Feb. 5, 1952 J. S. SKELLY 2,584,235

AUTOMATIC CONTROL MEANS FOR STOKERS

Filed April 30, 1948 4 Sheets-Sheet 1

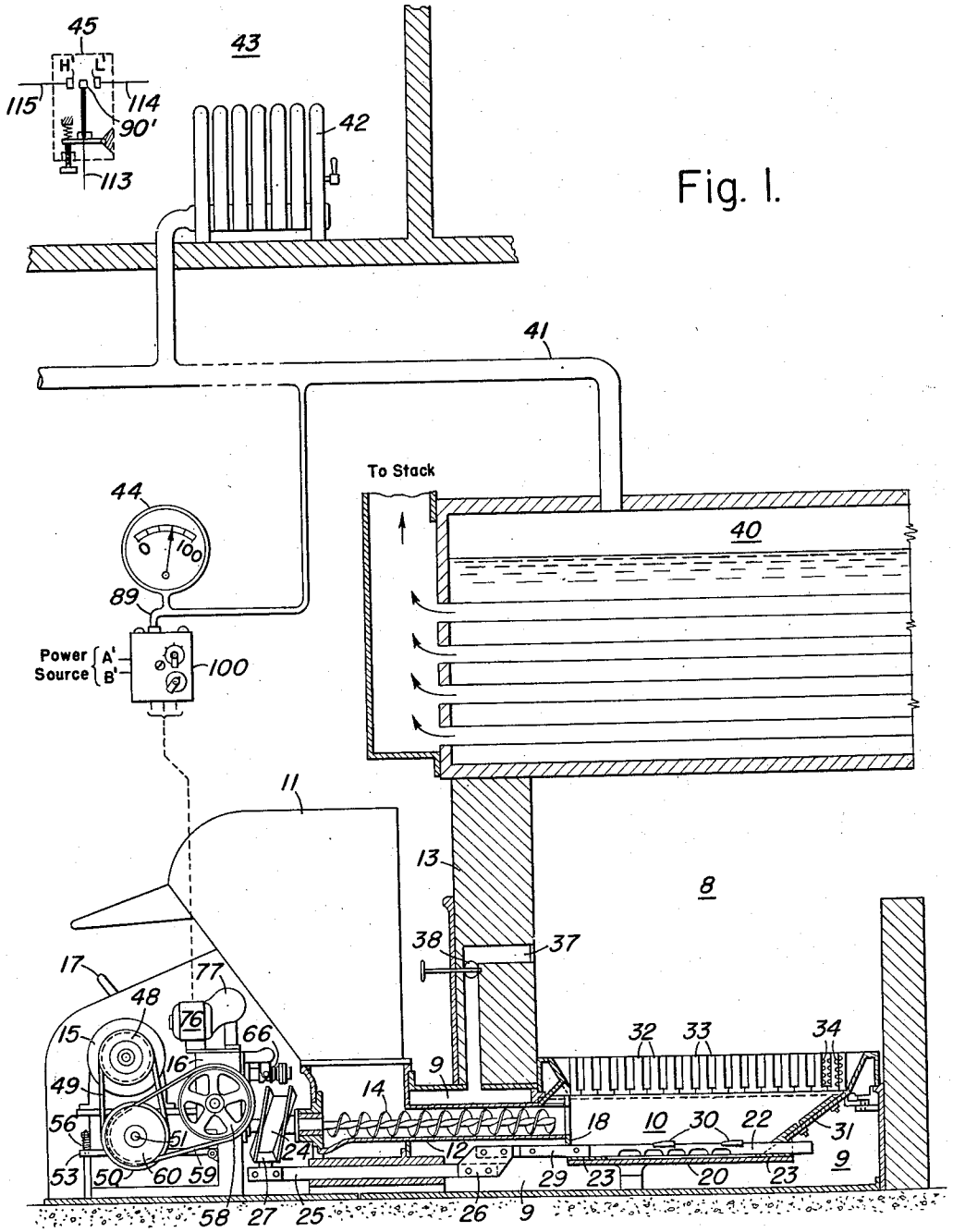


Fig. 1.

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AUTOMATIC CONTROL MEANS FOR STOKERS

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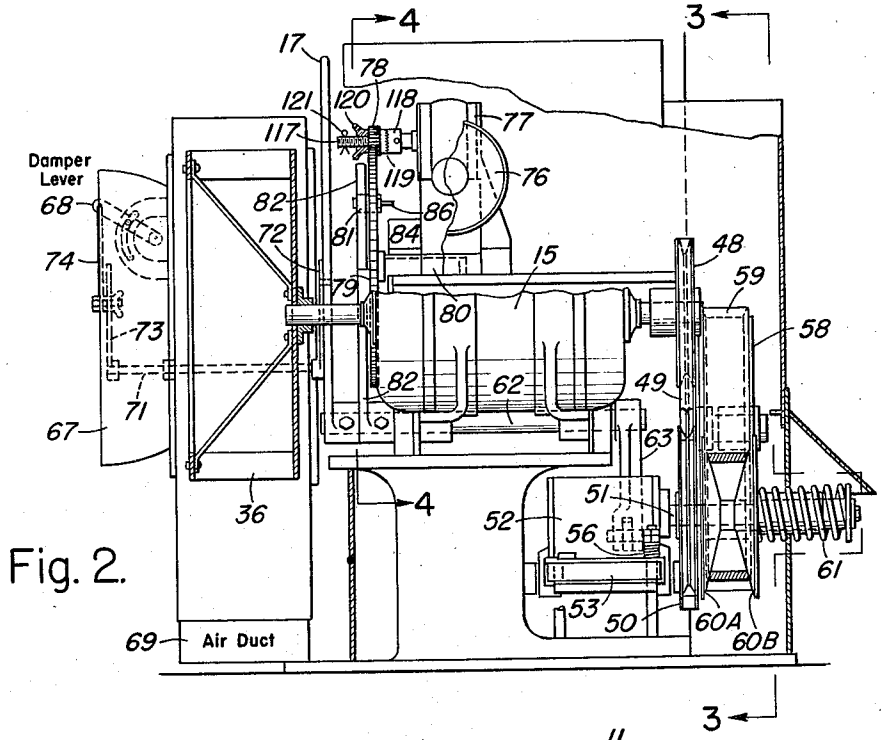


Fig. 2.

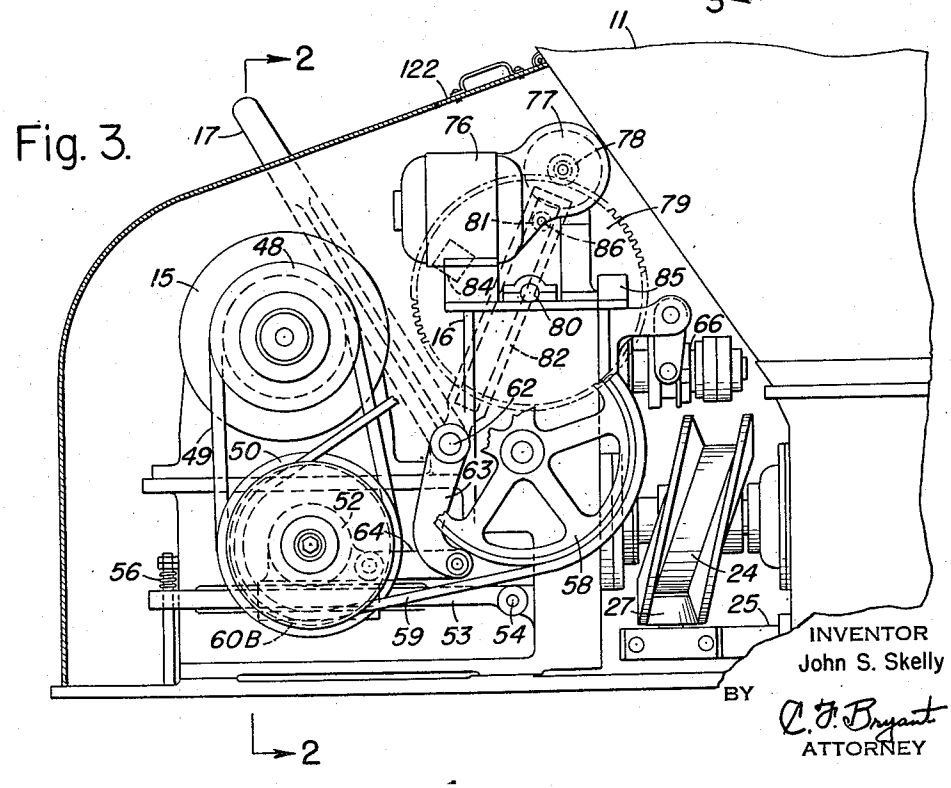


Fig. 3.

