

Oct. 17, 1950

J. E. VALLERIE

2,525,978

METHOD AND APPARATUS FOR CONDITIONING MOTORS

Filed May 23, 1944

3 Sheets-Sheet 1

Fig. 1

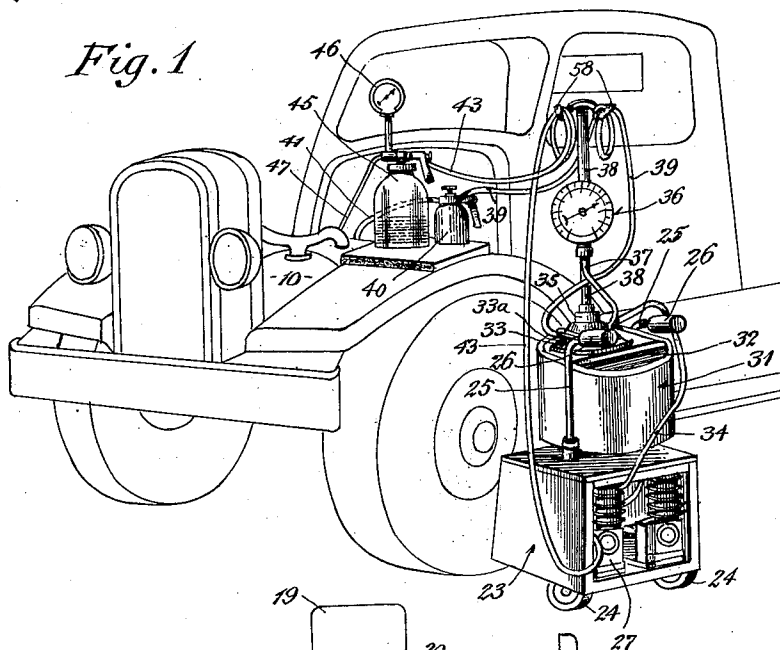
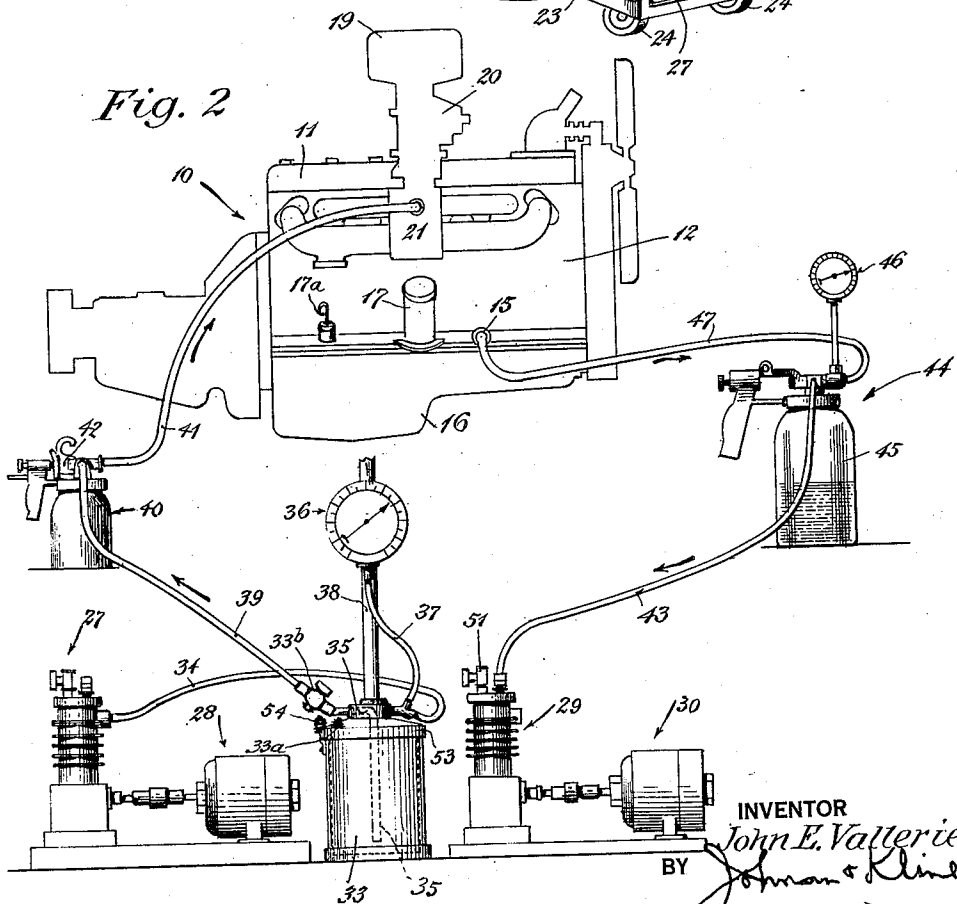


