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Ross

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[54] **COLD STARTING DEVICES**

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[51] **Int. Cl.²** **F02N 17/00**

[58] **Field of Search**......... 123/119 F, 180 T, 180 R, 123/179 G; 261/39 D, 50 A, 44 R

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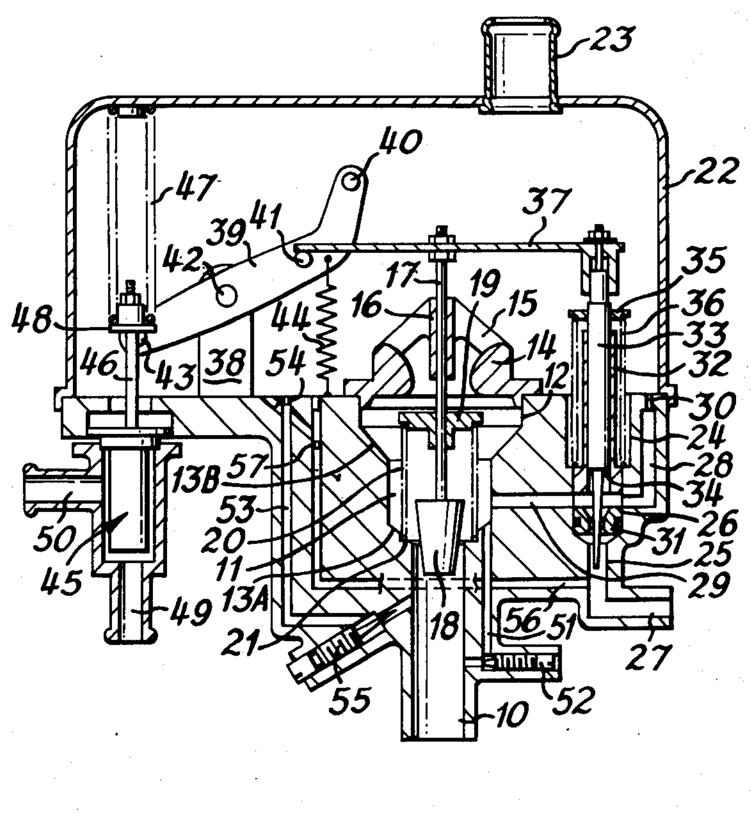
[57] **ABSTRACT**

An internal combustion engine cold start device has an air valve which co-operates with a valve seat to vary the cross-sectional area of an auxiliary air supply passage upstream of a plug valve in the passage. The air valve is urged towards the valve seat by coil spring. A fuel metering orifice communicates with the passage between the two valves. The plug valve has a profiled valve member which is linked to a profiled needle which projects into the fuel metering orifice, the needle and the plug valve member being guided for rectilinear movement together along parallel paths to respectively throttle the passage and vary the area of the metering orifice. A coil spring opposes rectilinear movement of the plug valve member and the needle to reduce flow through the passage and the orifice respectivey. A thermostatically controlled movable stop co-operates with the linkage which links the plug valve member and the needle so as to limit the permitted movement of the plug valve member and the needle together against the action of the coil spring and to increase that permitted movement as the temperature of the engine increases. In one embodiment the air valve and the plug valve are coaxial, the air valve being annular and being guided by a rod which carries the plug valve member. In another embodiment the air valve is carried by a plunger which slides in a through bore in the body of the device, the through bore being parallel to the plug valve path and communicating with the passage downstream of the plug valve.

