Sept. 18, 1934. L. CAMMEN 1,974,235

METHOD AND APPARATUS FOR SURFACE TENSION DIALYSIS

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Fig. 1,

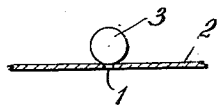


Fig. 2,

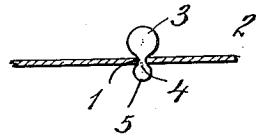


Fig. 3,

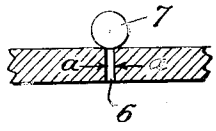


Fig. 4,

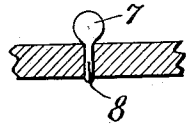


Fig. 5,

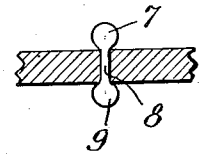
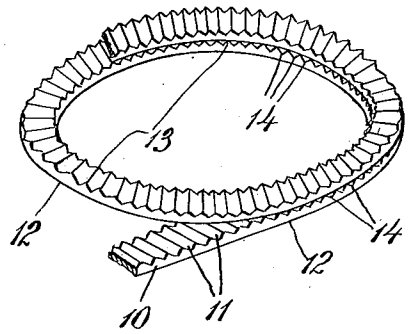


Fig. 6,



INVENTOR
Leon Cammen
BY
Pennie, Davis, Marvin & Edmonds
his ATTORNEYS

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Fig. 7.

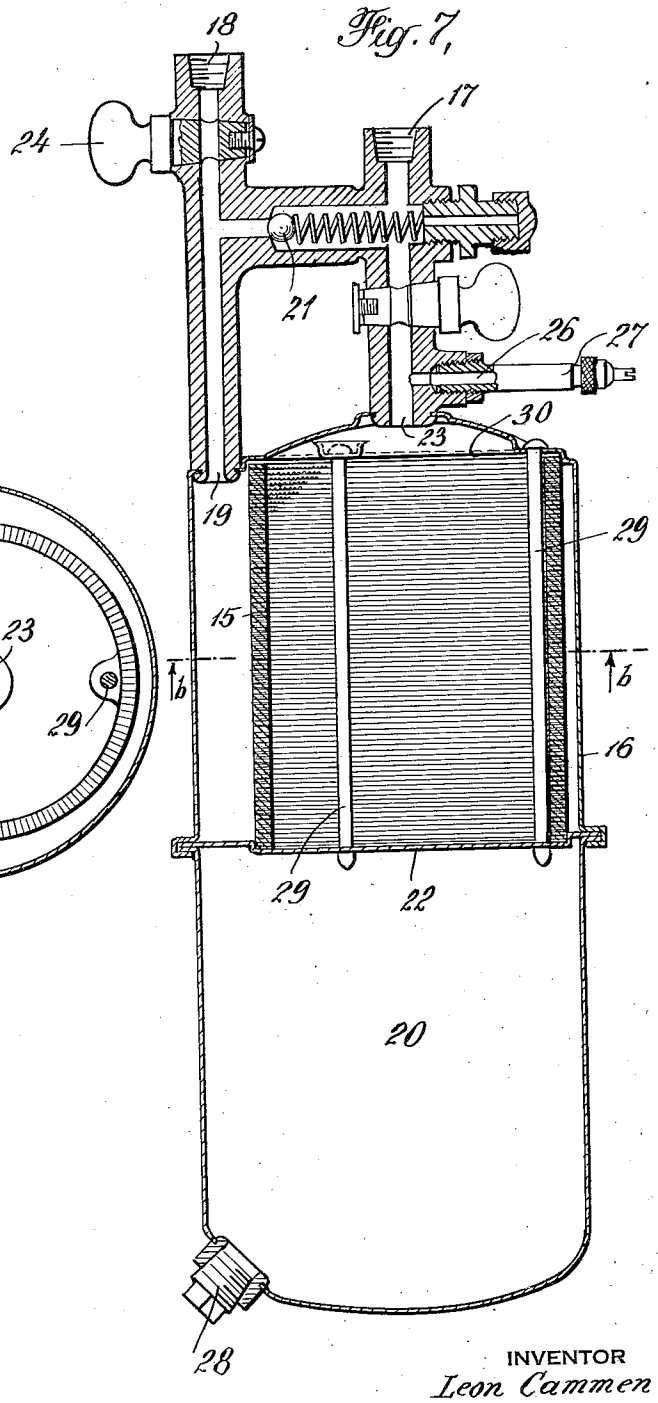
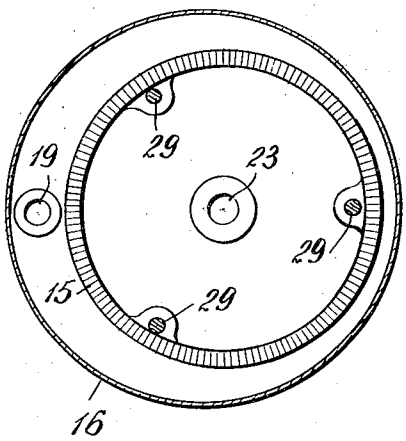


