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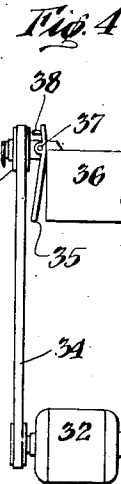
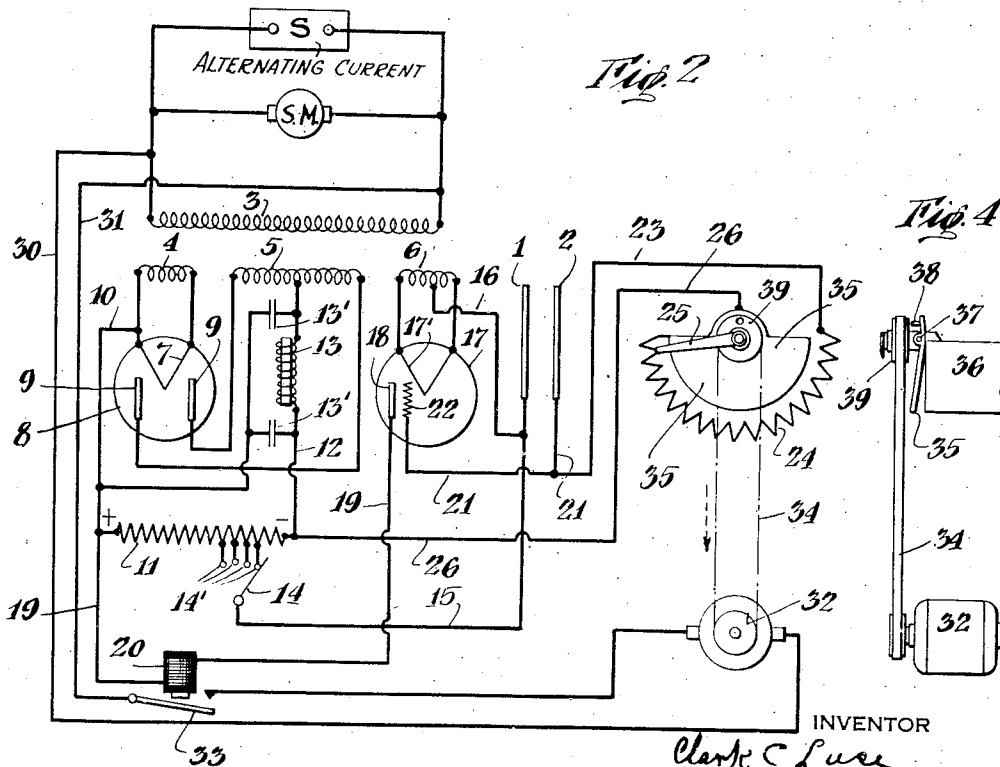
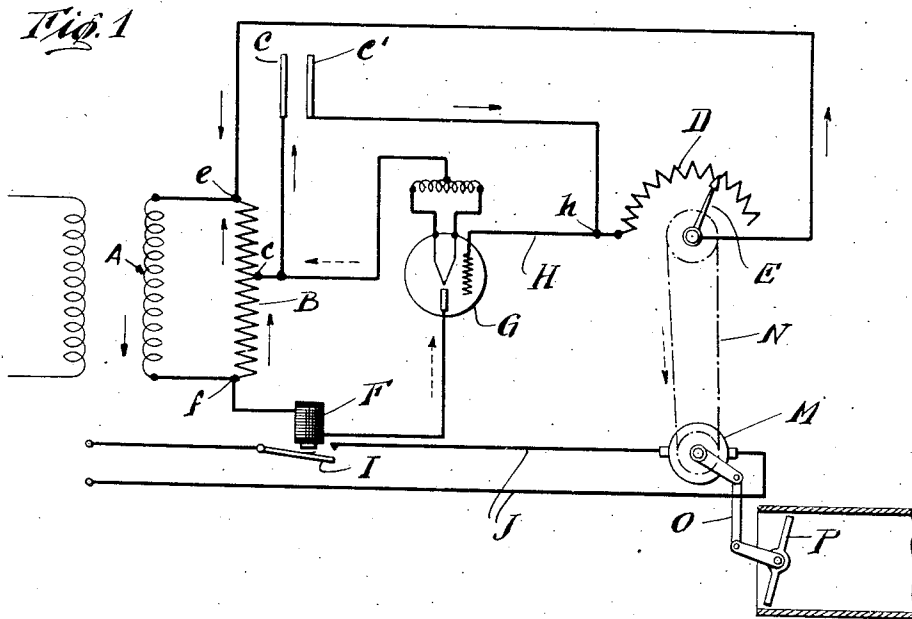
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2,268,411