24 Claims, 5 Drawing Figures



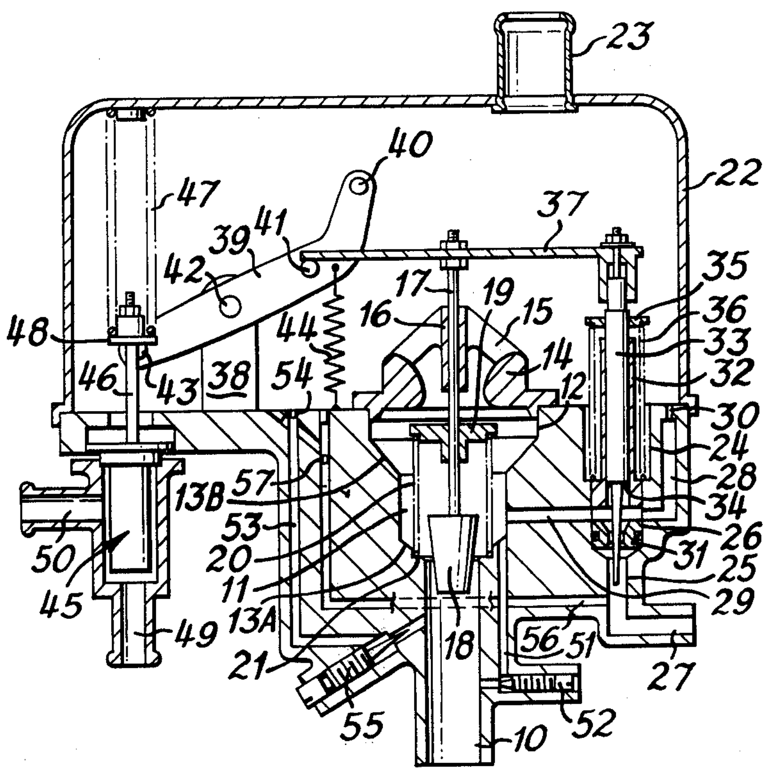

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Fig. 1

Fig. 3

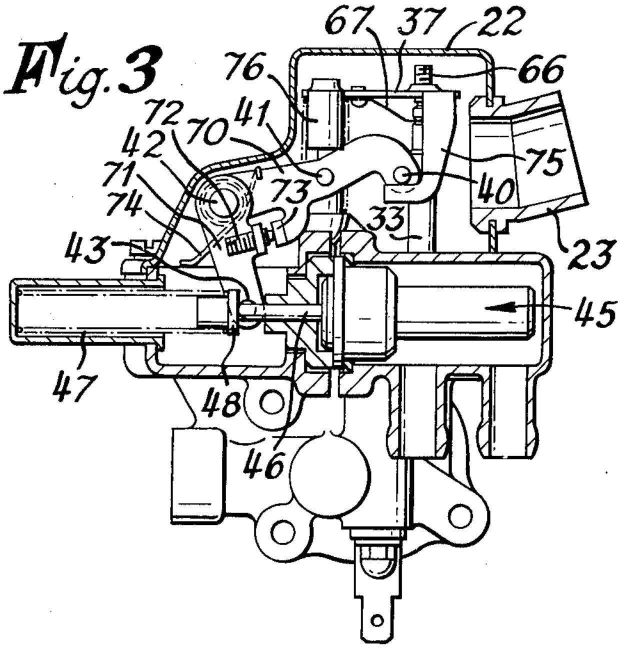
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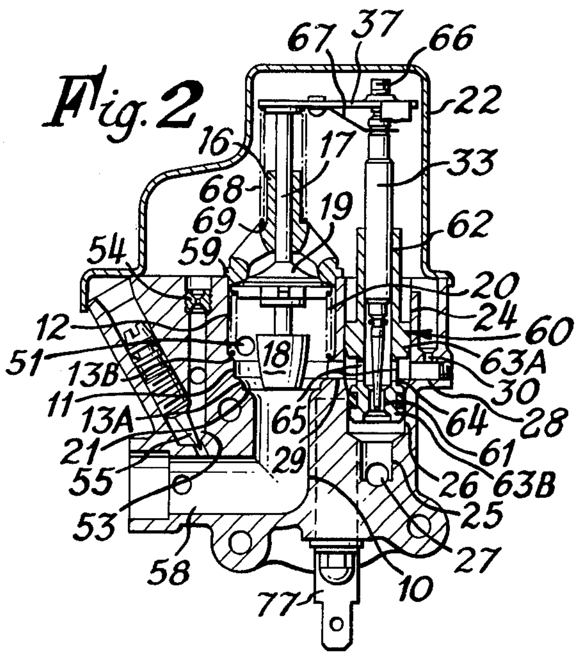
Fig. 2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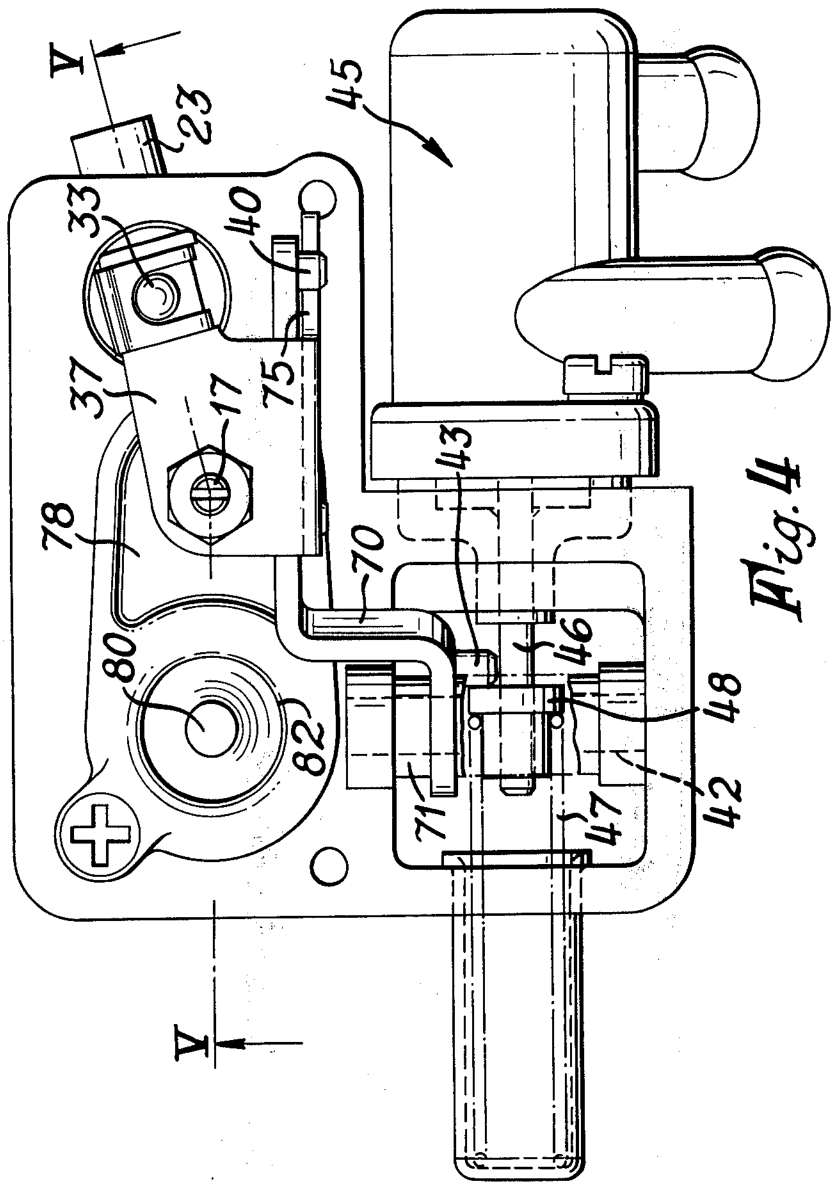
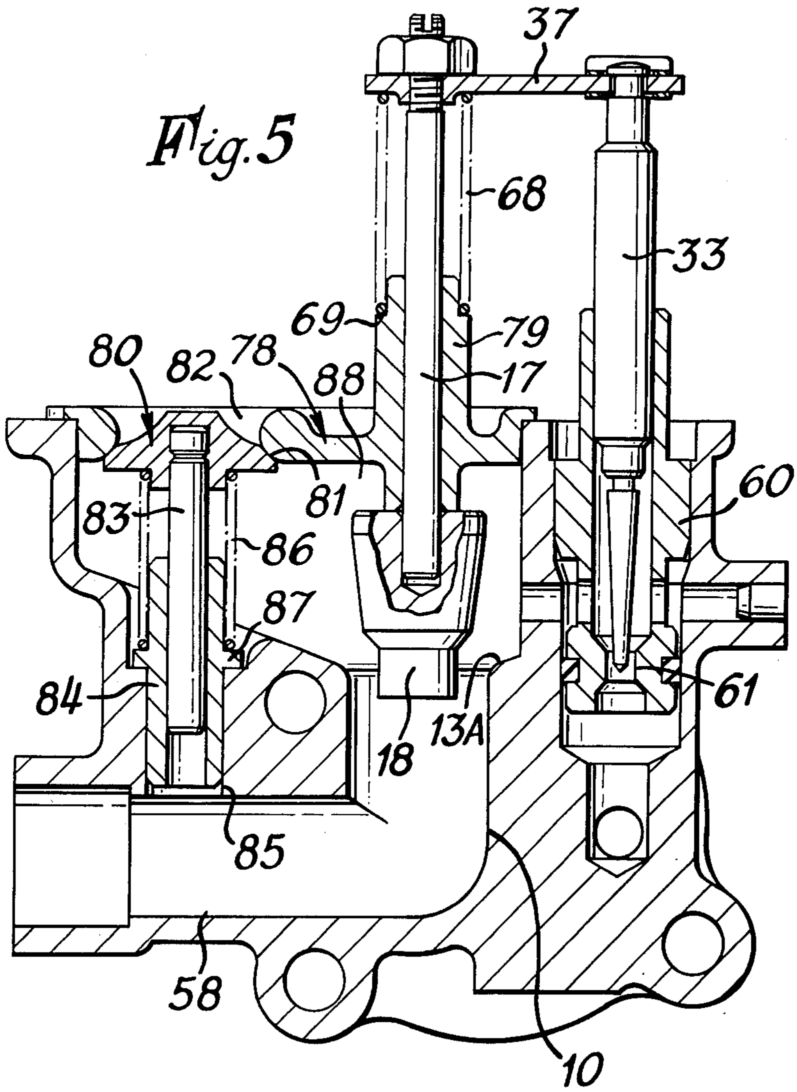


Fig. 4

Fig. 5



COLD STARTING DEVICES

This invention relates to cold starting devices for internal combustion engines, the cold starting devices being arranged so that, once the engine commences to run under its own power, the constitution of a fuel/air mixture supplied to the engine is changed progressively until the engine has obtained its normal operating temperature at which there is no further need for any extra fuel or air to be supplied to the engine by a cold starting device.

