Sept. 22, 1953 N. J. ANGELO 2,652,975

CENTRIFUGAL COUNTERCURRENT EXCHANGE DEVICE

Filed Oct. 12, 1951 2 Sheets-Sheet 1

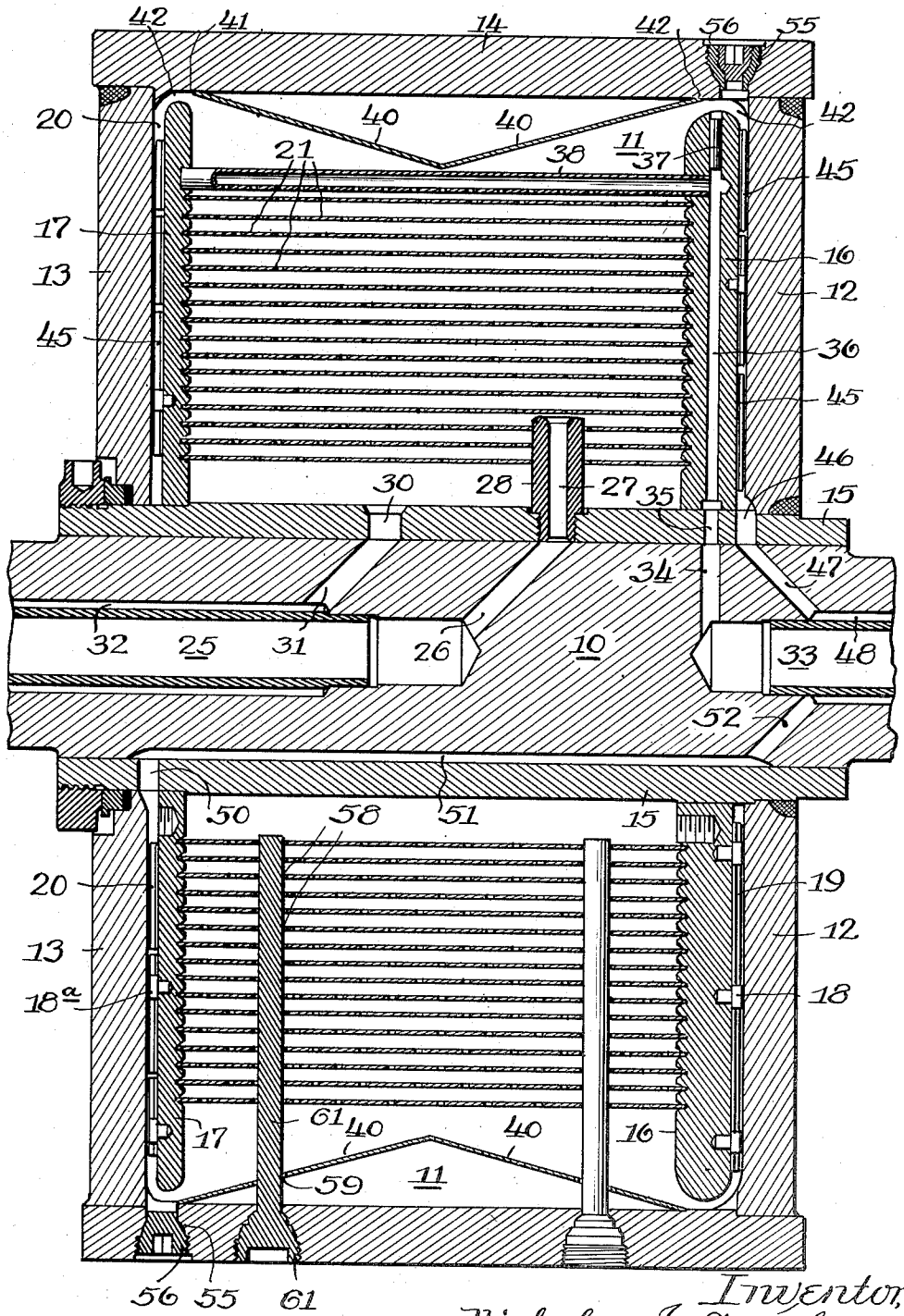


Fig. 1

Inventor,
Nicholas J. Angelo,
By: Schneider & Dressler,
Attys

