Dec. 24, 1940. T. R. COOK ET AL 2,226,219

STEAM LOCOMOTIVE

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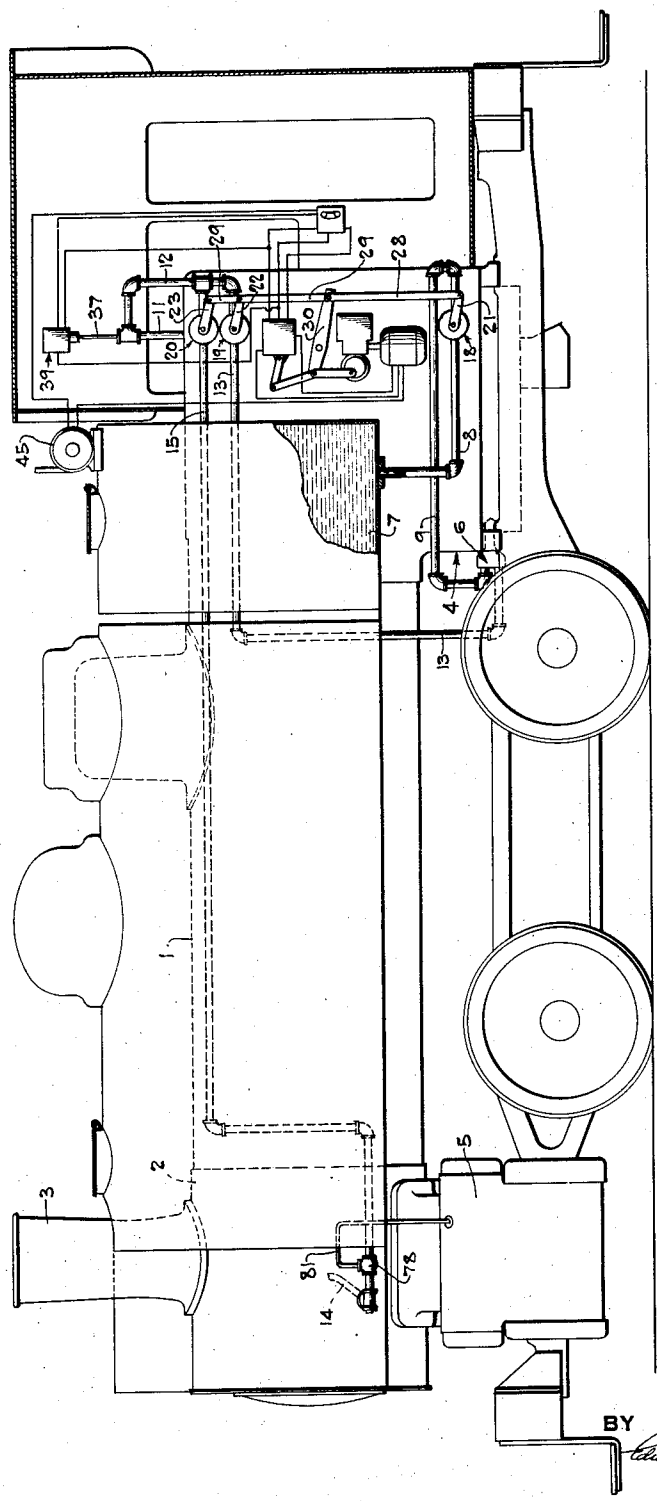


Fig. 1

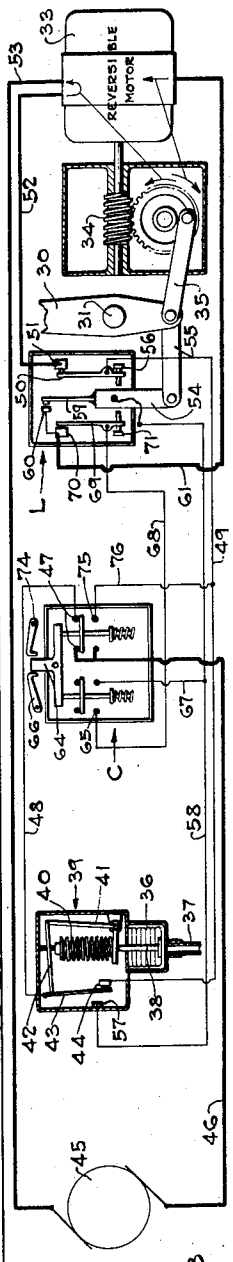


Fig. 3

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Fig. 4.

