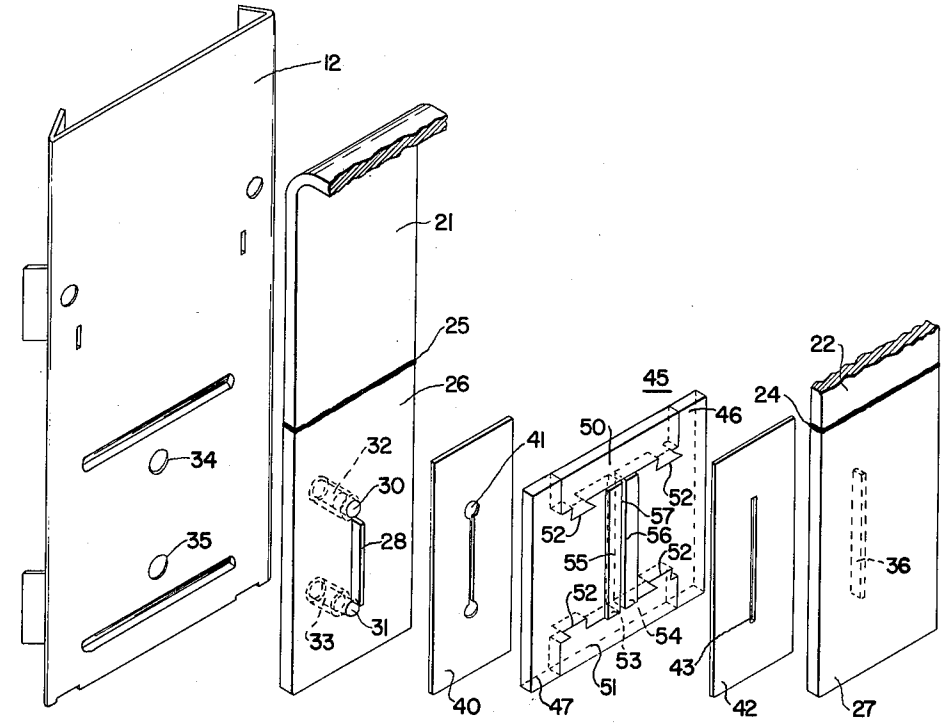


FIG. 3

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CONDUCTIVE FLUID PUMP

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4 Claims. (Cl. 103—1)

The novel device disclosed is directed to an unusually small and compact conductive fluid pump that is highly efficient, and more specifically the invention is directed to the construction of the pumping channel.

The electromagnetic conductive fluid pump was recognized by Faraday and commonly carries his name. For the most part in the past the Faraday pump has been a laboratory curiosity and has utilized mercury as the conductive fluid which was pumped. The principles involved in the Faraday pump can be applied to any conductive fluid and are well known to those versed in the art. At the present time many conductive fluids are known and the use of a Faraday pump to move these fluids has become common. It has also become common to utilize the Faraday pump principles in connection with flowmeter type devices where the liquid moving is conductive in nature.

For the most part any device using the Faraday principles has been large mechanically and quite simple to build. The parts have been large enough to work or join by use of conventional shop practices. Originally the devices were built up having a fluid flow channel that was made of an electrical insulating material that had some form of electrode welded, soldered, glued, or cemented in place and was satisfactory from an electrical standpoint. In more recent years fluids that are highly corrosive have been introduced that would be desirable to be moved by use of the Faraday type of pump but due to the corrosive nature of the liquid the insulating material used as part of the channel became inadequate. It then became necessary to construct the entire channel of a high electrical resistance steel and weld or join electrodes into the sides of the channel. This created a loss of efficiency by the fact that part of the current was diverted through the walls of the channel. While the loss of current was not severe, the principal problems of construction limited the reduction of size of the channel to that one easily handled in a conventional shop or laboratory.

It has become desirable now to build a Faraday type flowmeter, pump, or other conductive fluid flow device with a fluid channel that is much too small to utilize conventional shop techniques. It also became necessary to construct a unit that would easily withstand the more corrosive fluids and which had a minimum loss of efficiency by diversion of current in the walls of the channel. More specifically, the physical size of the channel became limited to a cross section of approximately 0.010 by 0.050 inch. It is obvious that the welding and common shop practices used in the past were not suitable to construct a substantially all metal channel that was of such small cross section.

It is an object of this invention to disclose a fluid flow channel for a Faraday type pump which is exceedingly small in cross section.

It is a further object to disclose a device which can be constructed having a substantially all metal fluid flow channel unaffected by the fluid being handled.

Still another object is to provide a device which is conveniently fabricated while still having a high efficiency for its size.

These and other objects will become apparent when the following is considered with the two sheets of attached drawings. It is understood that the drawings represent only one possible embodiment, that of a pump, wherein:

Figure 1 is a cross section of a conductive fluid pump having the novel channel construction;

Figure 2 is a cross section of the pump of Figure 1 along line 2—2;

Figure 3 is an exploded view of the components of the pump which make up the fluid flow channel, and

Figure 4 is a cross section along lines 4—4 of Figure 2.