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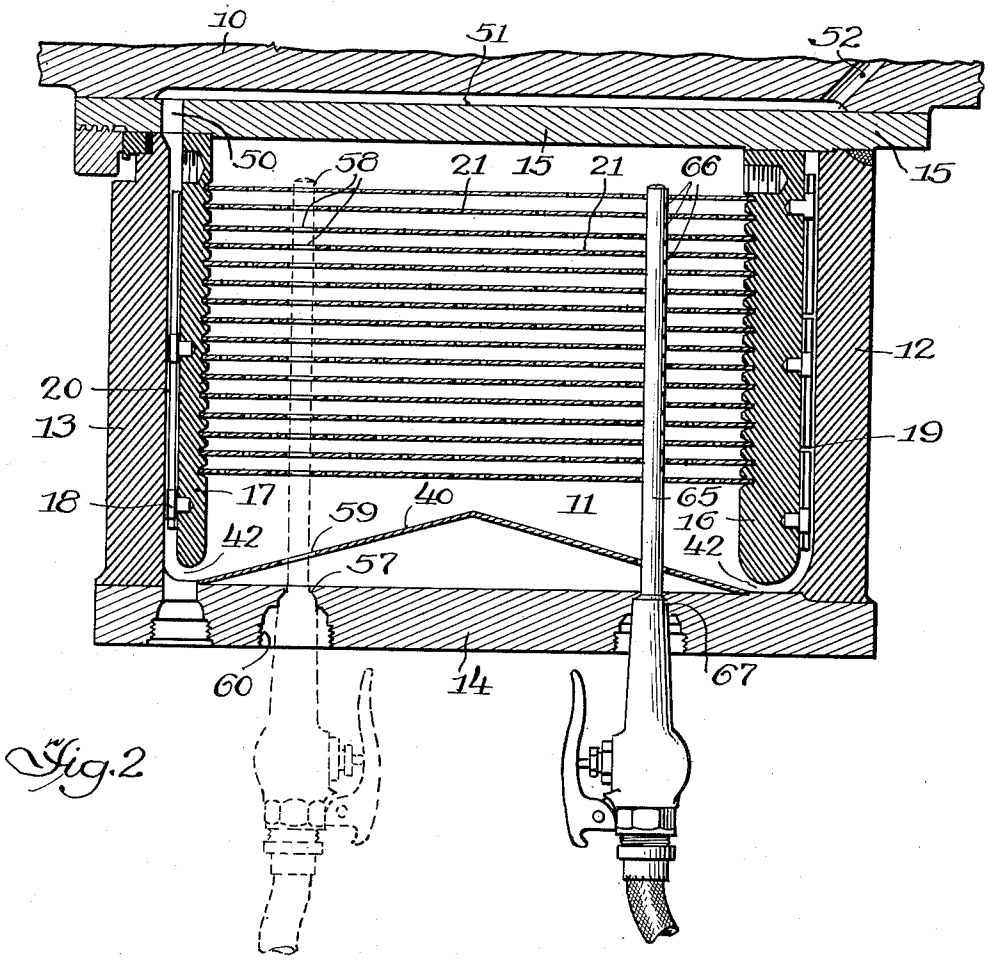


Fig. 2

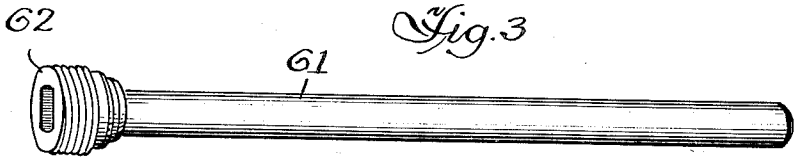


Fig. 3

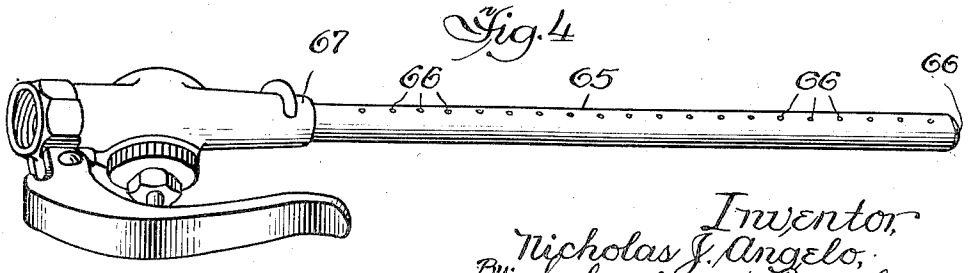


Fig. 4

Inventor,
Nicholas J. Angelo,
By: Schneider & Dressler,
Attys.