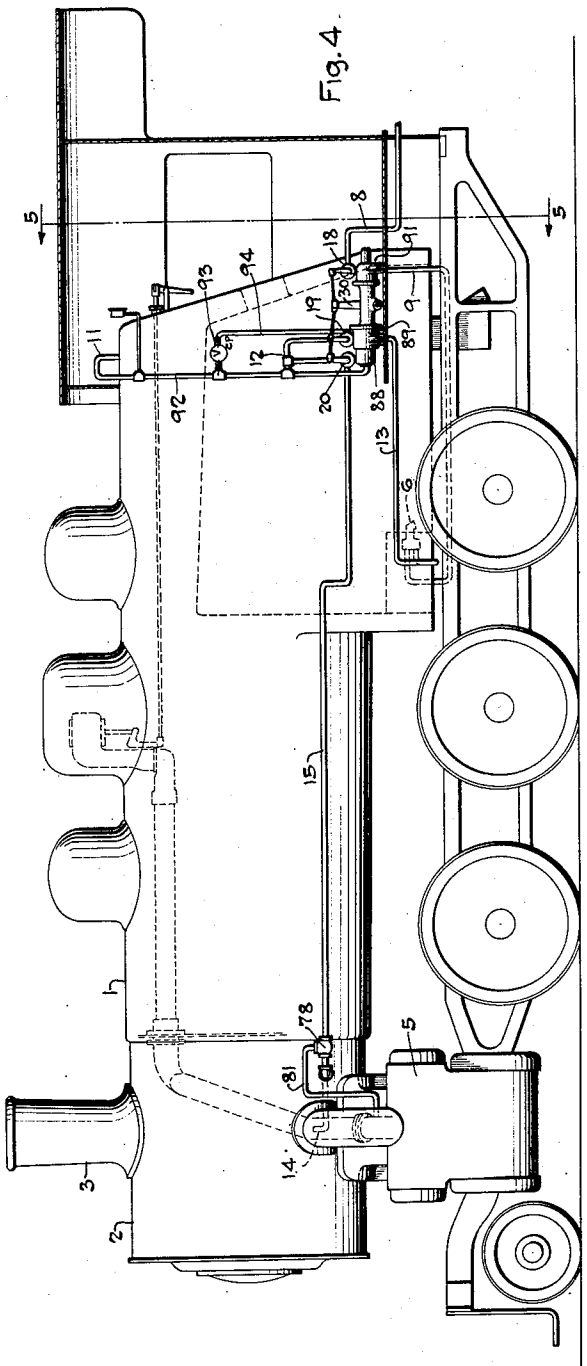


Fig. 5

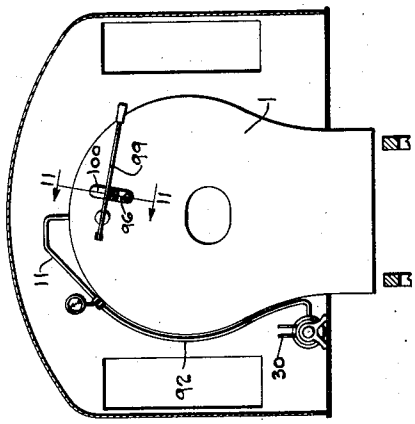


Fig. 11

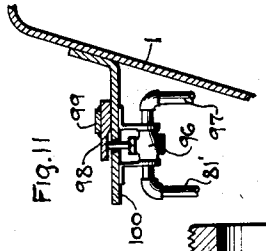
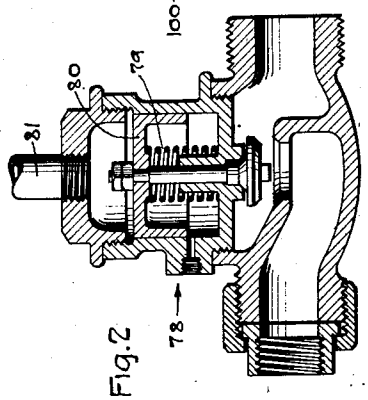


Fig. 2



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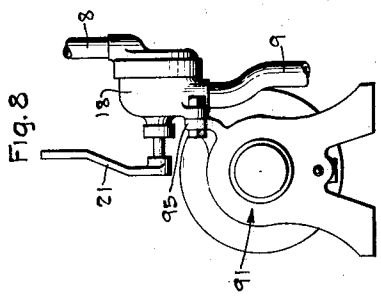


