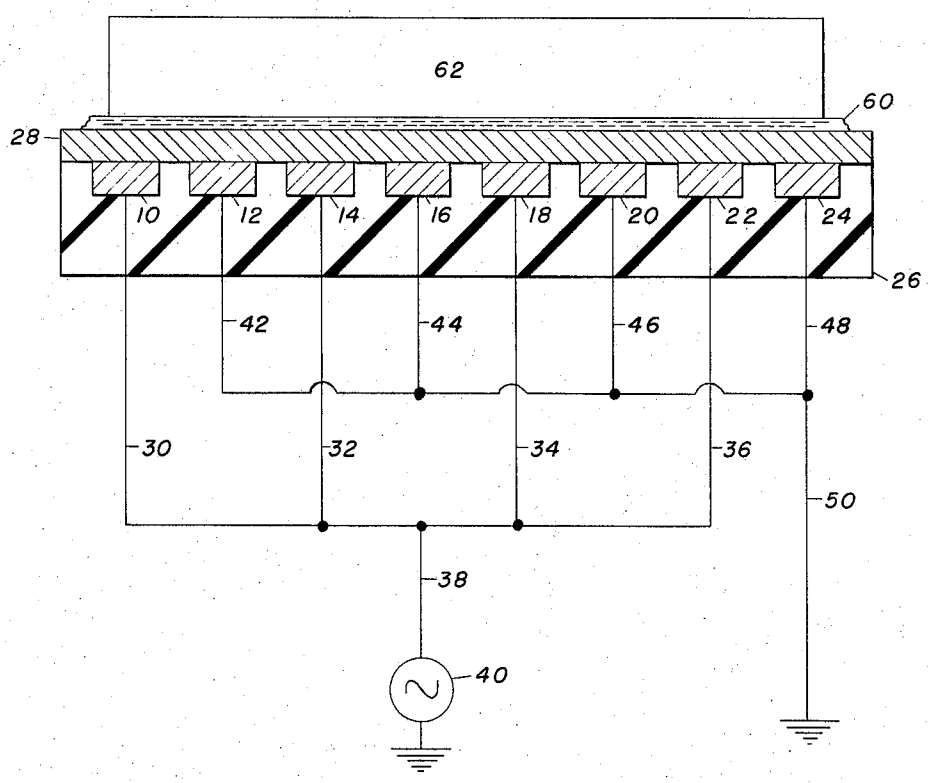
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ELECTRO-VISCOUS FLUID CHUCK

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ELECTRO-VISCOUS FLUID CHUCK

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This invention relates to an improved electro-viscous fluid chucking device and method for energizing the same.

It is known that certain fluids respond to the presence of alternating electric fields by manifesting a dramatic and reversible change in apparent bulk modulus. It is further known that these fluids, called electro-viscous fluids, exhibit an apparent change in bulk modulus under the influence of an alternating electric field, where the field is applied directly across the electro-viscous fluid film, and the electro-viscous fluid is in contact with both electrodes, as is taught, for example, by the United States patents to Winslow, 2,661,596, and 2,661,825. It is further known to the prior art that if a film of electro-viscous fluid is disposed on a thin layer of dielectric material, a conductive object is placed on or in the electro-viscous fluid film, and a polyphase electric field is applied to the film by means of electrodes disposed on the opposite side of the dielectric layer from the film, the electro-viscous fluid film, when energized by the electric field, will secure the object firmly in place. Thus electro-viscous fluid chucking devices were designed to provide a plurality of electrodes having flat upper surfaces, over which a layer of dielectric material could be secured. The electrodes were arranged in three sets, each set comprising one or more electrodes, and each set being connected to one pole of a three-phase power source. A layer of electro-viscous fluid was disposed on top of the dielectric layer, and the object to be secured positioned in or on the electro-viscuous fluid film. It was further known in the prior art that where the electro-viscous fluid employed was of itself non-conductive, the layer of dielectric material, such as barium titanate, could be eliminated, provided care was taking to insure that the object held by the chuck did not short-circuit the electrodes.

It has now been discovered, most unexpectedly that electro-viscous fluid chucking devices may be operated on single-phase alternating potential, by connecting alternate electrodes in the chucking device in parallel, and to one terminal of the single-phase potential source, and connecting the remaining electrodes in parallel to the other terminal of the potential source. An object placed in the fluid film is securely held in place, and under the application of a constant force will not move or "chatter" as the applied potential changes in magnitude and at any instant is zero in magnitude. This lack of chattering or intermittent motion of the secured object under applied load, even at alternating current frequencies as low as 60 cycles per second, is most surprising, since the response time of electro-viscous fluids is known to be extremely short, and the apparent change in condition of the electro-viscous fluid in the presence of an applied potential is known to be reversible.