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CENTRIFUGAL COUNTERCURRENT EXCHANGE DEVICE

Nicholas J. Angelo, Evergreen Park, Ill., assignor to Walter J. Podbielniak and Wladzia G. Podbielniak

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3 Claims. (Cl. 233—15)

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The present invention relates to improvements in centrifugal countercurrent solvent extractors or exchange devices and more particularly to such devices provided with effective means to facilitate their inspection and cleaning.

In the centrifugal countercurrent contact devices hitherto employed for solvent extraction, such as are shown in the patent to Walter J. Podbielniak, No. 2,093,645, granted September 21, 1947, and in the pending applications of Walter J. Podbielniak, Serial No. 111,218, filed August 19, 1949, and Walter J. Podbielniak et al., Serial No. 239,992, filed August 2, 1951, countercurrent contact or solvent extraction processes and apparatus are disclosed which involve the use of at least partially immiscible liquids of different densities, one of which carries the material to be extracted and the other acts as the extracting medium. In such apparatus a number of spaced spiral turns or concentric partitions are provided in a rotor which is subjected to rapid rotation at speeds, for example, of 2,000 to 5,000 R. P. M. or higher. The spiral or concentric turns are generally provided with perforations, which may vary in size depending upon the character of the action desired within the rotor and, as pointed out in the application of Podbielniak et al., hitherto referred to, upon the presence of solids in varying amounts in the materials treated. When solids are present, even in small proportions, some of these solids may deposit upon the inner faces of the inner turns or partition within the rotor. In devices intended for the handling of liquids containing substantial amounts of solids, such as the mycelia-containing penicillin fermentation beers, even though the device be particularly designed for handling such solids-containing material, such deposits may be formed. The deposits of solids formed within the machine, to the extent that they are not removed in the normal operation of the machine, must ultimately be removed.

The nature of the action involved and the high speeds of rotation employed make inadvisable the formation of the rotor in parts which can be readily disassembled, since the centrifugal action produced in operation results in very substantial hydraulic pressures being developed and the high rates of rotation make it important to have as smooth an exterior surface for the rotor as is possible to avoid windage effects, vibration and the like. In accordance with the present invention, suitable means are provided for effecting inspection and cleaning of the interior of the rotor in such devices.

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The invention will be more fully understood from the following description, illustrated by the accompanying drawings in which:

Figure 1 is a longitudinal sectional view, through the rotor and parts of the supporting shaft of a device embodying the present invention;

Fig. 2 is a broken longitudinal section through a part of the rotor of Fig. 1, showing the use of a spray nozzle in position for effectively cleaning the interior of the rotor;

Fig. 3 is a side view in perspective of a plug used in carrying out the present invention; and

Fig. 4 is a side view in perspective of a spray nozzle of a type which may be used in connection with the present invention for effectively cleaning the interior of the rotor.

Referring more particularly to Fig. 1, the numeral 10 indicates in section the rotor shaft, which is provided internally with passages, preferably concentric, for the supply of heavy and light liquids to the interior of the rotor of the countercurrent centrifugal solvent extractor and for the removal of light and heavy liquids therefrom after they have passed through the machine. The rotor is indicated by the numeral 11, the disks 12 and 13 constituting its side walls and the cylinder 14 its outer wall. These parts are preferably welded together to form a unitary cylindrical casing which is mounted upon a sleeve 15, which, in turn, is mounted securely upon the shaft 10, for example, by a shrink fit.