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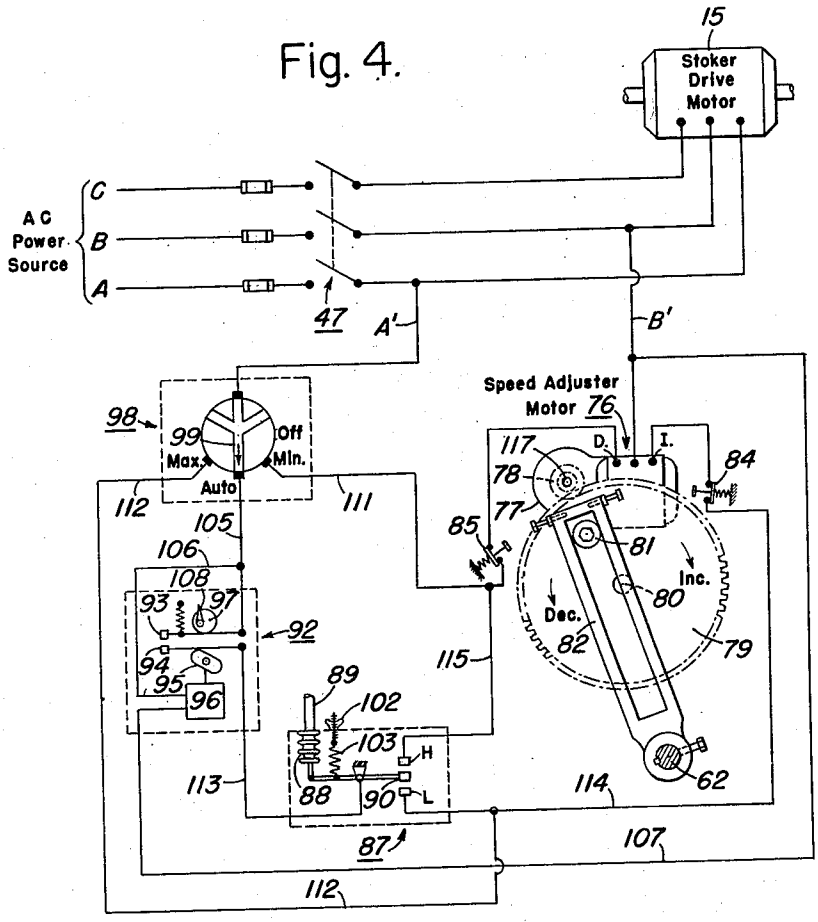
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Feb. 5, 1952 J. S. SKELLY 2,584,235

AUTOMATIC CONTROL MEANS FOR STOKERS

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Fig. 4.



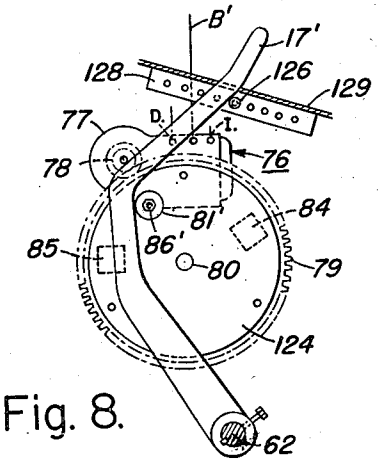


Fig. 8.

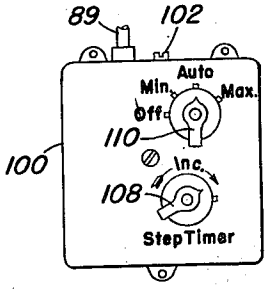


Fig. 5.

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AUTOMATIC CONTROL MEANS FOR STOKERS

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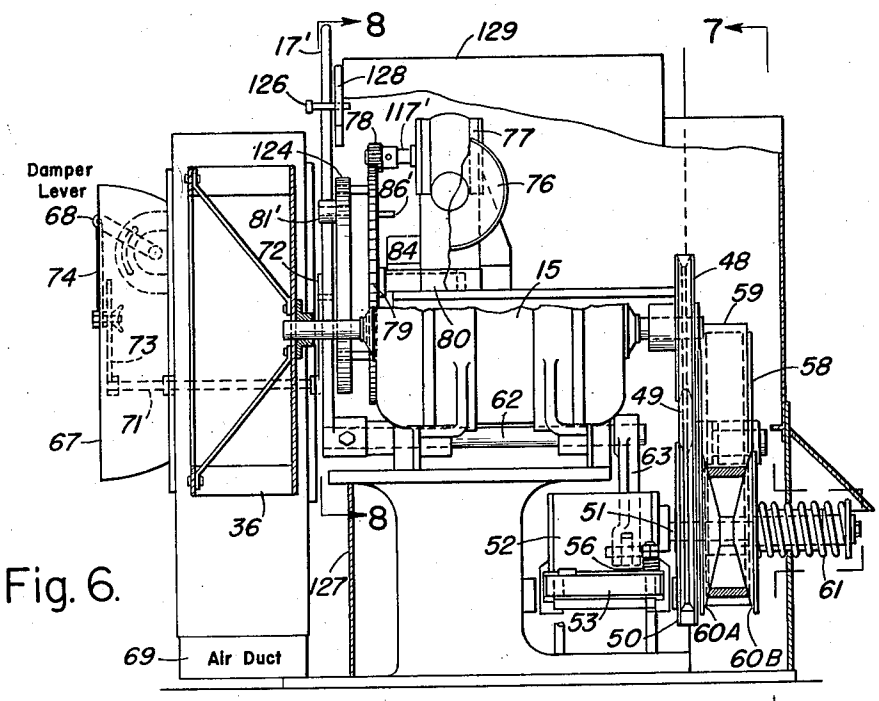


Fig. 6.

