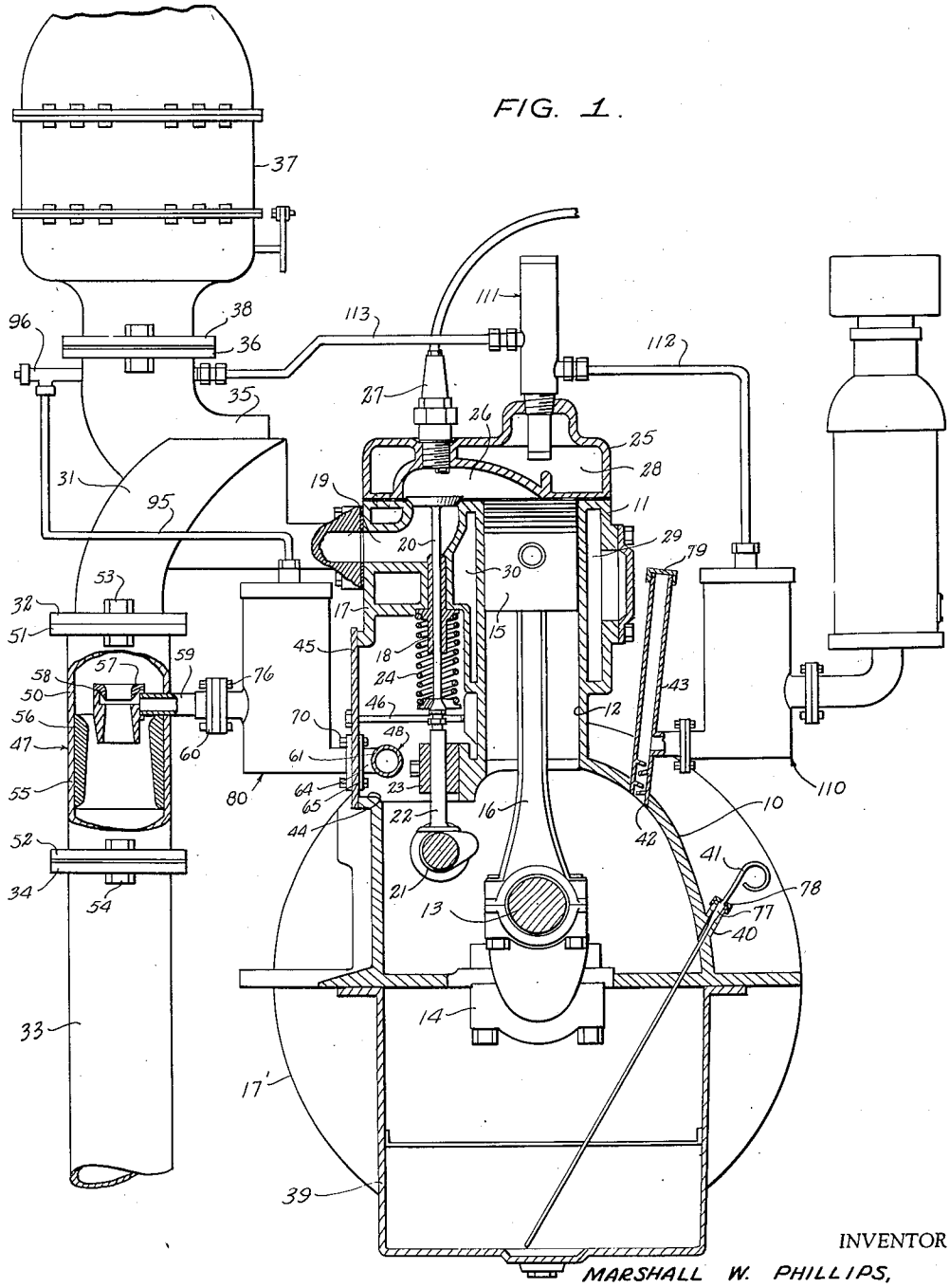
Feb. 12, 1952 M. W. PHILLIPS 2,585,495

ENGINE CRANKCASE SCAVENGING APPARATUS

Filed Jan. 13, 1950 3 Sheets-Sheet 1

FIG. 1.



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ENGINE CRANKCASE SCAVENGING APPARATUS

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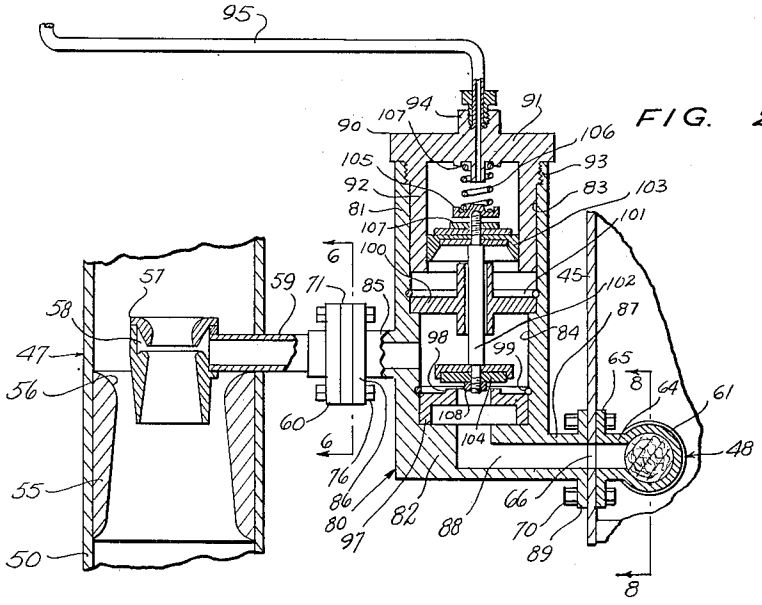


FIG. 2.

FIG. 6.

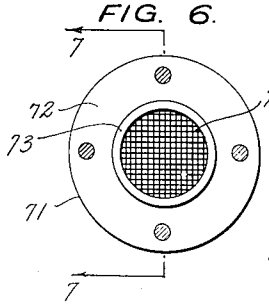
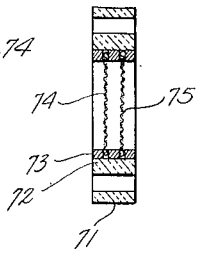


FIG. 7.



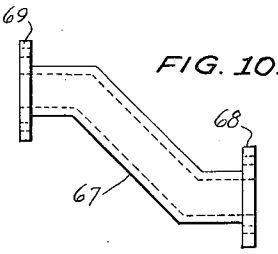
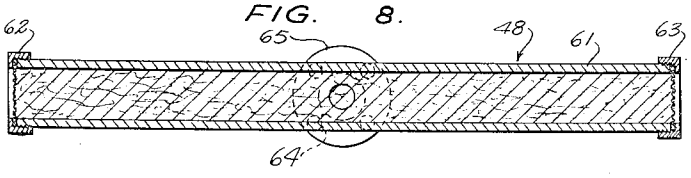


FIG. 10.