According to this invention there is provided a cold starting device for an internal combustion engine, the cold starting device comprising a valve member which is guided for rectilinear movement within an auxiliary air supply passage and which is biassed into an open position at least when the cold starting device is in use, the valve member being arranged so as to tend to be moved by engine suction into a closed position in which it restricts or prevents the flow of air past it to the engine, a fuel metering orifice which is in communication with the auxiliary air supply passage upstream of said closed position of said rectilinearly movable valve member so that metered quantities of fuel can be drawn therethrough into said auxiliary air supply passage by engine suction when said valve member is in the open position, and a thermostatically controlled movable stop for limiting rectilinear movement of the valve member towards said closed position, the position of said stop being related to engine temperature so that rectilinear movement of said valve member is minimised or prevented by said stop when the engine is cold and is allowed to increase as the engine warms up towards normal operating temperature whereat movement of said valve member to said closed position is permitted.

Preferably there is another valve member which is urged into engagement with a co-operating valve seat, the co-operating valve seat being positioned within said auxiliary air supply passage upstream of that part of the auxiliary air supply passage with which the fuel metering orifice communicates, the arrangement being such that the other valve member can be seated on said valve seat during the engine cranking period and moved by the depression which is established within said part of the auxiliary air supply passage against the action of the biassing load and away from said valve seat when the engine commences to run under its own power so that the constitution of fuel/air mixture supplied to the engine during starting from cold and warming up of the engine is changed firstly at the termination of the cranking period as well as being further changed progressively once the engine is running under its own power and until the engine has attained its normal operating temperature.

Conveniently said rectilinearly movable valve member is biassed into the open position by resilient means. Preferably said other valve member is guided for rectilinear movement towards and away from said co-operating valve seat and is urged into engagement with the co-operating valve seat by respective resilient means. Provision of the valve members which are guided for rectilinear movement renders coil springs particularly convenient for use as the associated resilient means, such coil springs being more convenient than torsion springs or other control spring arrangements which would be required if the valve members were of the butterfly type.

The first mentioned valve member may be a plug valve member which co-operates with an orifice in the auxiliary air supply passage to control the flow of fuel/air mixture through the said orifice to the engine. The plug valve member may be profiled so that the flow of fuel/air mixture past it to the engine is metered in accordance with engine temperature. The profiled plug valve member may be fixed to a rod. Conveniently the rod is guided for rectilinear movement within the auxiliary air supply passage by being in sliding interengagement within a guide sleeve which is supported within the auxiliary air supply passage. Conveniently said other valve member is annular and is guided for rectilinear sliding movement by said rod which is a sliding fit within its central aperture.

Provision of valve members for controlling the supply of fuel/air mixture through the auxiliary air supply passage to the engine in response to the depression established by operation of the engine, the valve members being guided for rectilinear sliding movement along the auxiliary air supply passage, leads to a more effective utilisation of the engine suction loads than it the case if the valve members are of the butterfly type.

The first mentioned valve member, the associated orifice in the auxiliary air supply passage, the other valve member, the associated valve seat, and the respective resilient means acting on the two valve members may be arranged so that, during operation of the cold starting device, a substantially constant depression is maintained in that part of the auxiliary air supply passage which extends between the closed positions of the two valve members.

Conveniently a profiled needle is coupled to the first mentioned valve member and is guided for rectilinear movement with rectilinear movement of said first mentioned valve member, the profiled needle projecting into the fuel metering orifice so that the effective area of the fuel metering orifice is varied with movement of the first mentioned valve member. The profiled needle may be urged resiliently into the position in which the effective cross-sectional area of the fuel metering orifice is at its greatest, and conveniently the profiled needle is so urged by said resilient means which urge the first mentioned valve member into an open position.

Where the first mentioned valve member comprises a plug valve member mounted on a rod, the rod may carry a laterally extending arm. The arm may be fixed to the needle so that the profiled needle and the rod are parallel. The arm may co-perate with the thermostatically controlled movable stop so that movement of the plug valve member towards said closed position is limited by the movable stop.

Conveniently the position of the thermostatically controlled movable stop is controlled by an expansible capsule which is arranged to expand with increase in engine temperature. The expansible capsule may act on a pivoted beam which carries said stop and may act to permit rotation of the beam about its pivot support, due to the action of resilient means, as the engine temperature increases. The expansible capsule may be arranged so that the plug valve member is held closed when the engine has attained its normal operating temperature. The beam may be arranged to engage the other valve member and hold the other valve member displaced from its associated valve seat when the engine has attained its normal operating temperature.

Sesaling means may be provided for closing the fuel metering orifice when the engine has attained its normal operating temperature so as to prevent fuel being drawn through the fuel metering orifice into the auxiliary air supply passage when the engine has attained its normal operating temperature. Conveniently the sealing means are carried by the profiled needle.

An air metering device may be provided and aarranged so that metered quantities of air can be drawn therethrough for mixture with metered quantities of fuel drawn through the fuel metering orifice, the metered quantities of fuel and air being mixed between the fuel metering orifice and the auxiliary air supply passage.

A by-pass passage around the orifice with which said plug valve member co-operates may be provided so that limited quantities of air can be drawn from upstream of the plug valve member by engine suction when the said orifice is closed by the plug valve member and the fuel metering orifice is closed by said sealing when the engine has attained its normal operating temperature. The by-pass passage may incorporate an adjustable volume screw which enables the quantity of air drawn therethrough to be adjusted.

Means may be provided for supplying a mixture of metered quantities of air and fuel to the auxiliary air supply passage downstream of said first mentioned valve member when the engine has attained its normal operating temperature. The volume of such a mixture of metered quantities of fuel and air fed to the auxiliary air supply passage downstream of the first mentioned valve member when the engine has attained its normal operating temperature may be controlled by an adjustable volume screw.

Where said other valve member is annular, is guided for rectilinear sliding movement by said rod which is a sliding fit within its central aperture, and is urged into engagement with the co-operating valve seat by respective resilient means, said resilient means preferably comprise a coil spring having a diameter greater than the diameter of said orifice with which the plug valve member co-operates and greater than the diameter of the valve seat with which said annular valve member co-operates and the annular valve member preferably has radially outwardly projecting spokes which are engaged by said coil spring.