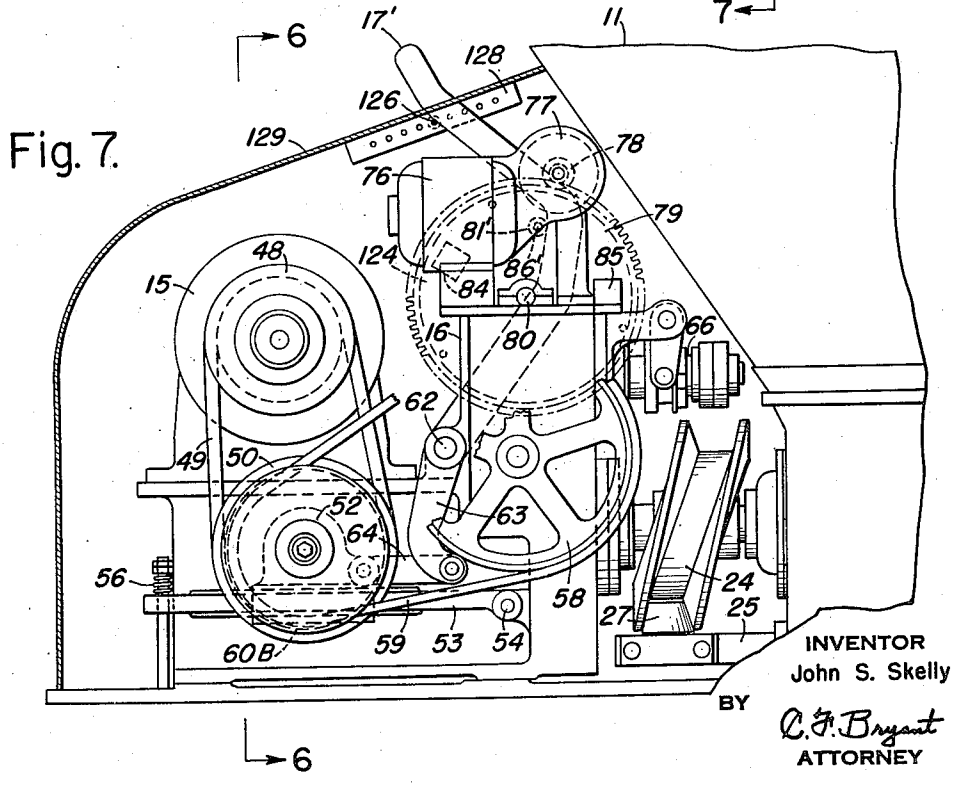


Fig. 7.

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Patented Feb. 5, 1952 2,584,235

UNITED STATES PATENT OFFICE

2,584,235

AUTOMATIC CONTROL MEANS FOR STOKERS

John S. Skelly, Monongahela, Pa., assignor to Combustion Engineering—Superheater, Inc., a corporation of Delaware

Application April 30, 1948, Serial No. 24,139

6 Claims. (Cl. 236—46)

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My invention relates to the control of stokers which feed and burn coal or other fuel in furnaces utilized by steam generating boilers and/or other heating systems.

Broadly stated the object of my invention is to provide means for automatically controlling the operating rate of such stokers including underfeed stokers equipped with an open-top retort having a screw-type fuel feeder and a reciprocating fuel pusher bar organized in the general manner disclosed by my U. S. Patent 2,049,688 of August 4, 1936, for "Fuel Burning Device."

A more specific object is to provide improved means responsive to stoker-supplied heat demand for effecting an automatic control of stokers such as are referred to above when same are equipped with variable-speed-drive mechanisms organized as disclosed by my U. S. Patent 2,070,756 of February 16, 1937, entitled "Variable Speed Drive for Mechanical Stokers."

Another object is to overcome certain deficiencies in prior systems of automatic stoker control such as that disclosed by my U. S. Patent 2,199,012 of April 30, 1940, entitled "Automatic Control Means for Stokers."

A further object is to effect the foregoing automatic control of stoker operating rate in such an improved way as to avoid wastage of fuel, minimize smoke and increase fuel burning efficiency.

A still further object is to accomplish the desired control through the medium of apparatus which is low in cost, simple and compact in construction and reliable and trouble-free in operation.

Other objects and advantages of my invention will become apparent from the following description of illustrative embodiments thereof when read in conjunction with the accompanying drawings wherein:

Figure 1 is a view in longitudinal vertical section of a stoker equipped with my improved automatic control and serving to fire a boiler which generates steam for heating and/or other purposes;

Figure 2 is a front elevational view (enlarged and looking from the left in Figure 1) of the stoker's operating and speed adjusting mechanism, some parts being shown in section on line 2—2 of Figure 3 to illustrate construction details;

Figure 3 is a side view, taken on line 3—3 of Figure 2, of the stoker driving mechanism showing my improved speed-selecting facilities applied thereto;

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Figure 4 is a diagram showing the electrical connections between the control instrument (pressure-responsive here) and the speed-adjusting motor (on the stoker) governed thereby pursuant to this invention;

Figure 5 is a front view of an instrument case in which the main control, step-timer and selector devices utilized by my invention may conveniently be housed;

Figures 6 and 7 are front and side views which correspond to Figs. 2 and 3 and which disclose another organization for the stoker's speed-selector actuating parts; and

Figure 8 is a diagrammatic showing of how the rearranged parts appear when viewed from line 8—8 of Fig. 6.

The drawings hereof show my automatic control improvements applied to an underfeed stoker whose organization is broadly similar to that disclosed and claimed by my earlier Patent 2,049,668 (of 1936) above identified. This showing is merely illustrative and is not to be considered as restrictive; as the description proceeds it will become evident that my automatc control improvements also are useful with adjustable-speed stokers of other designs.

The illustrative stoker to be benefited

In the stoker construction illustrated, a wind box 9 organized as in my earlier Patent 2,049,668 of 1936 supports the stoker's open-top retort 10 within the combustion chamber of a furnace 8. Coal or other fuel (not shown) is supplied to the retort from hopper 11 outside the furnace by way of conveyor tube 12 extending through the furnace front wall 13. Fuel conveyor screw 14 within the tube is rotated by motor 15 (or other power means) through reduction gearing 16, the screw speed (relatively slow as several R. P. M.) being selected by lever 17 to provide the desired rate of fuel supply. Entry of conveyor tube 12 into the retort's end wall 18 is somewhat above the retort bottom as shown.

Extending lengthwise of the retort 10 just above bottom wall 20 is the stoker's fuel feeder bar 22 which passes through front end wall 18 below conveyor tube 12. As here shown, this feeder bar 22 rests on end bearing plates 23 and has the "non-packing" cross section taught by my U. S. Patent 2,433,713 of December 30, 1947, for "Stoker Pusher Bar"; reciprocating motion is imparted thereto by wobble cam 24 through driving bar 25 (which carries roller 27) and connecting plates 26; the bar-driving wobble cam 24 is mounted in front of stoker hopper 11 outside the furnace where it is rotated with con-

veyor screw 14 by motor 15 at the speed (again relatively slow) selected by lever 17; and each full rotation of the cam produces a complete cycle of advance and return bar travel.

In the stoker construction shown the named feeder bar 22 has main pusher members 29 attached to its two sides (only one visible in Figure 1) as taught by my copending application Serial No. 710,260 filed November 16, 1946, for "Stoker Fuel Pusher Means," now Patent No. 2,549,252. Through the medium of these main pusher members 29 (aided in proper cases by auxiliary pushers 30 closer to the center of the main body of retort fuel) feeder bar 22, when reciprocated as aforesaid, progressively advances fuel delivered into the retort by conveyor 14 away from the retort's front end wall and into the main body of retort fuel (not here shown) toward inclining rear wall 31. Such advancement displaces other fuel in that body upwardly toward the burning fuel bed at the retort's open-top and outwardly upon grate bars 32—33 at the retort's top sides.

Air for supporting fuel combustion passes upwardly from wind box 9 and through small passages 34 between fire bars 32—33. Such air may be maintained under pressure in the wind box by a forced draft fan 36 (see Figure 2) driven by motor 15 as taught by my earlier Patent 2,049,668 of 1936. In proper cases a small portion of this wind box air may be admitted over the bed of burning fuel through overfire passage 37 here shown as including an adjusting damper 38.

All fire bars in the side rows 32—33 may be stationary, or certain bars in each row may be arranged to reciprocate toward and from the retort 10 as taught by my U. S. Patent 2,136,807 of November 15, 1938, for "Side Retort Stoker" and as further disclosed by my Patent 2, 142,701 of January 3, 1939 for "Underfeed Stoker." A dumping grate (not shown) also may be provided at the outer edge of each of these fire bar rows.

Stoker installation represented

Underfeed stokers organized as here disclosed in accordance with my earlier Patent 2,049,668 of 1936 (application therefor filed in 1932) have enjoyed high commercial success in such uses as firing the boilers of heating and power systems for schools, churches, apartment houses, garages and the like as well as in other applications including laundries, factories and other industrial establishments; this form of stoker uniquely combining the advantages of the screw feed stoker and of the sliding bottom, pressure and plunger type of stoker without being subject to the disadvantages inherent in those other stoker types.