FIG. 8.



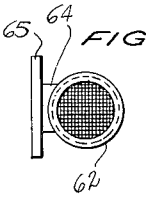


FIG. 9.

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ENGINE CRANKCASE SCAVENGING APPARATUS

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FIG. 3.

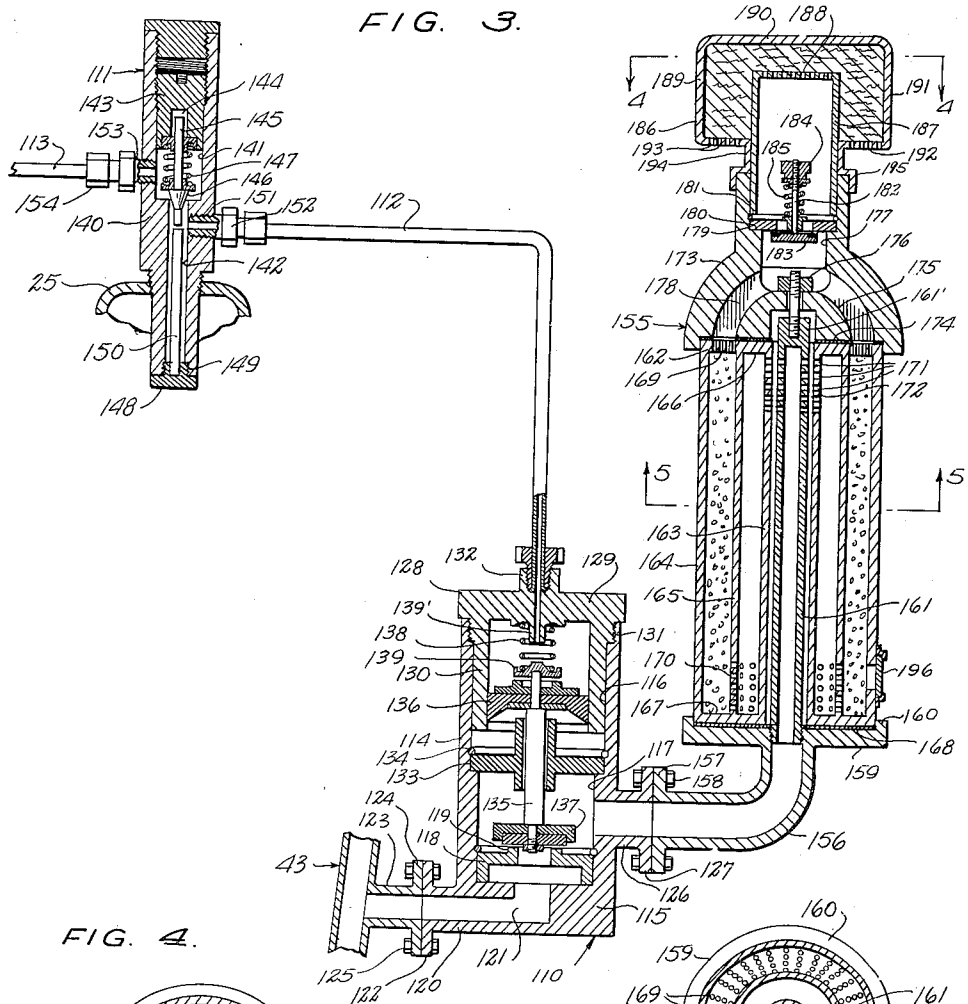


FIG. 4.

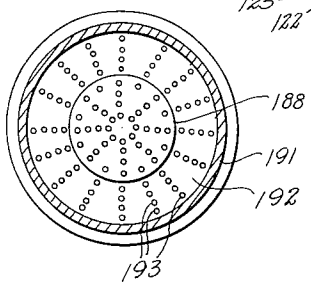
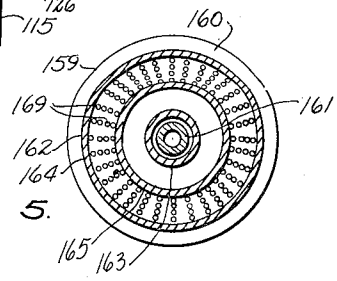


FIG. 5.



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UNITED STATES PATENT OFFICE

2,585,495

ENGINE CRANKCASE SCAVENGING APPARATUS

Marshall W. Phillips, Lima, Ohio

Application January 13, 1950, Serial No. 138,403

9 Claims. (Cl. 123—41.86)

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This invention relates to engine crankcase scavenging apparatus and more particularly to vacuum scavenging apparatus for removing water vapor, fuel vapor and other lubricating oil contaminating and metal corrosive substances from the engine crankcase and the engine lubricating oil.

It is among the objects of the invention to provide improved engine crankcase scavenging apparatus which is actuated by the flow of engine exhaust gases to maintain the air pressure in an engine crankcase below atmospheric pressure during engine operation to expedite and facilitate the evaporation of water and fuel condensate in the crankcase and withdraw the vapor from the crankcase and to retard or preclude the condensation of water and fuel vapors entering the crankcase during normal operation of the engine and constantly withdraw such vapors together with combustion products, lubricating oil conversion products and any other lubricating oil contaminating substances or metal corrosive substances of a gaseous or evaporative nature from the engine crankcase during engine operation, which is effective to separate lubricating oil mist and spray from the substances withdrawn and maintain the lubricating oil in the crankcase against loss through the scavenging system, which may be automatically operated to close off the scavenging outlet from the crankcase when the engine is not in operation to thereby restrain the flow of air into the crankcase and avoid condensation of atmospheric moisture in the engine when the latter is in a cold condition, may further operate to also substantially preclude entry of atmospheric air into the crankcase until the engine has reached its normal operating temperature to thereby maintain a subatmospheric pressure in the crankcase during the starting and warming up period of the engine to thereby facilitate the evaporation and removal of any moisture which may have condensed in the cold engine and any unvaporized or unburnt fuel which may enter the crankcase during the starting and warming up period of the engine, and to admit a measured quantity of air to the crankcase after the engine temperature reaches the normal operating range to facilitate the removal from the crankcase of oil contaminating and corrosive substances including the sulphur and bromine bearing products of fuel combustion which may leak into the crankcase past the engine pistons and exhaust valves, and may operate to artificially desiccate the air admitted to the crankcase, and which may be applied to substantially all types

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of reciprocating, internal combustion engines including L-head and valve in head engines either liquid or air cooled and having four cycle or two cycle operation.