Fig. 2



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3 Sheets-Sheet 2

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Fig. 5

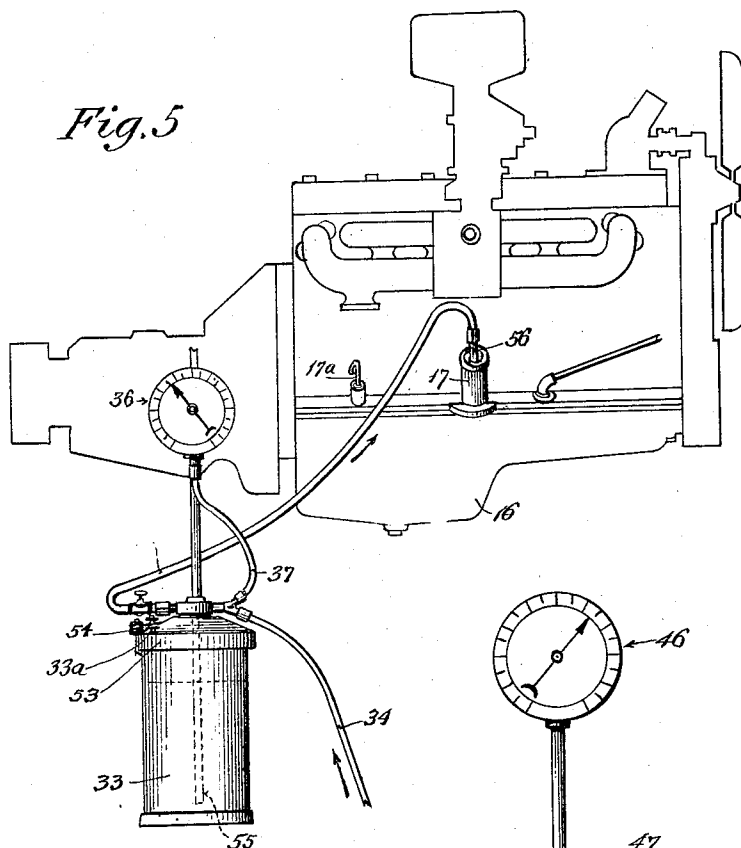
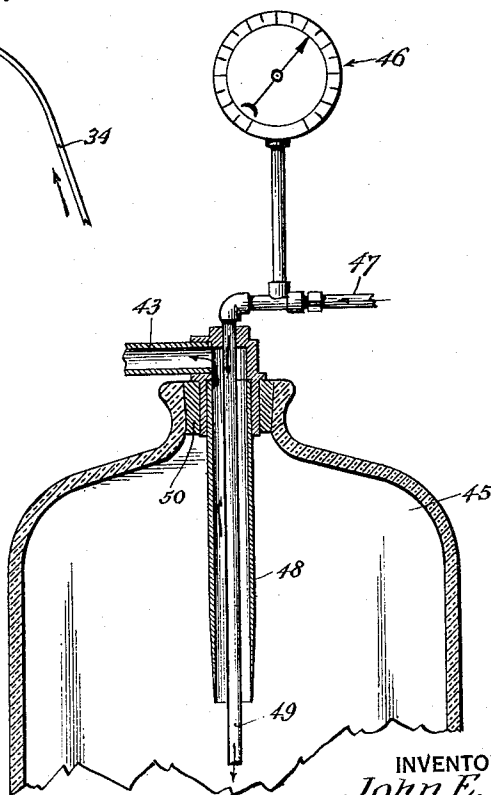


Fig. 6



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METHOD AND APPARATUS FOR CONDITIONING MOTORS

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18 Claims. (Cl. 134-21)

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This invention relates to cleaning and conditioning of engines, and more particularly to methods and apparatus for use in internally cleaning and conditioning an internal combustion engine without dismantling same.

In my copending application, S. N. 434,538, filed March 13, 1942, now Patent No. 2,366,073, dated December 26, 1944, relating to the same subject, I employ a single compressor connected with an atomizer for injecting atomized cleaning liquid into an interior chamber of an engine. The intake of the compressor is connected through a trap to another chamber of the engine having communication with the first chamber as through clearances between movable parts of the engine, the suction created in the second chamber aiding the escape of the vaporized liquid from the first chamber through the clearances between the movable parts. This vaporized cleaning liquid which may thus be forced past pistons, rings, poppet and butterfly valves, bearing surfaces through screens and the like, loosens accumulated sludge and other deposits of foreign matter and carries same to areas where these may be readily removed.

I have found that the removal of sludge and dirt and the cleaning of screens and the various surfaces of co-engaging parts such as bearings, valves, pistons and rings and the like, may be facilitated through the employment of gradually increasing pulsations in both the high pressure and low pressure portions of the apparatus, especially in connection with a greater difference in these pressures, these pulses being independently controllable so that they may be employed separately or conjointly. By the provision of such pulsating pressures the injected cleaning vapors may be made to forcibly pass through clogged passages, clearances and the like and in so doing carry with them the sludge and other clogging deposits so that the parts are thoroughly cleaned.

I accomplish this by the provision of a compressor unit connected with an atomizer for injecting atomized cleaning liquid into the engine, and the provision of a vacuum pump and trap which are separate from the compressor unit and atomizer, for sucking air and vapors out of the engine. The atomizer is provided with a trigger control valve and the hose line connecting to the atomizer with a manually operable cross-plug valve so that by operating the latter the atomized liquid may be injected either in a continuous stream or in pulsations at the will of the operator. On the low pressure side of the apparatus, the vacuum pump has a bleeder valve which may

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be operated to cause a steady suction in the liquid trap of the system and engine chamber to which the trap is connected, or to cause pulsations in the suction which may aid the pulsations in the pressure side of the apparatus in forcing the vapor through clogged passages.

By the provision of compressor and vacuum pump units which are separate, stronger pressures and vacuums may be produced, and there is also obviated any tendency for contaminated cleaning fluid to be carried over from the low pressure side of the apparatus to the high pressure side supplying the atomizer. As a result, the cleaning vapor injected into the engine will always be free from impurities, and the solvent action thereof will not be impaired in any way by the supply of air.

Associated with the high pressure side of the apparatus, is a compressed air tank in which a steady pressure may be built up for the atomizer unit. A pressure gauge is connected to the tank so that a visual indication may be had regarding the progress of movement of the cleaning vapors through the clogged channels. I also provide a vacuum gauge in connection with the trap in the low pressure side of the apparatus, to similarly indicate pressure changes inside the engine, and by means of these gauges a check may be made on the movement of foreign matter, and on the improvement of compression due to freeing of the piston rings, cleaning of the valves, etc. in the engine. In the apparatus disclosed in my above-mentioned application, I depended on the sense of hearing for detecting the passage of vapors, since this passage generally manifested itself by muffled gurgling noises in the engine crankcase which might be heard if an operator placed his ear close to the crankcase filler pipe. According to my new apparatus as disclosed herein, by the provision of gauges both the sonic and visual methods are available to indicate the passage of the cleaning vapors, and the improvement in the condition of the engine.

According to the present invention I also employ the compressed air tank as a canister for flushing the crankcase after the sludge has been loosened from the interior of the engine. For this purpose the tank is provided with a removable cover held in place by quickly releasable fastenings. When the cover is removed the tank may be filled with a flushing liquid suitable for use in cleaning the engine crankcase. When the cover is again replaced, the discharge hose from the tank, which may be provided with an elongate nozzle, is inserted into the oil filler pipe or

the dip-stick hole, and flushing liquid injected under high pressure to thoroughly cleanse the engine parts accessible to the crankcase.

