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# NEW, LONG LIFE, SELF CLEANING LUBE OIL FILTRATION FOR DIESEL ENGINES

## PUBLICATION 513

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## CONTENTS

# ABSTRACT

The role of the lube oil filter system on diesel engines is to protect critical engine components from harmful particles. Maximum engine life is dependent on the proper use of an oil filter system designed for that engine. This paper reviews a new low maintenance filtration system for use on diesel engines as designed by Alfa Laval Limited and developed by Cummins Engine Company. This new filter system, named Eliminator, is comprised of an integral full-flow and bypass filter. The full-flow filtration is designed as a series of wire mesh disks which are continually back-flushed as a self-cleaning feature. The bypass filtration consists of a highly effective centrifugal filter.

# INTRODUCTION

Diesel engine manufacturers have experienced an ever increasing demand for more power, longer engine life, and lower operating costs. Meeting these challenges has led to the development of many new engine technologies and designs. Extending the life of the lubricating oil and eliminating filter changes are two key ways to lower the operating costs of a diesel engine. A typical oil drain interval for a high horsepower diesel engine is 250 hours of operation. This service interval could be extended moderately if a premium oil was used or if the application was a particularly light engine duty cycle. An engine using the new Eliminator Filter System would benefit from an extended oil drain interval with no filter changes.

# PRODUCT DESIGN

In normal diesel engine operation a wide variety of contaminants are introduced to the lubricating oil. Although many contaminants are typically small enough as to not cause immediate engine damage, they can quickly agglomerate and form larger particles which will prove detrimental to the life of critical engine components. Combustion by-products can leak past the piston rings, valve guides, and turbocharger seals. These gases contain particles of carbon, water, acids, partially burned fuels, varnish and lacquers. As the lubricating oil comes into contact with hot engine components, oxidation and decomposition occur creating contaminants such as acids, varnish, and sludge. Abrasives and foreign material can enter the engine through the combustion air, fuel, worn engine parts, and inadequate service practices. Soot is caused by retarded injection timing and burning fuel mixing with oil on the cylinder liner. All of the above contaminants can lead to a dramatic decrease in both oil and engine life.

The effectiveness of an engine's oil filtration system is crucial to the durability of critical engine components. It is very common in today's high speed diesel engines for components to operate with dynamic clearances down to 2 microns. Loaded bearings operate with a minimum oil film thickness of 2 - 5 microns. Piston compression rings operate with as little as 2 microns of clearance. Cam follower rollers and rocker levers can operate with a 5 micron oil film thickness. The chart below should give the reader an appreciation of the relative size of particle contamination being discussed that the Eliminator system is capable of filtering.

| | |
|---|---|
| 50 microns | Human Hair Diameter |
| 40 microns | Pollen |
| 25 microns | White Blood Cell |
| 08 microns | Red Blood Cell |
| 02 microns | Bacteria |

Table 1: Particle Size Comparison

A commonly asked question regards whether a centrifuge will separate out the useful additives from the lubricating oil. In fact, these additives are sub-micron in size and they are not removed from the oil by the centrifuge. Extensive engine testing has verified this. If the contamination is not removed from the oil the particles can lead to different mechanisms of wear throughout the engine.

1. Abrasive wear is the primary wear mechanism on engines. Particles enter the clearance space between two moving surfaces, bury themselves in

of the surfaces, and act like cutting tools to ove material from the opposing surface.

2. Erosive wear is caused by particles that impinge on a component surface and remove material from that surface due to momentum effects. This type of wear is especially noticed in components with high velocity flows.

3. Adhesive wear occurs when surface asperities are 'cold welded' together and metal to metal contact occurs. This is caused by excessive loads, low speed, and/or reductions in fluid viscosity.

4. Fatigue wear can occur on bearing surfaces as a result of repeated stressing caused by particles trapped by the two moving surfaces.

When component clearances are bridged by particles in the oil a chain reaction of wear can occur. This will generate even more particles within the lubrication system, which further exasperates the wear rate of critical components.

Engine testing has proven the need for both a high flow main filter in conjunction with a lower flow bypass filter. Cummins Engine Company conducted an engine test to determine the wear rates of critical components with various filtration systems. Test dust was added to the sump every four hours for 150 hours and the wear rate of the connecting rod bearings, main bearings, and piston rings were measured. The wear rates of each component were drastically reduced when the bypass filter was used. This is shown in figure 1 below.

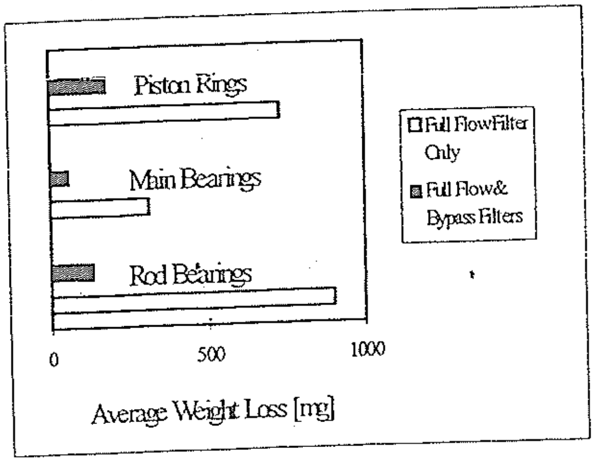

Figure 1: Component Wear Rates

Typically, a full flow filter receives 90 to 100 percent of the total engine flow whereas the bypass filter would receive three to ten percent of the flow.

The main filter is designed to effectively filter out particles in the oil above 30 microns in size. The bypass filter is designed to filter out particles in the oil below 20 microns. The use of a bypass filter is particularly effective in protecting bearings and bushings in an engine. The Eliminator filter was designed as an integrated full-flow and bypass filtration system using two existing filtration technologies. The filter is shown in Figures two and three.