It is an object of this invention to provide an improved method for connecting and energizing an electro-viscous fluid chuck. Another object of this invention is to provide an improved electro-viscous fluid chucking device. Other objects of the invention will become apparent from the following description.

The invention is best described with reference to the drawing, which shows a sectional view of a conventional electro-viscous fluid chuck connected in accordance with the method of this invention. Electrodes **10**, **12**, **14**, **16**, **18**, **20**, **22**, and **24** are imbedded in a non-conductive base member **26**, which is composed of an insulating material such as a thermoplastic or thermosetting resin, an epoxy resin, or other plastic material of high resistivity. The electrodes are provided with flat upper surfaces, and may be made of steel. The electrodes are covered with a layer **28** of material with high resistivity, high dielectric strength, and high dielectric constant, such as barium titanate. Electrodes **10**, **14**, **18**, and **22** are connected in parallel by electric lead wires **30**, **32**, **34**, and **36** through common lead wire **38** to one terminal of a single-phase, A.C. power supply **40**. Electrodes **12**, **16**, **20**, and **24** are connected by lead wires **42**, **44**, **46**, and **48** in parallel and through common lead **50** to the grounded (other) terminal of A.C. power supply **40**. An electro-viscous fluid film **60** is spread on top of the layer of barium titanate, and an object to be secured (block **62**), is placed in contact with the electro-viscous fluid film. When the chucking device is energized by potential source **40**, the block **62** is secured firmly to the dielectric layer **28**.

Various modifications of the device specifically described are possible. For example, the block **62** may be conductive or non-conductive, but where the lower surface of the block is not conductive, it is necessary to employ an electro-viscous fluid which in itself contains some conductive material. Where the object to be secured is conductive, or has a conductive lower surface in contact with the electro-viscous fluid, a conventional non-conductive electro-viscous fluid may be employed, and the layer of dielectric material may be eliminated altogether, provided that care is taken to prevent the object from touching and short-circuiting the electrodes. It is evident that the object to be secured must have a smooth surface, but this surface need not necessarily be flat. For example, the object to be secured may have a cylindrical lower surface, and may be secured by a chuck having electrodes arranged such that their upper surfaces are flush but form a cylindrical surface corresponding to that of the object to be secured, rather than a flat surface. The total number of electrodes employed in the chuck is not critical, but the electrodes must be divided into two sets, one set being connected to each terminal of a single-phase power source. The single-phase power source need not have one terminal grounded, though this expedient may be helpful in reducing shock hazard. Potentials applied will ordinarily be large, say 500 to 5,000 volts. The power requirements of the chuck, however, are infinitesimally small.

The operability of the method and apparatus of this invention has been demonstrated experimentally using an electro-viscous fluid chuck made up of four electrode sets in an epoxy resin and covered with a thin coating of barium titanate. The lower surface of the metal object secured to the chuck had an area of about five square inches, and was maintained at a distance of about 0.006 inch from the surface of the barium titanate. A silica-based electro-viscous fluid was used. When the electrodes were energized by the application of 900 volts, single phase, and a lateral force of 15 pounds was applied to the test object, the test object remained securely attached to the chuck and showed no tendency to move or chatter. When the A.C. source was disconnected, the test object moved freely under a force of one pound or less.

While the electro-viscous fluids themselves form no part of the instant invention, and afford no limitations to the instant invention, silica-based electro-viscous fluids comprising about 40% by volume of desiccant-grade silica having a particle size less than ten microns, 5% by volume of glycerol monooleate, and 55% by volume of a highly refined white oil have been found to be satisfactory.

The embodiments of the invention in which an inclusive property or privilege is claimed are defined as follows:

An electro-viscous fluid chuck comprising a plurality of electrodes, each having a substantially smooth surface, said electrodes being arranged in spaced relationship with said smooth surfaces of the electrodes flush with each other, means for supporting said electrodes in electrically insulated relationship a thin layer of dielectric material adjacent said flush surfaces, a layer of electro-viscous fluid supported adjacent to said layer of dielectric material, first conductor means connecting alternate electrodes of said plurality in parallel, second conductor means connecting the remaining electrodes of said plurality in parallel and a single-phase alternating potential source of not less than 500 volts, one terminal of which is connected to said first conductor means and the other terminal of which is connected to said second conductor means.

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