In the illustrative application of Figure 1 the described stoker is shown as being mounted underneath a boiler 40 arranged to generate steam supplied through outlet 41 to one or more utilizers typified by radiator 42 employed to heat a room or other enclosure 43. The steam pressure in supply line 41 is indicated by a conventional gauge 44, while the temperature of room 43 (heated by radiator 42) is responded to by a thermostat 45.

The purpose of my invention is to provide improved means responsive to changes in the reading of pressure gauge 44 or to the indication by thermostat 45 (or to some other measure of the demand for stoker-supplied heat) for automatically adjusting the stoker's speed-setting lever 17 in a way which maintains the boiler-steam pressure or the heated-room temperature (or other selected measure of the heat output by the controlled stoker) substantially constant.

The stoker's drive and speed change mechanism

The here represented variable-speed stoker drive is broadly similar to that disclosed and claimed by my earlier Patent 2,070,756 of 1937 previously identified. Stoker drive motor 15, stationarily mounted as shown, is of a conventional type suitable for energization from an electrical power circuit of commercial voltage and frequency (such as 110 or 220 volts, 25 or 60 cycles) and represented at A—B—C in Figure 4. When so energized (as upon the closure of switch 47) the motor rotates at a substantially constant speed (of the order of 1700 to 1800 R. P. M.) sufficiently fast to operate forced-draft fan 36 (see Figure 2) efficiently.

A pulley 48 on the other end (right in Figure 2) of the motor shaft drives belt 49 running over an intermediate pulley 50 mounted on a jack shaft 51 that is journaled in a bearing support 52 (see Figures 2—3) which is slidable along a track 53 that is pivoted at 54. Gravity and a spring 56 urge the free end of the track downwardly thereby keeping belt 49 under proper tightness regardless of the position of slide support 52 along track 53. In this way pulley 50 rotates jack shaft 51 at a substantially constant speed fixedly related to that of motor 15.

Driving into reduction gearing 16 for the purpose of rotating feed screw 14 and wobble cam 24 (at the relatively slow speed earlier indicated) is a third pulley 58 over which there rides a second belt 59 having the flat cross section shown. This second belt is driven from a composite pulley that is carried by the jack shaft 51 (see Figure 2) and that includes left and right members 60A and 60B having opposed frusto-conical faces against which the edges of belt 59 bear. Member 60A is fixed to motor-driven pulley 50 on the jack shaft while member 60B also receives turning movement from that shaft 51 but is slideable lengthwise thereof, it being urged toward 60A by spring 61 (again see Figure 2).

Upon separation of members 60A and 60B, produced by a pulling of flat belt 59 closer to the center of pulley 60, the effective diameter of that composite pulley is reduced with the result that the gear box input wheel 58 is driven at a lower rate of speed; likewise, upon closer approach of members 60A and 60B one to the other, as accompanies a riding (aided by spring 61) of belt 59 farther from the pulley center, the effective diameter of pulley 60 is increased with the result that the gear box input wheel 58 then is driven at a higher rate of speed. To facilitate the separation of members 60A and 60B when the belt 59 is placed under added tension, the latter may satisfactorily be provided with bevelled edges giving it the wedge shape represented.

Belt 59 being of constant total length, the aforesaid effective diameter of composite pulley 60 is determined by the position of jack shaft support 52 along slide 53. Serving to establish that position is the earlier mentioned speed change lever 17 keyed as shown in Figure 2 to the left end of an adjuster shaft 62 whose right end carries an arm 63 as shown in Figures 2—3. A link 64 connects the lower end of arm 63 with the slidable jack shaft support 52. With this arrangement movement of lever 17 away from hopper 11 (to the left in Figures 1 and 3) increases the effective diameter of composite pulley 60 and hence raises the speed of gear box drive

wheel 58; while movement of lever 17 toward hopper 11 (to the right in Figures 1 and 3) decreases the effective diameter of pulley 60 and correspondingly lowers the speed of gear box drive pulley 68.

Conventional reduction gearing within box 16 steps down the speed of input pulley 58 (of the order of several hundred of R. P. M. and adjustable as aforesaid) to a relatively low value (of the order of only several R. P. M.) suitable for rotating the stoker's feed screw 14 and wobble cam 24. These so driven feeder parts accordingly operate: (a) at their minimum speed when lever 17 is in the position closest in hopper 11; (b) at a progressively increasing speed as lever 17 is moved back (to the left in Figures 1 and 3) away from hopper 11; and (c) at their maximum speed when lever 17 occupies the position most remote from the hopper.

The gear box here illustrated is further provided with a clutch 66 by means of which the drive connection from motor 15 to the stoker's fuel feeder members 14 and 24 may at proper times be broken (as upon actuation of a suitable hand lever not represented). Such declutching completely stops the stoker's fuel feed thereby allowing forced draft fan 36 to continue in operation, as is sometimes useful when it is desired to burn all the fuel in retort 10 and on grate bars 32—33 before adding new fuel thereto.

The complete stoker of Figures 1—2—3 still further includes for fan 36 an air intake fitting 67 (see Figure 2) provided with conventional damper means (not here represented) controlled by a lever 68 and otherwise organized as disclosed by my earlier Patent 2,199,012 of 1940 as previously identified. Upward movement of this lever opens the inlet and thereby allows constant-speed fan 36 to supply (by way of air duct 69) more air to the stoker's burning fuel bed; downward movement of this lever cuts down the area of inlet opening and correspondingly reduces the supply of air to the fuel bed.

Through suitable linkage means including shaft 71 (see Figure 2) and associated elements 72—73—74, the position of damper lever 68 is made to follow the position of fuel-feed speed selector lever 17 in such a way that each increase in fuel feed rate is accompanied by a corresponding increase in fan-air output, and vice versa; all as taught by my earlier Patent 2,199,012 just mentioned. In this way the represented stoker simultaneously adjusts both its fuel-feed rate and its air-supply rate in a way assuring most effective fuel combustion throughout the entire range of stoker operating speed.

Means for actuating speed selector lever 17

My invention as here disclosed provides improved means for automatically adjusting the position of speed-selector lever 17 in response to variations in a measure (as by pressure gauge 44 or by thermostat 45 of Figure 1) of the stoker-supplied heat, the adjustment proceeding in such manner that only so much fuel will be burned in the stoker-fired furnace 8 as is required to satisfy the demand for heat or power.

For imparting the required speed-adjusting movements to lever 17 my new control system utilizes a reversing motor 76 which through reduction gearing 77 drives a pinion 78 that meshes with a large gear wheel 79 mounted on idler shaft 80 and carrying a roller 81 engaged by the forked opening (see Figure 4) in a lever 82 attached at its lower end to the same speed-adjuster shaft 62 as supports the stoker's speed selector lever 17 earlier described.

Control motor 76, shown as mounted on top of the stoker's main-drive gear box 16, may satisfactorily be of fractional horse power capacity suitable for energization from the alternating current voltage (110 or 220 volts, 25 or 60 cycles) appearing between two of the conductors A—B—C of the main power circuit which supplies stoker driving motor 15 as indicated in Figure 4. There current for operating control motor 76 is fed through conductors A' and B'. Connection (as later described) of conductor A' with motor terminal I produces "forward" rotation, while connection of A' (again as later described) with terminal D causes motor 76 to rotate in the "reverse" direction.

The normally high speed (such as of the order of 1700–1800 R. P. M.) of the control motor 76 is by gearing 77 (which may include a worm or other equivalent drive) stepped down to the point where pinion 78 is driven at the relatively slow speed of only two or three R. P. M. In consequence gear wheel 79 meshed with that pinion is during motor operation moved at an even slower rotational speed, so that forked lever 82 engaged by gear-carried roller 81 (see Figure 4) requires a substantial time to move from the extreme left position of Figure 4 (corresponding to the minimum stoker-speed setting of selector shaft 62) to the extreme right position of Figure 4 (corresponding to the maximum speed setting of shaft 62).