An improved means for injecting vaporized cleaning liquid in the form of a fog directly into the engine crankcase is also provided, this means comprising a flexible tube of large diameter adapted to fit closely to the inside of the crankcase filler pipe. I have found that when the atomizer nozzle is pressed against the exterior end of this tube the atomized particles of liquid more fully vaporize and expand so that a dense fog is created and injected into the engine crankcase, serving to permeate all of the crevices and small passages therein to loosen sludges and other deposits.

According to the present improved method for conditioning an engine, after cleaning vapor has been injected under pressure to flow downwardly past the pistons and rings of the engine, and after the cleaning process has been carried to completion, a reversal of the pressure is employed to return the piston rings to their normal seating positions. This is accomplished by connecting the vacuum or suction side of the apparatus to the chamber of the engine communicating with the tops of the pistons, as for instance the intake manifold, and connecting the pressure side of the apparatus to the crankcase so that air and vapor may be forced upwardly past the piston rings, and in so doing reseat the latter.

The apparatus as provided by the invention for carrying out these methods consists of a housing mounted on wheels to be readily transportable, enclosing the compressor and pump units, and driving motor therefor. Extending upwardly from the housing is a pair of upstanding bars having laterally extending handles by means of which the apparatus may be wheeled about. Between the bars is mounted a partitioned container, one compartment of which carries the compressed air tank. A support or standard extends upwardly from the tank, having mounted thereon the tank pressure gauge, and terminating in hooks on which the hose lines may be coiled and supported when not in use so that they are removed from proximity to the floor where vehicles might run over them. The other compartment of the container carries the atomizing and trap units, and tools for connecting and disconnecting the hose lines.

The overall height of the apparatus is such as to make it easily visible to drivers of vehicles, so that the likelihood of these latter striking and damaging it is minimized.

Other features and advantages will hereinafter appear.

In the accompanying drawings:

Figure 1 is a perspective view of the apparatus of the invention placed alongside an automobile, preparatory to cleaning and conditioning the engine thereof.

Fig. 2 is a diagrammatic view showing the apparatus and connections for injecting atomized cleaning liquid into the intake manifold of an engine, and for sucking out sludge and condensed cleaning vapor from the oil gallery of the engine pressure oiling system.

Fig. 3 illustrates diagrammatically the connections for injecting vaporized cleaning liquid into one cylinder of an engine through a spark plug hole, and for creating a vacuum in the oil-distributing system to aid escape of vapor past the piston.

Fig. 4 illustrates the method of injecting vaporized cleaning liquid into an engine crank-

case, and withdrawing condensed liquid and sludge from the oil gallery.

Fig. 5 shows the connections for using the apparatus to flush a crankcase, after the vapor cleaning of the engine and preparatory to draining of the contaminated oil.

Fig. 6 is a sectional detail of the liquid trap of the apparatus.

Fig. 7 shows a modified form of fog-producing connection from the atomizer, for use with crankcases having filler pipes of small diameter.

Fig. 8 is a detail, partly in section, of the jet-type injection fitting for connecting a hose line to the spark plug hole of a cylinder.

As shown particularly in Figs. 1 through 5, the method and apparatus of the present invention is for use in connection with an internal combustion engine 10, one type of such engine commonly supplying the motive power for land vehicles like the highway truck pictured in Fig. 1.

The engine 10 in its more common form is usually of the four-cycle type, comprising a cylinder head 11 and block 12, the latter having reciprocating pistons 13 (Fig. 3) with the usual sealing rings 14. Bearings for the crankshaft, camshaft, pistons etc. may be lubricated by a force-feed oiling system (not shown), an external fitting connecting to same, and communicating with the oil gallery thereof, being indicated at 15. The fitting 15 is commonly used for making connection to the oil gauge of the vehicle. The engine crankcase 16 has the usual filler pipe 17 through which oil may be supplied to the engine, and a dip-stick oil gauge 17a.

The head 11 of the engine is shown carrying spark plugs 18, and indicated in general outlines are the air strainer 19, carburetor 20, and intake manifold 21.

In practicing the method of internally cleaning and reconditioning an engine according to this invention, a determination is first obtained of the amount of compression each piston is capable of producing. This is done by using a pressure gauge suitable for this purpose, connecting it in place of each spark plug in turn, while turning over the engine slowly, as by hand.

If a cylinder is found that has noticeably less compression than the rest, this may be due to the formation of sludge or other deposits which prevent the proper functioning of the valves or rings. In order to remove this undesirable matter and correct the condition, a vaporized cleaning or solvent liquid, various types of which are available on the market, is injected under pressure into the engine through the spark plug hole of this particular cylinder, as shown in Fig. 3, while the piston is at top, dead center, and both valves are closed. At the beginning of this operation, the injection may be done at comparatively low pressures, and the pressures gradually increased and made to occur intermittently in a manner that strong pulses are produced, which cause the vaporized solvent to flow past the piston rings and past any improperly seated valves. In so doing, the vapors dissolve and loosen carbon, sludge, and the like, and this undesirable matter is carried with the now condensed vapor either into the engine manifolds or the crankcase, as the case may be.

While this procedure is being followed the injection pressure is noted, and I have found that when the cleaning, and removal of sludge and dirt from the valves and piston rings has progressed an extent this will be indicated by an increase in the resistance to vapor injection,

evidenced by a climbing of the injection pressure. This is due to the better seal which the cleaned valves and rings effect with their cooperating structures.

In cases where it may be particularly difficult to dislodge and force away dirt and deposits, the engine may be turned over slowly by an outside power source, such as by hand or with the self-starter, and to further accelerate the cleaning and removal of undesired matter, a vacuum may be created in the escape chambers for the vapors.

Thus, to increase the force tending to carry the vapors and dissolved dirt downwardly past the pistons and rings, according to the method of this invention, suction may be applied to the crankcase of the engine, as by a connection to the fitting 15 of the oil gallery, Fig. 2. This suction may be applied very gradually, to prevent clogging of dirt accumulations, and may be of a steady nature, or it may be pulsating to provide further impetus to the solvent vapors and dissolved matter, and I have found it to be particularly effective when a pulsating pressure and pulsating suction are employed together.