Other objects and advantages will become apparent from a consideration of the following description and the appended claims in conjunction with the accompanying drawings wherein:

Figure 1 is a somewhat diagrammatic transverse cross section of an integral combustion engine showing engine crankcase scavenging apparatus illustrative of the invention operatively applied to the engine;

Figure 2 is a medial cross section of a portion of the crankcase scavenging opparatus showing structural details thereof;

Figure 3 is a medial cross section of the portion of the crankcase scavenging apparatus not illustrated in Figure 2 and showing additional structural details of the apparatus;

Figure 4 is a cross section on the line 4—4 of Figure 3;

Figure 5 is a cross section on the line 5—5 of Figure 3;

Figure 6 is a cross section on the line 6—6 of Figure 2;

Figure 7 is a cross section on the line 7—7 of Figure 6;

Figure 8 is a cross section on the line 8—8 of Figure 2;

Figure 9 is an end elevation of the oil separating tube illustrated in Figure 8; and

Figure 10 is a side elevation of a conduit which may be used in the apparatus to replace certain automatic valve components of the apparatus.

With continued reference to the drawings, there is illustrated for the purpose of disclosing the invention an L-head, four cycle internal combustion engine such as is commonly employed for the propulsion of motor vehicles although, as explained above, the scavenging apparatus is not limited in its application to any particular type of reciprocating, internal combustion engine.

The engine illustrated has a crankcase 10 upon which is mounted a cylinder block 11 within which is provided a plurality of cylinders 12 disposed in alignment longitudinally of the engine. A crankshaft 13 is journaled in suitable main bearings 14 mounted in the crankcase and a piston 15 is reciprocable in each cylinder 12. A connecting rod 16 connects each piston 15 to a corresponding crank of the crankshaft 13 and the crankshaft is connected at one end to a flywheel enclosed in the flywheel housing 17'.

The cylinder block 11 is extended at one side

of the row of cylinders to provide a valve housing 17 and a plurality of tubular valve guides are mounted in this housing, an exhaust valve guide being illustrated in Figure 1 and indicated at 18. Intake and exhaust ports, such as the exhaust port 19, lead through the upper part of the valve housing 17 into the combustion chambers provided at the upper end of the cylinder block and a valve is slidably mounted in each valve guide, the exhaust valve 20 being mounted in the guide 18 and cooperating with a valve seat at the end of exhaust port 19 at the top end of the cylinder block. The valves are operated by a cam shaft 21 journaled in the crankcase adjacent the crankshaft 13 and driven by suitable timing gears, not illustrated, and by valve tappets 22 slidably mounted in tappet guides 23 and bearing at their lower ends on the cams of the cam shaft 21 and at their upper ends against the bottom ends of the stems of the intake and exhaust valves of the engine. Each intake and exhaust valve is resiliently urged to its seating position by a compression spring 24. A cylinder head 25 is mounted on the upper end of the cylinder block and secured to the block by the usual cylinder head hold down bolts and the cylinder head is formed to provide a combustion chamber 26 for each engine cylinder. Spark plugs 27 are mounted in the cylinder head for extension through the head into the combustion chambers and the cylinder head is made hollow to provide a water space 28 which surrounds the spark plugs and the combustion chambers for removal of heat from the cylinder head by the cooling fluid of the engine. The cylinder block is provided with water jackets 29 and 30 for engine cooling fluids and these jackets are connected with the interior of the hollow cylinder head so that one body of cooling fluid passes through the cylinder head and the water jackets to remove excess heat from the engine.

An exhaust manifold 31 is connected to all of the exhaust ports of the engine and has an end provided with an external flange 32 to which the exhaust pipe 33 is usually connected by an external flange 34 on the corresponding end of the exhaust pipe. An intake manifold 35 is connected to all of the intake ports of the engine and is provided with a carburetor attachment flange 36 to which the engine carburator 37 is attached by the flange 38 on the bottom end of the carburetor.

An oil pan 39 is attached to the lower side of the crankcase 10 and extends below the crankcase and the crankcase is provided with a tubular boss 40 through which a dip rod 41 extends into the oil pan to measure the depth of engine lubricating oil in the oil pan. In its upper side the crankcase is provided with an opening 42 and an oil filler tube 43 is secured at its lower end in the opening 42 and extends upwardly from the crankcase to provide a tubular conduit through which lubricating oil may be poured into the crankcase and oil pan of the engine. Ordinarily the upper end of the oil filler tube or spout 43 is closed by an air pervious cap so that air may pass through this filler spout into and out of the engine crankcase to provide the necessary breathing of the crankcase.

An inspection and adjustment opening 44 is provided in the outer side of the valve housing 17 along the valve tappet guides 23 to give access to the valve mechanism for inspection, adjusting and removing the valves. An inspection plate 45 closes the inspection opening 44 and is detachably secured to the engine cylinder block by suitable means such as the screws 46.

Since the engine may be of any desired or well known construction, this brief description of the principal engine components is believed sufficient for the purposes of the present disclosure. It is to be noted that when the engine is operating the interior of the intake manifold 35 is usually subjected to subatmospheric pressure which may rise substantially to atmospheric pressure when the engine throttle valve is fully opened and the speed of the engine is retarded by the load imposed on the engine and that the exhaust manifold and exhaust pipe are subject at all times of engine operation to the rapid flow of exhaust gases therethrough. It is further to be understood that in starting such an engine the fuel air mixture supplied to the engine may be enriched by closing or partly closing the choke valve to restrict the flow of air to the engine and that some portion of the excess fuel supplied to a cold engine for starting purposes is frequently not vaporized or burned by the engine and some of this fuel leaks into the engine crankcase past the engine pistons and the engine exhaust valve stems where the valve stems are slidably mounted in the valve guides, this leakage being facilitated by the clearances incident to the cold condition of the engine parts.

It is also well known that atmospheric air contains an appreciable amount of moisture or water vapor and that some of this vapor has a tendency to condense on objects contacted by the air when the air is chilled to the dew point or saturation point. It is also well known that internal combustion engine fuels, and particularly the detonating retarding fuels for gasoline engines, contain appreciable amounts of sulphur and bromide compounds and that these substances, particularly when dissolved in water to produce acid, have a highly corrosive action on metal parts and that condensed moisture, condensed fuel and the acid products of combustion have a deteriorating effect on engine lubricating oil, causing the oil to sludge and to lose a large portion of its lubricating effectiveness.