Fig. 8



INVENTOR
Leon Cammen
BY
Pennie, Davis, Marvin & Edmonds
his ATTORNEYS

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METHOD AND APPARATUS FOR SURFACE TENSION DIALYSIS

Leon Cammen, New York, N. Y., assignor to Preston Davie, New York, N. Y.

Application October 18, 1932, Serial No. 638,329

3 Claims. (Cl. 210—169)

This invention is directed to the selective separation of commingled liquid masses, such as liquid from commingled liquid, liquid from commingled suspensions sludges, water, emulsions, and the like. To this end the physical chemistry phenomena and property of liquids known as "surface tension" is employed in a novel manner.

Surface tension may be explained in terms of the molecular forces that hold a body of liquid together. These molecular forces are most strikingly manifest at the surface of a liquid and may be considered in terms of surface energy.

Now, liquid particles, due to the forces above explained, tend to, and do, assume globular form because the sphere is the geometrical form which gives to the greatest cubical content the least superficial area to which a liquid body may contract. Thus, whenever the surface of a liquid globule or sphere (or a liquid globule formed about a solid particle as a nucleus) is increased by substantially deforming it, for example, stretching to a considerable length, a surprisingly large amount of energy is required which gives rise to the phenomena known as surface tension.

As a general rule, the surface tension exhibited by one liquid differs from that of another and it is an object of this invention, among others, to provide an improved method and apparatus whereby the lubricating oil in a lubrication system may be selectively recovered in purified form from contaminating constituents commingled therewith by taking advantage of the different surface tensions possessed by the oil on the one hand, and the contaminating constituents, such as liquid sludges, suspensions, emulsions, water, etc., on the other.

It is well known that lubricating oil possesses a low surface tension, while the contaminants such as sludges, suspensions, emulsions, water and the like, usually present in a lubricating oil system possess different and greater surface tensions.

In accordance with the invention, I provide what will be termed a surface tension dialyser. Such a dialyser may be generally described as a foraminous element having a substantial but uniform thickness, and wherein a myriad of uniform and substantially identical macroscopic (in contradistinction to microscopic) foramina provide a myriad of macroscopic continuous passages of substantially greater length than the greatest dimension of cross section thereof, through which such a liquid as lubricating oil may flow as separate confined streams from one surface of the element to the other, upon the application of a proper predetermined and regulated effective pressure. The applied effective pressure must be carefully predetermined and regulated so as to bear a definite relation to the surface tension of the lubricating oil and contaminants thereof, and to both the greatest dimension of cross section of the uniform macroscopic passages and the length thereof. In any event, the difference in pressures between the inlet side of the dialyser element and the outlet side thereof should not exceed fifty pounds per square inch gauge pressure.