For aiding the solvent vapors in passing, and the removal of dirt from under an improperly seated intake valve, suction may be similarly applied to the intake manifold of the engine during the vapor injection through the spark plug hole, and for this operation the crankshaft of the engine should be turned to a position wherein all the intake valves are closed. Generally, however, this application of suction is not necessary if the valve is poorly seated. Here again, an improvement in the seating of the valve will be manifested by a climbing of the injection pressure, or increase in vacuum in the intake manifold 21, or both.

An important characteristic of the method of this invention is that it may be practised when the engine is cold, for which condition the clearances between the various fitted parts such as pistons, cylinders, rings, etc., are a maximum. This accounts for much of the success of the method in disposing of dissolved matter by carrying same through such clearance passages.

The sole application of vapor under pressure through the spark plug holes of the cylinder head may be employed to ascertain the condition of the exhaust and intake valves. For instance, if an exhaust valve is badly pitted, bent or improperly seated, the penetrating vapors will escape into the exhaust manifold, and may be heard if the operator applies his ear to the tail pipe of the muffler. In extreme cases it may be possible to observe vapors issuing from this pipe.

On the other hand, if an intake valve is not seating properly, the vapors may be seen escaping from the carburetor intake, if the air filter is removed. This method will also reveal faulty head gaskets, since the vapors will escape past the blown portion of the gasket into either an adjacent cylinder, or water packet, or into the atmosphere. The latter condition obviously may be detected at once. If the escape is into the water jacket, gurgling or bubbling noises may be heard if the operator puts his ear to the radiator filler pipe, and a gasket rupture between cylinders may be detected by removing the spark plugs from the adjacent cylinders and observing if vapors issue from the holes.

After completing the cleaning of any improperly functioning individual cylinders in the above manner, an indication may be had of the general condition of the piston and cylinder assem-

bly by using a suction through the spark plug hole of the cylinder. With the piston in top dead center position and both valves closed, a suction up to 25" of vacuum may be employed to reveal weak valve springs. If the suction gauge indicates violent pulsations in the vacuum, this may be caused by fluttering of the valves due to the springs being unable to hold them closed. In the event that the valve springs do not show weakness, the steady value of the suction may be taken as an indication of the degree of leakage past the pistons and valves.

Upon individual cylinders being reconditioned in the above manner, all of the cylinders of the engine, the pressure-feed oiling system and bearings associated therewith, and other parts such as valve stems and the like, may be cleaned simultaneously by making use of the intake manifold 21.

In carrying out this method, all spark plugs are first replaced, and all exterior connections to the intake manifold 21, as for the windshield wiper, brake booster, and the like, removed and the openings with the exception of one plugged up. The carburetor butterfly valve (throttle) is closed, and cleaning vapor under pressure injected into the intake manifold 21 through the remaining, unplugged connection. This injection may be done at various pressures, but preferably it is started at a lower value, and the pressure as it builds up applied intermittently to produce pulsations which accelerate the penetration of the cleaning vapors.

At the same time suction is applied, gradually at first, to the crankcase, as through the oil line fitting 15 leading to the oil gallery, the remaining crankcase fittings such as the filler pipe 17 and breather being preferably plugged up to make the crankcase airtight. This suction may be steady, but preferably it is caused to pulsate during the first part of the cleaning procedure, thus serving to prevent clogging of foreign matter in the oil tubing, thus aiding the cleaning process.

The engine is now slowly turned over, as by hand or with the self-starter. As the intake valve of each cylinder opens, the cleaning vapors in the intake manifold 21 rush into the cylinder under pressure and are forced past the rings and pistons thereof, this action being aided by the suction in the crankcase. When the intake valve closes for the compression stroke of the piston, the trapped vapors continue to force their way past the rings and piston as the latter approaches its uppermost position.

During the working stroke of the piston, the remaining trapped vapors expand due to the reduction of pressure, and this expanded rarified volume is expelled past the exhaust valve into the exhaust pipe of the exhaust stroke. Shortly before the exhaust valve again closes the intake valve opens to repeat the cycle.

The injection of the vaporized solvent into the engine through the intake manifold causes a dissolving of sludge, carbon, varnish and the like inside the engine cylinders, around the valves, valve stems, and piston rings, and frees any of these parts which may be stuck fast. A part of the injected vapors condenses, and carries this dissolved matter in solution, and this, together with the remaining vapors, is forced past the rings and pistons into the engine crankcase.

Here the non-volatile portion settles in the pan, and the volatile portion is forced past the

crankshaft and connecting rod bearings into the force feed oil lines, to the oil gallery. This passage of volatile vaporized penetrant, aided by the slow turning over of the engine, dissolves sludge in bearings and connecting lines, cleaning and freeing these so that when the engine is again operated the lubrication to bearings and working parts will be unimpeded and at the flow originally intended. The dissolved sludge and condensed vapors are carried along the oil lines and oil gallery in the opposite direction to the normal flow of lubricating oil, thus facilitating dislodgment of any dirt or sludge particles which may have become jammed in openings of reduced area, and are finally withdrawn to be disposed of through the fitting 15 of the gallery.

After this procedure has been gone through, the application of vaporized solvent and suction to the engine is reversed. That is, the solvent vapors are injected into the engine through the oil gallery fitting 15, and the suction connection is made to the intake manifold 21. The vapors are now forced through the force-feed oil line and past the bearings of the crankshaft and associated parts into the crankcase, this action being facilitated by turning over the engine while in the cold state, as before. From here the vapors are forced upwardly past the pistons and rings into the cylinder head cavities, and thence out through the intake manifold 21. This reverse procedure tends to dislodge and remove deposits which may have become jammed in openings when the vapor injecting was done through the intake manifold 21, and also serves as a second important function in that it raises the piston rings on the pistons and reseats them in the positions they occupied before the cleaning process.