The evaporation or vaporization of evaporative substances, such as water and liquid engine fuel, is known to be greatly enhanced by increasing the temperature of the substance and by reducing the pressure of the ambient atmosphere into which the substance evaporates. It is, therefore, conceived that such substances may be expeditiously removed from the interior of an engine crankcase by utilizing the exhaust gases of the engine to reduce the pressure in the crankcase below atmospheric pressure to cause rapid evaporation of the substances and to remove the vapors from the crankcase as the substances are evaporated.

In accordance with the present invention there is provided a special exhaust pipe section, generally indicated at 47, an oil separator tube, generally indicated at 48, mountable within an engine crankcase, and conduit means connecting the separator tube to the exhaust pipe section so that the exhaust gases passing through the exhaust pipe section will apply a suction to the oil separator tube.

The special exhaust pipe section 47 comprises a hollow, cylindrical body 50 having at one end an apertured external flange 51 which matches the flange 32 on the end of the exhaust manifold 31 and having at its opposite end an external flange 52 which matches the flange 34 on the

end of the exhaust pipe 33. The flanges 32, 34, 51 and 52 are suitably apertured and the flanges 32 and 51 are secured together by suitable means such as stud bolts 53, while the flanges 52 and 34 are secured together by similar stud bolts 54. A Venturi sleeve 55 is secured in the cylindrical body 50 intermediate the length of the latter and has a throat 56 near its end adjacent the flange 51. The Venturi structure in the section 47 is compounded by an auxiliary Venturi sleeve 57 circumspacially disposed in the throat 56 of the sleeve 55 and provided with an annular passage 58 opening to the interior of th sleeve 57 at the throat of the latter. The sleeve 57 is supported in the body 50 by a tube stem 59 which extends through the wall of the cylindrical body 50 and is secured at its end within the body to the sleeve 57 and communicates interiorly with the passage 58. A flange 60 is provided on the tube stem 59 at the end of the latter outside of the cylindrical body 50.

The oil separator tube 48 is particularly illustrated in Figures 8 and 9 and comprises an elongated tube 61 having a length somewhat less than the length of the engine crankcase and formed of a heat and oil resistant material, such as a reinforced synthetic resin plastic. The opposite ends of the tube 61 are covered by perforated caps 62 and 63 which may comprise flanged rings threaded onto the ends of the tube and discs of fine wire mesh held in position over the ends of the tubes by the corresponding flanged rings. An opening is provided in the tube intermediate its length and a tube or boss 64 surrounds this opening on the outer side of the tube and has an annular flange 65 on its end remote from the tube 61. The tube 61 is substantially filled with a body of elongated metal cuttings, of a nonferrous, corrosion resisting metal, so that any oil mist or droplets drawn into the tube will contact the metal cuttings and be deposited thereon. As the oil condenses on the metal cuttings it will flow to the bottom of the tube 61 and out of the tube through the perforated caps at the ends of the tube and back into the engine crankcase.

As particularly illustrated in Figures 1 and 2 the flange 65 is placed against the inner side of the inspection plate 45 and the inspection plate 45 is provided with an opening or aperture 66 which registers with the hollow interior of the boss 64.

In Figure 10 there is illustrated an offset conduit 67 having annular flanges 68 and 69 at its respectively opposite ends. One of the flanges of the conduit 67 may be placed against the outer side of the inspection plate 45 in position such that the interior of the conduit registers with the opening 66 in the inspection plate and suitable screws or bolts 70 may be extended through the flange 65 on the separator tube 48, the flange of the conduit 67 adjacent the inspection plate and through the inspection plate to secure the separator tube and the conduit 67 to the inspection plate with the interior of the conduit in communication with the interior of the oil separating tube. The other flange of the conduit 67 will then be placed adjacent the flange 60 on the tubular stem 59 and an annular washer or heat insulator 71 is disposed between these two adjacent flanges.

The heat insulator 71 comprises a flat circular disc 72 of suitable heat insulating material, such as asbestos or composition glass or rock wool having a large central opening therein. An annular metal ring 73 is secured in the central opening of the disc 72 and two spaced apart, substantially parallel screens 74 and 75 of fine wire mesh are peripherally secured to the ring 73 and extend transversely thereacross. The screens 74 and 75 constitute a flash back preventer so that the exhaust gases in the exhaust pipe section 47 cannot ignite the vapors in the conduit 67, the oil separator tube 48 or the engine crankcase.

With the above described arrangement, when the engine is in operation and exhaust gases are flowing through the exhaust manifold, the pipe section 47 and the exhaust pipe, these exhaust gases will impose a suction on the passage or channel 58 and this suction will reduce the pressure in the engine crankcase 10 and draw vapors and fumes out of the crankcase and discharge them into the exhaust gases flowing from the exhaust manifold through the exhaust pipe.

The disc 72 is provided with angularly spaced apart apertures and the flange 60 and the corresponding flange 68 or 69 is similarly apertured and the insulator 71 and the two adjacent flanges are secured together by suitable bolts 76 extending through registering apertures therein.

In order to maintain a subatmospheric pressure in the engine crankcase the boss 40 receiving the dip rod or oil gauge 41 and the oil filler spout 43 must be sealed so that replacement air does not enter the crankcase through these devices.

An air tight seal between the dip rod and the boss 40 is provided by internally tapering the boss 40 in a direction away from its outer end and placing a tapered plug 77 on the dip rod which plug makes an air tight seal with the tapered inner surface of the boss. In order to prevent dirt from falling into the boss and interfering with the seal between the boss and the plug, a suitable dust cap 78 is secured on the dip rod to cover the outer end of the boss when the dip rod is in its usual position, as illustrated in Figure 1.

In order to seal the oil filler spout or tube 43 the usual breather cap is removed from this tube and a suitable imperforate closure cap 79 is screw threaded or otherwise suitably secured on the upper end of the spout.

With the pressure in the engine crankcase thus reduced, any moisture which may have condensed in the crankcase on the engine parts, and any unvaporized fuel which may enter the crankcase during the starting and warming up period of the engine will be evaporated and the vapor withdrawn into the exhaust pipe of the engine and discharged therefrom. Any products of combustion and other oil contaminating or metal corroding substances entering the crankcase will also be withdrawn from the crankcase and discharged through the engine exhaust pipe.

Since the engine, including the interior of its crankcase, is hot when stopped after a period of operation, with the above described arrangement, as the engine cools air will be drawn into the engine to make up for the contraction of the air within the engine upon cooling of the latter. If the operation of the engine is such that it is started and stopped at frequent intervals, operating long enough to heat up the air in the crankcase and being stopped long enough at each stop for this air to cool, a large amount of air will be drawn into and expelled from the engine crankcase and a large amount of condensation of atmospheric moisture in the engine crankcase will take place. This condition may also be slightly aggravated by changes in barometric pressure of the atmosphere, variations in wind

velocity and direction and other natural causes.