Fig. 8

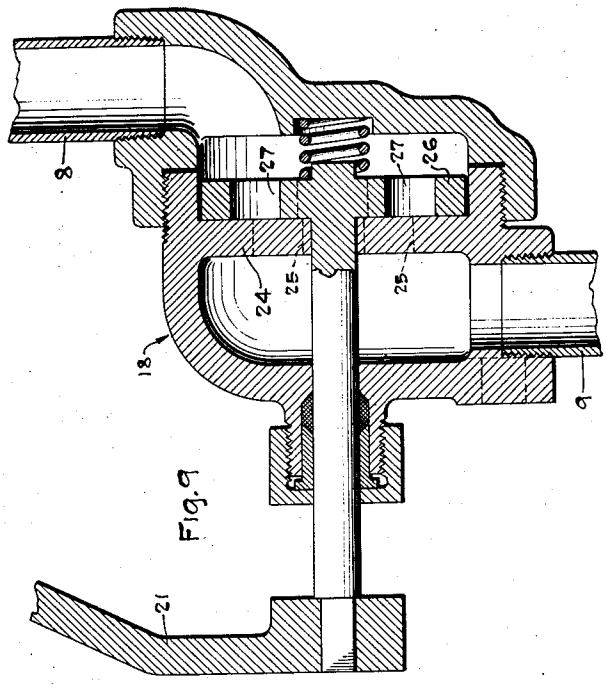


Fig. 9

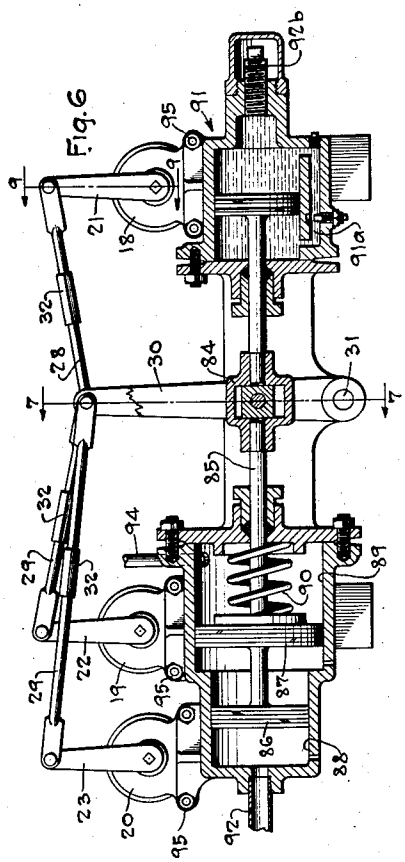


Fig. 6

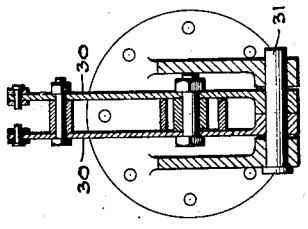


Fig. 7

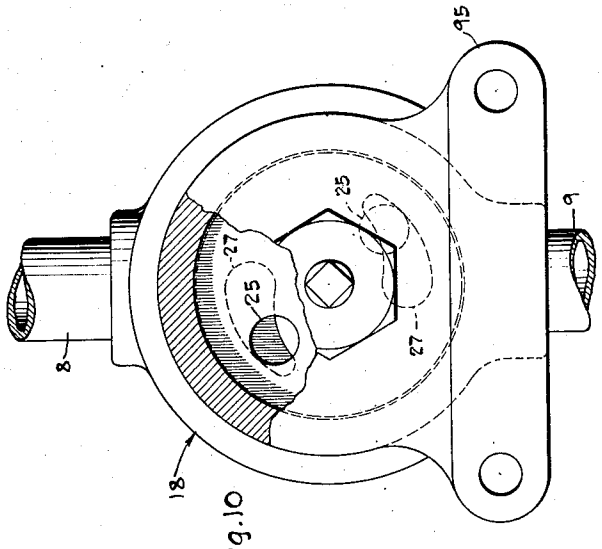


Fig. 10

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UNITED STATES PATENT OFFICE

2,226,219

STEAM LOCOMOTIVE

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Application November 2, 1936, Serial No. 108,859

11 Claims. (Cl. 236—26)

This invention relates generally to oil fired steam locomotives and more particularly to improved apparatus for automatically controlling the oil flame in accordance with operating conditions of the locomotive.

The invention disclosed herein is particularly adapted to locomotives for switching service which requires highly variable operation both in the amount of load to be moved and in the frequency of operation. A switching locomotive may stand by idly for an appreciable period of time and then suddenly be called upon to move a maximum load or it may move only a minimum load of one or two cars. Various types of locomotives have been employed for such switching service, but those of the steam engine type have necessarily employed a fireman and engineer, thereby increasing the cost of operation.

