Dec. 26, 1961 H. EILER 3,014,471

AUTOMATIC CHOKE FOR 2-CYCLE ENGINE

Filed Dec. 14, 1959 3 Sheets-Sheet 1

Fig. 1.

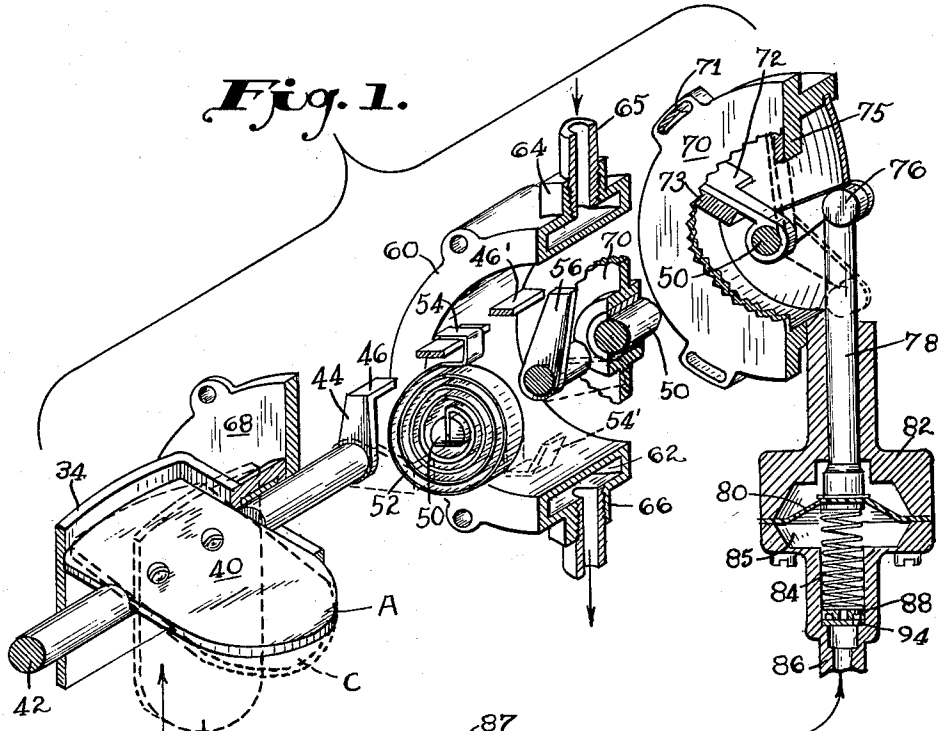
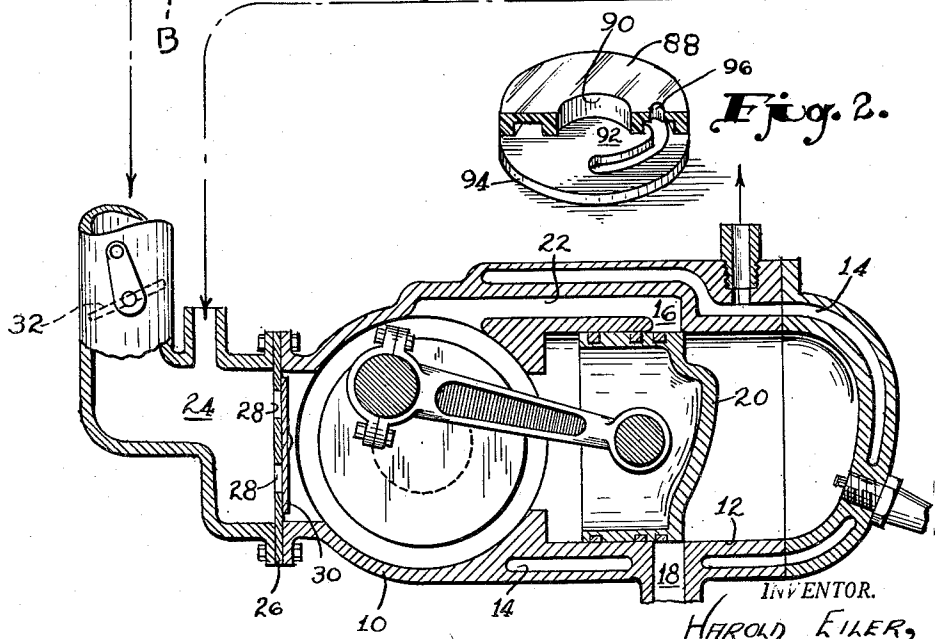


Fig. 2.



INVENTOR.
HAROLD EILER,
BY
Schley, Dark & Jenkins
Attorneys.

Dec. 26, 1961 H. EILER 3,014,471

AUTOMATIC CHOKE FOR 2-CYCLE ENGINE

Filed Dec. 14, 1959 3 Sheets-Sheet 2

Fig. 3.