In order to prevent motor 76 from moving forked lever 82 too far in either the speed-raising (right in Figure 4) or the speed-lowering (left in Figure 4) direction, use is made of normally-closed limit switches 84 and 85 respectively inserted in the "increase" and in the "decrease" supply leads to motor 76, as per the diagram of Figure 4. These limit switches are conventional and lend themselves to mounting in a number of well known ways; one of these is indicated in Figures 2 and 3 where the "box" representations 84—85 designate the two so numbered switches of Figure 4 and where the actuating means therefor take the form of a pin 86 protruding as shown from the bolt which secures roller 81 to the gear wheel 79. Still other arrangements may of course be employed to cause these limit switches 84—85 to selectively open when forked lever 82 approaches the extremes in its range of adjustment positioning.

Control devices and circuits for speed adjuster motor 76

In the illustrative organization shown by Figure 4 energization of reversing speed-adjuster motor 76 is automatically controlled by means of a novelly-organized system made up of: (1) a pressure-responsive device 87 including a bellows 88 connected at 89 (see Figure 1) with the steam offtake line 41 from boiler 40 and functioning to urge floating contact 90 against stationary contact H when the boiler pressure rises above a predetermined value and to engage floating contact 90 with stationary contact L when the boiler pressure drops below that value; (2) a step-timer device 92 including contacts 93—94 which are repeatedly closed and opened under the cyclic action of a cam 95 continuously rotated (at some relatively slow speed such as about 1 R. P. M.) by a clock-type of synchronous motor 96 energized from conductors A'—B'; (3) a selector switch 98 settable in any one of the four positions ("off";

"minimum"; "automatic"; "maximum") marked for purposes later to be made evident; and (4) the interconnecting conductors represented by Figure 4.

All three of the devices 87, 92 and 98 may satisfactorily be housed in an instrument casing indicated at 100 in each of Figures 1 and 5. This casing can be made relatively compact, one practical design therefor having height, width and depth dimensions approximating eight, seven and four inches respectively.

In this illustrative instrument organization the pressure-responsive device 87 is totally housed inside the casing 100, pressure connection thereto being established through top tubing 89. Calibration of this device 87 is adjusted by turning a top screw 102 which adjusts the tension on a spring 103 that opposes (see Figure 4) the tendency of bellows 88 to close contacts 90—H upon rising pressure of the boiler steam (see Figure 1). For each setting of screw 102 there exists a pressure at which floating contact 90 is disengaged from both contacts H and L. As the pressure in bellows 88 falls below that predetermined value spring 103 brings contacts 90 and L together; and as the bellows pressure rises above that predetermined value the added bellows expansion brings contacts 90 and H together.

In the illustrative step timer shown at 92 (Figure 4), clock motor 96 is during the represented "automatic" positioning of selector switch 98 continuously energized over a circuit extending from supply conductor A' through switch segment 99, conductors 105—106, the winding of timer motor 96 and conductor 107 back to supply conductor B'. Under this condition motor 96 rotates timer cam 95 at some slow and uniform speed such as one R. P. M.; the two cam lobes represented then serving to move timer contact 94 up and down once each 30 seconds in regularly repeated cycles. Each upward movement engages contact 94 with companion contact 93 while each downward movement breaks that engagement.

For adjusting the ratio of "on" (engaged) to "off" (disengaged) periods in these recurring timer contact cycles, provision is made for moving the upper contact 93 either closer to or further away from the lower contact 94. As here shown this provision takes the form of a second cam 97 settable in different rotational positions by a timer adjusting dial 108 protruding through the front of instrument casing 100 as indicated in Figure 5. When dial 108 is turned counterclockwise to the extreme left, each thirty second cycle of timer operation will include a five second "on" period during which contacts 93—94 are engaged, and a twenty-five second "off" period during which contacts 93—94 are disengaged.

Turning dial 108 clockwise increases the length of the timer "on" periods and decreases the length of the timer "off" periods. If set to the extreme clockwise direction (marked "Increase" in Figure 5) the timer contacts 93—94 will be engaged for twenty-five seconds and disengaged for five seconds during each thirty second cycle. In this way there is provided a simple and effective adjustment in the relative lengths of timer "on" and "off" periods throughout a relatively wide range.

The four-position selector switch represented at 98 in Figure 4 is arranged for setting by means of a knob 110 extending through the front of instrument casing 100 as shown in Figure 5. With the knob in the vertical or "automatic" position represented switch segment 99 connects conductor A' with conductor 105; turning knob 110 clockwise to the "maximum" position causes segment 99 to transfer the connection of conductor A' to a conductor 112; shifting of the knob counterclockwise to the "minimum" position connects conductor A' (through segment 99) to another conductor 111; and further counterclockwise rotation of knob 110 to the "off" position disconnects conductor A' from all three conductors 105, 111 and 112.

The three control devices just described (pressurestat 87; step timer 92; selector switch 98) are as shown in Figure 4 interconnected with each other, with supply conductor A'—B' and with the stoker's speed-adjuster motor 76 and limit switches 84—85 to constitute the complete automatic control system of this invention.

How the automatic control system of Figure 4 operates

In considering operation of the complete control system of Figure 4 assume that step timer 92 is adjusted so that each recurring thirty-second cycle of closing and opening by contacts 93—94 includes a fifteen second "on" period (contacts engaged) and a 15-second "off" period (contacts disengaged); that pressurestat 87 is set to hold contact 90 between contacts H and L when the pressure in boiler 40 (see Figure 1) has a selected value of 60 pounds per square inch (as indicated by gauge 44); and that selector switch 98 is in the "automatic" position with segment 99 vertical as indicated.

In order to maintain the steam pressure in boiler at this value of 60 pounds per square inch the stoker of Figure 1 will need to operate at some intermediate value of fuel-feed rate such as is typified by the represented position of manual speed selector lever 17 (Figures 1—2—3) and by the corresponding intermediate position of forked lever 82 which is fixed to the same speed-adjuster shaft 62 as is the first lever 17. Under these conditions contact 90 of pressurestat 87 floats between contacts H and L and keeps both of terminals D and I of speed-adjuster motor 76 disconnected (at pressurestat 87) from supply conductor A'.

Upon a drop in the steam pressure in boiler 40 (as may result when the demand for supplied steam increases) pressurestat contact 90 engages contact L thereby completing for feed adjuster motor 76 a "forward" energizing circuit which extends from supply conductor A' through selector switch 98, conductor 105, step-timer contacts 93—94 (when recurrently closed), conductor 113, contacts 90—L of pressurestat 87, conductor 114, limit switch 84, terminal I of motor 76, and the motor's "forward" driving winding back to supply conductor B'.

Thus energized motor 76 rotates forwardly causing pinion 78 to drive gear wheel 79 in a direction (clockwise as viewed in Figure 4) to increase the rate at which stoker feed screw 14 and wobble cam 24 (see Figure 1) are driven by motor 15 and further to open the air damper 67 for forced draft fan 36. This "increasing" adjustment in the rate of stoker fuel feed and air supply (accomplished through gear wheel 79 and forked lever 82) proceeds in "step" fashion; the adjuster motor 76 running only when step-timer contacts 93—94 are closed (fifteen out of each thirty seconds for the assumed setting of step timer 92) and stopping during the intervening "off" periods (also assumed to be fifteen seconds each) when the step timer contacts are opened.

In consequence of the increased supply of fuel and air by the stoker to furnace 8 the steam pressure in boiler 40 again builds up. Upon close approach thereof to 60 pounds per square inch, pressurestat contact 90 separates from contact L and thereby disconnects adjuster motor 76 from supply conductor A'. Further corrective action by motor 76 is now discontinued.