It is one of the objects to provide an improved apparatus and system for controlling and interrelating various fuel consumption factors in such a manner with respect to the actual operation of the locomotive that it is economical in operation and maintenance and is thoroughly reliable at all times to generate a completely adequate steam supply at any moment of a highly variable load demand while at the same time avoiding wastage of steam or fuel when the locomotive is standing by or is operating at a low load.

Another object is to provide an improved apparatus and control system so coordinated with the operation of the locomotive that a smokebox draft is maintained at all times with minimum fuel and steam consumption.

A still further object is to provide improved control apparatus that is relatively simple in construction, maintenance and operation, which is relatively free from possibility of trouble and which will require minimum space and attention.

Other objects and advantages will be more apparent to those skilled in the art from the following description of the accompanying drawings in which:

Fig. 1 is a side elevation of one form of locomotive among possible others in which my improved apparatus and control system are embodied;

Fig. 2 is an enlarged sectional view of the blower pipe control valve;

Fig. 3 is a wiring diagram of the control system;

Fig. 4 is a side elevation of a locomotive such as disclosed in Fig. 1 but employing a mechanically controlled system instead of the electrical control shown in the preferred form;

Fig. 5 is a view taken substantially on the line 5—5 of Fig. 4 but with many parts omitted for sake of clarity, this view showing the manner in which steam is taken from the boiler to operate a servo-motor of the control system shown in the Fig. 4 modification;

Fig. 6 is an enlarged sectional view of the servo-motor and pressure responsive apparatus embodied in the Fig. 4 modification;

Fig. 7 is a sectional view taken substantially on the line 7—7 of Fig. 6;

Fig. 8 is an end view of the right end of Fig. 6;

Fig. 9 is a vertical sectional view of a suitable type of valve such as is employed in both modifications, the view being taken substantially on the line 9—9 of Fig. 6;

Fig. 10 is a side view of Fig. 9 looked at from the left side thereof with the valve lever omitted and a portion of the valve casing broken away to show details of construction.

Fig. 11 is an enlarged longitudinal section taken substantially on the line 11—11 of Fig. 5.

In the particular embodiments of the invention which are shown herein merely for the purpose of illustrating certain specific forms among possible others that the invention might take in practice, we have disclosed the invention in connection with a conventional type locomotive diagrammatically indicated as having a boiler 1, a smokebox 2 with its usual smokestack 3 and a firebox indicated at 4. Inasmuch as the above elements as well as the engine cylinder 5, valve mechanism and linkages and all other usual locomotive elements are well-known in the art, it will not be necessary to describe or refer to the same.

Any suitable and usual type of oil burner generally indicated at 6 may be used in connection with the firebox 4, fuel oil being supplied to the burner from any suitable tank 7 through pipes 8 and 9. Inasmuch as the burner construction per se does not form part of my present invention and also because burner constructions are well known in the art, it will suffice to point out that the usual atomizing steam is supplied to the burner 6 from the boiler 1 through pipes 11, 12 and 13.

To provide proper draft particularly when the locomotive is standing still, there is provided in the smokebox a blower pipe 14 adapted to discharge upwardly into the smokestack 3 to induce a draft, all of which is well known in the art. The steam is supplied to the blower pipe from

pipe 12 thence through pipe 15. This usual form of blower pipe as embodied in my improved automatic system is coordinated in a very effective manner with the automatic control apparatus to be presently described whereby maximum cooperation is obtained at all times to produce efficient generation of the steam and minimum wastage thereof.

To control and coordinate the blower valve and the supply of fuel to the burner and the atomizing steam therefor, I have provided the fuel pipe 8, atomizing steam pipe 13 and blower pipe 15 with valves 18, 19 and 20, Fig. 1. These valves may be of any usual or suitable type having operating arms 21, 22 and 23, but for purposes of simplicity and convenience of control there may be employed a so-called disc type of valve such as shown in Figs. 9 and 10 wherein a partition 24 has a pair of circular ports 25 while a disc 26 yieldably held against the surface of partition 24 is provided with accurately tapered passages 27, Fig. 10, whereby various angular positions of the valve disc will effect varying degrees of flow passage through the ports 25.

All of the valve handles 21, 22 and 23 are commonly connected together by a series of links 28 and 29 pivotally connected to a master valve operating lever 30 pivoted at 31. The valves 18, 19 and 20 and the connecting links therefor as just described are so arranged that for any given position of master lever 30 all of the valves are relatively opened or closed to the extent desired or necessary for proper combustion and control. The relative positions of the valve may be varied by lengthening or shortening the links between the respective valves as by substituting links of different length or by the use of turn buckles such as is diagrammatically indicated at 32 in the modification of Fig. 6. Inasmuch as such adjusting devices or their equivalents are well known, it is not deemed necessary to disclose the details of such in connection with the Fig. 1 form.