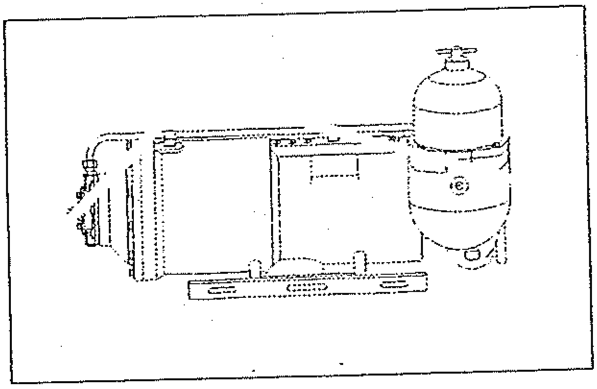

Figure 2: Eliminator Filter System

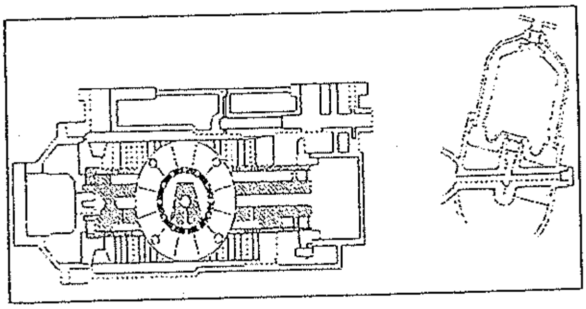

Figure 3: Eliminator Filter System
Cross-Sectional View

The full-flow section of the filter is a back-flushing self-cleaning series of wire mesh disks. The bypass filter section of the Eliminator is a highly effective centrifugal filter.

The first Eliminator filter was designed to bolt directly to the block of the Cummins KV engine family (38 litre 12 cylinder and 50 litre 16 cylinder). Based on the success of this application, the filter design is being modified for the Quantum engine family (45 litre 12 cylinder and 60 litre 16 cylinder). The Eliminator is shown installed on a Cummins QSKV60 engine in figures four and five.

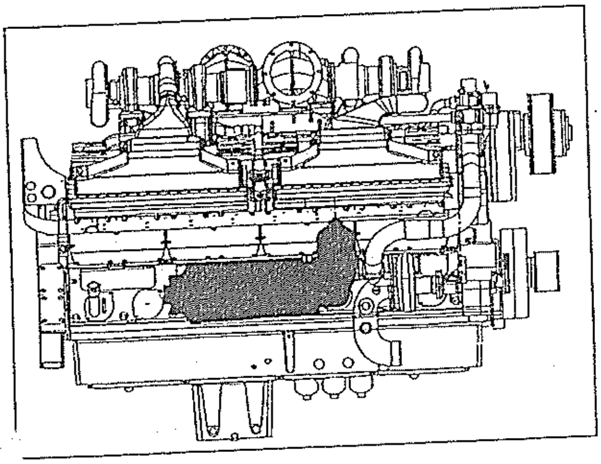

Figure 4: Eliminator installed on a Cummins QSKV60 Engine - Side View.

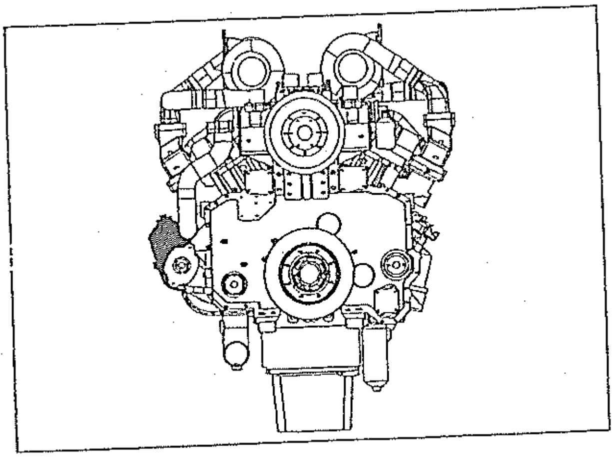

Figure 5: Eliminator (shown shaded) installed on a Cummins QSKV60 Engine - Front View.

The filter is also under review for other Cummins' engine families. The filter housing is an aluminium sand casting. Aluminium being chosen for weight and corrosivity considerations. The wire mesh disks are die cast aluminium while the mesh is stainless steel. Stainless steel was chosen for strength and its non-corrosivity properties.

Cummins developed a Product Technical Profile of the new filter system to identify key technical parameters. The profile listed the product requirements and records the product deliverables. Parameters considered during the design phase can be seen in table two.

| **PARAMETER** | **REQUIREMENT** |
|---|---|
| Oil Temperature Range | -20 to 150 Deg C |
| Pressure Drop across the Full-Flow Filter | 0.5 Kpa max. |
| Oil Pressure Range | 414-586 Kpa |
| Oil Types: | Monograde<br>Multigrade<br>Synthetic<br>Organic<br>CD, CE,<br>CF4, CG |
| Oil Flow through the Full-Flow Filter: | 605 litres per minute |
| Absolute Filtration of the Full-Flow Disks: | 38 microns max. |
| Nominal (85-90%) Filtration of the Full-Flow Disks: | 20 microns max. |
| Absolute Filtration of the Bypass Centrifuge: | 10 microns max. |
| Service interval of the centrifuge filter: | 1,500 hours |
| Service interval of the Full-Flow disks: | 20,000 hours |

Table 2: Technical Product Profile

The filtering media consists of three layers of mesh -- a fine mesh for filtration which is sandwiched between two coarse meshes for strength and tear resistance. The back-flushing feature is accomplished by a hydraulic motor which slowly rotates a distributor through 360 degrees. The distributor is driven entirely by oil pressure. No external power source is required to operate the Eliminator Filter. The back-flushing cycle takes 90 seconds and continually repeats. The dirty oil from the back-flushing is directed to the bypass centrifugal filter. This feature of directing all of the contamination of the full flow filter directly to the centrifuge makes the Eliminator uniquely effective in cleaning the engine lubricating oil. Whereas a number of engine owners operate a centrifugal bypass filter on their diesel engines, these centrifuges only see relatively clean oil. Hence, their ability to remove oil contamination is reduced greatly as compared to the Eliminator system. The centrifugal filter uses oil pressure directed through two nozzles to separate out the contamination in the oil.

## FILTER OPERATION

100 percent of the total engine oil flow enters the Eliminator filter at the block mounting pad. This flow passes over a pressure regulator which controls the oil pressure in the engine. If the oil pressure in the main oil rifle is too high, the regulator opens and a small flow of oil is directed to the oil sump. The total engine oil flow is then directed through the full-flow wire mesh disks. The total oil flow on the K2000E engine is 605 litres per minute at 1900 RPM. 2.5 percent of the total oil flow is used to drive the hydraulic motor which rotates the back-flushing distributor within the filter. This represents 15 litres per minute. An additional 2.5 percent of the oil flow is used to back-flush a given section of the full-flow disks. This back-flushed oil is then directed to the bypass centrifugal filter.

There are 24 interlocking full-flow disks. The oil enters the inside area of the wire mesh disks and the oil is filtered as it passes through the wire mesh. The inner wire mesh is specified at 35 microns absolute filtration. This level of filtration was chosen as a starting point for testing because it is a typical filtration level of disposable cellulose filters for diesel engines. This oil collects on the outside of the disks in a chamber and is then directed back into the engine for use during engine operation.