In the event that the steam pressure in boiler 40 rises above the assumed predetermined value of 60 pounds per square inch (as may result when the demand for boiler supplied steam suddenly drops) pressurestat 87 engages contact 90 with contact H and thereby completes for adjuster motor 76 a "reverse" circuit which extends from supply conductor A' through selector switch 98, conductor 105, contacts 93—94 of step timer 92, conductor 113, contacts 90—H of pressurestat 87, conductor 115, limit switch 85, terminal D of motor 76, and the motor's "reverse" driving winding back to supply conductor B'.

Thus energized motor 76 rotates reversely causing pinion 78 to drive gear wheel 79 in a direction (counterclockwise as viewed in Figure 4) to decrease the rate at which stoker feed screw 14 and wobble cam 24 (see Figure 1) are driven by motor 15 and to effect a closing adjustment in the air damper 67 for forced draft fan 36. This "decreasing" adjustment in the rate of stoker fuel and air feed proceeds in the same "step" fashion (due to timer 92) as was explained for the increasing adjustment by motor 76.

In consequence of the decreased supply of fuel and air by the stoker to furnace 8 the steam pressure in boiler 40 again falls. Upon close approach thereof to the assumed 60 pounds per square inch desired value, pressurestat contact 90 separates from contact H and thereby disconnects adjuster motor 76 (terminal D) from supply conductor A'. Further corrective action by motor 76 is thereupon discontinued.

To adapt the system for maintaining the boiler steam pressure constant at some value other than the 60 pounds per square inch above assumed, it is only necessary to reset the pressurestat 87 for contact disengagement at the other pressure selected. As already indicated, the necessary resetting is readily accomplished by simply turning the calibrating screw 102; to increase the tension on spring 103 when it is desired to maintain a higher pressure and to decrease the spring tension when it is desired to maintain a lower pressure.

Heat requirement measurements other than boiler steam pressure may also be used as the control factor in my improved automatic system. For example, the pressurestat 87 of Figure 4 may be directly replaced in the circuits disclosed by the thermostat 45 of Figure 1. In effecting such replacement the thermostat contacts L', 90' and H' will be connected with conductors 114, 113 and 115 in the same manner as are the pressurestat contacts L, 90 and H of Figure 4. Operation of the thermostat-controlled system will then be the same as that above described for the pressurestat-controlled system of Figure 4; subject to the single difference that the temperature of room 43 (Figure 1) will then be maintained constant instead of the steam pressure in boiler 40. Furthermore, temperature-responsive contacts such as H'—90—L' can also be incorporated into an "aquastat" (not shown) submerged in water heated by the stoker-fired furnace 8 and functioning through my new control

system of Figure 4 to hold the temperature of that water constant as some desired value.

The step timer 92 and connection variations therefor

In either arrangement step timer 92 functions to eliminate "hunting" or overrunning in the fuel-feed adjustment made through motor 76 in the stoker driving mechanism of Figures 1—2—3. Such hunting is prevented by adjusting the length of the timer "on" (closed contact) steps to suit the fuel burning characteristics of the stoker. As has been seen each "on" portion of the timer cycle is during corrective action accompanied by a running of adjuster motor 76 and each intervening "off" (open contact) interval produces a waiting period between motor operations.

Hence with the thirty second cycle timer illustrated at 92 the earlier assumed fifteen second "on" and fifteen second "off" periods were chosen merely to facilitate description. In certain fuel burning systems such equal "on" and "off" periods may proye most suitable; in other systems a shorter "on" and a longer "off" period may prove most satisfactory; and in still other systems a longer "on" and a shorter "off" period may result in the best operation. As earlier indicated the optimum adjustment for each installation is readily effected through timer-adjuster dial 198.

The step-timer 92 obviously may be connected into the control system in manners other than the illustrative one shown by Figure 4. For example, the timer contacts 93—94 may if desired (but not here shown) be reconnected to that they serve recurrently to interrupt only one of speed adjuster motor 76's "forward" and "reverse" energizing circuits 114 and 115 (instead of both as Figure 4 illustratively shows).

Moreover, by proper reorganization (not here illustrated) of the system it is possible to make energization of timer motor 96 dependent upon engagement of the contacts (90—H or 90—L) in master control device 87. With such an arrangement the timer cam 95 will be rotated only when the stoker's speed-adjuster motor 96 is energized (at one or the other of its terminals D and I); this permits inactivity on the part of timer device 92 at all times except when motor 76 actually is being called upon to adjust the stoker speed.

Non-automatic control of the stoker's fuel-feed speed

Under certain conditions it may be desirable to temporarily set the position of speed-adjuster shaft 62 under manual control independently of the automatic facilities just described. Provision for doing this is made in my new system. In the organization shown by Figures 1 to 5 such provision includes the selector switch 98 plus a releasable clutch mounting for pinion 78 which drives into gear wheel 79 (see Figure 4) from motor 76.

Referring to Figure 2, pinion 78 is there shown as being loosely mounted on the shaft 117 of the control motor assemblage 76—77 and receives turning movement therefrom through a collar 118 fixed to the shaft. Abutting ends of this collar and gear 78 are each provided with V notches 119 which lock into each other as long as a hand screw 120 on shaft 117's threaded end holds gear 78 against collar 118. Under these conditions pinion 78 is rigidly fixed to and rotates with the shaft 117 of speed adjuster motor

gearing 77. The effect then is the same as were pinion 78 to be keyed to shaft 117.

Should, however, it be desired to utilize manual lever 17 for setting the stoker's fuel-feed speed, it is only necessary to turn hand screw 120 along threaded shaft end 117 away from gear 78 for a short distance as limited by cotter key 121. The V notches 119 now are effective to disengage gear 78 from collar 118 and allow it to rotate freely on shaft 117.

Pinion 78 is in this way freed to turn loosely on shaft 117. Under this condition forked lever 82 (see Figure 4) can under the turning action (through shaft 62) of hand lever 17 rotate gear wheel 79 (through roller 81) to any speed-adjusting position which it may be desired to establish by lever 17. Once the position is so selected, it may be there held by retightening hand screw 120 against pinion 78, thereby again locking it to control gearing shaft 117. Access to hand screw 120 may conveniently be provided for by equipping the casing of the stoker drive mechanism with an access door as shown at 122 in Figure 3.

Incident to the foregoing manual setting of the stoker feed drive, the selector switch 98 of Figures 4 and 5 is preferably set to the "off" position wherein supply conductor A' is disconnected from all three of system conductors 105, 111 and 112.

Under certain conditions this selector switch 98 is further useful in selectively running the speed-adjuster motor 76 (with pinion 78 locked to shaft 117) to the extreme position for forked lever 82 in either the "maximum" or the "minimum" speed-adjusting direction.

Such maximum-direction running results when knob 110 of the switch is rotated clockwise to its "maximum" position to connect (through segment 99) supply conductor A' with system conductor 112. This by-passes both the step-timer 92 and pressurestat 87 by connecting A' directly to motor conductor 114, thereby energizing motor terminal I and causing gear wheel 79 to be advanced in the speed-increasing direction (clockwise as viewed in Figure 4) until forked lever 82 contacts and opens limit switch 84 in the motor circuit. Motor 76 then stops with forked lever 82 in the "maximum" fuel-feed position.

To run motor 76 to the opposite or "minimum" range of travel for speed adjusting lever 82, it is only necessary to turn knob 110 of selector switch 98 counterclockwise to the "minimum" position wherein segment 99 connects supply conductor A' with system conductor 111. Devices 92 and 87 are again by-passed and the resultant connection of A' with conductor 115 applies energizing voltage to terminal D of motor 76. This causes the motor to rotate gear wheel 79 in the fuel-speed decreasing direction (counterclockwise in Figure 4) until forked lever 82 contacts and opens selector switch 95 to interrupt the supply circuit and stop the motor with lever 82 in the position of "minimum" fuel-feed adjustment.