Shown in phantom in Figures 1 and 2 there is disclosed a conductive fluid operated device **10**. The exact nature of the fluid operated device **10** is immaterial to the disclosure of the novelty of this particular invention and has been shown only for the sake of continuity. The conductive fluid pump is shown generally at **11** mounted on the side of device **10**. A mounting bracket **12** is attached by any convenient method to unit **10** and forms a flat platform upon which the pump **11** can be mounted. The pump **11** consists of a step down transformer having a primary winding **13** mounted on the center leg **14** of a laminated transformer structure which has two outer legs **15** and **16**. A single turn secondary **17** is formed of a strap of solid copper. The copper strap **17** is insulated electrically by winding of insulated tape **20** so that the strap **17** does not come in electrical contact with legs **14**, **15** or **16** of the transformer. This particular type of transformer construction is well known to those versed in the art and the particular step down transformer considered in the disclosed embodiment supplies an alternating current of approximately 200 amperes at 50 millivolts. In some embodiments a current could be supplied by a direct current source or other energizing means. Leg **21** of strap **17** is joined directly to bracket **12** and helps form the necessary support for the transformer arrangement. Leg **21** is further attached to electrode **26** by a welded or soldered joint at **25**. The leg **22** of strap **17** is joined to electrode **27** by welding or soldering at junction **24**. The legs **21** and **22**, joints **24** and **25**, and electrodes **26** and **27** can best be seen in the exploded view of Figure 3.

Electrode **26** is formed of a rectangular section of copper which has a centrally located copper fin **28**. This copper fin is rectangular in cross section and can be formed integral with electrode **26** or may be formed separately from **26** and attached by any convenient method. Electrode **26** further has two holes **30** and **31** which pass through the electrode at each end of fin **28**. Each of the holes **30** and **31** has inserted into it a small metal tube **32** and **33**. The tubes **32** and **33** pass through holes **34** and **35** contained in the bracket **12** and thence into the device **10** (in a manner not shown). It is understood further that the junctions between tubes **32** and **33** and the device **10** and pump **11** are fluid tight and thereby form the fluid control passages from the pump **11** to the device **10**.

The electrode **27** is formed similar to electrode **26** in that a fin **36** is attached to the electrode **27**. The fin **36** is long enough to correspond to the fin **28** plus the diameters of holes **30** and **31**. It will be noted that the electrode **27** is solid and that it has no openings, as no passages are required through this electrode to provide any functional operation.

A piece of electrical insulating material in the form of a tape **40** is inserted adjacent the electrode **26** and

has an opening 41 which corresponds to the diameter of holes 30 and 31 and the fin 28. The tape 40 is an electrical insulating member which is cured by heat and pressure to form a bond between itself and any adjacent metal surfaces. The reason for this particular piece of tape will become apparent in the description below and will not be expanded upon at this point. A second piece of tape 42 having a slot 43 is inserted adjacent electrode 27 and the slot 43 fits over the fin 36 of the electrode. The composition of tape 42 is identical to that of 40.

A magnetic pole structure 45, best seen in Figure 3, is inserted between the pieces of tape 40 and 42. The magnetic pole structure 45 consists of two identical pole pieces 46 and 47 as well as two nonmagnetic, metallic spacers 50 and 51. The nonmagnetic, metallic spacers 50 and 51 have a plurality of keys 52 which interlock with key-ways in the pole pieces 46 and 47. By this arrangement it is possible to lock the two pole pieces 46 and 47 into a parallel, spaced relationship and to form a leak tight joint across the ends of these pole pieces. At the inner edges of pole pieces 46 and 47 there are two pole faces 53 and 54. These two pole faces are parallel and are spaced approximately 0.010 inch from one another in the preferred embodiment. The two pole faces or parts 53 and 54 are covered by a metal foil 55 and 56 which is composed of a high resistance steel which is impervious to the corrosive effects of fluids which are to be handled by the pump 11. The foils 55 and 56 are held in place by means of a coating of an insulative type of adhesive or bonding material 58, as best seen in Figure 4. The thickness of foils 55 and 56 and adhesive 58 have been exaggerated in an effort to show these items clearly. It will be understood that these foils and adhesive are each in the neighborhood of 0.001 of an inch thick, or less.

The magnetic structure 45 is inserted between tapes 40 and 42 such that the slots 41 and 43 of the tapes are in alignment with the gap or channel 57. It will be also noted that when the device is assembled that fins 28 and 36 form two opposite walls of the channel 57 and thereby a rectangular passage having two walls of copper and having two walls of a high resistance steel is formed. When the electrodes, tape, and magnetic structure 45 are assembled a fluid tight passage or channel 57 results by applying heat and pressure to the assembly. The tapes 40 and 42 soften under the application of heat and bond themselves in a fluid tight relationship with the adjacent metal surfaces. When the unit is removed from a heat treating zone with pressure applied to the assembly, the unit cools to form a single fluid tight channel from tube 32 through the upper end of channel 57 and lengthwise in channel 57 to its bottom. The channel or tube is then completed from the bottom of the channel 57 through the tube 33. It is easily seen therefore, that a fluid flowing from a device 10 through the tube 32 can be operated upon by pump 11 in the channel 57. Since the fluid contained in device 10 and in the channel 57 is of a conductive nature it will be apparent that a current will flow from the transformer secondary of strap 17 through the electrodes 26 and 27 to their fins 28 and 36. The current will then flow from the surface of the fin 28 through the fluid in the channel 57 to the opposite fin 36.