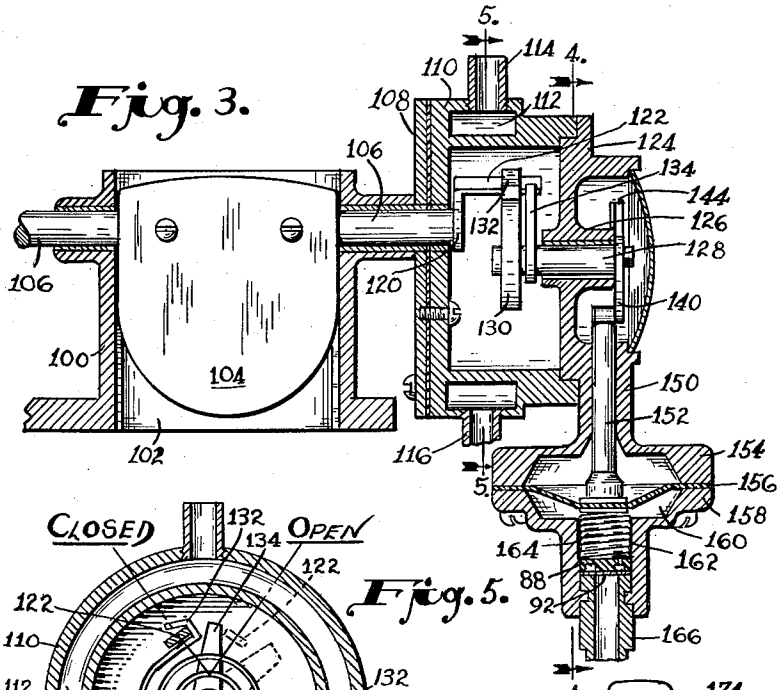


Fig. 5.

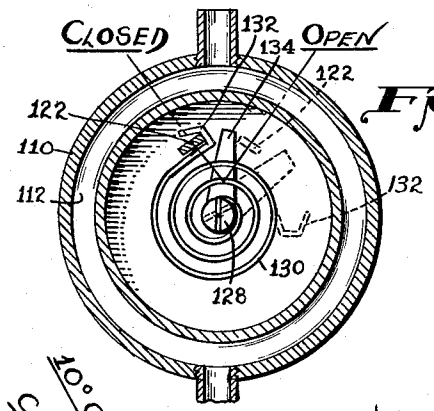


Fig. 4.

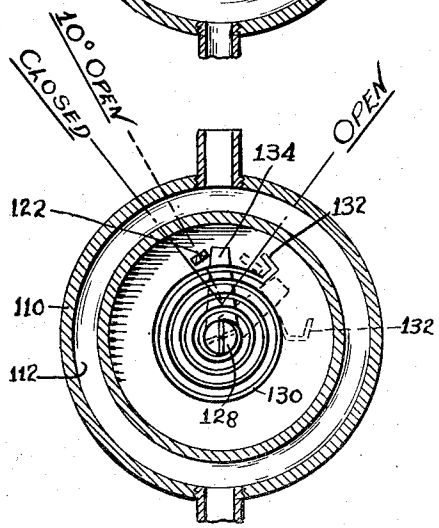


Fig. 6.

INVENTOR.
HAROLD EILER,
BY
Schley, Lusk & Jenkins
Attorneys.

Dec. 26, 1961 H. EILER 3,014,471

AUTOMATIC CHOKE FOR 2-CYCLE ENGINE

Filed Dec. 14, 1959 3 Sheets-Sheet 3

Fig. 7.

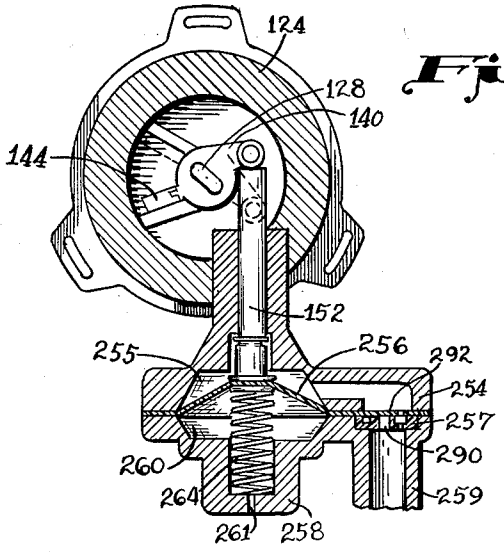


Fig. 8.

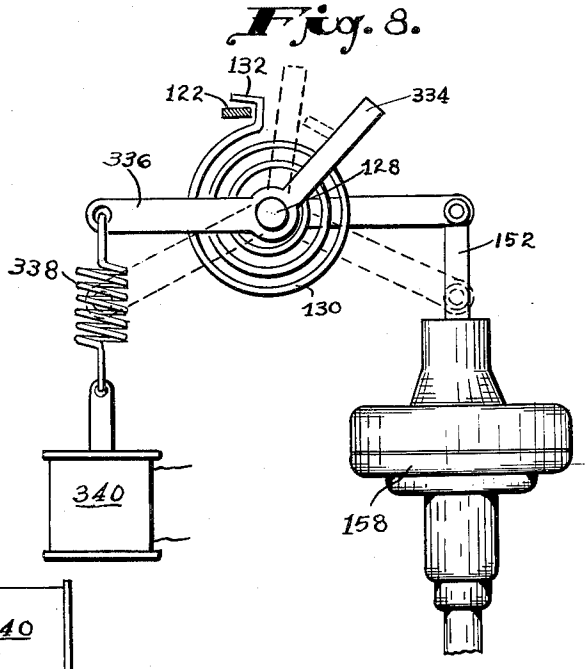
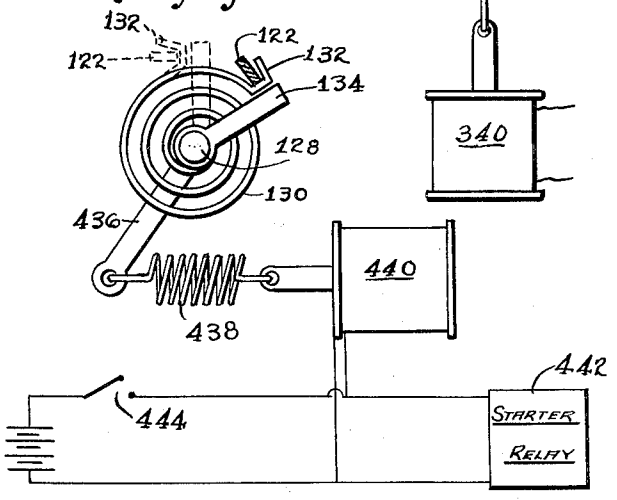


Fig. 9.