Furthermore, in accordance with the invention, the macroscopic foramina of the dialyser are preferably uniformly disposed throughout the element and should be of substantially uniform and identical cross section from one surface of the element to the other, throughout the thickness thereof.

As to dimensions, the macroscopic continuous passages formed by the walls of the foramina respectively, may be of the order of one hundredth (0.01) of an inch in their greatest dimensions of cross section normal to the direction of flow of the liquid, and their length of the order of four times the greatest dimension of cross section. If the greatest dimension of said cross section of the foramina is selected as five one-thousandths (0.005) of an inch or less, the length of the continuous passage should not be less than of the order of seven times the greatest dimension of cross section.

Good results have been obtained where all dimensions of cross section of the dialyser passages normal to the direction of flow were uniformly less than ten thousandths (0.010) of an inch, and in the direction of oil flow were not less than eighty thousandths (0.080) of an inch—the applied pressure being of the order of fifteen pounds per square inch, gauge pressure.

The mode of operation of the invention will be explained by considering the simple case of surface tension dialysing petroleum lubricating oil from water commingled therewith. It is well known that water possesses a high surface tension, while lubricating oil has a comparatively low surface tension. The method or process then comprises introducing the commingled lubricating oil and water onto said dialyser, applying to the commingled lubricating oil and water on said dialyser a regulated pressure bearing a definite relation to the surface tension of the lubricating oil and water, respectively, and to both the greatest dimension of cross section of said macroscopic passages normal to the direction of flow and the length thereof, to produce a flow of oil through said passages, whereby the flow of water, which

has a greater surface tension than that of lubricating oil, is substantially prevented.

It is only when macroscopic uniform continuous passages of the character described are employed with the proper applied pressure, that practical advantage may be taken of the surface tension phenomena for the purposes of this invention. The selective effect for a given applied presure increases both with the diminution in size of the largest dimension of said cross section of the passages respectively, and with increase in the length thereof, within practical limits. Thus, there are three variable factors, assuming the surface tensions of the oil and water as constants: The effective applied pressure, the greatest cross sectional dimension of the passage normal to the direction of flow, and the length of the passage. Each or all may be varied predeterminedly with respect to one another, depending upon the nature of the contaminants to be separated from the oil, as will be understood.

Thus, for a given pressure, macroscopic passages in the dialyser element having respectively their greatest dimension of cross section normal to the direction of flow, less than a given size, or where passages are of greater length, within the order of the relationship stated, will permit of only a relatively small volume of flow of lubricating oil—less than that which can be obtained with proper design of the element and still obtain the desired dialysis.

On the other hand, for a given pressure and with passages of the dialyser element above a certain size of greatest cross sectional dimension normal to the direction of flow, and in some cases irrespective of the length thereof, the attempt to secure surface tension dialysis will be frustrated by permitting a flow of a contaminant it is desired to prevent.

Referring now to "filters", as those devices are generally known, for the purpose of distinguishing my invention therefrom. A filter may be defined as a permeable septum so mounted that the material to be filtered can be brought to one side thereof at a pressure higher than that which exists on the other side. Under such circumstances, the pores and the like in the filter medium are of a suitable size so that the solid particles contained in the liquid are restrained or held back, while the liquid passes through. After the first short period of operation, the effective filtering medium is the layer of slime deposited on the original septum. This last described accumulation of a slimy deposit is most important in filter operation.

Now, the operation of my improved surface tension dialyser is not dependent upon any of the above described phenomena which occurs in filters. In the first place, with a surface tension dialyser it is distinctly disadvantageous in dialysing contaminated lubricating oil containing solid particles in suspension or otherwise, to permit of an accumulation of a slimy deposit on the surface of the dialyser. Thus, when utilizing my invention in the lubricating oil system of an automobile, airplane, motorboat or the like, the dialyser element is so arranged and mounted that the inherent vibration of the motor and automobile or airplane or boat dislodges such accumulation of liquid or solid particles which tend to form on the surface of the element, and causes them to fall into a sump or chamber located below the element which may be drained from time to time. In the second place, the foramina are of such dimension of cross section normal to the direction of flow, as to permit the passage of solid or liquid particle contaminants of such a size as to be unrestrained were it not for the fact that surface tension phenomena prevent their flow through the passages, as will be understood.