To control the operation of the control valves 18, 19 and 20, I preferably employ a reversible electric motor 33 operating a worm and worm gear 34, a link 35 being pivotally connected thereto and to master lever 30. In the position of worm wheel 34 as shown in Fig. 3, the control valves are approximately half open to give what may be termed the "normal flame" position, whereas upon counterclockwise rotation of worm wheel 34 through one quarter turn from its present position in Fig. 3 the valves will be only slightly open to give a "low flame" position. For a quarter turn of the worm wheel in a clockwise rotation from the position shown in Fig. 3, the control valves will be fully open to give a "high flame" position. To control operation of motor 33 in accordance with the demand for steam, I employ any suitable type of fluid pressure responsive means such as a diaphragm or Sylphon bellows diagrammatically indicated at 36 which is connected by a pipe 37 to pipe 11 and thence to the boiler whereby variations in boiler pressure will cause a stem 38, Fig. 3, to operate a pressure responsive control mechanism generally indicated at 39 and specifically shown in the preferred form of the invention as a switch mechanism.

Operation.—Assuming that the control valves are in their normal flame position so that steam pressure is being built up, then when full pressure is reached it will cause diaphragm 36 to move stem 38 upwardly against the action of an adjustable compression spring 40, the stem 38 and spring 40 acting on opposite sides of one arm of a bellcrank lever 41 which is suitably pivoted in the frame of control box 39. Clockwise rotation of said bellcrank 41 causes its link 42 to pull a switch arm 43 to the right and engage a contact 44. Upon closure of said contact, current flows from any suitable electrical source as a turbo-generator 45 through a wire 46, across closed contacts 47 to wire 48, contact 44, a wire 49, through a pivotal switch arm 50 and contact 51 to wire 52 and thence through the motor and back to generator 45 through a common terminal 53. The motor thus rotates worm wheel 34 in a counterclockwise direction to swing master lever 30 and accordingly move control valves 18, 19 and 20 to their low flame position. Simultaneously a pivoted arm 54 is moved to the right by a link 55 connected to master lever 30. Said link and arm are of such dimensions that when worm gear 34 has rotated one quarter turn, contact 51 is broken due to engagement of arm 54 with an adjustable screw 56 carried by the lower end of pivotal contact arm 50. Upon opening of contact 51, motor 33 will stop, thereby maintaining the burner in its low flame position.

If the boiler pressure should now drop several pounds or below some predetermined value, diaphragm 36 and spring 40 will cause bellcrank 41 to move switch arm 44 and thereby close contact 57, whereupon current from generator 45 is again supplied through wires 46 and 48 to contact 57 and thence through wire 58, arm 54, and a flexible switch arm 59 and contact 60 (which has been previously closed upon counterclockwise rotation of worm gear 34) and thence through wire 61 to motor 33 and back through the common wire 53 to generator 45. It will be understood that arm 59 has sufficient flexibility that its contact may close while still permitting movement of arm 54 to operate switch arm 50 as previously described in the first step of the operation. The motor thus rotates in the reverse direction to move worm gear 34 in a clockwise direction and thus restore master arm 30 to its normal position (vertical in Fig. 3 diagram). Thereupon contact 60 is opened to break the motor circuit which leaves the control valves in their normal flame position. This particular setting of the valves and control apparatus will remain fixed so long as the locomotive demands only the amount of steam generated under such normal flame. If the locomotive should stop so that the steam pressure increases, then diaphragm 36 will cause the motor 33 to reset the control valves in their low flame position as previously described. After such low flame position is reached and should the steam pressure fall below a predetermined value, then diaphragm 36 will again respond to cause motor 33 to restore the control valves to their normal flame setting as just described. In the operation above described the control apparatus cycles between low and normal flame. Hence it is seen that the limit switch mechanism including contacts 51, 60 and 70, lever 54 and associated elements, generally indicated at L, broadly constitute an automatic limit control means for flame positions.