Upon completion of the cleaning and removal of sludge, carbon, and the like from the engine interior, dry air is forced into the oil gallery, past the bearings, pistons, rings and the like, and sucked out of the intake manifold. This removes most of the solvent on these parts, leaving them comparatively dry. Now an oil film is restored to the parts by injecting atomized oil into the oil gallery, and forcing same past bearings, pistons, etc. The procedure is then reversed, and oil vapor injected into the intake manifold while the suction is again applied to the oil gallery. This operation, which I term "oil plating," restores an oil film to all moving parts, bearing surfaces and the like, as disclosed in my copending application above referred to.

I have found that by means of the above method, sticking and frozen valves and rings may be loosened and caused to function normally, and that a considerable amount of carbon, sludge, varnish and other undesirable matter may be removed from the interior of the engine without dismantling same. After this cleaning procedure the crankcase may be advantageously drained, flushed, and refilled with clean oil.

At times the oil lines, bearings, pump or screen etc. of the pressure lubricating system of an internal combustion engine may be prevented from functioning properly due to breaks, or to dirt, foreign matter and the like being present in the crankcase oil, such conditions being often manifested by a sudden drop in the reading of the oil pressure gauge, and this may occur even though the cylinder assemblies of the engine are clean and operating satisfactorily.

According to the method of this invention, these faults may be found, and clogged lines,

bearings, screens and other parts may be freed of obstructions and cleaned without dismantling the engine or involving the upper cylinder assemblies.

In accomplishing this a connection may be made to the fitting 15 of the oil gallery, for causing a suction in same, and vaporized liquid penetrant may be injected into the crankcase, either through the filler pipe 17 of the hole for the dip stick 17a of the engine, while the latter is being slowly turned over, as by hand or the self-starter. Preferably the crankcase is made airtight by plugging up openings through which the injected vapors might escape, so that a pressure may be built up. At the beginning of this procedure, only suction is employed, it being applied gradually and with pulsations to gently loosen and remove accumulated dirt. Then the suction is increased, and pressure injection of vapors started.

To facilitate the dissolving, dislodging and moving of clogged masses, the injection of vapor may be done intermittently to produce strong pulsations of pressure in the crankcase, and this action may be enhanced through the use of the pulsations in the suction in the oil gallery.

Measurement of the suction in the gallery, as by a gauge, will give an indication of the progress of the cleaning. A plugged oil line may result in the building up of a vacuum of several inches, and when the obstruction is dislodged and expelled from the system through the fitting 15, the vacuum reading will fall appreciably. If a moderately strong vacuum cannot be established in the oil gallery it is an indication of a break in one of the oil lines leading thereto.

To thoroughly clean the oil gallery and associated lines and bearings, oil pump, strainer, etc. the vacuum and the pressure injection are now reversed, the vacuum being created in the crankcase, and the vapor being injected through the fitting 15 into the oil gallery. This enables a check to be made also if it is suspected that the system has a broken oil line. If there is a definite break in the line, when vapor is injected a hissing noise may be heard upon listening at the crankcase filler pipe. A muffled sound instead indicates no break, since this is the usual noise made by the vapors passing through the bearings. The pressure built up in the oil gallery may be measured by a gauge, and as the parts become clean and free from dirt and gum this will be indicated by a drop in the pressure, due to the faster escape of air and vapors through bearing clearances, oil pump, screen, etc. When this cleaning procedure for the lubrication system is completed, the oil gallery may be flushed with a flushing compound. At this time the crankcase may also be drained, flushed, and refilled with new oil. After this air is forced into the oil gallery, and sucked out of the crankcase to remove all traces of solvent or flushing compound on bearings and the like, and then vaporized oil is injected in conjunction with the vacuum, to oil plate the parts, and replace the oil film. This injection may be done in both the oil gallery and crankcase, with suction being also applied in each instance.

The cleaning method of this invention may be advantageously used to clean the carburetor of an engine. First a quantity of solvent liquid is poured into the carburetor air intake, and allowed to remain for a period. Then cleaning vapors are injected into the intake manifold, intermittently to cause strong pulsations, the but-

terfly valve (throttle) of the carburetor being open to permit the vapors to pass through the various carburetor passages to dissolve and dislodge fine particles of accumulated dirt, which may then pass off during the subsequent running of the engine.

A novel apparatus is provided according to the present invention for enabling the above methods for cleaning and conditioning an internal combustion engine to be successfully conveniently carried out.

This apparatus is illustrated in perspective in Fig. 1, and diagrammatically in Fig. 2, and comprises a housing 23 in the form of a box open on one side, mounted on wheels or castors 24 so that it is readily transportable, and having a pair of upstanding bars 25 and handles 26 so that it may be conveniently wheeled from place to place.

Mounted within the housing 23 is a compressor 27 driven by an electric motor 28 shown in Fig. 2, and a vacuum pump 29 driven by another electric motor 30 (Fig. 2). The motors 28 and 30 are energized through the usual switches and electric lines (not shown), being connected so that each may be run independently of the other.

Carried by and between the bars 25 of the housing is an oval-shaped container 31 having a vertical partition 32 dividing it into two parts one of which carries a compressed air tank 33. The output of the compressor 27 is connected through a suitable hose 34 to the neck 35 of the compressed air tank so that an air pressure may be built up in the latter, this pressure being indicated on a gauge 36 connected to the tank through a hose 37 and carried by a post or standard 38 mounted on the tank. The pressure in the tank is prevented from reaching a dangerous value by a safety valve 33a, which may be set to restrict the pressure to a maximum of 50 lbs.

According to the invention, the tank 33 has an outlet controlled by a valve 33b, to which is connected a hose 39 in turn connecting to an atomizer or vaporizer 40, the nozzle of which is joined to a hose 41. Thus, by operating the valve 33b the flow of air to the atomizer, and therefore the injection of vapors into the engine may be shut off entirely, or partially, or allowed to proceed unimpeded, and injection pulses may thus be produced at will.

The atomizer 40, which may be similar to those commonly used in connection with the spraying of paint, is adapted to hold a quantity of cleaning or solvent liquid, and to vaporize same into very fine fog-like particles. The atomizer is provided with a trigger valve 42 which may function to control the atomization of the solvent liquid, so that the vapors may be shut off entirely and only air injected into the engine.