In order to minimize the changing of the air in the crankcase under such conditions an automatic valve, generally indicated at 80, may be interposed between the tubular stem 59 and the oil separator tube 48, replacing the conduit 67.

This valve, as particularly illustrated in Figure 2, comprises a hollow cylindrical body 81 having one end open and its opposite end closed by an end wall 82. The interior of the body 81 is divided into a bore 83 extending from the open end of the body to a position intermediate the length of the latter and a bore 84 of smaller diameter than the bore 83 extending from the inner end of the bore 83 to the end wall 82, an internal annular shoulder being provided at the adjacent ends of the bores 83 and 84. A hollow boss 85 extends laterally from the body 81 intermediate the length of the latter and communicates internally with the bore 84, and a flange 86 on the outer end of this boss is disposed against the adjacent side of the heat insulator 71 and connected to the flange 60 by the screws 76. A tubular boss 87 extends from the body 81 at the closed end of the latter and in a direction opposite the boss 85 and communicates through a channel 88 with the end of the bore 84 adjacent the end wall 82. This boss 87 is provided at its outer end with a flange 89 which bears against the inspection plate 45 and is secured to the flange 65 of the oil separator tube 48 by the bolts 70.

A hollow cylindrical body 90 is disposed in the bore 83 of the body 81 and has one end open and its opposite end closed by an end wall 91 which projects marginally beyond the skirt 92 of the body to provide a flange overlying and bearing upon the open end of the body 81. The body 81 is internally screw threaded at its open end and the body 90 is provided adjacent the flange provided by the outwardly projecting periphery of the end wall 91 with screw threads 93 which are threaded into the open end of the body 81 to secure the bodies 90 and 81 in assembled relationship. A hollow, internally screw threaded boss 94 is provided on the end wall 91 and communicates interiorily with the space within the skirt portion 92 of the body 90. A tubular conduit 95 is connected at one end to the boss 94 and is connected at its opposite end to an adjustable needle valve 96 which is tapped into the intake manifold 35 adjacent the carburetor 37. With this arrangement the intake manifold vacuum is applied to the space within the cylindrical body 90 through the end wall 91 and the application of the intake manifold vacuum to the interior of the body 90 is controlled by the adjustable needle valve 96 so that the pressure in the body 90 does not fluctuate widely with the fluctuations in the intake manifold pressure incident to opening and closing the engine throttle and variations in the speed and load of the engine.

A hollow, annular valve body 97 is disposed in the bore 84 of the body 81 against the end wall 82 and is provided with a central aperture surrounded by an annular valve seat 98, and is secured in position in the body 81 by suitable means, such as the snap ring 99. A valve guide 100 is mounted in the body 81 between the valve body 97 and the adjacent end of the body 90 and is held in place on the shoulder at the adjacent ends of the bores 83 and 84 by suitable means such as the snap ring 101. A piston rod 102 is slidably mounted in the valve guide 100 and a piston 103 is secured to one end of the piston rod 102 and is slidable in the cylinder provided in the skirt portion 92 of the body 90. A valve head or disc 104 is secured on the opposite end of the piston rod and cooperates with the valve seat 98 to close off the bore 84 from the passage 88. A spring seat 105 is mounted on the end of the piston rod 102 within the skirt portion of the body 90 and a compression spring 106 is disposed between this seat and the inner side of the end wall 91 of the body 90 to resiliently urge the piston rod 102 in a direction to seat the valve disc 104 on the valve seat 98. This spring is held in operative position relative to the end wall 91 by a spring guide boss 107 which extends from the inner side of the end wall 91 into the spring.

The piston rod 102 has end portions of reduced diameter and annular shoulders at the inner ends of these reduced end portions. The piston 103 has a central opening which receives the reduced portion at one end of the piston rod and the piston is held on the rod and against the adjacent annular shoulder by a nut 107 threaded onto the reduced end portion of the piston rod and the valve disc 104 has a central opening receiving the reduced portion at the opposite end of the piston rod and is secured on the rod by a nut 108 threaded onto the corresponding reduced portion of the piston rod. The piston 103 may conveniently comprise a cup washer of flexible and resilient material clamped between two flat metal washers and the valve head 104 conveniently comprises a disc of resilient or elastic material carried in a peripherally flanged metal washer.

The spring seat 105 is a peripherally flanged washer having at its center a rounded depression which receives the rounded adjacent end of the piston rod so that the valve seat washer rides on the adjacent end of the piston rod and is tiltable relative to the piston rod to accommodate its position to the flexing of the spring.

With this arrangement, when the engine is not in operation the spring 106 will seat the valve disc 104 on the valve seat 98 and the tubular stem 59 will then be cut off from the oil separator tube 48 so that air cannot flow through the oil separator tube and the tubular stem into or out of the engine crankcase. When the engine is placed in operation, the subatmospheric pressure in the intake manifold of the engine acting on the piston 103 will move the piston and the pitson rod 102 in a direction to unseat the valve 104 and the flow of exhaust gases through the exhaust pipe section 47 will then reduce the pressure in the crankcase and draw the vapors out of the crankcase.

In the arrangement illustrated the valve guide 100 may be apertured or suitable clearance may be provided between the valve guide and the piston rod to subject the side of the piston 103 opposite that acted on by the intake manifold vacuum to the pressure in the tubular stem 59 and the space connected thereto. When the air and vapor from the crankcase starts to flow through the channel 88 into the bore 84 the differential pressure thus exerted on the valve disc 104 will assist the intake manifold vacuum in opening the valve.

If the pressure differential thus existing were found insufficient to open the valve or maintain it open during engine operation the valve guide 100 may be modified to close off the bore 84 from the bore 83 and the interior of the body 90 and suitable vents may be provided in the wall of the body 81 between the valve guide and the adjacent end of the body 90 to subject the corresponding side of piston 103 to atmospheric pressure.

While the above described arrangement is effective to prevent excessive changing of the air in the engine crankcase and accumulation of moisture under operating conditions involving frequent starting and stopping of the engine, it is highly desirable under operating conditions involving continued operation of the engine over long periods of time that some air be admitted to the crankcase to assist in sweeping the moisture and fuel vapors therefrom and to remove vapors or fumes containing such substances as sulphur and bromine, which may leak into the crankcase from the combustion of certain types of engine fuel. Such inlet air should not be admitted however until the operating temperature of the engine has reached a value at which the substances vaporize or remain in a vaporous state at substantially atmospheric pressure.

In order to provide a controlled admission of air to the engine crankcase a cut off valve, generally indicated at 110, is connected to the crankcase through a suitable inlet, such as the oil filler spout 43, and is also connected to the interior of the engine intake manifold by a suitable conduit, and a temperature responsive valve, generally indicated at 111, is connected between the two parts 112 and 113 of the vacuum conduit. As the cut off valve 110 may be substantially identical in construction and operation to the valve 80, a detailed description of the valve 110 is not considered necessary for the purposes of the present disclosure.