As earlier indicated a setting of selector switch 98 in the "off" position disconnects supply conductor A' from all other system conductors and thereby renders speed adjuster motor 76 totally inactive.

The modified speed-adjusting mechanism of Figs. 6—7—8

Figures 6—7—8 disclose an alternative organization for the parts through which gear wheel 79 (driven by control motor 76) transmits speed adjusting movements to the shaft 62 of the stoker's speed selector mechanism earlier described. In this alternative organization: (*a*) the two arms 17 and 82 of Figures 2—3 are replaced by a single arm shown at 17' in Figures 6—7—8; (*b*) the pinion 78 for driving gear wheel 79 is fixedly mounted on the shaft 117' of the control motor assemblage 76—77; (*c*) gear wheel 79 has supported from its left face (as viewed in Figure 6) a disc 124 upon which is mounted the roller 81' that engages one side of arm 17' as shown; (*d*) enough of the casing wall 127 is cut away opposite gear wheel 79 to permit the engagement named; and (*e*) movement of arm 17' in the speed raising direction can at proper times be limited to a selected position by placing a stop pin 126 ahead of the arm (on same side as roller 81') in one of the holes provided in a bracket 128 that is secured to the stoker casing 129 as shown.

Except for the changes above listed, the speed-change mechanism represented in Figures 6—7—8 duplicates that already described by reference to Figures 2—3. In it lever 17' is continuously urged against (to the left in Figure 7 and to the right in Figure 8) roller 81' due to the tendency of composite pulley 60 to ride belt 59 as far towards the outer edges of beveled members 60A—60B as the positions of link 64, arm 63 and speed-change shaft 62 will permit. The named tendency results from the continuous urging by pulley spring 61 (see Figure 6) of member 60B towards member 60A; this, in turn, urges belt 59 away from the center of pulley 60; and, in consequence, the shaft support 62 for that pulley continuously urges link 64 to the right in Figure 7. Arm 63 converts that urge into a torque on shaft 62 which is counterclockwise as viewed in Figure 7 and clockwise as viewed in Figure 8 and which continuously urges lever 17' towards roller 81' as earlier stated.

This modified mechanism of Figures 6—7—8 employs the same reversing motor 76 as does the mechanism of Figures 1—2—3 and it contemplates that this motor 76 be automatically controlled through the novel apparatus shown in Figure 4, as earlier described in detail. In actual use the parts of Figure 8 therefore form part of the complete automatic control system of Figure 4; lever 17' of Figure 8 then replacing the forked arm 82 of Figure 4 and limit switches 84 and 85 then being actuated (at proper times) directly from the gear wheel 79 through the actuator 86' carried thereby as indicated in each of Figures 6—7—8.

Operation of the complete automatic control system so disclosed by Figures 4, 6—7—8 therefore proceeds in the same way as was earlier explained for the equipment of Figures 1 through 5. In examining this operation first assume that stop pin 126 is removed from bracket 128 thereby allowing lever 17' freely to follow roller 81' through all speed adjusting rotations of gear wheel 79. Under this condition the modified linkage mechanism of Figures 6—7—8 functions in precisely the same manner as does the mechanism of Figures 2—3—4, except that lever 17' takes the place of forked arm 82.

Thus, rotation of gear wheel 79 in the speed decreasing direction (counterclockwise in Figure 8 and clockwise in Figure 7) pushes lever 17' to the right in Figure 7 (and to the left in Figure 8) thereby causing link 64 to push composite pulley 60 further away (to the left in Figure 7) from

the fixedly mounted pulley 58 over which the belt 59 rides. This pulls belt 59 closer to the composite pulley's center and thereby appropriately reduces the stoker driving speed; such reduction being accompanied by a corresponding adjustment of air damper 68 (through linkage 71—74) in the draft reducing direction.

Similarly, rotation of gear wheel 79 in the speed increasing direction (clockwise in Figure 8 and counterclockwise in Figure 7) allows lever 17' to follow roller 81' to the left in Figure 7 (and to the right in Figure 8) and thereby permits composite pulley 60 (urged by spring 61) to ride belt 59 closer to the pulley's outer edges with a resultant increase in stoker driving speed. In moving, as stated, lever 17' effects a corresponding adjustment of air damper 68 in the draft increasing direction.

This modified apparatus of Figures 6—7—8 offers special advantages. The first of these is that of permitting ready establishment of an upper driving speed limit at some selected value that is less than the highest attainable stoker speed which rotation of gear wheel 79 into its extreme speed increasing position (wherein limit switch 84 opens) determines. Such establishment of a reduced upper limit is accomplished by inserting stop pin 126 into the opening along the length of bracket 128 which corresponds to the particular reduced upper limit desired.

Under this condition (represented in each of Figures 6—7—8), automatic stoker adjustments within the speed range below that selected by pin 126 continue to proceed as before. However, once lever 17' is by roller 81' allowed to move into contact with pin 126 then further advancement of the lever is prevented even though gear wheel 79 may be further rotated by control motor 76 in the speed increasing direction. This means that the automatic control facilities are rendered ineffective within the range above the intermediate speed value selected by pin 126.

A second advantage afforded by the modified apparatus of Figures 6—7—8 is that of permitting a setting of the speed adjuster lever 17' under full manual control and with complete independence of the automatic facilities diagrammed in Figures 4 and 8. To accomplish this it is only necessary to turn selector switch 98 of Figure 4 to the "maximum" position.

Such turning connects (through segment 99) supply conductor A' with system conductor 112. This by-passes both the step timer 92 and pressurestat 87 by connecting A' directly to the motor conductor 114 thereby energizing terminal I of motor 76 and causing gear wheel 79 to be advanced in the speed increasing direction (clockwise as viewed in Figure 8) until actuator 86' contacts and opens limit switch 84 in the forward motor circuit. Motor 76 then stops with the roller 81' in the "maximum" full speed position (to the right in Figure 8 and to the left in Figure 7).

Roller 81' is now completely out of the normal-range path of lever 17' and that lever is accordingly free for manual setting to any position in the stoker speed range which may be desired. Each such selected position can now readily be retained by inserting stop pin 126 in the appropriate place along the length of bracket 128. It will thus be seen that the modified organization of Figures 6—7—8 permits manual setting of the stoker feed speed to be effected without disconnecting gear drive pinion 78 from motor assemblage shaft 117'.

Restoration of the stoker to automatic control is effected with equal simplicity merely by turning selector switch 98 of Figure 4 back into the "automatic" position wherein segment 99 reconnects conductor A' with system conductor 105, and thereby conditions speed adjuster motor 76 of Figures 6—7—8 for response to pressurestat 87.

Summary

From the foregoing it will be seen that I have provided improved means for automatically controlling the operating rate of stokers including underfeed stokers organized as taught by my Patent 2,049,668 of 1936 and equipped with variable speed drive mechanisms as taught by my Patent 2,070,756 of 1937; that I have effected the foregoing automatic control of stoker operating rate in such an improved way as to avoid wastage of fuel, minimize smoke and increase fuel burning efficiency; that I have accomplished the desired control through the medium of equipment which is low in cost, simple and compact in construction and reliable and trouble-free in operation; and that I have organized the automatic control apparatus in a way permitting the stoker operating speed to be adjusted manually, when and if desired.

My inventive improvements are therefore extensive in their application and hence are not to be restricted to the specific form here disclosed by way of illustration.