The hydraulic motor receives filtered oil from the full flow chamber and rotates the distributor to its next position where the back-flushing is repeated in the next filtering column. The back-flushing is performed with filtered oil and the entire filter surface is cleaned once every 90 seconds. This prevents retained solids from sticking to the filter surface, ensuring a low and constant pressure drop.

The back-flushed dirty oil from the full-flow chamber is directed to the bypass centrifugal filter. The centrifugal filter spins at 5200 RPM at an oil pressure of 7.25 Kpa. This operation spins the heavier density particles to collect on the outside of the centrifuge housing while the lighter density oil is allowed to drain to the engine oil sump.

## FILTER EFFICIENCY TEST RESULTS

Whilst all of the key parameters considered during the design phase are important, perhaps the most important is the filtration efficiency. What percentage of particles of a known size will pass through the filter and potentially damage the engine? Separate tests were conducted to determine the efficiency of the full flow wire mesh disks and the centrifuge.

The wire mesh disks used as the full flow filter media were tested at an independant laboratory in France - Institut de la Filtration et des Techniques Separatives. A sheet of the stainless steel mesh was used for the test. 200 ml of microfiltered water solution (filtered to 0.2 microns) with glass beads was then filtered through the sheet at 333 l/min.m$^2$. A granulometric analysis by Coulter Counter, based on the variation of resistivity, was performed on the upstream and downstream solutions. This test was repeated for three different wire mesh sizes to allow for further product development. The results are shown in Figure six below.

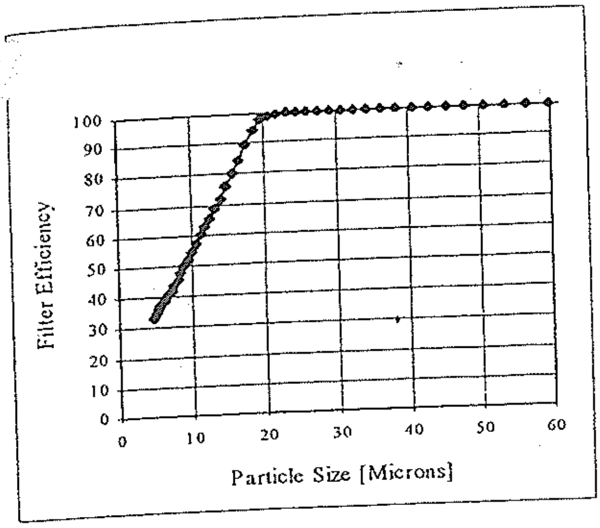

Figure 6: Wire Mesh Efficiency Test Results

These results show that the media will filter out 33% of all particles that are 5 microns in size; 55% of all particles that are 10 microns in size; and 99% of all particles that are 20 microns in size. These results compare very favourably against tests using conventional cellulose disposable oil filters.

In reviewing the data, some engineers have suggested that a barrier filter with 36 micron screen openings would only filter out those particles larger than 36 microns - and everything smaller would flow through the filter. Several phenomenons allow the filtration effectiveness curves plotted above. First, the particles filtered out by the filter are not perfectly round. These particles take on a variety of shapes. If the width of one such particle is less than 36 microns - the length might be longer than 36 microns. Secondly, as the barrier screens trap particles the effective screen opening size is reduced. Thirdly, the particles often combine with other particles to form larger particles. This is especially true of soot in the oil.

The bypass centrifuge was not tested for efficiency as such, but the solids, which were deposited inside the centrifuge, were analysed for size distribution. As before, the samples were analysed using an automatic Coulter Counter. This information is shown in Figure seven below.

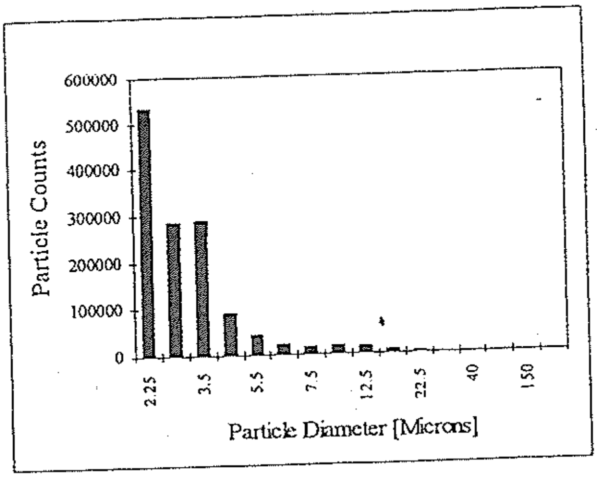

Figure 7: Centrifuge Particle Distribution

The graph above shows that the centrifuge is separating out particles as small as 2 microns from the lubricating oil. This is crucial to the life of the oil. Oil oxidation is increased in the presence of water and particulate contamination. Small metal particles act as catalysts to rapidly increase the neutralisation number or acid level.

New oil will contain some particles which are either introduced during the refinery processing or residual from the crude petroleum. As a means of comparing with figures four and five above, a particle distribution for new 10W40 CF4 oil is plotted in figure eight.

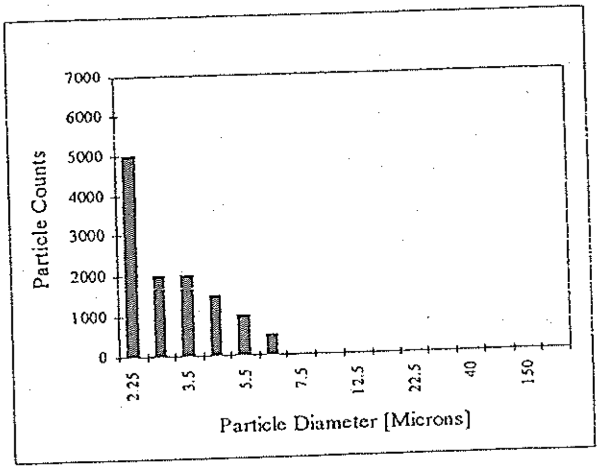

Figure 8: New Oil Particle Distribution

The effectiveness of a centrifuge in separating out a particle from a fluid can be determined by Stokes law.

$$V_c = \frac{d^2 (p_p - p_l) r w^2}{18n}$$

with:

$Vc$ = Centrifugal Settling Velocity
$d$ = particle diameter
$p_p$ = particle density
$p_l$ = liquid density
$r$ = radial distance from axis of rotation
$w$ = rotational speed
$n$ = viscosity of the liquid

For a given engine application, one can assume that the particle size (d) and particle and liquid densities ($p_p$ and $p_l$) will remain fairly constant. The radial distance (r) of the particle from the axis of rotation is constant throughout the test. This leaves the rotational speed (w) and viscosity of the oil (n) as the primary factors in the equation. The rotational speed of the centrifuge is determined primarily by the supply oil pressure acting through the exit nozzles. For the centrifuge to effectively separate out particles from the oil it must be spinning at a relatively fast speed to generate the necessary centrifugal fields. The centrifuge on the Eliminator is designed to spin at 5200 revolutions per minute at rated engine speed (1900 RPM crank speed; 50 PSI oil pressure). The oil viscosity is also a major contributing factor in determining the efficiency of the centrifuge. The viscosity of the oil changes dramatically with changes in oil temperature. Hence, the temperature of the lubricating oil will directly affect the efficiency of the centrifuge.