INVENTOR.
HAROLD EILER,
BY
Schley, Zark & Jenkins
Attorneys.

United States Patent Office 3,014,471 Patented Dec. 26, 1961

3,014,471

AUTOMATIC CHOKE FOR 2-CYCLE ENGINE

Harold Eiler, Lapel, Ind., assignor to The Pierce Governor Company, Inc., Anderson, Ind., a corporation of Indiana

Filed Dec. 14, 1959, Ser. No. 859,477
17 Claims. (Cl. 123—73)

This invention relates to an automatic choke for an internal combustion engine and especially to a choke which will meet the various requirements of a 2-cycle engine such as an outboard marine engine, and which may be controlled by the pulsating pressure conditions available with such a 2-cycle engine.

In 2-cycle engines such as the common outboard marine engine the operating cycle is such that only a relatively low suction is produced in the intake manifold, so that at least partial choking is essential for starting even when the engine is at operating temperature. The chokes heretofore available have not met this need. Moreover, the only pressure conditions available for control of an automatic choke in such a 2-cycle engine, as for example the reduced pressure or suction in the intake manifold, are pulsating pressures which drop to such low values between pulses that they are unsuitable for control of usual pressure responsive mechanisms. Further, the choking requirements in relation to the physical arrangement and functioning of common outboard marines engines are such that it is not satisfactory to modulate the choking action in response to the temperature of some part of the exhaust system, as is done in common automotive choke mechanisms.

It is therefore an object of this invention to provide an automatic choke mechanism which will produce the choking requirements of a 2-cycle engine, including not only the requirements for cold starting, but also those for starting when the engine is hot. It is a further object of the invention to provide a choke mechanism which will be controlled in response to a pulsating pressure, such as the pulsating intake suction available in a 2-cycle engine. It is a further object of the invention to provide a choking action which is continuously correlated with and modulated in relation to the requirements of a 2-cycle engine, by controlling the automatic choke in response to the temperature of the engine cooling water. It is a further object of the invention, in its preferred form, to provide an automatic choke which will be operative both when the engine is electrically started and when the engine is manually started.

In accordance with the invention, I utilize a choke-control of the type in which a choke valve is arranged to be biased to closed position by a bi-metal thermostatic spring which exerts a choking bias that varies inversely with its temperature and which has a mechanically advanced position in which it exerts a maximum or starting bias during engine cranking and a retracted position in which it exerts a decreased running bias once the engine is self-operating, which decreased or running bias progressively relaxes and disappears as the engine approaches and reaches operating temperature. To produce a hot-choking action when the bi-metal spring is fully relaxed, the invention provides a second choke-actuating means, which is independent of temperature, and which lies in an advanced position during cranking to bias the choke valve to at least a partial choking position and which is retracted when the engine starts. The temperature-responsive actuating means and the independent actuating means may be operated in common or separately, either or both may be normally retracted and advanced automatically during starting, as by an electromagnetic device energized concurrently with a starting motor. Preferably, however, the temperature-responsive and independent actuating

means are normally advanced so that they exert maximum choking action during cranking regardless of whether the engine is cranked manually or electrically, and are moved to retracted position when the engine becomes self-operating and in response to such self-operation. This movement to retracted position may be effected by a pressure-actuated motor device, which may be a device actuated by positive pressure but is conveniently and desirably a suction-actuated device. To render such device operative by a pulsating pressure available with a 2-cycle engine, it is connected to the pulsating pressure source through a check valve which opens with pressure, so that the peak values of the pulsating pressure (or suction) are transmitted through such check valve to actuate the motor device and the check valve maintains the device actuated between the peaks of the pressure pulses. The check valve would normally also tend to maintain the motor device in actuated position after the pulsating pressure has ceased, that is, after the engine has ceased being self-operating; and to prevent this, the check valve is bypassed by a return bleed opening which is sufficiently restricted to delay de-actuation between normal pulses but which is sufficiently open to allow the motor device to rapidly bleed off the pressure trapped by the check valve when the engine stops. Further objects and novel features of the invention will appear from embodiments described below.

The accompanying drawings illustrate the invention. In such drawings:

FIG. 1 is a composite diagrammatic view of an apparatus embodying the invention;

FIG. 2 is an enlarged isometric view of the check valve used in the apparatus of FIGS. 1 and 3;

FIG. 3 is an axial section of a preferred embodiment of the invention as applied to an outboard marine engine, showing the parts in non-choking position;

FIG. 4 is a section taken on the line 4—4 of FIG. 3;

FIG. 5 is a section taken on the line 5—5 of FIG. 3, and showing in full lines the advanced, cold-start position of the parts and in dotted lines the retracted running condition of the parts;

FIG. 6 is a section similar to FIG. 5 but illustrating the hot-start positions of the parts;

FIG. 7 shows a modification in which the pulsating positive pressure taken from the crank case of a 2-cycle engine is used to control the choke instead of the suction used in FIGS. 1 and 3;

FIG. 8 shows a modification in which the temperature responsive biasing element and the independent biasing element are separately controlled, one being normally advanced and retracted by a pressure motor, and the other being normally retracted and advanced electromagnetically during cranking; and

FIG. 9 shows a modification in which both the temperature-responsive and independent biasing means are normally retracted and jointly are electromagnetically advanced during cranking.