In a preferred embodiment of cold starting device according to this invention which includes both said valve members, said other valve member is connected to a movable wall so as to move with movement of the movable wall, the surface of the movable wall remote from said other valve member being exposed to the pressure which is existent in that part of the auxiliary air supply passage that is downstream of the closed position of said rectilinearly movable valve member so that the position of said other valve member relative to the co-operating valve seat is dependent upon the depression established within the auxiliary air supply passage downstream of the closed position of said rectilinearly movable valve member as well as upon the depression which is established within that part of the auxiliary air supply passage with which the fuel metering orifice communicates and the biassing load which acts to urge said other valve member toward said valve seat, the arrangement being such the depression established by engine suction within that part of the auxiliary air supply passage with which the fuel metering orifice communicates is a function of the depression established within the auxiliary air supply passage downstream of the closed position of said rectilinearly movable valve member. Conveniently the relationship between said biassing load and the dimensions of said other valve, said valve seat and said movable wall is such that the depression established by engine suction within said part of the auxiliary air supply passage with which the fuel metering orifice communicates is a function of the inverse of the depression established within the auxiliary air supply passage downstream of the closed position of the rectilinearly movable valve member. Preferably said other valve member is guided for rectilinear movement towards and away from said co-operating valve seat, is displaced laterally with respect to said rectilinearly movable member and is fixed to one end of a plunger which is engaged for sliding movement within a bore in a body within which said auxiliary air supply passage is defined, the other end of said plunger comprising said movable wall surface. Where said other valve member is urged into engagement with the co-operating valve seat by respective resilient means, said bore may be the bore of a tubular member which is housed in a bore in said body, and a coil spring, which functions as said resilient means may react against said tubular member, the location of said tubular member within said body being adjustable axially in order to alter the biassing load exerted by said coil spring upon said other valve member. Conveniently said tubular member is screwed into the bore in said body within which it is housed so that it can be rotated for axial adjustment relative to the body.

Several embodiments of this invention will be described now by way of example with reference to the accompanying drawings, of which:

FIG. 1 is a schematic illustration of one form of automatic cold starting device according to this invention, the various parts of the device being shown in the positions they adopt when the engine is idling at a temperature (say 0°C) which is intermediate the range of temperature for which the device is designed to operate;

FIG. 2 is a transverse section through the fuel and air flow control valves of another form of automatic cold starting device according to this invention which is similar in most respects to that which is illustrated in FIG. 1, the various parts being shown in the positions they adopt when the engine is inoperative;

FIG. 3 is a section of the cold starting device shown in FIG. 2 which shows the thermostatically controlled mechanism the section being a plane substantially parallel to the plane of the section of FIG. 2, the thermostatically controlled mechanism being in the condition it adopts when the engine is cold and not running;

FIG. 4 is a plan view of a third form of automatic cold starting device according to this inveniton which is in a similar condition to the device shown in FIGS. 2 and 3; and

FIG. 5 is a section on the line V—V of FIG. 4.

Referring to FIG. 1 of the drawings, the automatic cold starting device comprises a body which defines a stepped through bore which is composed of three cylindrical bore portions **10**, **11** and **12** of different diameters, the two smaller diameter bore portions **10** and **11** being interconnected by a frusto-conical bore portion **13A**, and the two larger diameter bore portions **11** and **12** being interconnected by another frusto-conical bore portion **13B**. The smallest diameter bore portion **10** is arranged to be connected to the induction manifold of an internal combustion engine so that the stepped through bore is in communication with the induction manifold. The larger of the mouths at the ends of the through bore, which is defined by the largest diameter bore portion **12,** receives an annular valve seat **14,** which in turn supports, via radial spider arms **15,** a cylindrical guide **16** for a rod **17.** The rod **17** carries a profiled plug valve member **18** which co-operates with the orifice defined by the nearer end of the smallest diameter bore portion **10** to control fluid flow from the medial diameter bore portion **11** to the smallest diameter bore portion **10.** The rod **17** is engaged slidably within the central aperturs of an annular valve member **19** which is urged to seat upon the annular valve seat **14** by a coil spring **20** which takes its reaction from an annular shoulder **21** formed in the frusto-conical portion **13A.** The annular valve member **19** controls communication between the stepped through bore and an enclosure defined between the body and a cup-shaped cover **22** of sheet material which has an inlet port **23** for connection to the outlet of an air cleaner.

A through passage defined within the body has a stepped main bore portion which is substantially parallel with the through bore, and a laterally extending end bore portion which is for connection to a fuel float chamber. The largest diameter bore portion **24** of the stepped main bore portion is in direct communication with the enclosure defined between the body and the cover **22.** The smallest diameter bore portion **25** of the stepped main bore portion is separated from the largest diameter bore portion **24** by the medial diameter bore portion **26** and communicates directly with the said laterally extending bore portion **27.** The medial diameter bore portion **26** communicates with the enclosure defined between the body and the cover **22** via a passage **28** in the body and with the medial bore portion **11** of the stepped through bore via another passage **29** in the body. A restriction **30** in the passage **28** serves as an air metering orifice. An annular member **31** is fitted into that part of the medial diameter bore portion **26** which extends between the smallest diameter bore portion **25** on the one side and the passages **28** and **29** on the other side, the annular member **31** serving as a fuel metering orifice. The passages **28** and **29** communicate with the medial diameter bore portion **26** between the annular member **31** and a tubular guide **32** for a cylindrical member **33** which carries a profiled needle. The tubular guide **32** is spigotted into the medial diameter bore portion **26** of the through passage, extends through the largest diameter bore portion **24** of the through passage and projects into the enclosure defined between the body and the cover **22.** The profiled needle projects through the fuel metering orifice and carries an annular sealing ring **34** at its largest diameter end which is the end that is attached to the cylindrical member **33.** The cylindrical member **33** has a radial flange **35** at its end remote from the profiled needle. A coil spring **36** takes its reaction from the annular shoulder defined within the through passage between the intermediate diameter bore portion **26** and the largest diameter bore portion **24** and acts upon the annular flange **35** to urge the profiled needle into the position in which the profiled needle is withdrawn from the fuel metering orifice. A laterally extending arm **37** which is fixed at one end to the respective end of the cylindrical member **33** is carried by the rod **17** within

the enclosure defined between the body and the casing **22.**

A pillar **38** projects from the body into the enclosure defined between the body and the cover **22** and is on the side of the rod **17** remote from the cylindrical member **33.** A beam **39** is hinged between its ends to the pillar **38.** The beam **39** carries a peg **40** at its end nearer the rod **17,** another peg **41** between the peg **40** and the hinge pin **42,** and a third peg **43** at the other end. The arm **37** projects between the two pegs **40** and **41** so as to be engageable with either one of the two pegs **40** and **41.** A tension spring **44** is anchored at one end to the body **10** between the pillar **38** and the rod **17** and at the other end to the beam **39** adjacent the peg **41.**

A temperature sensitive capsule **45,** which is mounted on the body, controls the angular position of the beam **39.** The capsule **45** is filled with wax or other suitable substance having a high thermal expansion. The arrangement is such that, with increase of temperature, the wax or other substance expands and moves a rod **46** along its length against the action of a coil spring **47.** The rod **46** projects from the capsule **45** into the enclosure defined between the body and the cover **22** and carries an annular flange **48** on the side of the peg **43** remote from the body. The spring **44** acts upon the beam **39** so as to hold the peg **43** in contact with the flange **48.** The coil spring **47** reacts against the cover **22.**

The temperature sensitive capsule **45** conveniently is sensitive to the engine water termperature, the pipes **49** and **50** being connected into the engine cooling system. However the temperature sensitive capsule **45** may be arranged so as to be sensitive to an electric heater or any other suitable means by which the angular position of the beam **39** can be related to the temperature of the engine.