The rotational speed of the centrifuge was measured using a magnetic speed sensor. The engine speed was varied between low idle and rated power conditions. The oil temperature was stabilised at 98 degrees C for the test - as this is within the range of expected oil temperatures for a heavy-duty diesel engine. The data is plotted in figure 9.

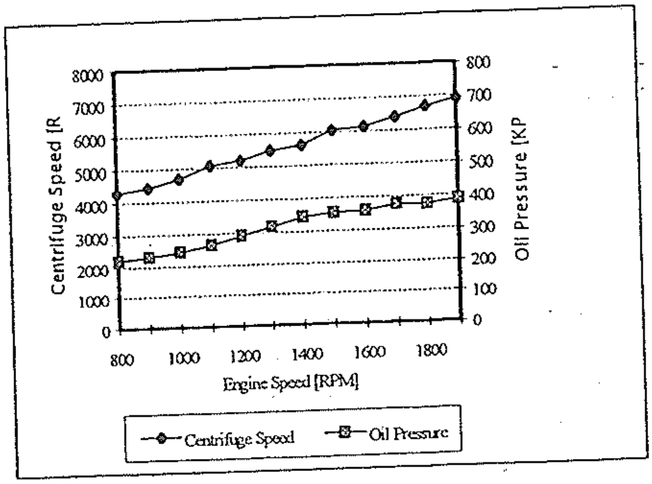

Figure 9: Graph showing Centrifuge Speed and Oil Pressure versus Engine Speed.

The graph shows the speed of the centrifuge varies between 4300 and 6900 RPM as the engine operates between 800 and 1900 RPM respectively. As the centrifuge was designed to be most effective at speeds greater than 5000 RPM, this test showed the centrifuge to operate as designed.

## ENGINE TEST RESULTS

The Eliminator filter system has been tested on engine in both test cells and field test applications. These tests have also included performance testing and vibration analysis on test rigs. Testing has included the use of various oil types as well, including synthetic, organic, CF-4, CD, and CG oils. One such test run with the Eliminator filter system was a cyclic 750 hour test. The cycle was designed to aggressively test the integrity of the exhaust manifolds. The engine was run at high speed in an overfueled hot condition for 6 minutes and then run at idle for 11 minutes. The test cell vents are opened during the idle portion of the test to put a larger temperature gradient across the engine.

Past tests of this type have been severe on engine oils due to the extremely high temperatures. Typically, an organic oil would last less than 200 hours, while a synthetic oil would allow for the standard oil change interval of 250 hours. For the entire 750 hours of the latest test, the Eliminator filter was used on the engine and the original hetic oil was used throughout the entire test.

Oil samples were analysed every 50 hours during the test. Figures three through seven document some of these results.

The test specifics are recorded in table three.

| | |
|---|---|
| Engine: | Cummins KV2000E |
| Oil Make: | Premium Blue 2000 |
| Oil Type: | Synthetic 10W40 |
| Test Duration: | 750 hours |
| High speed: | 2100 RPM |
| High power: | 1492 KW |
| gh duration: | 6 minutes |
| High turbine inlet temperature: | 850 degrees C |
| Low speed: | 750 RPM |
| Low power: | 37 KW |
| Low duration: | 11 minutes |
| Low turbine inlet temperature: | 150 degrees C |

Table 3: Eliminator Test Parameters

The oil in this test was analysed for 27 separate parameters throughout the testing. All parameters were below normal condemnation levels at the onclusion of the 750 hour test.

The Total Acid Number reading of the oil is an indication of the acidity of the oil. New oil contains base additives to counter the formulation of acids from the combustion process. Oil which has become too acidic can be detrimental to engine components -- especially bushings and bearings. The Total Acid Number of the oil in this test shows that the acidity level of the oil was acceptable throughout the entire test. This is shown in Figure ten.

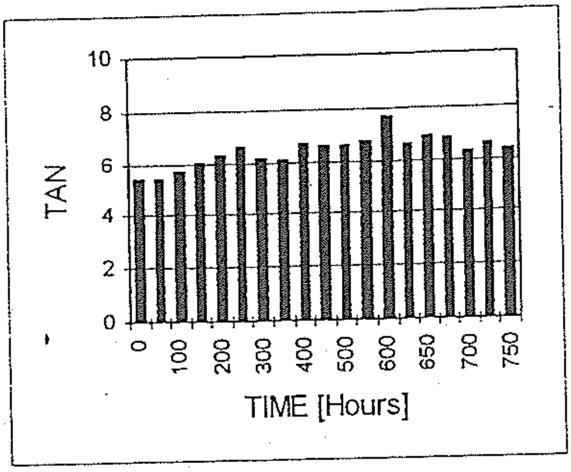

Figure 10: Total Acid Number of Oil

The Total Base Number is an indication of the base level of the oil. This measures the ability of the oil to neutralise acids. Figure eleven shows that the Total Base Number of the oil in this test was favourable throughout the test.

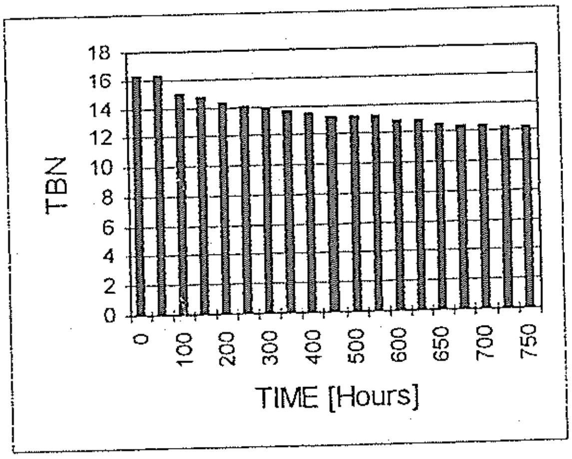

Figure 11: Total Base Number of Oil

The Insolubles reading is a measurement of soot, wear debris, and fuel resins within the oil. These can significantly affect the life of the oil and are detrimental to component wear. The Insoluble measurement of the oil was acceptable throughout the entire 750 hour test as shown in Figure twelve.