Within the casing, the disks 16 and 17 are mounted on the sleeve 15 and are spaced from the walls 12 and 13 respectively by screw studs 18. The studs 18 are provided at suitable intervals to maintain uniform spacing between the inner disks 16 and 17 and the outer walls 12 and 13 respectively. In this way, inter-disk passages 19 and 20, of uniform width, are provided which may be utilized, as hereinafter pointed out, for the removal of heavy liquid from the outer portion of the interior of the rotor. For this purpose, the outer diameter of the inner disks 16 and 17 is such as to provide a free space between the peripheries of these disks and the inner surface of the cylindrical wall 14 of the rotor for the passage of the heavy liquid.

Between the inner surfaces of the inner disks 16 and 17 partition walls (shown as concentric rings 21) are mounted in grooves provided for the purpose, so as to surround or circumscribe the axis of the rotor. The rings 21 may be perforated in accordance with the purpose for

which the device is intended. Thus, when it is intended to operate upon liquids containing solids, such as the mycelia or residues of the organisms employed in the production of penicillin, chloromycetin, bacitracin and the like, finely divided iron or other metal used in various organic reduction processes, or vegetable or animal tissue materials present in oil extraction, vitamin concentration and the like, uniformly spaced perforations of say about ¼ inch in diameter may be employed, as set forth in the application of Podbielniak et al., hitherto referred to. When liquids free or substantially free of solids are under treatment, smaller openings or slots, variably spaced, may be employed. The perforations in adjacent partition walls or rings are preferably staggered or nonaligned with respect to one another. Likewise, the number and spacing of the rings may vary in accordance with the purpose for which the device is to be employed, the number of stages efficiency to be secured and the like. Instead of concentric rings, spiral turns may be employed, forming walls which may be similarly perforated, or may be imperforate, as shown in the prior patent to Podbielniak, above referred to.

In normal operation of the device, the liquids to be handled and between which countercurrent exchange is to be effected are immiscible or partially immiscible liquids of different densities, one of which carries a constituent which is to be removed from it by the solvent action of the other liquid. Thus, the heavy liquid may be an acidified penicillin beer, containing a greater or less proportion of the mycelia of the organism, depending upon whether clarification has previously been effected and if so, the extent of the clarification. The light liquid may be a suitable solvent for the penicillin contained in the beer, as for example, amyl acetate, butyl acetate or the like. These are merely illustrative of the types of liquids which may be employed in devices of the character here involved and in the ensuing description of the action taking place, the liquids involved will be designated respectively as the heavy liquid and the light liquid.

The heavy liquid to be treated is introduced through the central passageway **25**, as shown at the left in Fig. 1. It passes through a bore **26** drilled in the shaft **10** and through the central opening **27** in the hollow plug **28** which is securely screwed into the sleeve **15**. The hollow plug **28** may suitably pass through one or more of the inner rings or walls **21** in the rotor, opening some distance from the shaft of the rotor so as to provide within the rotor, inside of the point at which the opening **27** of the plug **28** empties, a suitable space for the demulsification and clarification of the light liquid which has passed through the system and is about to leave. The light liquid passes out through the opening **30** and the bore **31** in the sleeve **15** and the shaft **10** respectively, and discharges through the annular conduit **32** which surrounds the central passage **25** previously referred to. As is readily apparent, a number of such inlets for heavy liquid and outlets for light liquid may be provided at equiangular intervals around the shaft **10**.

Light liquid enters the system through the central passageway **33** formed in the shaft **10** and to the right of Fig. 1, as shown. The light liquid then passes through the bores or conduits **34** and **35**, drilled in the shaft **10** and sleeve **15** respectively, and then passes through the opening **36** drilled radially through the disk **16**. This passageway is closed at its outer end by the plug **37**. A perforated distributing pipe **38** is mounted between the inner disks **16** and **17** and communicates at one end with the opening **36**. Tube **38** is perforated at intervals, the perforations being directed inwardly so as to distribute the entering light liquid over the width of the outermost of the concentric walls or turns **21**. A number of the inlets for light liquid as described may be provided at equiangular intervals around the shaft **10** for the uniform or approximately uniform distribution of the light liquid entering the rotor.