Referring now to so-called "edge" or "plate" filters, for example, of the type disclosed in Cuno Patent No. 1,657,346, usually made up of plates and separating elements—the passages in this type of filter are provided by separating the plates by means of thin narrow strips of metal or fine wire. Thus, one dimension of the effective filtering medium in this type of filter is determined by the thickness of the separating elements and the other dimension by the spacing of the separating elements. It is also necessary, with this type of filter, in order to obtain good filtering action, to permit of an accumulation of slimy material in the openings and on the surfaces of the plates and separating elements, although of course comparatively frequent cleaning is required to prevent clogging. This type of filter, however, will not continue to perform efficiently without frequent cleaning and it is not self-cleaning.

The passages in the plate or edge type filter are of the long narrow slot type. If, therefore, we assume, for exaggerated example, a sphere of liquid having a volume of one cubic inch and being positioned at the entrance of such a slot, then, if the sphere of liquid is subjected to pressure so as to stretch and deform it to enable its passage through a slot one-eighth inch wide and one inch long, the resultant form of the liquid will be a slab eight inches long, one inch wide and one-eighth inch in thickness. This slab of liquid will then contain the same volume of liquid (one cubic inch) as the original sphere.

Consider now a surface tension dialyser element of the type described, and again assume, for exaggerated example, a sphere of liquid one cubic inch in volume. Then assume again, for exaggerated example, a continuous passage having an opening one-eighth inch by one-eighth inch in rectangular cross section normal to the ultimate direction of flow. Now, in order to enable the sphere of liquid to pass through this opening and through the continuous passage, it must be stretched and deformed into a column of liquid sixty-four inches long by one-eighth inch wide and one-eighth inch in thickness to secure the same volume (one cubic inch).

As the ability of a liquid to pass through a fine orifice varies substantially with the amount of stretching it requires, we see that in the case of the long narrow slot the surface of the liquid sphere must be stretched only about three times, namely from approximately five square inches to 18.25 square inches. In the case of the liquid column, the surface of the sphere must be stretched on the order of six times, namely, from approximately five square inches to 32.31 square inches.

Thus little, if any, useful surface tension phenomena is permitted to become exhibited by liquids alone or liquid droplets containing a nucleus of solid material when subjected to the action of the edge or plate type filters.

In accordance with my invention, it is the relationship of applied regulated pressure with respect to the greatest dimension of cross section of the passage normal to the direction of flow which is first effective at the surface of the dialyser element, and the next controlling factor is the length of the continuous passage, meaning

thereby a passage closed end to end and formed by the continuous walls of the foramina respectively.

Undoubtedly adsorption phenomena plays some part in the operation of my improved surface tension dialyser. Thus, during the course of operation in accordance with my invention, the velocity of liquid flow through the element, induced by the application of the regulated pressure, tends to apply to the surface of the dialyser element not only the lubricating oil to be selectively recovered, but also the deleterious solids in suspension and other commingled liquids. But the surface presented to the constituents, the flow of which it is desired to prevent, is small in comparison with the effective surface available to be wetted by the oil. And, since the lubricating oil has a low surface tension, it flows into the passageways and wets them, thus preventing the other liquid constituents from so doing. Hence, adsorption assists the surface tension phenomena in preventing the passage of water, water emulsions and the like. Vibration, as pointed out hereinbefore, tends to dislodge particles tending to adhere to the surface of the dialyser element.