A by-pass passage **51** in the body interconnects the frusto-conical bore portion **13A** and the smallest diameter bore portion **10** of the stepped through bore. An adjustable volume screw **52** is provided within the body so as to enable the effective area of the outlet orifice by which the by-pass passage **51** communicates with the smallest diameter bore portion **10** to be adjusted.

An idling fuel/air mixture supply passage **53** in the body places the enclosure defined between the body and the cover **22** in communication with smallest diameter portion **10** of the stepped through bore. The passage **53** includes a restriction **54,** which serves as an auxiliary air metering orifice, and an adjustable volume screw **55** which can be manipulated to adjust the effective area of the orifice by which the passage **53** communicates with the smallest diameter bore portion **10** of the stepped through bore. An auxiliary fuel supply passage **56** in the body places the smallest diameter bore portion **25** of the through passage in communication with the passage **53** between the restriction **54** and the volume screw **55.** The auxiliary fuel supply passage **56** includes a restriction **57** which serves as an auxiliary fuel metering orifice.

When an engine, to which the cold starting device is fitted, is cold, the temperature sensitive capsule **45** allows the spring **47** to hold the rod **46** in the position in which the flange **48** is nearest to the body. Thus, due to the interengagement of the peg **43** and the flange **48,** the beam **39** is held against the action of the tension spring **44** in the position in which the peg **40** is furthest from the body, the spring **44** being extended. The coil spring **36** acts through the flange **35** and the cylindrical member 33 to hold the arm 37 in its position furthest from the body and in contact with the peg 40. Thus the plug valve member 18 is spaced from the associated orifice. The peg 41 serves to stop movement of the arm 37 towards the body and thus to stop movement of the plug valve member 18 towards the associated orifice. The annular valve member 19 is seated upon the associated valve seat 14 by the action of the coil spring 20.

When the engine is cranked for starting, the parts remain in the position just described. Suction exerted by the engine causes a metered quantity of fuel to be drawn into the medial bore portion 11 of the stepped through bore through the fuel metering orifice defined by the annular member 31 and the passage 29. At the same time a metered quantity of air is drawn from the enclosure between the body and the cover 22 into the passage 28 via the orifice 30, the air so drawn is mixed within the passage 29 with fuel drawn through the fuel metering orifice, so as to form a fuel/air emulsion, and assists fuel flow through the passage 29. Fuel is drawn through the fuel metering orifice at a high rate because the profiled needle is withdrawn and the effective area of the fuel metering orifice is at its greatest.

With the engine begins to run under its own power, increased suction exerted by the engine acts to unseat the annular valve member 19 from the associated valve seat and to urge the plug valve member 18 towards its associated orifice. Movement of the plug valve member 18, and movement of the profiled needle with it, is limited by the stop 41 which abuts the arm 37. The coil spring 20 and the annular valve member 19 are arranged so that the depression in the medial bore portion 11 and the largest diameter bore portion 12, which together function as a mixing chamber, is maintained substantially constant.

As the engine temperature increases, the temperature sensitive capsule 45 urges the rod 46 against the action of the coil spring 47 thus allowing the beam 39 to be rotated by the action of the tension spring 44 in the direction which moves the peg 41 towards the body. Such movement of the peg 41 allows following movement of the arm 37, due to the action of engine suction on the plug valve member 18, so that the plug valve member 18 is moved to reduce the effective area of the associated orifice and the profiled needle is moved with it to reduce the effective area of the fuel metering orifice. This continues until the engine temperature has increased to the normal working temperature whereupon the plug valve member 18 reduces the effective area of the associated orifice in the through bore to a minimum and the sealing ring 34 carried by the profiled needle seats on the annular member 31 to close the fuel metering orifice.

It will be understood that the rate of flow of fuel through the fuel metering orifice is dependent upon the effective area of the fuel metering orifice and thus is altered in accordance with changes in engine temperature by the profiled needle which is allowed to move with changes in engine temperature. Likewise the rate of flow of fuel/air mixture through the orifice associated with the profiled plug valve member 18 is altered in accordance with changes in engine temperature by the profiled plug valve member 18 which is allowed to move with changes in engine temperature.

The degree of suction exerted by the engine upon the plug valve member 18 is reduced if the main throttle valve of the engine is opened for vehicle acceleration before the engine temperature reaches the normal working temperature. Furthermore if that reduction is sufficient to reduce the force which that suction exerts upon the plug valve member 18 to a force which is less than the opposing force exerted by the coil spring 36, the plug valve member 18 and the fuel metering meedle are moved to increase the effective area of the orifices with which they are associated. Such movement of the plug valve member 18 and the fuel metering needle is limited by engagement of the arm 37 with the peg 40. Thus the rate of flow of fuel drawn through the fuel metering orifice 31 and supplied to the medial diameter stepped bore portion 11 via the passage 29 is increased because of the action of the annular valve member 19 which functions to maintain the depression in the mixing chamber substantially constant, that is to say within acceptable upper and lower limits.

Air can still be drawn past the plug valve member 18 from the mixing chamber to the smallest diameter bore portion 10 of the stepped through bore and then to the engine inlet manifold, via the by-pass passage 51 once the plug valve member 18 has reduced to a minimum the area of the associated orifice in the through bore. The volume of air drawn through the by-pass passage 51 can be determined for engine idling conditions by the setting of the volume screw 52. Air which flows through the by-pass passage can be drawn into the smallest diameter bore portion 10 either past the annular valve member 19, or through the restrictor 30 and the passages 28 and 29. At the same time a controlled volume of fuel/air mixture can be drawn into the smallest diameter bore portion 10 from the idling fuel/air mixture supply passage 53, metered quantities of air being drawn into the passage 53 through the auxiliary air metering orifice 54 for mixture in the passage 53 with metered quantities of fuel drawn through the auxiliary fuel metering orifice 57. The volume of fuel/air mixture drawn from the passage 53 can be determined, for engine idling conditions, by the setting of the volume screw 55.

The fuel/air mixture drawn from the idling fuel/air mixture supply passage 53 and the air drawn through the by-pass passage 51 may be a proportion of the engine fuel requirements under engine idling conditions. Hot engine idle speed and fuel/air mixture strengths can be controlled by the setting of the volume screws 52 and 55.

Various modifications or refinements of the cold starting device described above with reference to FIG. 1 the accompanying drawing can be incorporated without departing from the scope of this invention. For example, the beam 39 may be projected beyond the peg 40, the extension being arranged to engage the annular valve member 19, hold it unseated and thereby minimise the depression established within the medial bore portion 11 when the plug valve member 18 is positioned to reduce the area of the associated orifice to a minimum. A non-return valve may be included in the auxiliary fuel supply passage 56 in order to oppose the flow of air from the smallest diameter bore portion 10 through the idling fuel/air mixture supply passage 53 and the auxiliary fuel supply passage 56 to the fuel metering orifice which could happen if the throttle valve of the carburetter, which supplies the fuel/air mixture to the engine when the engine has attained its normal working temperature, is opened before the engine has attained its normal working temperature.

FIGS. 2 and 3 show an automatic cold starting device which is similar in most respects to that shown in FIG.