The 2-cycle engine shown diagrammatically at the bottom of FIG. 1 is conventional. It comprises a crank case 10 supporting a cylinder 12 whose walls contain a water passage 14 through which cooling water is pumped by an engine driven pump. Such water in the case of a marine engine is taken in fresh from outside and not recirculated through any radiator. The cylinder 12 has an intake port 16 and an exhaust port 18 positioned to be opened and closed at the proper times by the piston 20. The intake port 16 is connected to the crank case by a transfer passage 22, and the crank case communicates with an intake manifold 24 through a reed plate 26 provided with intake ports 28 closed by a reed valve 30. The intake manifold connects with a carburetor of conventional construction which includes a throttle valve 32.

The carburetor has an intake conduit 34 which is provided with an unbalanced choke valve 40 mounted on a choke shaft 42. Such valve 40 has a fully closed position A shown in full lines, and both a fully open position B and an intermediate hot-choking position C shown in chain lines. The choke shaft 42 carries an operating arm 44 having an eccentric crank pin 46.

The control mechanism comprises a control shaft 50 on an axis parallel with the choke shaft 42 but conveniently offset downwardly therefrom. Such control shaft 50 carries a temperature-responsive helically-wound, bi-metal spring 52 having a hook 54 at its free end which normally engages the choke crank 46 to bias the choke valve 40 to closed position. The arrangement of the spring 52 is such that an increase of temperature tends to wind it on itself to relax the bias which it exerts. In FIG. 1, the position of the bi-metal spring 52 shown in full lines assumes the spring to be cold. When the spring is heated, its end hook 54 moves clockwise, as to the position 54' indicated in dotted lines.

Immediately behind the bi-metal spring 52, the control shaft 50 carries a fixed choke-actuating arm 56 in an axial position for engagement with the end portion 46' of the choke crank pin 46, and in an angular position relative to the bi-metal spring 52 such that the arm 56 stands slightly clockwise from the cold position of the bi-metal spring hook 54, and in a position relative to the choke crank 46 such that in the absence (or thermal retraction) of the bi-metal spring hook, engagement of the choke crank 46 with the arm 56 would hold the choke valve in its nearly closed position C. The arm 56 is thus fixed on the shaft 50 angularly between the cold position of the spring hook 54 and the hot position marked 54' of that spring hook.

The bi-metal spring 52 is housed in a water jacket housing 60 having a circumferential wall containing a water passage 62 provided with a water inlet 64 at the top and a water outlet 66 at the bottom. The water inlet is connected to the engine water jacket by a conduit 65. The housing 60 has a front mounting plate 68 fixed on the carburetor intake 34, and has a rear cover casting 70 provided with a central bearing hub in which the shaft 50 is journaled.

The rear end of the shaft 50 carries a stop lever 72 which swings between two stops 73 and 75 on the casting 70 to limit rotational movement of the shaft. Such control shaft 50 also carries an actuating arm 76 by which the shaft 50 is moved between a counter-clockwise, advanced position indicated by the full lines position of the arm 76 and a clockwise, retracted position indicated by the dotted line showing of the arm 76. In the preferred arrangement shown, the shaft is normally biased to its advanced position and the bias is arranged to be retracted by a motor device responsive to suction produced in the intake manifold of the engine by normal running operation of the engine. The biasing and motor means shown comprises a plunger 78 carried by a diaphragm 80 mounted in a housing 82 and biased upward by a spring 84. The motor chamber 85 below the diaphragm communicates with a suction nipple 86 through a check valve which is shown on an enlarged scale in FIG. 2. The check valve comprises an annular body 88 of inverted U-shaped cross-section forming a central valve port 90 surrounded at its lower end by a valve seat. The valve is normally closed by a flap 92 formed integral with a gasket 94. The valve opens with pressure, in the direction of the suction nipple 86. In addition to the main valve port 90, the valve body contains a restricted by-pass opening 96 through the web of the annular body 88 and communicating with the edge opening of the flap 92.

The suction nipple 86 of the control mechanism is connected to the intake manifold 24 of the engine by a suitable suction conduit 87, and the water jacket inlet 66 is connected by the pipe 65 to receive water which has been heated by operation of the engine, under pressure from the engine pump. The water outlet 66, in an outboard engine, will normally discharge to waste.

The operation of the automatic choke valve of FIG. 1 is as follows: Under normal cold starting conditions, with the engine at rest, the biasing spring 84 will bias the plunger 78 upward to raise the actuating arm 76 and turn the operating shaft 50 to its advanced, counter-clockwise position, limited by engagement of the stop arm 72 against the fixed stop 73. The cold bi-metal spring 52 will tend to unwind and will strongly bias the crank pin 46 counter-clockwise to hold the choke valve 40 with a substantial biasing force in its fully closed position A. In this arrangement, the temperature-responsive biasing spring 52 and the independent or non-temperature-responsive biasing spring 84 are in series, and under extreme cold conditions, the reaction of the spring 52 may partially collapse the spring 84, and this latter spring 84 will determine the ultimum maximum bias which the system can impose on the unbalanced choke valve 40.