In order that a pumping pressure or force be developed in the fluid in channel 57, it is necessary to have a magnetic field across the channel 57 from poles 46 to 47. This magnetic field is supplied by a second coil 60 of any convenient number of turns of wire. The coil 60 may be selected to be energized from any convenient alternating current source depending upon the type of energization that is supplied to coil 13. Coil 60 is insulated from a laminated magnetic structure 61 by insulating core 62. The laminated magnetic structure 61 is attached to two magnetic end pieces 64 and 63 which are joined to the magnetic poles 46 and 47 by any convenient manner. It will be seen therefore that the flux generated by the energization of coil 60 passes through the poles 46 and 47 thereby creating a magnetic flux across the channel 57. In an embodiment using a direct current energizing means, coil 60 can be powered by direct current or structure 61 replaced by permanent magnets. The flux across channel 57 is at right angles to the direction of current flow between fins 28 and 36 and thereby a force is developed along the direction of the length of channel 57 according to the principles recognized by Faraday.

The construction disclosed by the applicant yields an electromagnetic fluid conduction pump which is exceedingly small, compact, and easily built. In view of the physical size of the pumping channel 57 it is obvious that conventional methods of assembly such as welding, soldering, or cementing would be of little or no avail in supplying the fluid tight channel which would be capable of handling highly corrosive fluids. Liquids which are typical of these corrosive fluids are liquid sodium, and combinations of sodium and potassium. A liquid composed of a combination of sodium and potassium is normally fluid at normal ambient temperatures. It is therefore obvious that this type of fluid could be used in this particular design of pump and that a pump channel 57 would have to be supplied which would be capable of withstanding their highly corrosive action. The arrangement disclosed was proved highly successful in developing substantial pressures at nominal electrical power inputs to both of coils 13 and 60.

It is obvious that the teachings of the applicant could be applied to a channel devoted to electromagnetic fluid pump as well as to the use of flow meters and such devices where the pressure was supplied in lieu of the electrical current between fins 28 and 36. With this particular arrangement, if a pressure were supplied an electrical output would be developed across the channel 57 and the amount of current would be indicative of the flow of the fluid in channel 57. With this in mind the applicant believes that the teachings disclosed could be applied to numerous types of devices and situations and thereby wishes to be limited only by the appended claims.

I claim as my invention:

1. In a device of the class described: a fluid flow device having a conductive fluid filled channel; two electrodes forming first opposite walls of said channel; two magnetic poles covered with an insulative type of bonding material; a thin covering of high electrical resistance metal impervious to said conductive fluid attached to said bonding material to conform to the contour of said magnetic poles; said poles covered with said electrical resistance metal forming second opposite walls of said channel; said bonding material acting to electrically insulate said poles from said high electrical resistance metal as well as hold the high electrical resistance metal in place; and an electrical insulating material located between said magnetic poles and said electrodes; said walls of said channel further being sealed fluid tight with said electrical insulating material.

2. In a conductive fluid pump of the class described: two spaced electrodes; two spaced magnetic pole pieces interposed between said electrodes and covered with an insulative type of bonding material; a thin covering of high electrical resistance metal impervious to said conductive fluid attached to said bonding material to conform to the contour of said pole pieces; and an electrical insulating material insulating the electrodes and pole pieces from each other to form a fluid tight channel; said bonding material acting to electrically insulate said pole pieces from said electrical resistance metal as well as hold the electrical resistance metal in place.

3. In an electromagnetic liquid metal pump: two parallel spaced electrodes; two spaced magnetic pole pieces

interposed between said electrodes; said pole pieces including pole faces having a covering of an electrical resistance adhesive material; a thin high electrical resistance metal foil held on said pole faces by said adhesive material to conform to the contour of said pole pieces; an electrical insulating material sealing between the electrodes and the pole pieces to form a liquid tight channel; energizing means attached to said electrodes to pass a current therebetween through said liquid metal; and flux generating means further generating a magnetic flux between said pole pieces normal to said current flow; said current and flux creating a force in said liquid metal to move said liquid metal in said channel.

4. In a device of the class described: an electromagnetic conductive liquid metal pump having a liquid filled pumping channel and further including energizing means; two electrodes forming first opposite walls of said channel; said electrodes connected to said energizing means to pass a current therebetween; two magnetic poles including pole pieces forming the second opposite walls of said channel and including flux generating means; a part of said pole pieces further having a coating of an electrical resistance bonding material; said coating of an electrical resistance bonding material holding a thin foil of high

electrical resistance metal which is unaffected by said liquid; said foil conforming to the contour of said pole pieces to protect said pole pieces from said liquid metal; and the walls of said channel sealed fluid tight with an electrical insulating material; said current and flux being normal to each other in said channel and creating a force in said liquid to move said liquid through said channel.

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