1. Parts of the device shown in FIGS. 2 and 3 which correspond with like parts of the device shown in FIG. 1 are identified by the reference numerals that were used for the like parts in the foregoing description of the device shown in FIG. 1. The main features by which the device shown in FIGS. 2 and 3 differs from the device shown in FIG. 1 are described below.

The stepped bore that defines the orifice with which the plug valve member **18** co-operates has its smallest diameter bore portion **10** connected to the induction manifold of an internal combustion engine by an additional bore **58** which runs at right angles to the stepped bore. The relative axial dimensions of the largest diameter bore portion **12** and the medial diameter bore portion differ from those of the device shown in FIG. 1 in that the largest diameter bore portion **12** is longer than the medial diameter portion **11**. Instead of reacting against the annular shoulder **21** formed in the frusto-conical bore portion **13A** of the device shown in FIG. 1 in order to urge the annular valve member **19** to seat upon the annular valve seat **14**, the coil spring **20** reacts against an annular reaction surface afforded by the frusto-conical bore portion **13B** and engages four radial spokes **59** which project radially from the radially outer periphery of the annular valve member **19**. Thus the diameter of the coil spring **20** of the device shown in FIGS. 2 and 3 is greater than the diameters of both the annular valve seat **14** and the orifice with which the plug valve member **18** co-operates so that the turns of the coil spring **20** do not obstruct the path of air flow from the annular valve seat **14** to the orifice with which the plug valve member **18** co-operates nor do they obstruct the distibution within the mixing chamber of the air/fuel mixture fed to the medial diameter bore portion through the passage **29**.

The tubular guide for the profiled fuel metering needle and the annular member which defines the fuel metering orifice are formed as a single integral tubular component **60** in the device shown in FIGS. 2 and 3. The tubular component **60** has a stepped through bore. The smaller diameter portion **61** of the stepped through bore serves as the fuel metering orifice. The cylindrical member **33**, which carries the profiled fuel metering needle, slides within the larger diameter portion **62** of the stepped through bore. The outer cylindrical surface of the tubular component **60** is stepped and comprises a larger diameter cylindrical portion **63A**, which is engaged in a fluid tight manner within the largest diameter bore portion **24** of the stepped main bore portion of the through passage within which the tubular component **60** is housed, and a smaller diameter cylindrical portion **63B** which is engaged in a fluid tight manner within the medial diameter bore portion **26** of the said stepped main bore portion. An annular recess **64** is defined within the largest diameter bore portion **24** by that part of the tubular component **60** which is located therein and which separates the two cylindrical portions **63A** and **63B**. The passages **28** and **29** communicate with the annular recess **64**. Radial passages **65** place the annular recess **64** in communication with the stepped through bore of the tubular component **60** immediately downstream of the fuel metering orifice **61**.

The end of the cylindrical member **33** remote from the profiled needle which it carries is held against an adjuster screw **66** by a leaf spring **67** which is fixed to the arm **37**. The adjuster screw **66** is carried by the arm **37** and is provided for adjusting the relative disposition of the profiled needle and the fuel metering orifice **61**. A coil spring **68** reacts against an annular shoulder **69** defined by the outer surface of the cylindical guide **16** for the plug valve rod **17** and urges the arm **37** away from the body of the device. Thus the coil spring **68** has the same function as the coil spring **36** of the device shown in FIG. 1 which it replaces.

The beam **39** of the device shown in FIG. 1 is replaced by a pair of arms **70** and **71** which are both mounted pivotally on the hinge pin **42**. The pegs **40** and **41** are carried by the arm **70** and the peg **43** is carried by the arm **71**. The arm **71** carries an adjustable stop **72** which co-operates with an abutment **73** on the lever **70** so that the two arms **70** and **71** rotate together as one if the flange **48** is urged towards the temperature sensitive capsule **45** whilst the arm **71** can be moved in the opposite sense relative to the arm **70** and against the action of a torsion spring **74** which reacts against the body of the device and acts upon the arm **70** to urge the abutment **73** into contact with the adjustable stop **72**. It will be apparent therefore that the function of the torsion spring **74** is analogous to that of the tension spring **44** of the device described above with reference to FIG. 1.

The arm **37** carries a cranked arm **75** the outer limb of which extends between the peg **40** and the body of the device and is engaged by the peg **40**. The peg **41** co-operates with an abutment **76** which projects from the arm **37** parallel to the rod **17** and towards the arm **70**. Provision of the two arms **70** and **71** and the adjustable stop **72** enables the device to be adjusted so that the peg **43** is in contact with the flange **48** and the peg **40** is in contact with the outer limb of the cranked arm **75** at the same time. FIG. 3 shows that the axes of the rod **46** and the spring **47** are normal to the axes of the plug valve rod **17** and the fuel metering meedle instead of being parallel thereto as in the device shown in FIG. 1.

The by-pass passage **51** communicates with the largest diameter bore portion **12** instead of with the medial diameter bore portion **11** as in the device shown in FIG. 1.

An electric heater element cartridge **77**, which is spigotted into a closed ended bore which runs parallel and adjacent to the smallest diameter bore portion **10**, is provided to minimise the incidence of ice being formed in the through passage during operation of the device.

The manner in which the cold starting device shown in FIGS. 2 and 3 operates will be apparent from the foregoing description of the device shown in FIG. 1.

FIGS. 4 and 5 show an automatic cold starting device which is similar in most respects to that shown in FIGS. 2 and 3. Parts of the device shown in FIGS. 4 and 5 which correspond with like parts of the device shown in FIGS. 2 and 3 are identified by the reference numerals that were used for the like parts in the foregoing description of the device shown in FIGS. 2 and 3. The main features by which the device shown in FIGS. 4 and 5 differs from the device shown in FIGS. 2 and 3 are described below.

The through passage that defines the orifice with which the plug valve member **18** co-operates is modified to eliminate the medial diameter bore portion and to replace the largest diameter bors portion by a chamber **88** which is closed at its upstream end by a closure plate **78**. The plug valve rod **17** is guided for axial movement within a tubular guide **79** which is integral with the closure plate **78.** The tubular guide **79** defines the annular shoulder **69** against which the coil spring **68** reacts.

The annular valve member **19** of the cold starting device described above with reference to FIGS. 2 and 3 of the accompanying drawings is dispensed with and a separate rectilinearly movable valve member **80** is provided instead. The valve member **80** co-operates with a valve seat **81** to close an aperture **82** formed in the closure plate **78.** The tubular guide part **79** of the closure plate **78** is located between the aperture **82** and that part of the body of the device which houses the tubular component **60** that defines the fuel metering orifice **61** and guides the cylindrical member **33** that carries the fuel metering needle.