When the engine is cranked, insufficient suction will be produced in the intake manifold to actuate the diaphragm 80 against the biasing force of the spring 84, and the control shaft 50 will remain in advanced position. Moreover, the bi-metal spring 52, being cold, will exert a maximum bias tending to hold the choke valve 40 closed. A full choking action will occur. When the engine starts, its normal operation even at idling speeds will produce a pulsating suction in the manifold 24, and the peak suction pulses, being transmitted through suction nipple 86 and check valve 92 will depress the diaphragm 80 and collapse the biasing spring 84, to remove its bias from the system. This will lower the plunger 78 and allow the control shaft 50 to rotate clockwise to its retracted position, limited by engagement of the stop arm 72 with the fixed stop 75. This clockwise rotation will rotate the inner supported end of the bi-metal spring 52 clockwise and relieve the bias which such spring exerts on the crank pin 46 and the choke valve 40. A substantial reduction of the choking action will then result; but the bi-metal spring 52, being still cold, will continue in its retracted position to exert a degree of choke-actuating bias, sufficient to maintain operation of the now-started engine. As the engine continues to operate, its cooling water will be heated and the circulation of such heated water through the water jacket 60 enclosing the bi-metal spring 52 will heat that housing and the spring 52. This will cause the spring 52 to wind upon itself, and relax its choking bias and progressively reduce the choking action as the engine approaches normal running temperature. When such temperature is reached, the spring 52 may wind upon itself to such extent as to move its actuating hook 54 from the relative position shown in full lines in FIG. 1 to the relative position shown in dotted lines in FIG. 1 and marked 54', and the choke valve 40 will take its fully open position B.

Moreover, under these conditions of normal engine operating temperature, and with the operating hook 54 of the bi-metal spring 52 in its fully relaxed position 54', the spring 52 will be incapable of exerting any choking bias even with its supporting shaft 50 rotated counter-clockwise to its advanced position. Nevertheless, if the engine stops and it is desired to re-start it while the engine and spring 52 remain at or above normal operating temperature, the low suction characteristics of the 2-cycle engine make it necessary to produce a substantial choking action if starting is to be accomplished. This hot choking is accomplished as follows. When the engine stops, the suction which holds the diaphragm 80 and the plunger 78 in retracted position will fail, and although the main flap valve 92 will be closed against back-flow to relieve the low pressure in the diaphragm chamber 85, the restricted by-pass 96 will permit sufficient back-flow past the valve to relieve such low pressure. Accordingly, when the engine stops, the diaphragm 80 and plunger 78 will

promptly rise under the force of the spring 84, to drive the control shaft 50 to its counter-clockwise advanced position. This movement will advance the fixed lever 56 on the control shaft 50 against the crank pin 46 and will move the choke valve 40 to its position C, where it will exert a choking action sufficient for hot starting but less than that exerted during cold starting. In this hot choking action, the choke valve is biased to its hot-choking position C by the spring 84 which is independent of the temperature of the engine. As soon as the engine starts, suction pulses will again occur in the manifold 24 and will act to reduce the pressure in the motor chamber 25, to retract the diaphragm and the plunger 78, and allow the control shaft 50 to rotate to retracted position. This will retract the arm 56 and allow the choke valve 40 to move to its fully open position B.

The control shaft 50 and the various elements 52, 56, 72 and 76 mounted on it are all carried in a sub-assembly by the cover casting 70 and the motor body 82 integral therewith, and limited rotation of this sub-assembly about the axis of the shaft 50 relative to the choke crank 44 will serve to adjust the choke-control action. Accordingly, the cover casting 70 is secured to the fixed water jacket by screws received through arcuate slots 71 in the casting 70 which permit such adjusting rotation.

A preferred embodiment of my new automatic choke as applied to an outboard marine engine is shown in FIGS. 3 to 6. A carburetor intake conduit 100 defining an intake passage 102 contains an unbalanced choke valve 104 mounted on a choke shaft 106. The left-hand end of the shaft 106 may extend to a second choke valve in a dual inlet carburetor. The choke shaft 106 extends through a mounting plate 108 on which is mounted a control housing 110, the outer walls of which form a water passage 112 having an inlet 114 and an outlet 116. Within the housing 110 the end of the choke shaft 106 carries a crank arm 120 having a crank pin 122.

The end of the control housing is closed by a cover body 124 having a central bearing hub 126 for a control shaft 128. The left end of the shaft carries a helically wound bi-metal spring 130 terminating in a hook 132 to engage the crank pin 122. Immediately adjacent the bi-metal spring 130, the control shaft 128 carries a fixed arm 134.

The right end of the control shaft 128 carries a stop arm 144 and an actuating arm 140 having a roller 142 at its end. The stop arm 144 swings between a pair of fixed stops 146 and 147 formed in the cover body 124.

A downward extending boss 150 on the cover body slidably supports an actuating plunger 152 beneath the actuating roller 142, and forms a supporting flange 154 for a diaphragm 156 fixed thereto by a motor body 158. The motor body defines a suction chamber 160 below the diaphragm 158 and provides a cylindrical bore 162 for the reception of a compression spring 164, which biases upward the diaphragm 156 and the plunger 152. The bottom of the bore 162 contains a check valve 88—96 as shown in FIG. 2 which controls flow between the chamber 160 and a nipple 166 adapted to be connected to the intake manifold of the carburetor. The check valve flap 92 opens in the direction of flow from the motor chamber 160 to the nipple 166, and suction pulses from the manifold will be transmitted through the valve to reduce the pressure in the motor chamber 160 and lower the diaphragm 156 against the spring 164. While the small by-pass 96 is open to allow reverse flow in the intervals between suction pulses, the relationship is such that the reverse flow is insufficient to destroy the actuating pressure reduction in the diaphragm chamber 160 and the diaphragm is held steady in lowered position under all running conditions of the engine.

The cover body 124 carries assembled to it substantially the entire choke control mechanism, including the bi-metal spring 130 and the arm 134 which engage the crank pin 122 on the choke shaft 106. To provide for adjustment of the choking action, this assembly is secured to the control housing 110 by three screws passing through slotted openings 174 in projections formed at the periphery of the cover body, which permit angular adjustment of the cover body assembly relative to the choke shaft.