By this arrangement, when the hose 41 is connected, as shown in Fig. 2, to the intake manifold of the engine 10, atomized liquid may be injected continuously or intermittently, the latter procedure, in connection with a pressure head in the tank 33, being employed in carrying out the pulsative method of the invention already described. To produce effective powerful pulses with the intermittent injection of vapor, the valve 33b is allowed to remain closed until a substantial air pressure is built up in the tank 33. Upon this being accomplished, the opening of the valve will release a large quantity of air under substantial pressure, which will produce a fine fog-like vapor and inject same into the engine with a strong pulse which I have found to be very

effective in loosening sludge and dirt deposits, and forcing the penetrating vapors past close fitting parts to be freed and cleaned, such as the pistons 13, rings 14 and the like.

Referring to Fig. 3, the hose 41 is shown connected by a fitting 41a to the spark plug hole of the last cylinder, as for the purpose of reconditioning this, freeing and cleaning the rings 14 to restore the compression prior to performing the operation on all cylinders simultaneously. This fitting, shown in detail in Fig. 8, has an orifice which when vapors are injected through it produces a jet striking against the top of the piston. The injected vapors forming this jet form a crater in the carbon deposits on the piston, baring the metal and when the engine is subsequently run, the remaining carbon has a tendency to chip off, and pass out through the exhaust valve.

After this connection has been made and the pressure is building up in the tank 33, with the trigger valve 42 open, the valve 33b is opened, then closed again, then opened, and so on. At the beginning of this operation, the difference in the readings of the gauge 36 is noted, between open and closed positions of the valve. After the operation has progressed, and the vapors have freed and cleaned the piston rings, according to the method described, the differential of the valve readings is again noted, the improved condition of the rings 14 being manifested by a lesser differential in the gauge readings. Or if the valve 33b should be held open, as the cleaning progresses to the point where the rings 14 are freed and again seal the clearances between the piston 13 and cylinder walls, a rise in the gauge reading will be noted.

In order to accelerate the cleaning action, and the passage of the penetrating vapors past the parts to be cleaned, and to remove from the engine the undesired deposits, dirt, etc. the invention provides a mechanism independent of the high-pressure injection part of the apparatus, for attachment to engine chambers adjacent and having restricted communication with those in which the cleaning vapors are injected. Referring again to Figs. 1 and 2, this mechanism includes the vacuum pump 29, motor 30, and further comprises a hose 43 connecting the intake of the pump 29 to a trap 44 having a glass jar 45, the trap carrying a vacuum gauge 46 and being attached to a hose 47 by means of which it may be connected to the engine 10.

As shown in Fig. 6, the trap 44 has a pair of vertical pipes 48 and 49 carried by a stopper 50, one pipe extending through the other, and the outer pipe 48 terminating near the top of the jar 45, to constitute the air outlet from the latter.

The gauge 46 is connected so that it measures the vacuum in the hoses 43 and 47, and jar 45.

As shown in Figs. 2, 3 and 4, the hose 47 is provided with a fitting so that it may be connected to the fitting 15 of the engine, communicating with the oil gallery of the pressure lubricating system to create a suction therein when the pump 29 is operating.

Referring to Fig. 3 illustrating the operation of conditioning the last cylinder of the engine 10, I have found it advantageous to supplement the pulsating injection of vapors into the cylinder by applying suction to the oil gallery through the fitting 15, by means of the vacuum apparatus and trap 44 just described. This suction aids the passage of penetrant vapors past the piston 13 and rings 14, since it creates a vacuum in the

crankcase 16, and oil gallery, and the vapors sucked into the latter and condensed during the process will be withdrawn, together with dissolved sludge, dirt and the like, through the hose 47 to be deposited in the jar 45.

To further accelerate the cleaning operation, the head of the pump 29 may be provided with a bleeder valve 51, Fig. 2, which may be used as a relief to control the suction in the jar 45, and consequently in the engine 10. If the valve 51 is opened, the sucking of the pump 29 is reduced, and the vacuum in the jar 45 will become less. The valve 51 may be left open, in which event the vacuum in the jar 45 will be reduced to such an extent that the pulsations occasioned by the reciprocation of the piston of the pump will be felt in the jar, and in the hose line 47 and oil gallery of the engine.

These pulsations may be employed to augment the effect of the pulses of injected vapor, and as a result a more effective dislodgement of sludge and dirt, and passage of vapors is obtained.

In carrying out the individual cylinder conditioning illustrated in Fig. 3, the reversal of injection and suction is accomplished by connecting the hose 47 to the spark plug hole of the cylinder, and if desired, connecting the hose 41 to the fitting 15 of the oil gallery. This reversal will dislodge jammed particles which cannot pass downwardly between the piston 13 and cylinder, and will also reseat the rings 14 in their proper positions.

The connections of the apparatus for cleaning the cylinder assemblies simultaneously are illustrated in Fig. 2. The injection hose 41 is connected to the intake manifold 21 and the suction hose 47 to the oil gallery fitting 15, and the step of reversing the injection and suction is accomplished by connecting the hose 47 to the manifold 21, and the hose 41 to the fitting 15.

The apparatus and method of this invention may also be employed to remove deposits and generally clean the radiator and cooling system of an engine, by connecting the hose 41 to the radiator filler pipe, and the hose 47 to the bottom connection from the radiator to the engine. For this purpose a liquid solvent suitable for dislodging and dissolving scale and rust deposits is preferably used in the atomizer 40. A reversal of these connections may be employed alternately with the above to further facilitate the removal of the objectionable matter.

The method of correcting faulty lubrication in the pressure oil-distributing system is illustrated in Fig. 4, wherein the suction connection of the hose 47 is again made to the oil gallery fitting 15. However, according to the invention an improved means is provided for producing and injecting a dense fog into the crankcase 16 for penetration through the crankcase bearings etc. to the oil gallery. This means comprises a rubber hose 52 of such a diameter that it fits closely inside the oil filler pipe 17 of the crankcase, which pipe is of the larger type in use. The outer end of the hose is cut squarely so that the nozzle of the atomizer may be fitted tightly against it, as shown. The inside diameter of the hose 52 is substantially larger than the orifice of the atomizer nozzle, and I have found that as a result the vapors issuing from the nozzle may expand and subdivide so that a dense persisting fog is produced, which is forced under pressure into the crankcase 16. Where smaller oil-filler pipes are encountered, injection of vapors is preferably accomplished through the use of a small hose and

an enlarged chamber between the hose and atomizer, as illustrated in Fig. 7. This device is shown in detail in my copending application referred to.