As an illustration of the application of the invention herein described, consider the case of lubricating oil in an internal combustion engine, e. g., the one on a motor car. Here two different groups of materials are encountered. One of them may be described as solid dirt, and may consist of road dust and particles of metal. The other consists of sludges from the oil, and water. Of these, the sludges provide most of the bulk of the material that has to be removed, and it has been found by actual measurements that from ten to twelve per cent of the oil by volume is converted into sludges by the various processes to which the oil is subjected. It therefore becomes very important to provide a chamber for the collection and holding of the sludge between drainings of the surface tension dialyser, the frequency of such drainings being entirely dependent upon the amount of sludge that can be retained or stored without impairing the action of the dialyser. In other words, the effective performance of the dialyser is directly related to the size of its sludge chamber.

Thus, with surface tension dialysers it is not desirable to permit the sludge to remain for long in contact with the dialyser surface. If sludge is permitted to accumulate and fill the chamber and to partially or entirely fill the space adjacent the dialyser element, and is left for too long in contact with the dialyser surface, particularly where there is a good deal of vibration, the liquid with the higher surface tension will tend to slip through the passages. For the same reason the use of scrapers and similar devices for removing contaminants from the surface of a dialyser element is highly undesirable since they would aid in tending to permit the sludge and the like to enter the passages and thus counteract the surface tension dialysis which is the purpose of the use of the specially designed elements herein described.

The manner of constructing my preferred form of surface tension dialyser element, as well as the mode of operation of the invention, will be apparent from a consideration of the following description, considered with the drawings, in which:

Fig. 1 illustrates diagrammatically, and on a greatly enlarged scale, a globule of liquid poised at the entrance of a macroscopic passage in a thin plate;

Fig. 2 shows the liquid globule in the course of its flow through the passage of Fig. 1;

Fig. 3 shows, on a greatly enlarged scale, a globule of liquid poised at the entrance of a single macroscopic passage whose length is substantially greater than the greatest dimension of its cross section;

Figs. 4 and 5 show the globule at different stages in the course of its distortion and flow through the passage shown in Fig. 3, upon application of a predetermined regulated pressure;

Fig. 6 shows, on a greatly enlarged scale, a strip of metal provided with macroscopic grooves on one surface thereof and the manner of winding the grooved strip helically upon itself to form a surface tension dialyser element in the shape of a hollow cylinder;

Fig. 7 illustrates a helically wound surface tension dialyser element assembled in a closed container, adapted for use in a lubricating oil system; and

Fig. 8 is a sectional view taken along *b*—*b* of Fig. 7.

Referring now to Fig. 1, assume the hole 1 in the thin plate 2 to be of the order of ten one-thousandths (0.010) of an inch in diameter, and the globule of liquid 3, having a certain surface tension, poised thereover, to have a substantially greater diameter. Neglecting other factors, the tendency for the globule is to remain in spherical form and poised as shown. A change from its spherical form to a shape whereby it will be enabled to pass through the hole requires a deformation or stretching of its surface which in turn requires an expenditure of energy. But, since the plate 2 is thin, the depth of the hole 1 is of the order of the diameter thereof, only a small stretching of the surface of the globule will be required. Upon the application of an externally applied force or pressure the formation of a meniscus 4 may be effected, just sufficient to project through the hole 1 in the plate 2, as illustrated in Fig. 2. As soon as some of the liquid shown at 5 has flowed through the hole 1 in the form of the meniscus 4, there will be a tendency to reform the globule as at 5. But a true sphere is not formed immediately because of the connecting meniscus 4. Once a sphere or globule has been formed, however, on the under side of the plate 2, the flow of liquid through the hole 1 takes place with only a small change in the total surface area of the globule.

Thus, we see that the tendency of a liquid to flow through a small orifice in a thin plate is only slightly retarded by the surface tension possessed or exhibited by the liquid. If we assume the presence of two commingled liquids poised above the orifice, one possessing a high shurface tension and the other a low surface tension, both liquids will flow through the hole 1 in the thin plate 2 upon substantially the same expenditure of energy, and hence there will be no selective effect.