As stated above, the cut off valve 110 is similar to the valve 80 and comprises a hollow cylindrical body 114 having one end open and its opposite end closed by an end wall 115. The interior of the body 114 is divided into two bores 116 and 117 of different diameters and arranged in end to end relationship with the smaller bore adjacent the end wall 115 and an annular internal shoulder between the adjacent ends of the two bores. A hollow valve body 118 is disposed in the smaller bore 117 against the end wall 115 and has a central opening therein surrounded by an annular valve seat 119. A hollow boss 120 extends laterally from the end wall 115 and communicates with the interior of the valve body 118 through a channel 121 and an outwardly extending annular flange 122 is provided on the outer end of this boss 120. A tubular boss 123 extends outwardly from the oil filler spout 43 and communicates with the interior of the filler spout and a flange 124 is provided on the outer end of the boss 123 and is secured to the flange 122 by suitable means, such as the screws 125 so that the interior of the valve body 118 is connected with the interior of the oil filler spout 43.

A hollow or tubular boss 126 extends laterally from the body 114 intermediate the length of the latter and communicates with the bore 117 and an annular outwardly extending flange 127 is provided on the outer end of this boss.

A hollow cylindrical body 128 is received in the bore 116 of the body 114 and has an open end disposed inwardly of the body 114 and an end wall 129 closing its opposite end which end wall extends marginally beyond the skirt portion 130 of the body 128 and overlies the open end of the body 114. The body 128 is secured to the body 114 by a screw threaded connection 131 and a hollow internally screw threaded boss 132 is formed on the outer side of the end wall 129 and communicates with the space within the skirt portion 130 of the body 128 and the conduit portion 112 is connected at one end to this boss 132. A piston rod guide 133 is secured in the body 114 on the internal annular shoulder between the bores 116 and 117 by a snap ring 134 and a piston rod 135 extends slidably through this guide. A piston 136 is secured on one end of the piston rod 135 and is reciprocable in the cylinder provided by the skirt portion 130 of the body 128 and a valve head or disc 137 is secured on the opposite end of the piston rod and cooperates with the valve seat 119 to open and close the valve. A compression spring 138 is interposed between the end of the piston rod 135 adjacent the end wall 129 and this end wall and resiliently urges the piston rod in a direction to seat the valve disc 137 on the valve seat 119. This spring bears at one end on a spring seat washer 139 carried on the adjacent end of piston rod 135 and receives at its opposite end a spring guide boss 139' which projects inwardly from the end wall 129.

With this arrangement when the valve disc 137 engages the valve seat 119 no air is admitted to the engine crankcase through the cut off valve 110 but when the valve disc is displaced from the valve seat, air is admitted to the engine crankcase through the boss 126, the valve body 118, the channel 121, the boss 123 and the oil filler spout 43. The space within the skirt portion 130 of the body 128 between the piston 136 and the end wall 129 is connected by the tubes or conduits 112 and 113 to the intake manifold of the engine so that when the engine is operating the engine intake manifold will be applied to this space to open the cut off valve 110 if the temperature responsive valve 111 is also open.

The temperature responsive valve 111 comprises an elongated hollow body 140 the interior of which is divided into two bores 141 and 142 of different diameters and arranged in end to end relationship with an annular internal shoulder at their adjoining ends. An end portion of that part of the body 140 containing the smaller bore 142 is reduced in external diameter and externally screw threaded near its inner end and is received in an opening provided in the wall of the cylinder head 25 and secured in this opening by engagement of its screw threads with screw threads provided in the opening in the cylinder head, the portion of the body 140 within the cylinder head being exposed to the temperature of the cooling fluid in the engine cylinder head and water jackets. The larger bore 141 is screw threaded near its outer end and a valve guide plug 143 is threaded into this bore and is provided with a central well or recess 144. A needle valve 145 is disposed between the plug 143 and the annular shoulder within the body 140 and has one end received in the well 144. This needle valve has a tapered valve head 146 and the internal shoulder in the body 140 cooperates with this valve head to constitute a valve seat. A compression spring 147 surrounds the stem of the needle valve between the head 146 and the guide plug 143 and resiliently urges the valve head into seating engagement with the valve seat to close the valve. The end of the smaller bore 142 opposite the larger bore 141 is internally screw threaded and a cap 148 is provided with a central screw threaded boss threaded into the end of the bore 142. This boss 149 is provided with a central well or recess and an elongated thermostatic element 150 is secured at one end in the recess in the boss of the cap 148 and extends through the bore 142 to the adjacent end of the needle valve

145. When the element 150 is subjected to the temperature of the engine cooling fluid at the normal operating temperature of the engine it elongates sufficiently to unseat the valve head 146 and connect the bore 141 with the bore 142.

The body 140 is provided in its side wall with a tapped hole 151 communicating with the bore 142 and the tube or conduit 112 is connected to the body 140 by a fitting 152 which is threaded into the hole 151 and receives the adjacent end of the tube 112. The body is also provided with a tapped hole 153 which communicates with the bore 141 and the tube 113 is connected to the body by fitting 154 which is threaded into the hole 153 and receives the adjacent end of the tube 113.

With this arrangement, when the valve head 146 is unseated the space within the skirt portion 130 of the body 128 between the end wall 129 and the piston 136 is connected to the interior of the engine intake manifold through the tubes 112 and 113 and the valve 111 so that the intake manifold vacuum is rendered effective to open the valve 110 for the admission of air to the interior of the engine crankcase.

With the construction so far described the engine crankcase will be substantially sealed off while the engine is not operating, will be subjected to a partial vacuum during the starting and warming up period of the engine and will be subjected to a flow of scavenging air therethrough during operation of the engine at normal operating temperature. In order to facilitate the scavenging of the engine crankcase suitable means may be provided for artifically drying or desiccating the air admitted to the crankcase. In the illustrated arrangement this means comprises a desiccating cartridge and filter assembly generally indicated at 155.

In this arrangement an elbow conduit 156 has at one end an annular, external flange 157 secured to the flange 127 by suitable means such as the screw 158 and has at its opposite end a circular plate or base 159 disposed substantially at right angles to the flange 157 and provided with a central opening registering with the interior of the elbow conduit 56 and a marginal flange 160 on side thereof opposite this fitting.