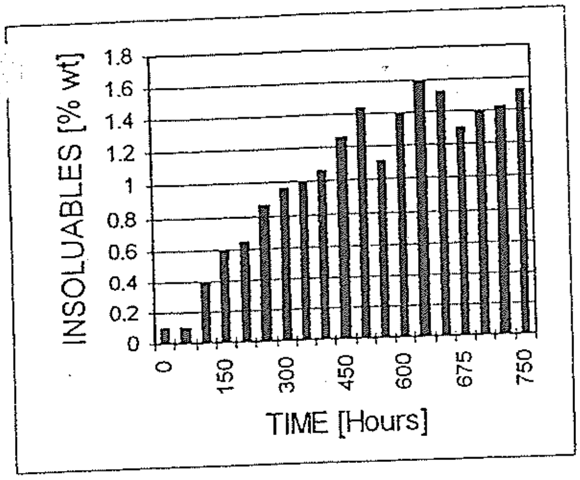

Figure 12: Insolubles in the Oil

Viscosity is one of the most important properties of a lubricating oil. The coefficient of friction of lubricated surfaces depends upon the viscosity of the lubrication, the relative sliding velocity, and the pressure between the surfaces. A large drop in viscosity might indicate a fuel dilution problem on an engine. An increase in viscosity may indicate excessive oxidation or soot thickening of the oil. Figure thirteen shows that the viscosity measurement of the oil was acceptable. The values indicate a normal viscosity drop which is indicative of shearing of the viscosity index improver additive.

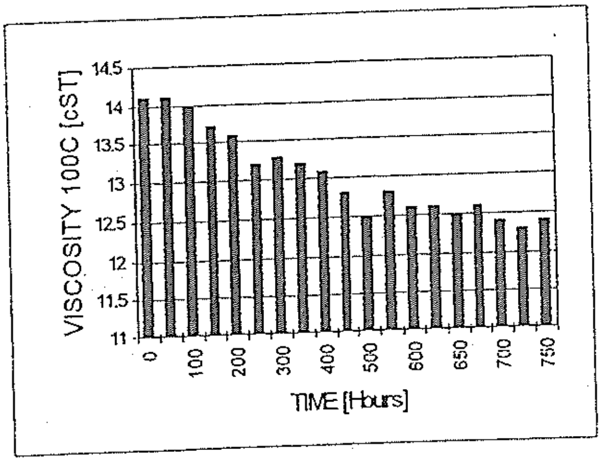

Figure 13: Viscosity of Oil

The Iron measurement is an indication of the wear rate of the ferrous engine components. Figure fourteen demonstrates that the values for the oil are still acceptable at the end of the test.

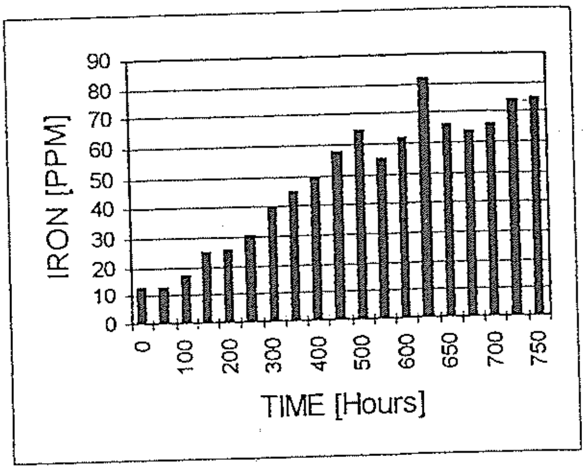

Figure 14: Iron in the Oil

In addition to having been engine and rig tested, the Eliminator filter was analysed in an Applied Mechanics laboratory for structural integrity. Engine vibration measurements were used to determine the vibration amplitudes and frequencies. An Operating Deflecting Shape analysis determined the resonance modes of structure and the levels of excitation. The highest stressed regions of the mounting flanges were measured using a photoelastic coating analysis. Strain gage measurements in these high stress regions then determined the dynamic strain measurements. Finally, the filter was tested with an Inertial Load test in which strain gage measurements were recorded under a simulated 5g vertical load to reproduce a mobile equipment application. The predicted stress levels were then compared with the material strength properties to predict the filter unreliability. The analysis showed that the Eliminator filter has acceptable structural strength. Also, the mounting flange stress levels were low and well within the fatigue strength limits when tested under both engine operation and inertial loading tests.

## LIFE CYCLE OPERATING COSTS

An example of the lower life cycle costs for the Eliminator filter is presented below as compared to a conventional disposable paper filter system.

Assumptions:

16 Cylinder Engine 2000 Horsepower
Mining Application
7000 Hours per year operation
7 year life of machine
Engine Sump = 204 litre
Labour rates 12.0 UK Pounds per hour

Standard repair times
0.75 Hour Filter change
0.50 Hour Oil change
1.00 Hour Centrifuge cleanout
5.00 Hour Eliminator cleanout

Replacement Costs
Full Flow filter @ 14.80 UK Pounds
pass filter @ 13.50 UK Pounds
Oil @ 0.75 UK Pounds per litre

Conventional Disposable Filter System:

Using 250 hour drain intervals, the operator would need to make 28 oil changes per year.

Oil replacement cost per year:
28 x 204 litres x £0.75 per litre £ 4284

Filter costs per year:
28 x (5x £14.80) + 28 x (2x £13.50) = £ 2828

Labour costs per year:
Filter change: 28 x (0.75 x £ 12) £ 252
il change: 28 x (0.50 x £ 12) £ 168

Total cost per year:
Oil + Labour + Filters £ 7532

Total life cycle costs for 7 years operation:
£ 52,724

New Eliminator Filter System:

Using 500 hour drain intervals, the operator would need to make 14 oil changes per year. At 7000 hours of operation per year, the centrifuge would need to be cleaned out 4.6 times per year.

Oil replacement cost per year:
14 x 204 litres x £0.75 per litre £ 2142

Labour costs per year:

Centrifuge cleanout:
4.6 x (1.0 x £ 12) £ 55
Oil change: 14 x (0.50 x £12) £ 84

Total cost per year: £ 2281

The wire mesh disks of the Eliminator Filter should be cleaned out every 20000 hours. At 7000 hours per year, this would require a cleanout every 2.9 years. With a projected machine life of 7 years, the filter would need to be cleaned out 2.4 times. This will be rounded up to 3 times for this analysis.