In carrying out the method the connections for which are illustrated in Fig. 4, the vacuum gauge 46, being connected to the hose line 47, will give an indication of the amount of suction in the oil gallery and associated pipe lines of the engine, so that the readings of the gauge may be used as indications of breaks, plugged lines, etc. as already described.

The apparatus of the present invention is adapted for carrying out the step of flushing the crankcase, as part of the engine conditioning method.

For this purpose the cover 53 of the air tank 33 is made easily removable, being held in place on the tank by quickly releasable fastenings 54. Also, the neck 35 of the cover supports a vertical open-ended pipe 55 extending into the tank and terminating at a point near the bottom, the pipe being connected to the hose line 39.

As thus arranged, the tank 33 may function as a canister, and may be filled with a substantial quantity of crankcase flushing liquid, which can then be forced out under pressure through the hose line 39. As shown, in Fig. 5, the hose 39 is disconnected from the atomizer 40 and provided with a tubular extension 56 which is inserted in the oil filler pipe 17. After the old oil has been drained from the crankcase 16 the drain plug is replaced, and the flushing liquid in the tank 33 squirted into the crankcase by running the compressor 27. If desired, the dip-stick gauge 57 may be removed and the tube 56 inserted into the dip-stick hole to aid the flushing liquid to more readily reach other parts of the crankcase.

For the purpose of racking the hoses 39 and 43, the standard 38 mounted on the tank 33 is extended upward beyond the gauge 36, and provided with hooks 58 on which the hoses may be coiled, as shown in Fig. 1.

The compartment of the container 41 adjacent that occupied by the tank 33 is preferably large enough to hold the liquid trap 44, vaporizer 40, rubber hose 52, and tools required in connecting the apparatus.

While the method and apparatus of this invention has been described in connection with an internal combustion engine of the four-cycle type, it should be understood that it may be used with two-cycle engines, Diesels, and other.

Variations and modifications may be made within the scope of this invention and portions of the improvements may be used without others.

I claim:

1. In the art of cleaning relatively movable parts and an interior chamber of an internal combustion engine without dismantling same, which parts have clearances between them accessible to the interior chamber of the engine, the method including the steps of turning-over the engine while cold and unexpanded to cause relative movement of said parts; and simultaneously injecting with an intermittent pressure a cleaning material in vapor form into said interior chamber producing pulsations tending to dislodge foreign matter, said cleaning material passing through the clearances between said relatively moving engine parts into areas of lower pressure and carrying with it foreign matter collected thereby.

2. In the art of cleaning relatively movable parts and an interior chamber of an internal

combustion engine without dismantling same, which parts have clearances between them accessible to the interior chamber of the engine, the method including the steps of turning-over the engine while cold and unexpanded to cause relative movement of said parts; simultaneously injecting with an intermittent pressure a cleaning material in vapor form into said interior chamber producing pulsations tending to dislodge foreign matter, said cleaning material passing through the clearances between said relatively moving engine parts into areas of lower pressure and carrying with it foreign matter collected thereby; and gradually increasing said pressure and the violence of said pulsations to loosen the more tenacious particles of foreign matter.

3. In the art of cleaning relatively movable parts and an interior chamber of an internal combustion engine without dismantling same, which parts have clearances between them accessible to the interior chamber of the engine, the method including the steps of turning-over the engine to cause relative movement of said parts; simultaneously injecting with an intermittent pressure a cleaning material in vapor form into said interior chamber producing pulsations tending to dislodge foreign matter, said cleaning material passing through the clearances between said relatively moving engine parts into areas of lower pressure and carrying with it foreign matter collected thereby; gradually increasing said pressure and the violence of said pulsations to loosen the more tenacious particles of foreign matter; and thereafter withdrawing atmosphere from said lower pressure area to accelerate the passage of said cleaning material and foreign matter from the said interior chamber.

4. In the art of cleaning relatively movable parts and an interior chamber of an internal combustion engine without dismantling same, which parts have clearances between them accessible to the interior chamber of the engine, the method including the steps of turning-over the engine to cause relative movement of said parts; simultaneously injecting with an intermittent pressure a cleaning material in vapor form into said interior chamber producing pulsations tending to dislodge foreign matter, said cleaning material passing through the clearances between said relatively moving engine parts into an adjacent interior chamber of lower pressure and carrying with it foreign matter collected from said parts; and simultaneously withdrawing the atmosphere from said adjacent chamber to reduce the pressure therein and to accelerate the passage of the cleaning vapor and foreign matter from the first-mentioned chamber.

5. In the art of cleaning relatively movable parts and an interior chamber of an internal combustion engine without dismantling same, which parts have clearances between them accessible to the interior chamber of the engine, the method including the steps of turning-over the engine to cause relative movement of said parts; simultaneously injecting with an intermittent pressure a cleaning material in vapor form into said interior chamber producing pulsations tending to dislodge foreign matter, said cleaning material passing through the clearances between said relatively moving engine parts into an adjacent interior chamber of lower pressure and carrying with it foreign matter collected from said parts; and intermittently withdrawing the atmosphere from said adjacent chamber during said turning over of the engine to intermittently

reduce the pressure therein and facilitate the passage of the cleaning vapor and foreign matter from the first-mentioned chamber.

6. In the art of cleaning the top cylinder, piston and valves of an internal combustion engine without dismantling same, the method including the steps of turning over the engine while cold and unexpanded to cause movement of the piston and valves through a cycle of operations; and simultaneously injecting with an intermittent pressure a cleaning material in vapor form into an interior chamber communicating with said top cylinder producing pulsations tending to dislodge foreign matter, said material flowing past said piston and valves into areas of lower pressure and carrying with it foreign matter.