A tubular core 161 has one open end and its opposite end closed by an end wall 161' provided with a screw threaded recess or tapped hole. At its open end this core is provided with external screw threads and is threaded into the central opening in the base plate 159 and projects from the base plate substantially perpendicular thereto. A desiccating cartridge 162 is supported at one end on the base plate 159 and has an inner cylindrical wall 163 closely surrounding the core 161, an outer cylindrical wall 164 received at one end in the flange 160 on the base plate 159 and an intermediate cylindrical wall 165 disposed substantially midway between the inner wall 163 and the outer wall 164, the cylindrical walls 163, 164 and 165 being substantially coaxial. The cartidge has end walls 166 and 167 closing its opposite ends, the wall 167 being supported on the base plate 159 with a gasket 168 interposed between this end wall and the base plate. The end wall 166 is provided with an annularly arranged group of small apertures 169 disposed between the outer wall 164 and the intermediate wall 165, the intermediate wall 165 being provided at its end adjacent the end wall 167 with a plurality of small apertures 170 and the inner wall 163 is provided at its end adjacent the end wall 166 with a series of small apertures 171. The tubular core 161 is also provided near its closed end with a series of small apertures 172 which are substantially in registry with the apertures 171 in the inner wall 163 of the cartridge.

With this arrangement air flowing into the cartridge through the apertures 169 flows between the outer wall 164 and the intermediate wall 165 from the end wall 166 toward the end wall 167 and thence through the apertures 170 into the space between the intermediate wall 165 and the inner wall 163. It then flows through this space from the end wall 167 toward the end wall 166 and through the apertures 171 and 172 into the core 161 and through the core to the elbow fitting 156. The spaces within the cartridge between the inner and the intermediate and the intermediate and the outer wall are filled with a suitable drying or desiccating material, such as silica gel crystals so that most of the entrained moisture is extracted from the air during its tortuous passage through the desiccating cartridge.

A cap 173 is disposed on the end wall 166 of the cartridge and separated therefrom by a gasket 174. This cap is provided in its end adjacent the cartridge with a circular recess which receives the corresponding end of the cartridge and has a central portion 175 recessed to receive the closed end of the core 162 and provided with an aperture which registers with the tapped hole in the closed end of the core. A screw 176 extending through the aperture in the cap portion 175 and threaded into the tapped hole in the closed end of the core secures the cap 173 onto the adjacent end of the cartridge and also secures the cap and the cartridge onto the base plate 159 through the intermediacy of the tubular core 161.

The cap 173 is provided with a bore 177 opening to its end opposite the end adjacent the cartridge 164 and terminating at the central portion 175 of the cap. Passages 178 extend from the inner end of this bore 177 to the end of the cap adjacent the cartridge and have their ends in registry with the apertures 169 in the end wall 166 of the cartridge. A counterbore is provided in the outer end of the bore 177 and terminates at its inner end in an internal shoulder 179 and a valve guide disc 180 is held on this shoulder by a snap ring 181. A valve has an elongated stem 182' extending slidably through the valve guide disc and a head 183 secured to one end of the stem and opposed to the side of the disc adjacent the inner end of the bore 177. An adjusting nut 184 is threaded onto the end of the stem 182 opposite the head 183 and a compression spring 185 surrounds the stem between the valve guide disc 180 and the nut 184 to resiliently urge the valve head 183 into closing relationship with the apertured valve guide disc 180. This valve will prevent air from entering the desiccator cartridge 164 until the pressure in the elbow fitting 156 has been reduced below atmospheric pressure an amount sufficient to overcome the force of spring 185 and open the valve. Air will thus not pass into the desiccator cartridge except when the engine is operating at or above its normal operating temperature.

An air filter 186 is mounted on the cap 173 and comprises a hollow cylindrical body 187 having an open end and at its opposite end a perforated end wall 188. This cylindrical body 187 is slidably received at its open end in the counterbore in the outer end of the bore 177 of the cap and a hollow filter body 189 receives the opposite end of the

cylindrical body 187. The filter body has an imperforate top wall 190, an annular imperforate side wall 191 to the upper end of which the top wall 190 is marginally joined, and a bottom wall 192 marginally joined to the bottom edge of the side wall and provided with a central aperture receiving the cylindrical body 187. This bottom wall has an annularly arranged group of small apertures 193 therein surrounding the body 187. A boss 194 extends downwardly from the bottom wall 192 surrounding the central aperture therein and the body 187 is secured in this boss by suitable means such as by being welded therein. At its outer end the boss 194 is provided with an annular offset 195 which receives the top end of the cap 173 surrounding the open end of the bore 177. The body 189 is filled with a suitable air filtering material, such as non-ferrous metal wool saturated with lubricating oil so that dust and grit will be removed from air passing through the filter. As the air passes upwardly through the apertures 193, over the top of the body 187 and then downwardly through the apertures in the end wall 188 of this body, water or precipitation will not enter the filter and any moisture condensing on the outer surface of the filter will drop off and will not be entrained by the air flowing through the filter into the cap 173 and the desiccating cartridge.

A transparent window 196 is provided in the outer wall 164 of the desiccating cartridge for observation of the crystals within the cartridge. Where silican gel crystals are used their color will indicate their condition and advise the observer when the cartridge requires drying or replacement by a new cartridge.

The invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The present embodiment is, therefore, to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are, therefore, intended to be embraced therein.

What is claimed is:

1. Vapor scavenging means for an internal combustion engine crankcase comprising an exhaust pipe section having a venturi sleeve therein, a venturi circumspatially positioned in the throat of said venturi sleeve and having therein an annular vapor passage surrounding the throat of said venturi and opening to the interior of the latter, a Venturi supporting tube extending from said venturi through the wall of said exhaust pipe section and communicating internally with said passage, an elongated oil separator tube disposable in the engine crankcase and having an outlet fitting intermediate its length, conduit means connecting said outlet fitting to said venturi supporting tube, a perforated cap covering each end of said separator tube, and a body of metallic cuttings in said separator tube for separating oil mist and droplets from air passing through said separator tube and condensing such oil for return to the engine crankcase.

2. Engine crankcase scavenging means comprising an exhaust pipe section having a venturi therein, a tubular stem extending from the venturi through the wall of said exhaust pipe section for the suction of fluid into said section by said venturi, an oil separator device disposable in an engine crankcase and having an outlet fitting for the passage of gases and vapors therefrom, conduit means extending from said outlet fitting toward said tubular stem, and a combined heat insulator and flame shield disposed between said conduit means and said tubular stem, said conduit means and said combined heat insulator and flame shield providing a fluid passage from said oil separator to said tubular stem.