Eliminator cleanout costs:
3 x (5.0 hours x £ 12) £ 180

Total life cycle costs for 7 years operation:
£ 16,147

Potential savings per year for using the Eliminator filter as compared with a standard disposable filter system: £ 5,251

Potential savings for a 7 year operation for using the Eliminator filter as compared with a standard disposable filter system: £ 36,617

Additional cost considerations for many applications include the high disposal costs for used lubricating oil and oil filters. Many countries classify used oil and filters as a hazardous material of a carcinogenic nature and therefore these products must be disposed of in an appropriate manner. These disposal costs can be quite high from both a monetary and time consideration. Because the Eliminator filter extends the life of the oil and eliminates the disposal of filters, any engine running in an area which legislates how to dispose of oil and filters would recognise a further cost avoidance benefit. In addition, some companies track engine downtime and assign a cost to this. Because using the Eliminator will reduce maintenance requirements and therefore downtime, any company tracking this cost will realise a significant savings.

Oil change interval frequency is dependent on machine application, load factor, oil quality, and environmental considerations such as dust levels. Although Cummins offers a detailed lifetime payback analysis for specific applications, it is possible to predict the annual savings in the graph below for all applications.

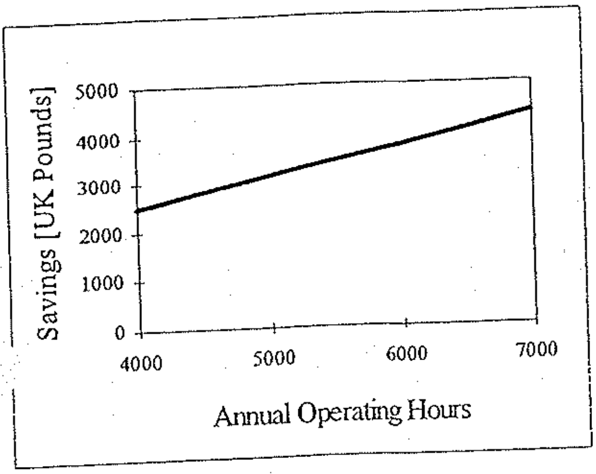

Figure 15: Annual Savings using the Eliminator Filter System on KV engines.

## CONCLUSIONS

This paper has attempted to show the benefits of the new Eliminator oil filter system as developed by Cummins Engine company. This filtration unit combines both the full-flow and bypass filters for a high speed diesel engine application. The main engine filters consist of a series of wire mesh disks. The bypass filter is a highly effective centrifugal filter. The Eliminator has very low maintenance requirements due to the self-cleaning feature of the full flow filter section. Because this contaminated oil is then directed to the highly efficient bypass centrifugal filter, the Eliminator is uniquely able to thoroughly clean the engine's lubricating oil. Eliminating the conventional filter changes and extending the life of the oil greatly reduces the required maintenance of this new filter system. The yearly operating costs and the total life cycle costs of the new filter have been shown to be considerably lower than the current disposable filter system presently in use today. In addition to lower operation costs, the new system offers a more effective filtration of the engine oil. Because the lubricating oil is kept cleaner, the oil change interval can be extended using the new filter.

Using the new Eliminator Filter System will allow for lower operating costs, less engine downtime, extended oil life, and the elimination of costly filter disposals. While the filter was originally designed for use with Cummins high horsepower engines, it is now being developed for smaller Cummins engines as well.

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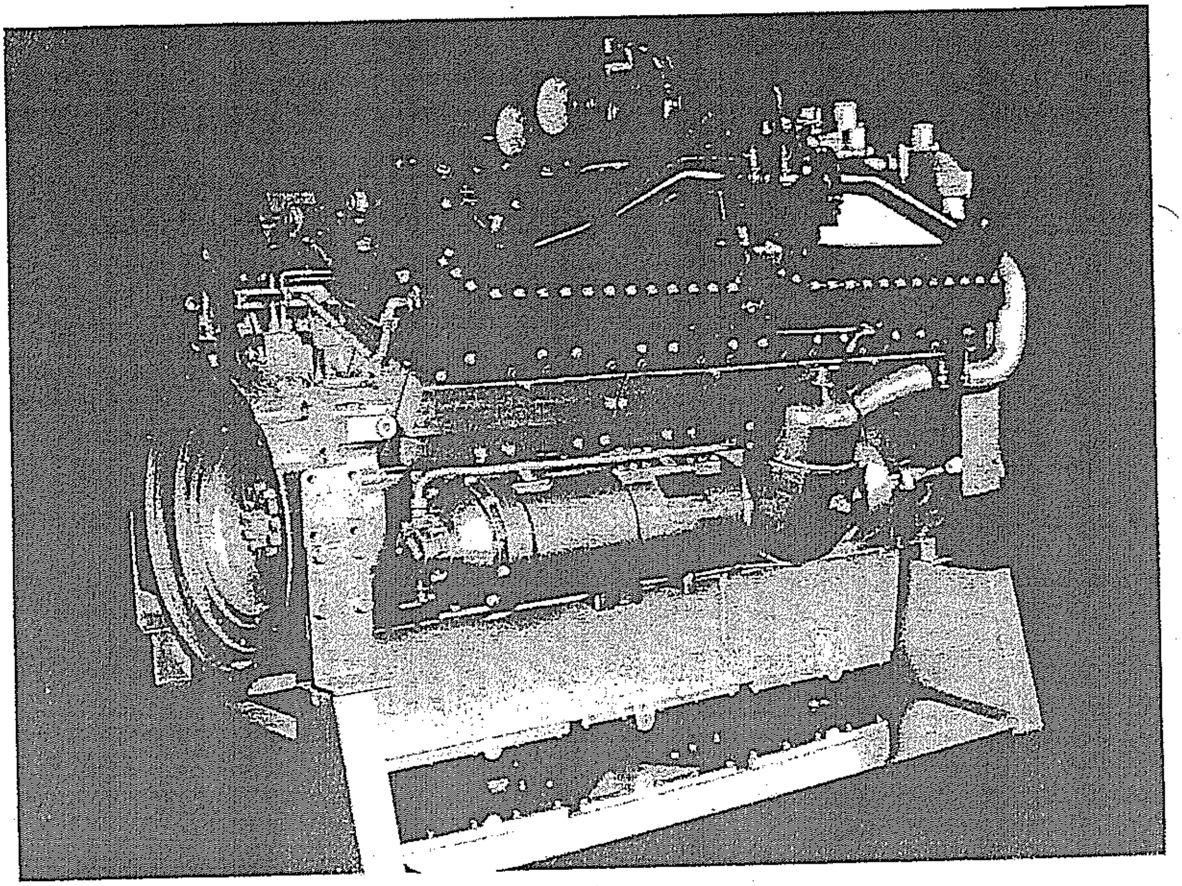

Figure 16: Photograph showing the Eliminator Filter System on the Cummins QSKV45 Engine.