The heavy liquid leaving the rotor passes outwardly beyond the distributing pipes **38** for the light liquid, which are set far enough within the rotor to provide an outer space within the rotor for the clarification and demulsification of the heavy liquid. When solids heavier than the light liquid are present in substantial amounts, their movement with the heavy liquid is facilitated by providing within the inner surface of the outer wall of the rotor the angular baffles **40**, which, as illustrated, are frustro-conical in form and are held in position by shoulders formed on the inner wall of the casing **14** of the rotor. Whether such baffles are provided or not, the heavy liquid discharges through the passageways **42** between the peripheries of the inner disks **16** and **17** and the outer wall **14** of the rotor, and then through the inter-disk spaces **19** and **20** heretofore mentioned.

As described in the prior application of Podbielniak et al., hereinbefore referred to, broken or staggered vanes **45** are provided in these inter-disk spaces, being mounted upon the outer surfaces of the inner disks **16** and **17** respectively, so as to prevent the development of excessive pressure drops by reason of the swirl set up by centrifugal force in the operation of the rotor. The inter-disk space **19** on one side of the rotor communicates through opening **46** in sleeve **15** and bore **47** in the shaft with the annular passageway **48**, through which the heavy liquid leaving the machine is discharged. A number of the outlet passageways such as **46** and **47** may be provided at equiangular distances around the shaft.

From the inter-disk space **20** at the opposite end of the rotor, the heavy liquid passes out through the opening **50** in the sleeve **15**, the slot or groove **51** milled in the shaft **10**, and the bore **52** drilled in the shaft, to the annular passageway **48**. A number of these passageways may likewise be provided at equiangular intervals around the shaft.

In operation, with the shaft **10** and the rotor **11** rotating at the desired speed, which may be from 2,000 to 5,000 R. P. M. or higher, the heavy liquid is supplied through the conduit **25** and discharges into the interior of the rotor at the outlet of the plugs **28**. The light liquid enters through the passageway **33** under sufficient pressure to force it through the rotor, and is discharged into the interior of the rotor through the perforations in the distributing pipes **38**. The heavy liquid and the light liquid pass through the openings in the partitions **21**, effective countercurrent contact and solvent extraction taking place. As this action is concluded, the light liquid collects near the axis of the rotor, is clarified and demulsified in the space within the area determined by the point of entrance of the heavy

liquid, and discharges through the openings **30** and **31** and the conduit **32**. The heavy liquid is likewise demulsified and clarified in the rotor in the outer space beyond the distributing pipe **38**, and discharges through the inter-disk spaces **19** and **20** and the annular passageway **48**. When the solids are heavier than the light liquid, they pass out either entirely or for the greater part with the heavy liquid. In operation with solids present in substantial amounts, or even when solids are present in very small amounts, some solids or other foreign matter may accumulate within the rotor or the partition **21**, in the spaces between them, and in the inter-disk spaces **19** and **20**. In accordance with the present invention, means are provided for inspecting these surfaces and spaces and to facilitate their cleaning. Openings **55** are formed in the cylindrical wall **14** of the rotor opposite the inter-disk passages **19** and **20**, which are closed by the screw plugs **56**. These plugs can be removed for inspection and cleaning of the inter-disk spaces **19** and **20**. In addition to such openings, in accordance with the present invention means are provided for securing access to the spaces between the rings or turns **21**, for inspection and cleaning. For this purpose, as shown most clearly in Fig. 2, a radial opening **57** is drilled or suitably formed in the outer wall **14** of the casing. In axial alignment with this opening, a series of openings **58** are drilled through the partitions **21** and if the rotor is provided with baffles such as the baffle **40**, opening **59** is drilled through it in alignment with the openings **58**. The opening **57** is enlarged at the outer part of the wall or cylindrical casing **14** and is internally screw threaded, as at **60**.

A cylindrical plug **61** having an enlarged screw threaded head **62** (shown separately in Fig. 3) is passed through the opening **57** in the cylindrical rotor wall **14** and through the openings **58** in the partitions **21** and the opening **59** in the baffle **40**. This cylindrical plug is of a length sufficient to permit it to pass through the rings or turns **21** and is of a diameter to fit the openings **59** so as to preclude any significant channeling through the openings thus sealed, but not too tightly for easy removal. In normal operation of the device, the plug **61** is screwed into position and remains in position until it is desired to inspect or clean the rotor. Preferably, the outer surface of the head of the plug **61** is substantially flush with the outer surface of the rotor wall **14**. A plurality of such plugs, with corresponding openings therefor in the wall of the casing and in the partitions and baffles within the casing, may be arranged at angular intervals around the rotor and at various intervals along the length thereof, depending upon the size of the rotor.