Now, assume the macroscopic passage 6 of Fig. 3 to be of the order of ten one-thousandths (0.010) of an inch in its greatest dimension of cross section *a*—*a*, the globule 7 to have a substantially greater diameter than the dimension *a*—*a*, and the length of the passage 6 to be of the order of eight times said greatest dimension—eight one-hundredths (0.08) of an inch. Then the globule 7 must be deformed and stretched as shown in Figs. 4 and 5 to form the columnar meniscus 8. Thus, the globule 7 must be progressively elongated into a columnar meniscus 8 until it reforms on the underside as at 9, which represents a con-

tinuous and substantial change both in shape and surface area.

To accomplish this deformation there is required a very substantial stretching of the spherical surface and consequently a material expenditure of energy is required to bring this about. This expenditure of energy is directly proportional to the surface tension possessed by the liquid with respect to the greatest dimension of cross section of the passage and the length thereof. Such deformation upon the application of a given predetermined regulated pressure is readily accomplished with a liquid having a low surface tension, but a liquid having a substantially higher surface tension would require the application of a proportionately greater amount of energy and therefore a higher applied effective pressure.

Of course, if the applied effective pressure is very high, and bearing in mind that surface tensions of liquids do not attain high values, then all liquids would be forced through the passage 6, irrespective of their surface tensions.

Referring now to Fig. 6, which illustrates the preferred manner of constructing the surface tension dialyser element, 10 is a thin strip of copper, brass, or any other suitable material, in which grooves 11 have been formed on a surface thereof, for example, by means of a knurling tool. The strip 10 is then wound upon itself in a helical manner so that the resulting contour and shape is that of a hollow cylinder. As the strip is so wound, the ungrooved surface 12, contacts with the uniformly protruding portions 13, of grooved surface to form adjacent uniform macroscopic passages 14, from one surface of the cylinder wall to the other throughout the thickness thereof.

The greatest dimension of cross section of the passages 12 is determined by the dimensions of the groove and the smooth surface of the strip in contact with the protruding portions, as will be understood. The length of the passages 14 is determined by the angle of the groove with respect to the edges of the strip 10 and the width thereof, i. e., the thickness between cylindrical walls. These dimensions are selectively predemined with values of the order hereinbefore described.

Since uniformity of the passages 14 is required for efficient operation, the completed dialyser element should be constructed from a continuous strip of metal so that welding or soldering is not required. Soldering and welding tends to vary both the cross sectional dimensions of the passages at the point soldered or welded and the uniform contact with the smooth surface of the next adjacent helix.

Great care should be taken in the construction of the element to see that the grooving is effected in a uniform manner and that the helical winding of the grooved strip is progressively and evenly carried out, to avoid irregularities.

When the desired length of the resulting cylindrical dialyser element has been obtained by helical winding as described, the resulting cylinder formed of the helices should be clamped in position by some mechanical arrangement so that concentric smooth cylindrical surfaces are permanently obtained at both the inner and outer cylindrical walls of the element.

When the element is so constructed, the cooperation of the grooves 11 and the smooth surface 12 of the strip produces a myriad of uniform macroscopic continuous passages between the inner and outer cylindrical surfaces of the walls of the element, and such passages will be alike and of substantially uniform and identical cross section and length.

The mode of surface tension operation with the dialyser elements of Fig. 6 is analogous to that described in connection with Figs. 3, 4 and 5.

In Fig. 7 there is illustrated (in vertical cross section) a completely assembled, helically wound cylindrical dialyser element 15, arranged within a closed container 16 which is particularly adapted for the selective separation of lubricating oil and contaminating constituents commingled therewith in the lubricating system of a motor car, motor boat or airplane and the like.