Acknowledgements:

The author appreciates the permission and encouragement of Cummins Engine Company and Alfa Laval to publish this report.

Special thanks to Leif Larsson, Pierre Maillard, Jean-Claude Chrupalla, Remy Mangano, and Theophile Christophe of Alfa Laval for their technical support.

Special thanks to Tony Lake, Jim Evan, and Tom Boberg of Cummins Engine Company for their technical support and leadership.

Biography for Rob Andrews:

Author has worked for Cummins Engine Company for 14 years. He graduated with a Bachelor of Science degree in Mechanical Engineering from Purdue University (USA) in 1984 and an MBA from Ball State University (USA) in 1993. His career has included work as a product engineer at the Walesboro, Indiana facility; design engineer at the main Technical Centre in Columbus, Indiana; and as a development manager for the past five years at the Daventry, England facility. Rob is married and has three children.

# DISCUSSION:

**Mr. R.G. Hull of Roger Hull Associates opened the questions:**
I congratulate Mr. Andrews for his professional presentation of a most interesting paper on Diesel Engine Lubricating Oil Filtration. I have three questions:

It is not appreciated why Cummins Engine do not advocate the use of the well proven cylinder liner flame rings which would undoubtedly reduce the amount of contaminants entering the lube oil system as well as preventing liner bore polish. Will the author comment on the reasons for not using flame rings?

**R. Andrews**
Cummins Engine Company is constantly reviewing different technologies to implement on diesel and natural gas engines. The device referred to as a flame ring has been in existence in different forms for many years – dating back into the 1930's. In recent years the problem of cylinder liner bore polishing have become more widespread in the medium-speed diesel engine industry. A number of factors have contributed to this condition. Maximum cylinder pressures have increased, specific fuel consumption has decreased, and changes in the composition of the fuel oils has also occurred. The effect of these changes has produced a change in the structure of deposits that accumulate on the piston crown. The flame ring is one potential solution for this condition. The cylinder liner flame ring is being used on the 73 litre engine produced at the Daventry England facility.

**R.G. Hull**
Does the new filter system incorporate any type of alarm which would alert the engine user as to the following:

JW coolant entering the crankcase via the liner seals or a cracked liner?
Fuel oil dilution?

**R. Andrews**
Currently the Eliminator Filter system offers a Delta-P (pressure differential measurement comparing the inlet and outlet pressures of the filter). The pressure differential measurement is used as an indicator to show if the full flow disks have become plugged. Lab and engine testing of a speed sensor for the centrifugal separator have also been completed and documented in technical reports.

Cummins is evaluating a number of new sensors that could be implemented on the Eliminator Filter. Work continues in this area to ensure each sensor is robust enough for a diesel engine application.

**R.G. Hull**
Do Cummins issue any warnings to engine users with respect to the use of once through or disposable lubricants which some oil companies supply to truck engine/some generation users which cannot be centrifuged due to their molecular construction?

**R. Andrews**
Cummins recommends the use of a high quality SAE 15W-40 engine oil for all diesel applications. Cummins recommends the use of oil that meets the American Petroleum Institute (API) performance categories of CF-4, CG-4, CF-4/SG, or CG-4/SH. Special 'break-in' oils are not recommended for use in new or rebuilt Cummins engines. Synthetic or partially synthetic oils cannot be used in a new or rebuilt engine during break-in. The operator must use a standard petroleum based oil for the first drain interval.

Rerefined lubricating oils can be used in Cummins engines if they have an API quality designation signifying they have been tested and meet the minimum standards for that quality level. It is important to be certain that these oils are actually rerefined and not just reclaimed. Rerefined oils have been treated to remove additive and wear metal debris, distilled and refortified with additives.

Synthetic engine oils, API-category III, are recommended for use in Cummins engines operating in ambient temperature conditions consistently below minus 25 degrees C. Above this temperature it is recommended that mineral oil based multigrade lubricants be used. Use of synthetic 0W-30 oils which meet the API category III may be used in operations where the ambient temperature never exceeds 0 degrees C. 0W-30 oils do not offer the same level of protection for fuel dilution as do the higher multigrade oils. Higher cylinder wear may be experienced when using 0W-30 oils in high load applications.

**Mr. Chris Fleming; Select Power Consulting Ltd**
Can the author say what quantity of either water or insolubles the centrifuge can retain before the buildup reaches the disks when I assume the centrifuge would cease to be effective? In this respect would it not be preferable to maintain the centrifuge, a short task, at the same time as the oil is changed rather than at every third oil change as shown in the example?

**R. Andrews**
Yes, the questioner is correct to assume the efficiency of the centrifuge changes if the contamination buildup reaches the disks. However, the centrifuge will continue to separate debris at this condition, just in a less efficient manner. Most centrifuges today do not incorporate the stacked disk technology of the Alfa Laval model. The Eliminator centrifugal separator will remove 1.0 liter of sludge before the buildup reaches the stacked disks.

As the service cleaning of the centrifuge only requires 15 minutes of time, it may be advantageous for some operations to clean the centrifuge when they change the oil. However, some generator, construction, and marine applications strive to minimize any downtime and these applications may find the longer cleaning intervals to be preferable.

**R.F. Waddy; Consultant.**
The retro-fitting of the unit is technically very simple being an external bolt-on unit which replaces the standard filtration system.

**R. Andrews**
The Eliminator was designed to exactly replace the current disposable filter system. The Eliminator uses the same bolting arrangement and gaskets as the current system. Many Eliminators have been retro-fitted in-chasis in marine and construction equipment.

**Gerald Parkinson; Consulting Engineer**
What is the cost of a retrofit filter?

**R. Andrews**
A retrofit filter costs approximately 6000 Pounds Sterling. When one compares the total costs (labour, parts, oil) of using a conventional disposable filter system to the total costs associated with the Eliminator Filter system – an operation can save over 3000 Pounds Sterling every year resulting in a pay back period of less than two years.

**D.L. Jones; Consulting Engineer**
What size are iron particles on your chart?

**R. Andrews**
The oil analysis was performed with a industry standard Atomic Absorption Spectroscopy. In addition, a sample was sent to Alfa Laval for size distribution analysis using a Coulter automated counter. This analysis showed the following distribution for the given sample:

| Particle Size | Particle Count |
|---|---|
| 0 – 2 microns | 500,000 |
| 2 – 4 microns | 300,000 |
| 4 – 6 microns | 100,000 |
| 6 – 8 microns | 15,000 |
| 8 – 10 microns | 10,000 |
| 10 – 20 microns | 10,000 |

As one can see from the tabulated results, the centrifugal separator is very effective at removing small contamination from the lubricating oil.