7. In the art of cleaning relatively movable parts and an interior chamber of an internal combustion engine without dismantling same, which parts have clearances between them accessible to the engine crankcase, including the steps of turning-over the engine while cold and unexpanded to cause relative movement of said parts; and simultaneously injecting with an intermittent pressure a cleaning material in vapor form into said crankcase producing pulsations tending to dislodge foreign matter, said cleaning material passing through the clearances between said relatively moving engine parts into areas of lower pressure and carrying with it foreign matter collected thereby.

8. In the art of cleaning relatively movable parts and an interior chamber of an internal combustion engine without dismantling same, which parts have clearances between them accessible to the engine crankcase, including the steps of turning-over the engine to cause relative movement of said parts; simultaneously injecting with an intermittent pressure a cleaning material in vapor form into said crankcase producing pulsations tending to dislodge foreign matter, said cleaning material passing through the clearances between said relatively moving engine parts into areas of lower pressure and carrying with it foreign matter collected thereby; and thereafter withdrawing atmosphere from said lower pressure area to accelerate the passage of said cleaning material and foreign matter from the said interior chamber.

9. In the art of cleaning the piston rings and mounting grooves therefor of an internal combustion engine without dismantling same, the method including the steps of turning over the engine while cold and unexpanded to cause movement of the piston through a cycle of operations; and injecting with an intermittent pressure a cleaning material in vapor form into the top cylinder above the piston producing pulsations tending to dislodge foreign matter during said turning over of the engine, said material passing around the rings into the crankcase and carrying with it foreign matter collected at the rings.

10. In the art of cleaning an internal combustion engine, the method including the steps of turning over the engine to cause movement of the piston through a cycle of operations; injecting with an intermittent pressure a cleaning material in vapor form into a chamber having access to the top of the piston during said cycle of operations, producing pulsations tending to dislodge foreign matter, said material passing over and around the piston rings into the crankcase and carrying with it foreign matter collected at said rings, said pressure displacing the rings downward from a normal seating position on the

piston; turning over the engine through another cycle of operations; and creating a suction in said chamber during the second-mentioned cycle of operations to return the rings to their normal seating positions.

11. In the art of cleaning the pressure oil-distributing system of an internal combustion engine without dismantling same, the method including the steps of turning over the engine to cause movement of the bearings associated with said system; and simultaneously injecting with an intermittent pressure a cleaning material in vapor form into said system, producing pulsations tending to dislodge foreign matter, said material passing through said bearings into areas of lower pressure and carrying with it foreign matter collected from said system and bearings.

12. In the art of cleaning the pressure oil-distributing system of an internal combustion engine without dismantling same, the method including the steps of turning over the engine to cause movement of the bearings associated with said system; simultaneously injecting with an intermittent pressure a cleaning material in vapor form into the engine crankcase while turning over of the engine, said material passing through said bearings into the oil-distributing system and carrying with it foreign matter collected from the bearings; and simultaneously withdrawing said vapor and foreign matter from the oil-distributing system while turning over of the engine.

13. In the art of cleaning the pressure oil-distributing system of an internal combustion engine without dismantling same, the method including the steps of turning over the engine to cause movement of the bearings associated with said system; simultaneously injecting with an intermittent pressure a cleaning material in vapor form into said system, producing pulsations tending to dislodge foreign matter, said material passing through said bearings into the engine crankcase; and simultaneously withdrawing the atmosphere from the engine crankcase during said turning-over of the engine to reduce the pressure therein and accelerate the passage of the cleaning vapor past the said rings, and foreign matter carried thereby.

14. A device for cleaning and conditioning an internal combustion engine, comprising a pressure-operated atomizer; pressure-producing means for the atomizer; means connected with the atomizer for injecting a stream of atomized liquid under pressure into an interior chamber of an internal combustion engine, and causing a pressure in said chamber; a vacuum pump operable independently of the pressure-producing means; and means for connecting the vacuum pump to an interior chamber of the engine at a point remote from the injecting point for simultaneously withdrawing the atmosphere therefrom so that atomized liquid injected into the engine may be drawn through and withdrawn from same.

15. The invention as defined in claim 14, in which there are means for producing pressure pulsations of atomized liquid for injection into the engine chamber, for overcoming the resistance of clogged escape passages in the chamber.

16. The invention as defined in claim 14 in which there are means for controlling the injection of atomized liquid whereby the stream may be alternately turned off and on to produce pulsations in the pressure of the chamber into which the liquid is injected, for overcoming the resistance of clogged escape passages in the chamber.

17. A device for cleaning and conditioning an internal combustion engine, comprising a pressure-operated atomizer; pressure-producing means for the atomizer; means connected with the atomizer for injecting a stream of atomized liquid under pressure into an interior chamber of an internal combustion engine, and causing a pressure in said chamber; a vacuum pump operable independently of the pressure-producing means; means for connecting the vacuum pump to an interior chamber of the engine at a point remote from the injecting point for simultaneously withdrawing the atmosphere therefrom so that atomized liquid injected into the engine may be withdrawn from same; means for producing pressure pulsations of the atomized liquid; and means for producing pulsations in the vacuum produced by the vacuum pump, said pulsations being independent of the pressure produced by the pressure-producing means, said pressure and vacuum pulsations aiding the injection and withdrawal of atomized liquid from the engine.

18. The invention as defined in claim 14 in which the means for injecting a stream of atomized liquid into the engine chamber comprises a tube extending from the atomizer into said chamber, the inside diameter of the tube being larger than the orifice of the atomizer an extent sufficient to permit expansion of the vaporized liquid so that the particles thereof become substantially less dense and create a fog.

JOHN E. VALLERIE.

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Certificate of Correction

Patent No. 2,525,978

October 17, 1950

JOHN E. VALLERIE

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows:

Column 5, line 63, for the word "packet" read *jacket*; column 12, line 44, for "container 41" read *container 31*; column 16, line 56, list of references cited, for "1,889,019" read *1,899,019*;

and that the said Letters Patent should be read as corrected above, so that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 2nd day of January, A. D. 1951.

[SEAL]

THOMAS F. MURPHY,
Assistant Commissioner of Patents.