The container 16 may be installed at any convenient point in a lubricating oil line adjacent the engine and crankcase, and to this end there is provided suitable connections 17 and 18 for inserting the dialyser element in a lubricating oil line through which contaminated lubricating oil may be circulated. In such a line it is customary to provide a circulating pump by means of which the contaminated oil may be continuously supplied under pressure to the dialyser element 15 through the connection 18 and inlet port 19.

At first, the lubricating oil and the contaminating constituents commingled therewith will fill the chamber 20 and then gradually fill completely the entire volume of the closed container 16 surrounding the dialyser element 15. As soon as the pressure to be ultimately produced by the circulating pump has been built up to a predetermined value, and as limited by the bypass valve 21 (which is generally set at of the order of fifteen pounds per square inch gauge pressure), oil will be caused to flow to the exclusion of the contaminating constituents commingled therewith, through the myriad of macroscopic passages in the dialyser element 15, from the outer surface to the inner surface thereof. Since the element 15 is sealed or closed at one end by the plate 22, the oil will then flow through the outlet port 23 and thence through the connection 17 back into the lubricating oil system.

As the lubricating oil is continuously and selectively separated from the contaminating constituents commingled therewith by the element 15, the contaminants, due to the force of gravity and to the vibration of the motor, will fall off or become dislodged from the surface of the dialyser element 15 and settle into the chamber 20.

This process is permitted to continue until the chamber 20 is filled. As soon as the chamber 20 is filled, which by observation and test occurs about every thousand miles of running, in the case of an ordinary motor car with an element and container such as illustrated in Fig. 7, the chamber 20 may be drained and the container 16 and the macroscopic passages of the dialyser element 15 may be completely evacuated of all oil and contaminants by closing both the cocks or valves 24 and 25 which are located in the inlet and outlet ports respectively in the following manner: At 26 there is provided an auxiliary port leading to the outlet port 23, through which compressed air may be admitted to the interior cylindrical surface of the dialyser element 15, by means of an ordinary air valve 27. Upon the application of air pressure to the valve 27, for example, from the compressed air supply systems carrying air at substantial pressures for tires and to be found in garages or filling stations, and upon removing the screw drainage plug 28 at the bottom of the chamber 20, and preferably stopping the engine, the whole container and

dialyser element may be blown out so as to discharge the entire contents thereof, including all of the contained oil but more particularly the contaminants which have accumulated in the chamber 20.

When this operation has been completed, the drainage plug 28 is again inserted, the air hose removed from the valve 27, and the cocks 24 and 25 turned to the position indicated in the drawings, whereupon the dialyser element is again ready to function.

In Fig. 8 there is illustrated a horizontal section taken along the lines *b*—*b* of Fig. 7, showing the dialyser element 15 mounted eccentrically within the closed cylindrical container 16. This manner of arranging the element has been found to be advantageous for the reason that it permits of sufficient room for the unobstructed entrance of the oil through an inlet port, such as 19.

The helices of the dialyser element are firmly clamped and held in position by the pins 29, as shown in Fig. 7. These pins 29 are arranged at three points adjacent the interior wall of the dialyser element as shown in Fig. 8. The pins 29 extend from the upper end of the element 15 to the lower end thereof, where they are secured in the metallic plate 22 which seals that end of the element 15 against the flow and leakage of oil or sludge and the like from the chamber 20 or otherwise, into the interior portion of the element 15. The pins 29 are also secured in the top of the container 16 which serves as a clamping ring 30 at the upper end of the element. This clamping ring, however, may be a separate ring if it is not desired to assemble initially the element 15 integrally with the top of the container 16. In either case, the element 15 is arranged to be sealed against undesired leakage of contaminated oil at both ends thereof.

It will be understood that the method and apparatus of this invention, while particularly adapted for use in a lubricating oil system as described, may be effectively applied to such other uses as removing impurities from oils employed in electrical transformers for insulating purposes, the de-waxing of oils, separating water from kerosene or gasolene, and like purposes, in physical chemistry processes. It will also be obvious to skilled workers that changes may be made in the construction and arrangements illustrated herein without departing from the scope of the invention as defined in the claims.