As is shown in FIGS. 3, 5, and 6, the control shaft 128 is desirably offset from the choke shaft 126 so that a given angular movement of the actuating elements 130 and 134 on the control shaft 128 produce a larger angular movement of crank 120 and the choke shaft 106.

FIG. 5, taken with FIGS. 3 and 4, illustrate the operation of the automatic choke in starting a cold engine. In FIGS. 4 and 5, the parts are shown in full lines in the positions they normally occupy when the engine is at rest and cold. Under these conditions, the vacuum chamber 160 will be at atmospheric pressure and the biasing spring 164 will be extended to raise the diaphragm 156 and the plunger 152, and such plunger will hold the actuating lever 140 in its extreme counter-clockwise position shown in full lines in FIG. 4. This will position the control shaft 128 in its counter-clockwise advanced position as shown in full lines in FIG. 5. The temperature responsive bi-metal spring 130 will be cold and will tend to take its extreme unwound condition, and its operating hook 132 will force the crank pin 122 and the choke shaft counter-clockwise to hold the choke in closed position. If the engine is now cranked, insufficient suction will be created to actuate the diaphragm 156 and the parts will remain in the positions just described and shown in full lines in FIGS. 4 and 5, and a full choking action will occur.

When the engine starts and becomes self-operating, the pulsating suction occurring in the intake manifold will be transmitted through the check valve 92 to actuate the diaphragm 156 downward, compress the biasing spring 164, and retract the plunger 152. This will allow the actuating lever 140 to rotate clockwise to its dotted line position shown in FIG. 4, and will allow the control shaft 128 to rotate clockwise in FIG. 5 to its retracted position. This will partly back off the supported inner end of the bi-metal spring 132, and reduce the choking bias which such spring exerts. The action in response to engine self-operation will remove from the choke valve 104 all effect of the pressure-controlled biasing spring 164, leaving effective only the temperature-responsive bi-metal spring 130. This, being cold, will exert a continuing partial choking bias on the choke valve 104, which will progressively decrease as the engine temperature rises and its heated cooling water, pumped by the engine pump through the water jacket 110 of the automatic choke, heats the bi-metal spring 130. Such heating causes such bi-metal spring to wind upon itself, to relax its bias on the choke actuating crank and move its actuating hook 132 clockwise. At full operating temperature, the hook 132 may move to the dotted line position shown in FIG. 5, where it lies clockwise beyond the fixed arm 134 and completely out of position to bias the choke crank 122. The choke crank will then lie in its fully open position shown in dotted lines in FIG. 5, being urged thereto by the effect of fluid flow past the unbalanced check valve 104. It may be noted that while an unbalanced choke valve 104 is preferred, one may also use other types, such as a balanced choke valve biased to open position.

When a 2-cycle engine stops and is to be re-started while still at normal operating temperature, a partial choking action must be provided in view of the low cranking suction characteristics of the engine. The hot-choking operation action of the device of FIG. 3 is illustrated in FIG. 6, taken with FIG. 4. The hot running positions of the parts are as described above and shown in dotted lines in FIGS. 4 and 5, the choke crank pin 122 being at its extreme clockwise position, and the hook 132 of the

bi-metal spring lying in a position spaced clockwise from that crank. When the hot engine stops, the reduced pressure in the motor chamber **160** is destroyed by flow through the restricted valve by-pass **96** and the biasing spring **164** raises the diaphragm **156**, the plunger **152**, and the arm **142**, and rotates the control shaft **128** to its advanced normal position shown in full lines in FIGS. 4 and 6. This rotates the bi-metal spring **130** clockwise, but the operating hook **134** of the hot spring is too far counterclockwise to produce any choking action. The kicker arm **134**, however, being fixed on the control shaft **128**, drives the choke crank pin **122** counter-clockwise to a partially choking position, as to the 10° open position indicated in FIG. 6, corresponding to choke valve position C shown in FIG. 1. The parts are held in this position by the pressure-controlled biasing spring **164** during cranking of the hot engine, and sufficient choking occurs to start the hot engine. When the engine starts, suction pulses are again transferred to the diaphragm chamber **160** to lower the diaphragm **156**, collapse the biasing spring **164**, lower the plunger **152**, and allow the control lever **140** and the control shaft **128** to rotate clockwise to the dotted line positions shown in FIGS. 4 and 6. This allows the choke to move to fully open position and terminates the choking action provided during the hot cranking operation.

The modification shown in FIG. 7 is similar to the preferred modification shown in FIGS. 3 and 4, save that instead of using suction to actuate the diaphragm, the modification uses positive pressure, as from the crank case of the engine. FIG. 7 may be considered similar to FIG. 4, and to represent a section of a choke control device similar to that shown in FIG. 3. The choke control shaft **128** is rotatably mounted in the cover body **124** and carries an actuating arm **140** and a stop arm **144**. The actuating arm **140** is raised by the plunger **152** carried by a pressure diaphragm **256** biased upward by a spring **264**. The cover **124** carries a motor body **254** to which the diaphragm **256** is secured at its edges by a body **258** which forms a seat for the spring and provides a clearance space **260** for the diaphragm, and such space is vented to the atmosphere through a vent **261**. The motor body **254** forms a motor chamber **255** above the diaphragm **256** communicating through an inwardly-opening check valve **257** with a pressure inlet nipple **259**. The check valve **257** is similar to that shown in FIG. 2 and has a central valve port **290** closed by a flap valve **292** formed integral with the diaphragm **256**. The operation is similar to that of the device of FIGS. 3 and 4. The choke control shaft **128** is normally biased to its counter-clockwise advanced position as shown in full lines in FIG. 7, and it remains in this position during cranking of the engine. When the engine starts, positive pressure pulses are transmitted from the crank case through the valve **292** to raise the pressure in the motor chamber **255** and depress the diaphragm **256** against the spring **264**. This lowers the plunger **152** and allows the control shaft **128** to rotate clockwise to its retracted position.