If the locomotive should be called upon to pull an excessive load above normal, the engineer will foresee this and thereupon effect a suitable adjustment so as to provide for a high flame whereby steam will be generated at a rate faster than normal. The apparatus will thereupon cycle between high and low flame. To accomplish this the engineer manually adjusts a flame cycle con-

trol means, generally indicated at C, as by moving a pivotal switch lever 64, Fig. 3, in a counterclockwise direction to close contacts 65 and may if desired either personally hold the switch in such position or latch the same by any suitable latch mechanism diagrammatically indicated at 66. In this position, current flows from generator 45 through wire 46, contacts 47, wires 48 and contacts 57 (assuming that the boiler pressure has dropped below normal so that contact 57 is closed) and thence through wires 58, 67, contact 65, wire 68, pivotal contact arm 69, contact 70, wire 61, motor 33, and wire 53 to the generator 45. Motor 33 thereupon rotates worm gear 34 in a clockwise direction until master lever 30 moves the control valves 18, 19 and 20 to their full open position. When this occurs, arm 54 has moved sufficiently in a clockwise direction to engage an adjustable screw 71 and thereby swing contact arm 69 to open contact 70. Upon opening of this contact, the motor 33 stops. Screw 71 is so adjusted that the motor stops when links 35 and 55 are in their maximum left hand position. The high flame will now generate steam at a rate faster than normal, thereby adequately taking care of the heavier load to be pulled by the locomotive. As soon as the steam supply again builds up to normal, diaphragm 36 and spring 40 will be compressed so as to throw switch arm 44 to the right and accordingly close contact 44 whereupon the control valves are returned to their low flame position by reason of closing a circuit from wire 48 through wire 49, contact 51, wire 52, motor 33 and wire 53 to the generator. This circuit causes reverse operation of the motor so that worm gear 34 rotates in a counterclockwise direction until arm 54 engages screw 56 to break contact 51. If the pressure again drops below normal, contact 57 is again closed by action of diaphragm 36 and spring 40 to thereby reestablish the high flame position of the valves. Hence it is seen that in this phase of operation the control valves cycle between high and low flame. By merely releasing latch 66 so that it returns to normal, then the control equipment will cycle between normal and low flame in the manner as heretofore described.

If it is intended to allow the locomotive to stand by for an appreciable period of time and thereby not necessitate that normal pressure be maintained, or if the locomotive is to be started up "cold" after being completely shut down, then in either case it is desirable to have the control apparatus held in only a low flame position without any possibility of automatic shifting to the normal or high flame position. This is accomplished by manually shifting switch 64 in a clockwise direction and holding the same by a latch 74. Thus contacts 75 are closed so that current is supplied through wire 46, contacts 75, wires 76, 49, contact 51, wire 52, motor 33 and wire 53 to the generator. Thus worm gear 34 will be rotated counterclockwise to its extreme right position until arm 54 engages screw 56 to open contact 51. Hence it is seen that regardless of the steam pressure at the time switch 64 is moved to this new position, a circuit is either established or made available for compelling operation of motor 33 so as to return the control valves to and maintain the same in their low flame position. To reestablish either of the two main operating cycles heretofore described, it is only necessary to disengage latch 74 to return switch 64 to its normal position or to shift the switch to its high flame position.

From the disclosure herein it is seen that control valve 20 will effect a variable supply of steam through pipe 15 to blower pipe 14 automatically in accordance with the intensity of the flame. However, when the locomotive is running, then a draft is created by the exhaust steam discharging from cylinder 5 into stack 3 in a manner well known in the art. To avoid superimposing the actions of the cylinder exhaust and blower pipe upon each other and thereby cause an unnecessary waste of steam and fuel, we have provided improved means for coordinating the operation of the automatic control equipment with the running of the locomotive whereby when the locomotive is running and accordingly using steam, the blower pipe will be inoperative but immediately when the engine cylinders are not using steam, then the blower pipe becomes operative and in addition this automatic control of the blower pipe is at all times subject to the position of the automatic control valve 20. Hence by this arrangement to be described, the varying flame positions and cycles of the control apparatus will affect the amount of steam supplied to the blower pipe and the discharge of such steam therefrom will be controlled automatically in accordance with running of the locomotive. Hence at all times the operation of the blower pipe and of the steam supply therefor is subject to a nicety of control while at the same time a sufficiently complete draft is always insured. This is accomplished by providing a valve 78 in blower supply pipe 15, Fig. 1, the valve being normally yieldably urged to an open position by a spring 79, Fig. 2, while a pressure responsive piston 80 is adapted to be moved downwardly by steam supplied through a pipe 81 from the engine cylinder 5. Thus when steam is supplied from the boiler to the engine cylinder 5 in a manner well known in the art, this engine cylinder steam will flow through pipe 81 to move piston 80 downwardly and close the valve 78. The exhaust steam from the engine cylinders will discharge into stack 3 and thus create the necesasry draft for the burner flame. If the steam supplied to the engine cylinders is shut off, then valve 78 will immediately open and steam will be supplied from the boiler through pipe 15 to the blower pipe 14 which discharges into stack 3 to maintain a draft for the burner flame.