What I claim is:

1. Apparatus for surface tension dialysing lubricating oil and contaminating constituents commingled therewith in a lubricating oil system, comprising, a hollow cylindrical foraminous metallic element of substantial and uniform thickness between the walls thereof, the foramina being macroscopic and of substantially uniform cross section, and disposed throughout the element to form a myriad of macroscopic continuous passages of substantially greater length than the greatest dimension of cross-section thereof between the inner and outer cylindrical surfaces of the walls of the element the length of said passages being not less than of the order of seven times the greatest dimension of cross-section thereof, means for sealing one end of said cylindrical element, a closed container therefor, inlet and outlet ports in said container, means for continuously conducting commingled oil and contaminating constituents from the system to the inlet port and to one of the cylindrical surfaces of the element under a predetermined and regulated pressure related to the respective surface tensions of the oil and contaminating constituents and to both the greatest dimension of cross-section of the uniform macroscopic passages and the length thereof, means for continuously conducting oil from the other of said surfaces to the outlet port and back into said system, a chamber arranged in said container to receive and hold the contaminating constituents as they are separated from the oil, and a drainage port for said chamber.

2. Apparatus for surface tension dialysing lubricating oil and contaminating constituents commingled therewith in a lubricating oil system, comprising, a foraminous element having substantially concentric inner and outer wall surfaces in the form of closed curves, and of substantial and uniform thickness between the walls thereof; the foramina being macroscopic and of substantially uniform cross section, and disposed throughout the element to form a myriad of macroscopic continuous passages of substantially greater length than the greatest dimension of cross-section thereof between the inner and outer wall surfaces thereof all dimensions of cross-section of the passages being less than ten one-thousandths of an inch and the uniform length of the passages not less than eighty one-thousandths of an inch, means for sealing the inner wall surface against liquid access at one end of the element, a closed container for said element, inlet and outlet ports in said container, means for continuously conducting commingled oil and contaminating constituents from the system to the inlet port and to one of the surfaces of the element under a predetermined and regulated pressure which is related to the respective surface tensions of the oil and the contaminating constituents and to both the greatest dimensions of cross-section of the uniform macroscopic passages and the length thereof, means for continuously conducting oil from the other of said surfaces to the outlet port and back into said system, a chamber arranged in said container to receive and hold the contaminating constituents as they are separated from the oil, and a drainage port for said chamber.

3. In a lubricating oil system, apparatus for selectively separating lubricating oil and contaminating constituents commingled therewith, according to their respective surface tensions, comprising, a helically wound metallic strip provided with macroscopic grooves on one surface thereof, means for maintaining said helices under compression and in the form of a hollow cylinder, said grooves in cooperation with the adjacent ungrooved surface of the strip forming a cylindrical foraminous element having a myriad of macroscopic continuous passages of substantially greater length than the greatest dimension of cross-section thereof between the inner and outer wall surfaces of said cylinder all dimensions of cross-section of the passages being less than twenty one-thousandths of an inch and the uniform length of the passages not less than eighty one-thousands of an inch, means for sealing the inner wall surface against liquid access at one end of the element, a closed container therefor, inlet and outlet ports in said container, means for continuously conducting commingled oil and contaminating constituents from the lubricating oil system to the inlet port and to one of the cylindrical surfaces of the element under a predetermined and regulated pressure which is related to the respective surface tensions of the oil and

contaminating constituents and to both the greatest dimension of cross-section of the uniform macroscopic passages and the length thereof, means for continuously conducting oil from the other of said surfaces of the element to the outlet port and back into said system, a chamber arranged in said container to receive and hold the contaminating constituents as they are separated from the oil, a drainage port for said chamber and means for completely evacuating the container of its contents through said drainage port including the oil content within the said cylindrical element and its macroscopic passages.

LEON CAMMEN.