In the modification of FIG. 8, the temperature-responsive actuating means for the choke valve is identical with that shown in FIG. 3. The positive-acting choke actuating means, however, instead of being fixed on the same shaft with the bi-metal spring is independently movable about the same axis and is advanced and retracted independently of the bi-metal spring. The modification of FIG. 8 thus includes a main choke control shaft **128** which carries a bi-metal spring **130** having a hooked end **132** which actuates the crank pin **122** of the choke shaft. The control shaft **128** is normally in its counter-clockwise advanced position, and is retracted by the plunger **152** of a suction-operated motor device **158**. For hot-choking, a positive-acting choke actuating arm **334** is rotatably carried on the shaft **128** and is operated by an operating arm **336** connected through a spring **338** to a solenoid **340**. The arm **334** is normally retracted so that it lies in the position shown in full lines in FIG. 8. Its actuating solenoid **340** is connected in parallel with the electric starting circuit of the engine so that during cranking the solenoid **340** actuates the arm **334** to its advanced position shown in dotted lines in FIG. 8. If the engine is hot so that the bi-metal spring **130** is inoperative to produce a choking actuation of the crank pin **122**, the arm **334** will engage such crank pin **122** and move it to a position in which it will cause partial closing of the choke valve.

In this modification of FIG. 8 the temperature-responsive means and the independent choke-actuating means are separately controlled. The temperature-responsive means is normally advanced and is retracted when the engine starts. The independent actuating means is normally retracted and is advanced to choking position electromagnetically during cranking of the engine.

In the modification of FIG. 9, the bi-metal spring **130** and the independent choke actuating arm **134** are mounted on the shaft **128** as in FIGS. 3 and 4, but the shaft normally lies in its retracted position shown in full lines in FIG. 9, instead of its advanced position as in FIGS. 3 and 4. It is driven to advanced position shown in dotted lines in FIG. 9 during cranking of the engine by means of a solenoid **440** acting through a spring **438** on an arm **436**. The solenoid is connected in parallel with the starter relay **442** for actuation by the starting switch **444**. The operation is similar to that of the device of FIGS. 3 and 4. During cranking of the engine, the shaft **128** is actuated by the solenoid **440** to its advanced position. If the engine and the bi-metal spring **130** are cold, such bi-metal spring will bias the crank pin **122** to its full-choking position. When the engine starts and the starting circuit is open, the solenoid **440** will be de-energized and the shaft **128** will move to its retracted position, such reducing the choking action. If the engine and the bi-metal spring **130** are hot, so that the bi-metal spring **130** is incapable of producing the necessary choking action, the arm **134** will engage the crank pin **122** to move the same to a nearly closed position, to provide the partial choking required for hot starting.

I claim as my invention:

1. An automatic choke for an engine which requires partial choking for starting when the engine is hot, comprising a choke valve, temperature-responsive choke actuating means operative during cold cranking of the engine to bias said valve to cold-choking position, said means including a thermal element responsive to engine temperature and operative to render said choke actuating means relatively ineffective at normal engine operating temperature, said temperature-responsive actuating means including a one-way connection permitting closing of said choke valve independently of said means, and a second choke actuating means in parallel with said temperature-responsive actuating means and having an advanced starting position and a retracted running position, said second choke actuating means being operative in advanced position to actuate said valve to at least partial choking position independently of said temperature-responsive means and being retracted from choke actuating position when in retracted running position, and motor means to automatically position said second means in advanced position during cranking of the engine and in retracted position during self-operation of the engine.

2. An automatic choke for an engine which requires partial choking for starting when the engine is hot, comprising a choke valve, temperature-responsive choke actuating means operative during cold cranking of the engine to bias said valve to cold-choking position, said means including a thermal element responsive to engine temperature and operative to render said choke actuating means relatively ineffective at normal engine operating temperature, said temperature-responsive actuating means including a one-way connection permitting closing of said choke valve independently of said means, and a second choke actuating means in parallel with said temperature-

responsive actuating means and having an advanced starting position and a retracted running position, said second choke actuating means being operative in advanced position to actuate said valve to at least partial choking position independently of said temperature-responsive means and being retracted from choke actuating position when in retracted running position, biasing means normally biasing said second choke actuating means to advanced position, and means responsive to self-operation of the engine for moving said second choke-actuating means to retracted position.

3. An automatic choke for an engine which requires partial choking for starting when the engine is hot, comprising a choke valve, temperature-responsive choke actuating means operative during cold cranking of the engine to bias said valve to cold-choking position, said means including a thermal element responsive to engine temperature and operative to render said choke actuating means relatively ineffective at normal engine operating temperature, said temperature-responsive actuating means including a one-way connection permitting closing of said choke valve independently of said means, and a second choke actuating means in parallel with said temperature-responsive actuating means and having an advanced starting position and a retracted running position, said second choke actuating means being operative in advanced position to actuate said valve to at least partial choking position independently of said temperature-responsive means and being retracted from choke actuating position when in retracted running position, said second choke actuating means being normally retracted, and motor means operative during cranking of the engine to move said second choke actuating means to advanced position.

4. An automatic choke for an engine, comprising a choke valve, temperature-responsive means which in cold state normally biases said valve to closed position and which is rendered less effective in response to increased engine temperature, said temperature-responsive means including a one-way connection permitting closing of said choke valve without limitation from said temperature responsive means, a second biasing means for biasing said valve to at least partially closed position, mechanical means in parallel with said temperature-responsive means to transmit bias force from said second means to said choke valve, and automatic control means operable to transmit such biasing force through said mechanical means during cranking of the engine and to withdraw said biasing force when the engine becomes self-operating.