From the description of the preferred embodiment of the invention as heretofore described, it is seen that we have provided an extremely effective and highly coordinated control system for insuring maximum efficiency with minimum attention, it being understood, however, that instead of actuating the blower pipe valve 78 in accordance with the supply of steam in the steam chest 5 that this broad principle of operation may be mechanically effected by providing as shown in Figs. 4, 5 and 11 a valve 96 for controlling flow of operating fluid through a pipe 97 connected to any suitable fluid source such as steam or air and thence through a pipe 81' connected to valve 78 in place of pipe 81. When valve 96 is open, fluid pressure will cause piston 80 to close valve 78, whereas upon closing of valve 96 fluid pressure acting on top of piston 80 will leak past the same and permit spring 79 to open the valve, whereupon boiler steam is supplied to the blower pipe 14 in a manner as previously described. To control valve 96 in accordance with operation of the locomotive, I have provided a cam 98, Fig. 11, welded or otherwise suitably secured to a suitable hand throttle lever 99 which

is supported upon a usual bracket 100. As the throttle lever 99 is initially pulled out (toward the left, Fig. 11) to start operation of the locomotive, cam 98 will open valve 96 due to the valve stem engaging said cam. This will cause blower valve 78 to close, whereupon exhaust steam from the engine will create a draft as above explained. It will be noted that the surface of cam 98 is somewhat elongated so that a limited amount of movement of throttle lever 99 can take place before valve 96 is opened. This will insure that all lost motion in the linkage connections can be taken up and steam actually supplied to the engine cylinders before valve 96 is opened. Hence a draft will be maintained at all times while the burner is in operation without any thought or attention on the part of the engine man. Conversely when the throttle lever 99 is moved to its closed position, cam 98 will permit valve 96 to close as the throttle lever nears its final closed position, thereby opening blower valve 78 to maintain a draft.

In the modification shown in Figs. 6 to 10, the master lever 30 is operated by a cylinder and piston type servo-motor. Lever 30 is connected by a crosshead connection 84 to a piston rod 85 which carries differential pistons 86 and 87 in cylinders 88 and 89. A spring 90 normally urges the pistons toward the high flame position while a hydraulic dashpot generally indicated at 91 is operatively connected to the servo-motor pistons to insure smooth operation. This dashpot is provided with a suitable adjustable bypass 91*a* and an adjustable screw plug 92*b* adapted to be screwed inwardly upon occurrence of leakage from the cylinder thereby insuring that the cylinder will always be completely filled with oil.

Steam from the boiler is supplied through a pipe 92 to cylinder 88 while constant pressure steam is supplied to cylinder 89 from pipe 92 through any suitable and well known form of constant pressure outlet valve 93 in pipe 94. For purposes of simplicity the control valves and all other remaining elements are given the identical reference numbers as the corresponding parts of the preferred form. It will be noted, however, that the control valves in Fig. 6 are arranged in a very compact and simple manner with respect to the servo-motor and hydraulic dashpot by being mounted directly thereon through suitably bolted ears and lugs 95.

In operation of the modified form of the invention, it is seen that the constant pressure in cylinder 89 plus the force of spring 90 will move the servo-motor toward the left (high flame position) as the boiler pressure in the small cylinder 88 decreases until finally the burner is operating under a full flame. As the boiler pressure approaches normal, the force acting on piston 86 will move the same toward the right (low flame position) against the constant force exerted by the combined action of the spring 90 and the constant steam pressure in cylinder 89 until finally the burner is operating under a low flame. Hence it is seen that a very satisfactory and uniform burner control is effected through the full range of the apparatus, the "full flame" position being taken care of automatically without the necessity of the engineer operating any mechanism such as switch 66 in the preferred form. Combined with this control is the blower valve arrangement as previously described in the preferred form, it being noted that this blower valve has the same coordinated operation with the operation of the burner as in the preferred form.

Hence it is seen from the disclosure of the two modifications herein that a locomotive, especially of the switcher type, may be effectively operated by one man while at the same time insuring a full supply of steam with maximum efficiency in fuel consumption and steam generation whether the locomotive is standing still or running.

We claim:

1. The combination in an oil fired steam locomotive having engine cylinders and a boiler and smokestack, an oil burner and a blower pipe discharging into the stack to create a draft for the fire, comprising passages and control valves therefor for supplying oil fuel and fuel atomizing steam to the burner, a valve controlled passage discharging steam into said blower pipe whenever steam is not supplied to said engine cylinders from said boiler, means operatively interconnecting all of said valves, power means adapted at all times to actuate said burner and blower control valves to effect varying flame positions and draft control therefor, and means whereby said power means is controlled automatically in accordance with the boiler pressure.