The valve member **80** is supported within the chamber **88** that is defined between the closure plate **78** and the orifice with which the plug valve closure member **18** co-operates by being mounted upon one end of a plunger **83.** The plunger **83** slides within the bore of a tubular insert **84** which is housed within a through bore **85** formed in that part of the body of the device which extends between the bore **58** and the chamber **88.** The axes of the plunger **83,** the tubular insert **84** and the through bore **85** are parallel to the axes of the plug valve member rod **17** and the fuel metering needle cylindrical support member **33.** A coil spring **86** reacts against an annular flange **87** formed on the outer surface of the tubular insert **84** and urges the valve member **80** to seat upon the annular valve seat **81.** The end of the plunger **83** remote from the valve member **80** is exposed to the bore **58.** The cross-sectional area of the plunger **83,** the effective area of the valve member **80** which is exposed to the depression that is established in the chamber **88** and the loading of the coil spring **86** are selected so that the depression within the chamber **88** is a function of the inverse of the depression which exists in the bore **58** when the engine is running.

The fuel metering needle cylindrical support member **33** is connected to the arm **37** with clearance therearound so that it can move laterally relative to the arm **37** whilst being retained against axial movement relative thereto. The air supply passage **28** and related metering orifice **30,** which are not shown in FIG. 5, may be omitted. In all other respects the fuel flow control valve assembly which comprises the combined fuel metering needle and cylindrical support member **33** and the tubular component **60** that is housed within the stepped bore portion of the through passage is substantially identical to the corresponding part of the device shown in FIGS. 2 and 3.

The device shown in FIGS. **4** and **5** also includes the temperature sensitive capsule **45** which is operatively coupled with the arm **37** in substantially the same manner as has been described above with reference to and as shown in FIGS. **2** and **3** of the accompanying drawings.

The basic operation of the device shown in FIGS. **4** and **5** of the accompanying drawings will be apparent from the foregoing description with reference to FIGS. **1** to **3** of the accompanying drawings. There is one significant difference however.

During operation of the cold starting device shown in FIGS. **4** and **5,** the valve member **80** is urged against the action of the biassing spring **86,** and thereby unseated from the co-operating valve seat **81,** by the action upon the end of the plunger **83** remote from the valve member **80** of engine manifold depression which is established in the bore **58,** as well as by the action of the depression established within the chamber **88.** Thus the depression within the chamber **88** is a function of the inverse of the depression which exists in the bore **58.** Consequently if the engine stalls or tends to stall before it has attained its normal operating temperature, the resultant reduction in the depression established in the bore **58** downstream of the orifice with which the plug valve member **18** co-operates will be accompanied by movement of the valve member **80** towards the co-operating valve seat **81** under the action of the biassing load exerted thereon by the coil spring **86,** due to the reduction in the counterload exerted upon the plunger **83** by the depression in the bore **58** so that the depression established within the chamber **88** is increased. Such an increase in the depression established within the chamber **88** constitutes an increase in the fuel demand signal by which fuel is drawn through the fuel metering orifice **61** so that a greater quantity of fuel is supplied to the engine to counteract the tendency for the engine to stall. On the other hand, if, once the engine begins running under its own power, the engine speed increases progressively until the engine has attained its normal operating temperature, the accompanying progressive increase in the depression established by engine suction in the bore **58** will be accompanied by a progressive decrease in the depression established within the chamber **88** so that the fuel demand signal is reduced progressively and the air fuel mixture supplied to the engine is weakened progressively as the temperature of the engine approaches the normal operating temperature.

The axial position of the tubular insert **84** within the bore **85** may be adjusted in order to alter the biassing load exerted by the coil spring **86** and thereby to alter the relationship between the depression in the bore **58** and the depression in the chamber **88.**

The tubular insert **84** may be mounted adjustably within the bore **85** by tapping the bore **85,** forming a co-operating screw thread on the outer cylindrical surface of the tubular insert **84** and screwing the insert into the tapped bore **85.** The axial position of the tubular insert **84** can then be altered easily by rotating the tubular insert **84.** An especially convenient arrangement for rotating such a tubular insert **84** comprises the provision of a pair of tabs on the side of the valve member **80** which is nearer to the tubular insert **84,** the tabs conveniently being aligned diametrically on opposite sides of the plunger **83,** the formation of a corresponding pair of slots in the adjacent end face of the tubular insert **84** and the provision or formation of a hexagonal head, screwdriver slot or a hexagonal socket in the crown of the valve member **82** which is accessible through the aperture **82** when the valve member **80** is seated upon the co-operating valve seat **81.** When it is desired to rotate the tubular insert **84** in order to change its axial position within the bore **85,** the hexagonal head, screwdriver slot or hexagonal socket is engaged by the corresponding tool and depressed, against the action of the coil spring **86,** until the tabs engage within the corresponding slots in the tubular insert **84.** The valve member **84** and the tubular insert **84** are then rotated together by the tool until the tubular insert **84** has been repositioned as desired. The tool is then removed allowing the valve member **80** to reseat upon the valve seat **81.**

It is known that the optimum air/fuel ratio varies with changes in engine loading and, in certain circumstances it is possible that it may be desirable to control the depression established in the chamber **88** so that it is substantially constant or so that it is directly proportional to the depression which exists in the bore **58** when the engine is running. It will be appreciated that the cross-sectional area of the plunger **83,** the effective area of the valve member **80** which is exposed to the depression that is established in the chamber **88** and the loading of the coil spring **86** can be selected so that the depression established within the chamber **88** is constant or is any desired function of the depression established in the bore **58** when the engine is running.

I claim:

1. A cold starting device for an internal combustion engine, the cold starting device comprising an auxiliary air supply passage; a first valve member within said auxiliary air supply passage; first biasing means which bias said valve member into an open position at least when the cold starting device is in use, the valve member being arranged so as to tend to be moved when the device is installed on an internal combustion engine by engine suction into a closed position in which it minimizes the flow of air past it to the engine; guide means which guide said valve member for rectilinear movement within said auxiliary air supply passage between said open and closed positions; a fuel metering orifice; conduit means which place said fuel metering orifice in communication with the auxiliary air supply passage upstream of said closed position of said valve member so that metered quantities of fuel can be drawn therethrough into said auxiliary air supply passage by engine suction when said valve member is in the open position; and a thermostatically controlled movable stop for limiting the movement of the valve member towards said closed position, the position of said stop being related to engine temperature so that movement of said valve member is minimized by said stop when the engine is cold and is allowed to increase as the engine warms up towards normal operating temperature whereby movement of said valve member to said closed position is permitted, wherein the improvement comprises a second valve member; a cooperating valve seat positioned within said auxiliary air supply passage upstream of that part of the auxiliary air supply passage with which the fuel metering orifice communicates; second biasing means which urge the second valve member into engagement with said valve seat; the arrangement being such that the second valve member can be seated on said valve seat during the engine cranking period and moved by the depression which is established within said part of the auxiliary air supply passage against the action of the biasing load and away from said valve seat when the engine commences to run under its own power so that the constitution of fuel/air mixture supplied to the engine during starting from cold and warming up of the engine is changed firstly at the termination of the cranking period as well as being further changed progressively once the engine is running under its own power and until it has attained its normal operating temperature.

2. A cold starting device as claimed in claim **1,** wherein said first biassing means comprises a coil spring.

3. A cold starting device according to claim **1,** wherein said second valve member is guided for rectilinear movement towards and away from said co-operating valve seat and said second biassing means comprise a coil spring.