5. An automatic choke as set forth in claim 4 in which said second biasing means comprises a stressed spring normally active to bias said choke to partially closed position, and a fluid motor is connected in opposition to said spring to retract the same for withdrawing the biasing force thereof.

6. An automatic choke as set forth in claim 4 in which a spring and motor device are connected in series for biasing said valve to partially closed position, and said motor device is actuated to render said spring effective during cranking of the engine.

7. An automatic choke for a 2-cycle internal combustion engine having an air intake, comprising a choke valve in said air intake and carried by a choke shaft, a crank on said shaft, a control shaft, a bi-metal spring carried by said control shaft and in cold state acting on said crank to bias said valve toward closed position, said bimetal spring in hot state being bent to a condition in which it is ineffective to bias said valve to choking position, said control shaft being rotatable between an advanced position and a retracted position, an arm carried by said control shaft in position to engage said crank and to actuate the same to at least a partial choking position when the control shaft is in its advanced position, and means to bias said shaft to its advanced position during cranking and to retract the same to its retracted position when the engine becomes self-operating.

8. An automatic choke for an engine which requires partial choking for starting when the engine is hot, comprising a choke valve operatively biased toward open position, an actuating element having advanced and retracted positions, a motor device for automatically biasing said element toward advanced position during cranking of the engine and positioning said element in retracted position during self-operation of the engine, a first thermostatic actuator forming a one-way connection between said element and choke valve to exert closing bias on said choke valve, the arrangement being such that said bias is increased by movement of said actuating element from retracted to advanced position, said thermostatic actuator including a a temperature-responsive means to vary its condition between an extended condition in which it exerts cold-choking bias on said choke valve and a withdrawn condition in which it exerts less than sufficient actuation of said choke valve for hot choking, and a second positive actuator for forming a second one-way connection between said element and choke valve, in parallel with said thermostatic actuator, said positive actuator being inoperative to produce actuation of said choke valve when said element is retracted and being operative to actuate said valve to hot-choking position when said element is in advanced position.

9. An automatic choke as defined in claim 8 with the addition of a water jacket surrounding the temperature-responsive means of said thermostatic actuator, and means for conducting liquid from the cooling system of the engine to said water jacket to heat said temperature-responsive means.

10. An automatic choke for a 2-cycle engine, comprising a choke valve, a pressure motor having an element normally biased to advanced position and operable by said pressure motor to a retracted position, a first thermostatic actuator forming a one-way connection between said element and said valve to bias the same to choking position, under cold conditions, and being advanced in choke-increasing direction by movement of said element from retracted to advanced position, said thermostatic actuator being responsive to temperature to decrease its choking bias and having a hot condition in which it is inoperative to actuate said choke to hot choking position, and a second positive actuator in parallel with said first actuator, said second actuator forming a positive choke-actuating connection from said element to said valve when said element is in advanced position and being inoperative to actuate said valve when said element is in retracted position, and means to connect said motor to a source of pulsating pressure on said engine, said connection-means including a check valve to maintain an actuating pressure condition in said motor between pulses, and means to bleed off such actuating pressure when said engine stops.

11. An automatic choke as defined in claim 10 with the addition of a water jacket surrounding the temperature-responsive means of said thermostatic actuator, and means for conducting liquid from the cooling system of the engine to said water jacket to heat said temperature-responsive means.

12. In combination with a 2-cycle engine having a carburetor and an intake passage in which self operation of the engine produces a succession of pressure pulses separated by pressure conditions of low value, an automatic choke for said carburetor, comprising a choke valve, choke actuating means having a normal advanced position for exerting a starting choking action during cranking of the engine and a retracted position for exerting less than starting choking action during self-operation of the engine, means biasing said device to advanced position, and a pressure motor connected to move said device to retracted position and maintain said condition during self-operation of the engine, said pressure motor being operable by pressure values existing at the peaks of said pressure pulses and being inoperable by the low-value pressure conditions existing between said pressure pulses, con-

nection means connecting said pressure motor to said intake passage for transmission of peak pressure values therein to operate said motor, said connection means including a check valve opening with pressure to maintain an actuating pressure condition in said motor between the successive pressure pulses in said intake passage.

13. The combination set forth in claim 12 with the addition of a restricted bleed for bleeding off the motor-actuating pressure condition when the succession of pressure pulses stops.

14. The combination set forth in claim 13 in which the pressure motor is a suction actuated motor and is connected to the intake manifold of the engine.

15. The combination set forth in claim 13 in which the pressure motor is a positive-pressure motor and is connected to a pre-compression chamber in the crank case of the engine.

16. The combination set forth in claim 12 in which the said choke actuating means includes a temperature-responsive element responsive to a rise in the temperature of the engine to decrease the choking action of said means.

17. The combination set forth in claim 12 in which said choke actuating means includes two choke-actuating means operable in parallel, one being temperature responsive and having a hot condition in which it is ineffective to produce hot choking, and the other comprising a positive-acting element which lies in non-choking position when retracted by said pressure motor and which moves to positive-choking position when advanced by said biasing means.

References Cited in the file of this patent

UNITED STATES PATENTS

1,598,677	Donning et al.	Sept. 7, 1926
2,030,331	Smith	Feb. 11, 1936
2,139,356	Coffey	Dec. 6, 1938
2,222,865	Chandler	Nov. 26, 1940
2,362,346	Blake	Nov. 7, 1944
2,705,484	Jorgensen et al.	Apr. 5, 1955
2,823,905	Brown	Feb. 18, 1958