3. Engine crankcase scavenging means comprising an exhaust pipe section having a venturi therein, a tubular stem extending from the venturi through the wall of said exhaust pipe section for the suction of fluid into said section by said venturi, an oil separator device disposable in an engine crankcase and having an outlet fitting for the passage of gases and vapors therefrom, conduit means extending from said outlet fitting toward said tubular stem, and a combined heat insulator and flame shield disposed between said conduit means and said tubular stem, said conduit means and said combined heat insulator and flame shield providing a fluid passage from said oil separator to said tubular stem. said conduit means including a pressure operated cut off valve, spring closed to cut off said tubular stem from said oil separator device and opened by subatmospheric engine intake manifold pressure to pneumatically connect said tubular stem with said oil separator device during engine operation.

4. Engine crankcase scavenging means comprising an exhaust pipe section having a venturi therein, a tubular stem extending from the venturi through the wall of said exhaust pipe section for the suction of fluid into said section by said venturi, an oil separator device disposable in an engine crankcase and having an outlet fitting for the passage of gases and vapors therefrom, conduit means extending from said outlet fitting toward said tubular stem, and a combined heat insulator and flame shield disposed between said conduit means and said tubular stem, said conduit means and said combined heat insulator and flame shield providing a fluid passage from said oil separator to said tubular stem, said conduit means including a pressure operated cut off valve, spring closed to cut off said tubular stem from said oil separator device and opened by subatmospheric engine intake manifold pressure to pneumatically connect said tubular stem with said oil separator device during engine operation, a crankcase air inlet fitting, a second cut off valve connected to said inlet fitting and spring closed to cut off crankcase inlet air, conduit means connected to said second cut off valve for applying subatmospheric engine intake manifold pressure to the valve to open the latter and admit crankcase inlet air, and an engine temperature responsive valve connected into said last mentioned conduit means to delay opening of said second cut off valve until said temperature responsive valve is subjected to normal operating engine temperature.

5. Engine crankcase scavenging means comprising an exhaust pipe section having a venturi therein, a tubular stem extending from the venturi through the wall of said exhaust pipe section for the suction of fluid into said section by said venturi, an oil separator device disposable in an engine crankcase and having an outlet fitting for the passage of gases and vapors therefrom, conduit means extending from said outlet fitting toward said tubular stem, and a combined heat insulator and flame shield disposed between said conduit means and said tubular stem, said conduit means and said combined heat insulator and flame shield providing a fluid passage from said

oil separator to said tubular stem, said conduit means including a pressure operated cut off valve, spring closed to cut off said tubular stem from said oil separator device and opened by subatmospheric engine intake manifold pressure to pneumatically connect said tubular stem with said oil separator device during engine operation, a crankcase air inlet fitting, a second cut off valve connected to said inlet fitting and spring closed to cut off crankcase inlet air, conduit means connected to said second cut off valve for applying subatmospheric engine intake manifold pressure to the valve to open the latter and admit crankcase inlet air, and an engine temperature responsive valve connected into said last mentioned conduit means to delay opening of said second cut off valve until said temperature responsive valve is subjected to normal operating engine temperatures, said second cut off valve having an air intake fitting thereon, and an air filtering and desiccating assembly pneumatically connected to the air inlet fitting of said second cut off valve to filter and dry the crankcase inlet air admitted by said second cut off valve.

6. Engine crankcase scavenging means comprising an exhaust pipe section having a venturi therein, a tubular stem extending from the venturi through the wall of said exhaust pipe section for the suction of fluid into said section by said venturi, an oil separator device disposable in an engine crankcase and having an outlet fitting for the passage of gases and vapors therefrom, conduit means extending from said outlet fitting toward said tubular stem, and a combined heat insulator and flame shield disposed between said conduit means and said tubular stem, said conduit means and said combined heat insulator and flame shield providing a fluid passage from said oil separator to said tubular stem, said conduit means including a pressure operated cut off valve, spring closed to cut off said tubular stem from said oil separator device and opened by subatmospheric engine intake manifold pressure to pneumatically connect said tubular stem with said oil separator device during engine operation, a crankcase air inlet fitting, and an air filtering and desiccating assembly connected to said crankcase air inlet fitting for filtering and drying crankcase inlet air.

7. A vacuum operated valve comprising a hollow body having an open end and an end wall closing its other end and provided with a cylindrical bore, a hollow valve body disposed in said bore and against said end wall and having a central opening and an annular valve seat surrounding such opening, a fluid passage leading from the interior of said hollow valve body through said end wall, a fluid passage leading into said bore at the side of said hollow valve body opposite said end wall, a hollow cylindrical body received in said bore at the open end of said first mentioned hollow body and having an end wall overlying the open end of said first mentioned body, a piston reciprocable in said hollow cylindrical body, a piston rod guide mounted in said bore between said hollow valve body and said hollow cylindrical body, a piston rod connected at one end to said piston and extending slidably through said piston rod guide, a valve disc secured to the other end of said piston rod and cooperating with the valve seat on said hollow valve body, a hollow boss on the end wall of said hollow cylindrical body communicating with the interior of said hollow cylindrical body and provided with internal screw threads, a tube connected at one end to said boss for connecting the space within said hollow cylindrical body between said piston and the end wall of said hollow cylindrical body to the interior of an engine intake manifold, and a compression spring disposed between said piston and the end wall of said hollow cylindrical body for resiliently urging said piston, said piston rod and said valve disc in a direction to seat said valve disc on the valve seat of said hollow valve body.

8. In combination with an internal combustion engine having a crankcase, an exhaust pipe and an intake manifold, engine crankcase, scavenging means comprising a venturi in said exhaust pipe, a valve assembly including a valve spring biased to closed position and vacuum responsive means connected to said valve for opening the latter, conduit means connecting one side of said valve to said venturi, conduit means connecting the other side of said valve to the interior of said crankcase, and conduit means connecting said vacuum responsive means to said intake manifold for opening said valve when the engine is in operation.

9. In combination with an internal combustion engine having a crankcase, an exhaust pipe, an intake manifold and a cooling system containing cooling fluid, engine crankcase scavenging means comprising a venturi in said exhaust pipe, a valve assembly including a valve spring biased to closed position and vacuum responsive means connected to said valve for opening the latter, conduit means connecting one side of said valve to said venturi, conduit means connecting the other side of said valve to the interior of said crankcase, conduit means connecting said vacuum responsive means to said intake manifold for opening said valve when the engine is in operation, a second valve assembly including a valve spring biased to closed position and vacuum responsive means connected to said valve for opening the latter, conduit means connecting one side of the valve of said second assembly to the interior of said crankcase, the other side of the valve of said second assembly being connected to atmosphere, conduit means connecting the vacuum responsive means of said second assembly to said intake manifold for opening the associated valve when the engine is in operation, and means responsive to the temperature of the cooling fluid in said cooling system connected into the last mentioned conduit means for delaying opening of the valve of said second assembly until the temperature of the cooling fluid has reached a predetermined value.

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