**J.H. Blowes; Diesel Consult**
Will centrifuging bring out oil additives if water is present? Are your filters suitable for use on engines burning heavy fuel oil?

**R. Andrews**
Under normal operation, a centrifuge will not remove oil additives from the oil. Most engine centrifugal separators of this size operate at approximately 5000 RPM. Tests have shown that the centrifuge would need to rotate at speeds approaching 10,000 RPM to remove the additives from the oil.

Modern engine oils have dispersants to disperse any water present in the lubrication system. Water would drop to the bottom of the sump and would become highly emulsified with the oil as it passes through the lubricating pump. Because of their larger combined size, a centrifuge will remove water and any dispersants that are attached to the water molecules. Above 100 degrees C the water will flash off from the oil, but the dispersants will remain in the oil. At temperatures below 100 degrees C, the water will eventually evaporate and leave the engine through the breather system.

Yes, the Eliminator Filter system is suitable for use on engines burning heavy fuel oil. Both a centrifugal separator and the full flow self-cleaning disks have been used extensively on larger marine heavy fuel oil applications. Field testing in Rotterdam has shown positive results for using this technology on this type of engine. Alfa Laval have many such heavy fuel oil applications around the world. The service intervals for the centrifuge, however, will be affected as more sludge will be removed from the oil and the centrifuge bowl will fill up more quickly.

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US005683342A

# United States Patent [19]

**McNair**

[11] **Patent Number:** 5,683,342

[45] **Date of Patent:** Nov. 4, 1997

[54] OIL CLEANING ASSEMBLIES FOR ENGINES

[75] Inventor: **James McNair**, Bristol, England

[73] Assignee: **The Glacier Metal Company Limited**, England

[21] Appl. No.: **433,405**

[22] PCT Filed: **Jan. 20, 1994**

[86] PCT No.: **PCT/GB94/00107**

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§ 102(e) Date: **May 18, 1995**

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PCT Pub. Date: **Aug. 4, 1994**

[30] **Foreign Application Priority Data**

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[51] **Int. Cl.**$^6$ ................ **B04B 9/06**

[52] **U.S. Cl.** ................ 494/49; 494/901

[58] **Field of Search** ................ 494/70, 68, 67, 494/43, 73, 49, 901, 36; 210/360.1, 380.1, 512.1

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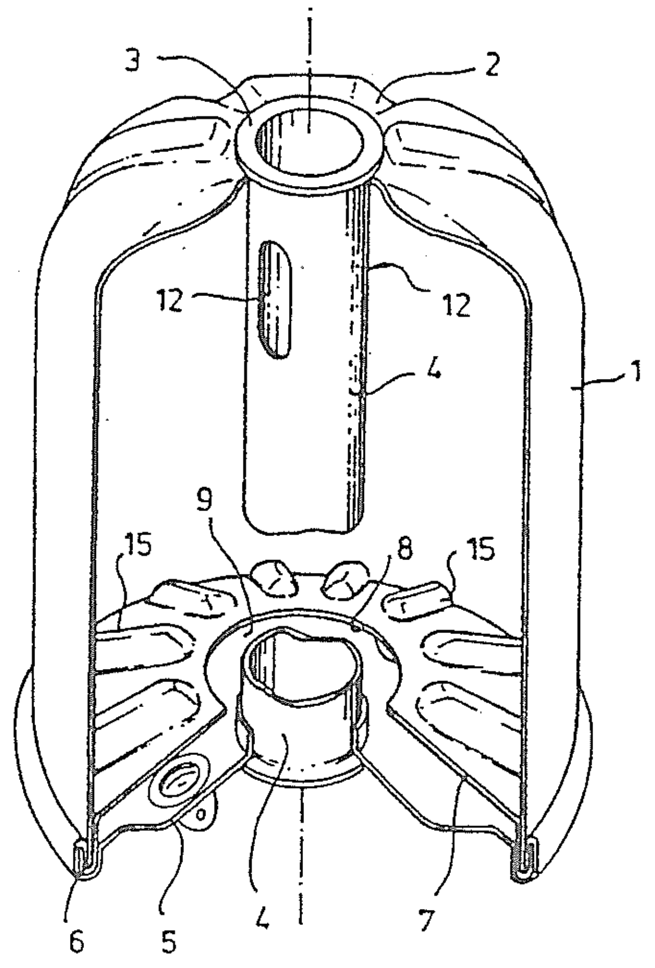
[57] **ABSTRACT**

In a centrifugal separator of the kind used for liquids such as oil, a rotor contains a separation cone interposed between the main volume of the rotor and the outlet nozzles which, in use, cause the rotor to spin. This cone includes a plurality of radially extending ribs.

**3 Claims, 1 Drawing Sheet**



It will be appreciated that the plate 7 is the separation cone for the rotor. In this case, it includes a plurality of radially extending ribs **15**, according to the invention. (For reasons of clarity, the lower portion of the central tube has been cut away so that the shape/disposition of these ribs 15 may be better seen.) In this instance, some ten ribs were provided, although in a smaller size of rotor, it would be preferably to have a smaller number, say five ribs in all, for the reason given earlier. The ribs were 2.5 mm deep and about 7 mm wide, with rounded side edges. The radially outward ends of the ribs were spaced from the casing 1; the inner ends were close to the margin 9, although for reasons of clarity the spacing is slightly exaggerated in the FIGURE.

I claim:

1. In a centrifugal separator for liquid media which includes a casing, a base plate connected to a lower end of the casing with discharge nozzles mounted in said base plate, a central tube extending through the base plate, upwardly into engagement with an upper part of the casing, and a separation cone in the form of a downwardly facing frustum of a cone, an upper radially inner rim of said separation cone being spaced from said central tube to thereby define an exit passageway between the separation cone and the tube, and a lower radially outer margin of said separation cone being attached to a lower rim of the casing throughout the circumference thereof and substantially adjacent the base plate so as to define an upward and inward flow path over the separation cone from said casing towards said upper rim, the improvement wherein said separation cone is provided with a plurality of generally radially directed and upwardly projecting ribs.

2. A centrifugal separator according to claim 1 wherein said separation cone is provided with from 5 to 10 radially directed ribs.

3. A centrifugal separator according to claim 1 wherein said ribs extend only part way down said cone, from said upper rim.

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