2. The combination in an oil fired steam locomotive having engine cylinders and a boiler and smokestack, an oil burner and a blower pipe discharging into the stack to create a draft for the fire, comprising passages and control valves therefor for supplying oil fuel and fuel atomizing steam to the burner, a valve controlled passage discharging steam into said blower pipe whenever steam is not supplied to said engine cylinders from said boiler, means operatively interconnecting all of said valves, power means adapted at all times to actuate said burner and blower control valves to effect varying flame positions and draft control therefor, and means including a pressure responsive switch mechanism for effecting varying positions of said power means automatically in accordance with boiler pressure.

3. The combination in an oil fired steam locomotive having a boiler and smokestack, an oil burner and a blower pipe discharging into the stack to create a draft for the fire, comprising passages and control valves therefor for supplying oil fuel and fuel atomizing steam to the burner, a valve controlled passage for supplying steam to said blower pipe, power means for actuating said burner and blower control valves to effect varying flame positions and draft control therefor, means automatically responsive to boiler pressure for variably controlling said power means to effect different flame positions thereof in accordance with a predetermined cycle of positions, and means for effecting a different cycle of flame positions while maintaining the cycle automatically operative in accordance with boiler pressure.

4. The combination in an oil fired steam locomotive having a boiler and smokestack, an oil burner and a blower pipe discharging into the stack to create a draft for the fire, comprising passages and control valves therefor for supplying oil fuel and fuel atomizing steam to the burner, a valve controlled passage for supplying steam to said blower pipe, power means for actuating said burner and blower control valves to effect varying flame positions and draft control therefor, means automatically responsive to boiler pressure for variably controlling said power means to effect a cycle of flame positions between low and normal flame, and means for changing the flame cycle so that it operates automatically between low and high flame positions.

5. The combination in an oil fired steam locomotive having a boiler and smokestack, an oil burner and a blower pipe discharging into the stack to create a draft for the fire, comprising passages and control valves therefor for supplying oil fuel and fuel atomizing steam to the burner, a valve controlled passage for supplying steam to said blower pipe, power means for actuating said burner and blower control valves to effect varying flame positions and draft control therefor, means automatically responsive to boiler pressure for variably controlling said power means to effect a cycle of flame positions between low and normal flame, and means for restraining said flame cycle so as to maintain the low flame position of the control valves regardless of boiler pressure.

6. The combination set forth in claim 1 further characterized in that said power means comprises a fluid operated servo-motor, and the means for controlling the same in accordance with boiler pressure includes means for effecting a variable differential fluid pressure force to operate said servo-motor.

7. The combination set forth in claim 1 further characterized in that said power means comprises a fluid operated servo-motor, and the means for controlling the same in accordance with boiler pressure includes means for effecting a variable differential fluid pressure force to operate said servo-motor, and a hydraulic dashpot for controlling movement of said servo-motor.

8. The combination set forth in claim 1 further characterized in that said power means comprises a fluid operated servo-motor, and the means for controlling the same in accordance with boiler pressure includes means for effecting a variable differential fluid pressure force to operate said servo-motor, and a hydraulic dashpot for controlling movement of said servo-motor including a follow-up device for maintaining the dashpot completely filled with liquid at all times.

9. The combination set forth in claim 1 further characterized in that said power means comprises a fluid operated servo-motor, and the means for controlling the same in accordance with boiler pressure includes means for effecting a variable differential fluid pressure force to operate said servo-motor, and means for supporting said control valves directly on said servo-motor.

10. The combination set forth in claim 1 further characterized in that said power means comprises a double acting differential piston and cylinder type servo-motor, and the means for controlling said power means includes means for supplying boiler steam under variable pressure to the smaller one of said differential pistons and for supplying a substantially constant pressure to the larger one of said pistons.

11. The combination set forth in claim 1 further characterized in that said power means comprises a double acting differential piston and cylinder type servo-motor, and the means for controlling said power means includes means for supplying boiler steam to the smaller one of said differential pistons and for supplying a substantially constant pressure to the larger one of said pistons, a spring for urging said differential piston against the boiler pressure which acts on the smaller area of said differential piston whereby the combined force of the spring and the pressure acting on the larger area of the differential piston is adapted to balance a variable boiler pressure acting on said smaller differential piston area thereby causing the piston and flame control valves to be adjusted in accordance with varying boiler pressure.

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