What I claim is:

1. In combination, a furnace, a stoker therefor including fuel-feed elements, continuously operable mechanism for driving said elements, a member in said mechanism movable to adjust the speed at which said fuel-feed elements are driven, a gear wheel rotatively mounted to impart speed-adjusting movement to said member, an electric motor for slowly rotating said gear wheel through a meshing pinion mounted on a motor-driven shaft, an instrument responsive to the demand for furnace-supplied heat, first contacts engaged by said instrument when said supplied heat falls below said demand, second contacts engaged by said instrument when said supplied heat rises above said demand, a forward energizing circuit for said motor completed during each engagement of said first contacts and then effective to cause the motor to move said stoker-adjusting member in the fuel-feed increasing direction, a reverse energizing circuit for said motor completed during each engagement of said second contacts and then effective to cause the motor to move said stoker-adjusting member in the fuel-feed decreasing direction, a selector switch for at times rendering said forward and reverse motor circuits both unresponsive to said automatic instrument control, and means mounting said gear-driving pinion on said motor-driven shaft in a way permitting selective release of the shaft-to-pinion driving connection when during the aforesaid times it may be desired to free said gear wheel for a manual rotative shifting to any selected point in said stoker-adjusting member's range of feed-speed varying movement.

2. In combination, a furnace, a stoker for supplying said furnace with fuel to be burned therewithin and with air to support said burning, continuously operable stoker driving mechanism including a lever effective to adjust the rate at which the stoker feeds both said fuel and said air into the furnace, a gear wheel rotatively mounted to impart speed-adjusting movement to

said lever, a pinion meshing with said gear wheel and carried by a shaft, an electric motor for driving said shaft in order slowly to rotate said gear wheel through said pinion, an instrument responsive to the demand for furnace-supplied heat and effective to engage a first set of contacts when said supplied heat is less than said demand and to engage a second set of contacts when said supplied heat is greater than said demand, a forward energizing circuit for said motor completed during each engagement of said first contacts and then effective to cause the motor to move said stoker-adjusting lever in the fuel-feed-increasing direction, a reverse energizing circuit for said motor completed during each engagement of said second contacts and then effective to cause the motor to move said lever in the fuel-feed-decreasing direction, a selector switch for at times rendering said forward and reverse motor circuits both unresponsive to said automatic instrument control, and means mounting said gear-driving pinion on said motor-driven shaft in a way permitting selective release of the shaft-to-pinion driving connection when during the aforesaid times it may be desired to free said gear wheel for a manual rotative shifting to any selected point in said stoker-adjusting lever's range of feed-rate varying movement.

3. In combination, a furnace, a stoker for supplying said furnace with fuel to be burned therewithin and with air to support said burning, continuously operable stoker driving mechanism including a lever effective to adjust the rate at which the stoker feeds said fuel and air into the furnace, said lever being settable anywhere between an extreme low speed position and an extreme high speed position, means urging said lever in the direction of its said high speed position, a gear wheel rotatively mounted and carrying at a point displaced from its axis a roller organized to restrain said lever from travel beyond the roller towards said extreme high speed position, an electric motor for imparting rotation to said gear wheel, a motor-control instrument responsive to the demand for furnace-supplied heat, a forward energizing circuit for said motor activated by said instrument when said supplied heat is less than said demand and then effective to produce forward rotation of said gear wheel causing said roller to allow advancement of said lever in the feed-speed-increasing direction, a reverse energizing circuit for said motor activated by said instrument when said supplied heat is greater than said demand and then effective to produce reverse rotation of said gear wheel causing said roller to move said lever in the feed-speed-decreasing direction, and means supplemental to said motor-driven gear wheel and roller for restricting said lever in its said speed-raising movement to a selected intermediate position in the aforesaid lever travel range notwithstanding that said gear wheel may advance said roller in the speed-raising direction to beyond said selected intermediate position.

4. In combination, a furnace, a stoker for supplying said furnace with fuel to be burned therewithin and with air to support said burning, continuously operable stoker driving mechanism including a lever effective to adjust the rate at which the stoker feeds said fuel and air into the furnace, said lever being settable anywhere between an extreme low speed position and an extreme high speed position, means urging said lever in the direction of its said extreme high speed position, a gear wheel rotatively mounted and carrying at a point displaced from its axis a roller organized to restrain said lever from travel beyond the roller towards said extreme high speed position, an electric motor for imparting rotation to said gear wheel, a motor-control instrument responsive to the demand for furnace-supplied heat, a forward energizing circuit for said motor activated by said instrument when said supplied heat is less than said demand and then effective to produce forward rotation of said gear wheel which causes said roller to allow advancement of said lever in the feed-speed-increasing direction, a reverse energizing circuit for said motor activated by said instrument when said supplied heat is greater than said demand and then effective to produce reverse rotation of said gear wheel which causes said roller to move said lever in the feed-speed-decreasing direction, means including a selector switch for at times rendering said forward and reverse motor circuits both unresponsive to said automatic instrument control and for thereupon causing the motor to drive said gear wheel forwardly to a position wherein said roller frees said lever for full advancement into its said extreme high speed position, and means effective to hold said lever in any position within its complete range of travel that during the aforesaid times it may be desired to select by manual setting.

5. In combination, a furnace, a stoker for supplying said furnace with fuel to be burned therewithin, continuously operable stoker driving mechanism including a lever effective to adjust the rate at which the stoker feeds said fuel into the furnace, said lever being movable between an extreme low-speed position and an extreme high-speed position, a gear wheel rotatively mounted and carrying a roller at a point displaced from the gear wheel axis, means causing said lever to move with said roller upon changes in the rotational position of said gear wheel, an electric motor for imparting rotation to said gear wheel, a motor-control instrument responsive to the demand for furnace-supplied heat, a forward energizing circuit for said motor activated by said instrument when said supplied heat is less than said demand and then effective to produce forward rotation of said gear wheel causing said roller and said lever to move in the feed-speed-increasing direction, a reverse energizing circuit for said motor activated by said instrument when said supplied heat is greater than said demand and then effective to produce reverse rotation of said gear wheel causing said roller and said lever to move in the feed-speed-decreasing direction, and a selector switch for at times rendering said forward and reverse motor circuits both unresponsive to said automatic instrument control and for at other times enabling each circuit selectively to be supplied with energizing current under manual control directly through the switch in by pass relation to said instrument.

6. In combination, a furnace, a stoker for supplying said furnace with fuel to be burned therewithin, continuously operable stoker driving mechanism including a lever effective to adjust the rate at which said stoker feeds fuel into the furnace, said lever being movable between an extreme low-speed position and an extreme high-speed position, a gear wheel rotatively mounted and carrying a roller at a point displaced from the gear wheel axis, means causing said lever to move with said roller upon changes in the

rotational position of said gear wheel, an electric motor for imparting rotation to said gear wheel, a motor-control instrument responsive to the demand for furnace-supplied heat, a forward energizing circuit for said motor activated by said instrument when said supplied heat is less than said demand and then effective to produce forward rotation of said gear wheel causing said roller and said lever to move in the feed-speed-increasing direction, a reverse energizing circuit for said motor activated by said instrument when said supplied heat is greater than said demand and then effective to produce reverse rotation of said gear wheel causing said roller and said lever to move in the feed-speed-decreasing direction, a timing device for said forward and reverse motor circuits effective upon activation of each as aforesaid then recurrently to interrupt the activated circuit and thereby cause said stoker-speed-adjusting motor to operate in recurring steps which are separated by intervening periods of motor stoppage, a selector switch for at times rendering said forward and reverse motor circuits both unresponsive to the foregoing automatic instrument control and for at other times enabling each circuit selectively to be supplied with energizing current under manual control directly through the switch in by pass relation to said instrument and said timing device, a first limit switch functioning to deactivate said forward motor circuit upon either instrument or selector-switch initiated movement by said motor of said stoker-adjusting lever to its extreme limit of travel in the fuel-feed-increasing direction, and a second limit switch functioning to deactivate said reverse motor circuit upon either instrument or selector-switch initiated movement by said motor of said stoker-adjusting lever to its extreme limit of travel in the fuel-feed-decreasing direction.

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