When it is desired to inspect or clean the rotor between operations and with the rotor at rest, the plugs **61** may be removed, thus providing openings extending to the innermost portion of the rotor. The interior of the rotor may then be inspected by the use of suitable lights and mirrors, and may readily be cleaned, for example, by spraying the interior thereof, using for distribution of the cleaning liquid a nozzle capable of passing through the openings provided for the plug **61**. Such a nozzle is illustrated in Fig. 4 and its method of use is shown in Fig. 2.

As illustrated, the spray nozzle or cleaning nozzle **65** may be provided with openings **66** at intervals along its length and at its end, these openings being so placed that, when the nozzle is inserted and is arrested in its movement, for example, by having an enlarged portion thereof, designated by the numeral **67**, come in contact with a constricted portion of the opening **57** in the casing wall, the side openings **66** in the nozzle are in alignment with the spaces between partitions **21** in the rotor. In this way, a spray of the cleaning liquid may be directed into the spaces between each of the turns to secure effective cleansing thereof. Likewise, through the opening **66** in the bottom of the spray nozzle **65**, a spray may be directed against the innermost portions of the rotor. If desired, spray nozzles may be used which are provided with openings to enable the cleaning liquid to be discharged in any desired area within the rotor.

Although in the foregoing description, the elements **21** have been described as concentric rings, it will be readily understood that they may be the successive turns of a spiral such as is shown, for example, in the prior patent of Walter J. Podbielniak, hereinbefore referred to. As is readily apparent, the turns of the spiral may or may not be perforated, since, by the present invention, inspection and cleaning may be effected, irrespective of the presence of openings in the walls within the rotor.

Although the present invention has been described in connection with details of a specific embodiment thereof, it is not intended that these details shall be regarded as limitations upon the scope of the invention, except insofar as included in the accompanying claims.

I claim:

1. In apparatus for countercurrent exchange of at least partly immiscible liquids of different densities, a rotor having an axial shaft, a plurality of radially spaced partition walls within said rotor and surrounding said shaft, means for supplying heavier liquid and for discharging lighter liquid from within said rotor at the inner portion thereof, means for supplying lighter liquid and discharging heavier liquid from within said rotor at the outer portion thereof, the said partition walls being provided with radially aligned openings and the outer wall of said rotor being provided with an opening in radial alignment with said aligned openings in the partition walls, and removable means for closing said radially aligned openings and the aligned opening in the rotor wall.

2. In apparatus for countercurrent exchange of at least partly immiscible liquids of different densities, a rotor having an axial shaft, a plurality of radially spaced partition walls within said rotor and surrounding said shaft, means for supplying heavier liquid and for discharging lighter liquid from within said rotor at the inner portion thereof, means for supplying lighter liquid and discharging heavier liquid from within said rotor at the outer portion thereof, the said partition walls being provided with radially aligned openings and the outer wall of said rotor being provided with an opening in radial alignment with said aligned openings in the partition walls, and an elongated, radially extending plug passing through and closing said radially aligned openings in the partition walls, the outer end of said plug being removably secured in the opening in the rotor wall in alignment with said aligned openings.

3. An apparatus for countercurrent exchange of at least partly immiscible liquids of different densities, a rotor having an axial shaft, a plurality of radially spaced concentric partition walls

within said rotor surrounding said shaft, means for supplying heavier liquid and for discharging lighter liquid from within said rotor at the inner portion thereof, means for supplying lighter liquid and discharging heavier liquid from within said rotor at the outer portion thereof, the said partition walls being provided with radially aligned openings and the outer wall of said rotor being provided with an opening in radial alignment with said aligned openings in the partition walls, and an elongated radially extending plug passing through and closing said radially aligned openings in the partition walls, the outer end of said

plug being removably secured in the opening in the rotor wall in alignment with said aligned openings.

NICHOLAS J. ANGELO.

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