4. A cold starting device according to claim **1,** wherein the first valve member is a plug valve member which co-operates with an orifice in the auxiliary air supply passage to control the flow of fuel/air mixture through the said orifice to the engine, the plug valve member being profiled so that the flow of fuel/air mixture past it to the engine is metered in accordance with engine temperature.

5. A cold starting device according to claim **4,** wherein the profiled plug valve member is fixed to a rod, and said guide means comprise a guide sleeve which is supported within the auxiliary air supply passage, the rod being in sliding engagement within the guide sleeve by which it is guided for rectilinear movement.

6. A cold starting device according to claim **5,** including a profiled needle; coupling means for coupling said profiled needle to the valve member and further guide means for guiding said profiled needle for rectilinear movement with movement of said valve member, the profiled needle projecting into the fuel metering orifice so that the effective area of the fuel metering orifice is varied with movement of the valve member, wherein said first biassing means comprise a coil spring which urges the profiled needle into the position in which the effective cross-sectional area of the fuel metering orifice is at its greatest.

7. A cold starting device according to claim **6,** wherein an arm is carried by the rod, from which it extends laterally, and is fixed to the needle so that the profiled needle and the rod are parallel, the arm being associated with the thermostatically controlled movable stop so that movement of the plug valve member towards said closed position is limited by the movable stop.

8. A cold starting device according to claim **1,** including an expansible capsule by which the position of the thermostatically controlled movable stop is controlled, the expansible capsule being arranged to expand with increase in engine temperature; and a pivoted beam which carries said stop; wherein the expansible capsule acts to permit rotation of the beam about its pivot support, due to the action of resilient means, as the engine temperature increases.

9. A cold starting device according to claim **8** wherein the expansible capsule acts to hold the valve member in its closed position when the engine has attained its normal operating temperature.

10. A cold starting device according to claim **5** wherein said second valve member is annular and is guided for rectilinear sliding movement by said rod which is a sliding fit within its central aperture.

11. A cold starting device as claimed in claim **1,** wherein said second valve member is connected to a movable wall so as to move with movement of the movable wall, the surface of the movable wall remote from said other valve member being exposed to the pressure which is existent in that part of the auxiliary air supply passage that is downstream of the closed position of said rectilinearly movable valve member so that the position of said second valve member relative to the co-operating valve seat is dependent upon the depression established within the auxiliary air supply passage downstream of the closed position of said rectilinearly movable valve member as well as upon the depression which is established within that part of the auxiliary air supply passage with which the fuel metering orifice communicates and the biassing load which acts to urge said second valve member towards said valve seat.

12. A cold starting device according to claim 11, wherein the relationship between said biassing load and the dimensions of said second valve member, said valve seat and said movable wall is such that the depression established by engine suction within that part of the auxiliary air supply passage with which the fuel metering orifice communicates is a function of the inverse of the depression established within the auxiliary air supply passage downstream of the closed position of the rectilinearly movable valve member.

13. A cold starting device according to claim 11 wherein said second valve is guided for rectilinear movement towards and away from said co-operating valve seat, is displaced laterally with respect to said rectilinearly movable valve member and is fixed to one end of a plunger which is engaged for sliding movement within a bore in a body within which said auxiliary air supply passage is defined, the other end of said plunger comprising said movable wall surface.

14. A cold starting device according to claim 13, wherein said second biassing means comprise a coil spring, said bore is the bore of a tubular member housed in a bore in said body, and the coil spring reacts against said tubular member, the location of said tubular member within said body being adjustable axially in order to alter the biassing load exerted by said coil spring upon said other valve member.

15. A cold starting device according to claim 14, wherein said tubular member is screwed into the bore in said body within which it is housed so that it can be rotated for axial adjustment relative to the body.

16. A cold starting device according to claim 10, wherein said first biasing means comprises a coil spring which has a diameter greater than the diameter of said orifice with which the plug valve member co-operates and greater than the diameter of the valve seat with which said annular valve member co-operates and the annular valve member has radially outwardly projecting spokes which are engaged by said coil spring.

17. A cold starting device according to claim 8 wherein the beam is adapted to engage said second valve member and hold said second valve member displaced from its associated valve seat when the engine has attained its normal operating temperature.

18. A cold starting device for an internal combustion engine, the cold starting device comprising an auxiliary air supply passage; one end of the auxiliary air supply passage being for connection to the inlet manifold of an internal combustion engine so that air can be drawn through the auxiliary air supply passage by the action of engine suction when the device is installed on an internal combustion engine; throttling means for throttling such air flow through the auxiliary air supply passage; means for varying the effective cross-sectional area of a part of said auxiliary air supply passage upstream of said throttling means so as to control the depression established within the auxiliary air supply passage between said passage part and said throttling means, yieldable biassing means for biassing said area varying means to minimise the effective cross-sectional area of said passage part, said yieldable biassing means acting in opposition to the effect upon said area varying means of a depression established within the auxiliary air supply passage between said passage part and said throttling means which tends to increase the effective area of said passage part; and a fuel control valve which is operable to allow fuel to be drawn from a fuel supply system into the auxiliary air supply passage between said passage part and said throttling means by the action of a depression which is established in the auxiliary air supply passage between said passage part and said throttling means, wherein the improvement comprises a movable wall having a surface which is exposed to the pressure which is existent in the auxiliary air supply passage downstream of said throttling means, the movable wall being coupled to the area varying means by thrust transmitting means so that the thrust due to the action on said movable wall surface of the pressure in said auxiliary air supply passage downstream of said throttling means is transmitted to said area varying means to act thereon in opposition to the action of said yieldable biassing means, the arrangement being such that the effective cross-sectional area of said passage part is dependent upon the depression established with the auxiliary air supply passage downstream of said throttling means by engine suction as well as upon the depression which is established within the auxiliary air supply passage between said passage part and the throttling means, and upon the biassing load exerted by yieldable biassing means.

19. A cold starting device according to claim 18, wherein the throttling means comprise a throttle valve having a throttle valve member and biassing means which bias said throttle valve member into an open position at least when the cold starting device is in use, the throttle valve member being arranged so as to tend to be moved by engine suction into a closed position in which it minimises the flow of air past it to the engine.

20. A cold starting device according to claim 19, including guide means which guide said throttle valve memeber for rectilinear movement within said auxiliary air supply passage between said open and closed positions.

21. A cold starting device according to claim 19, including a thermostatically controlled movable stop for limiting movement of said valve member towards said closed position, the position of said stop being related to engine temperature so that the permitted movement of said valve member is minimised by said stop when the engine is cold and is increased as the engine warms up towards normal operating temperature whereby movement of said valve member to said closed position is permitted.

22. A cold starting device according to claim 18, wherein said area varying means comprise a valve member, and a co-operating valve seat positioned within said auxiliary air supply passage upstream of said throttling means, said yieldable biassing means urging said valve member into engagement with said valve seat.

23. A cold starting device according to claim 22, wherein said yieldable biassing means comprise a coil spring.

24. A cold starting device according to claim 22, wherein said passage part is displaced laterally with respect to said throttling means and said valve member is fixed to one end of a plunger which is engaged for sliding movement within a bore in a body within which said auxiliary air supply passage is defined, the other end of said plunger comprising said movable wall surface.

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