STOKER CONTROL METHOD AND APPARATUS

Filed May 22, 1939

2 Sheets-Sheet 1



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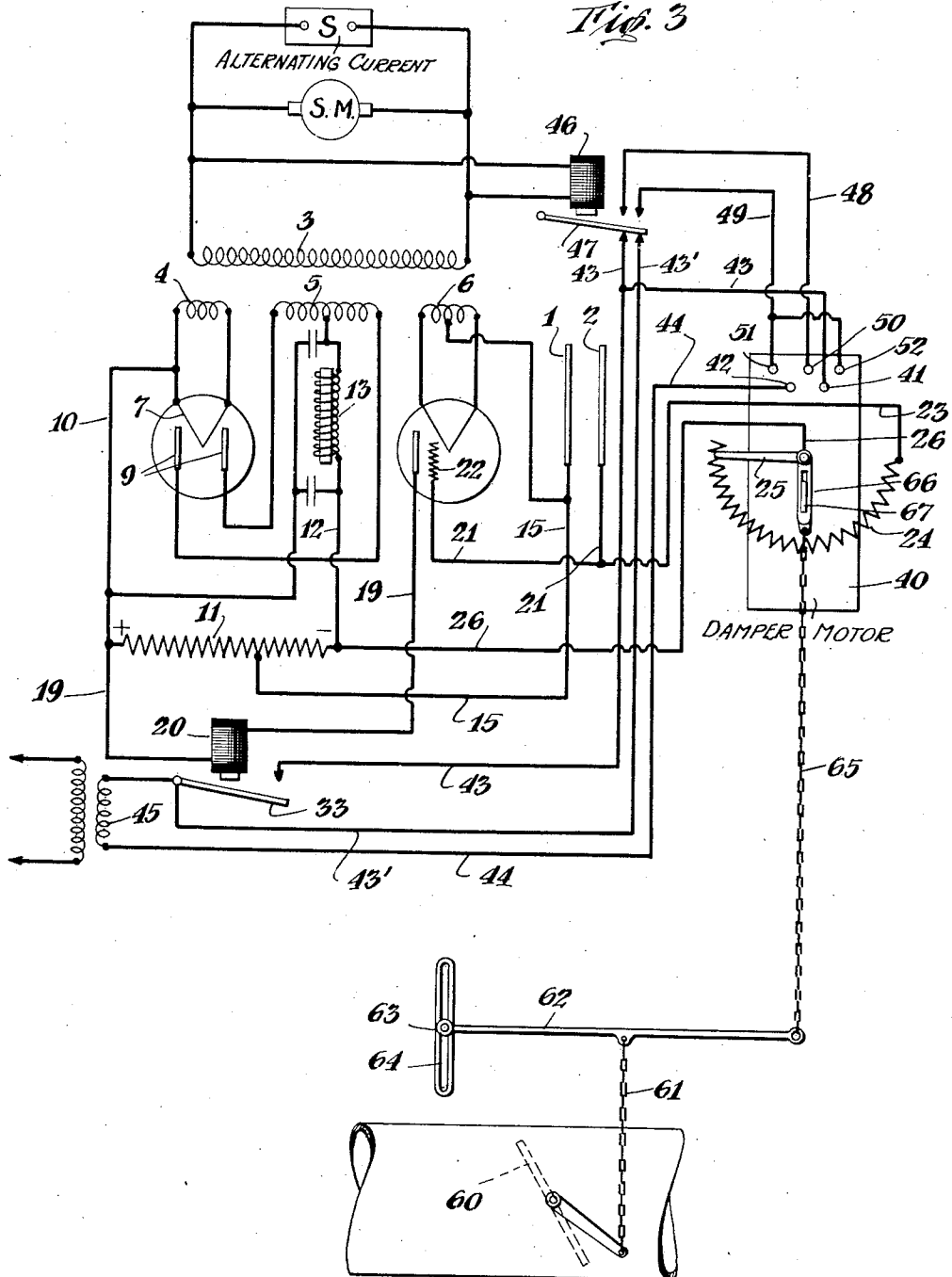
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STOKER CONTROL METHOD AND APPARATUS

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2 Sheets-Sheet 2



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STOKER CONTROL METHOD AND APPARATUS

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Application May 22, 1939, Serial No. 275,125

13 Claims. (Cl. 110—72)

This invention relates to a method and apparatus for regulating the supply of air to a stoker-fired furnace in accordance with variations in the sort of coal that is used and also in accordance with the size of the coal as well as the degree of moisture therein.

It is well known that in order to obtain the maximum efficiency in the burning of coal in a stoker-fired furnace the rate at which air is supplied to the furnace should be so regulated with respect to the rate of travel of the coal through the furnace that all of the coal is burned before it is carried out of the desired combustion zone, thus avoiding losses due to unburned coal in the ash pit. On the other hand, so much air should not be supplied to the furnace as to burn off all of the coal from the grate before it reaches the rear edge of the furnace, as this would result in relatively cold air passing through the combustion chamber and wasting the heat.

In operating stoker-fed boiler furnaces it is the practice to drive the stokers at a rate to furnish enough fuel to generate the desired amount of heat or steam and to adjust the air feed accordingly. In stoker-fired heating installations for domestic and other purposes, the rate at which the stokers are driven is set so as to take care of the maximum condition of winter cold, and the air damper setting is changed by hand as the user thinks desirable, being guided by his estimate of the change in setting that is needed from time to time.

However, it is desirable to change the proportion of air to coal in such furnaces not only with changes in the quality of the coal that is used, but also with changes in the size of the coal particles that are fed to the furnace and with changes in the moisture content of the coal. For example, a quick-burning anthracite coal requires less air pressure below the grate than a slow-burning one at a given rate of feed of the coal in order to avoid having the layer of coal on the grate burn out in spots or areas before the rear edge of the furnace is reached, thereby permitting cold air to pass. Therefore, the dampers should be kept more nearly closed when quick-burning coal is used than when slow-burning coal is used, or the air blowers should be so regulated as to compensate for the differences.

As set forth in my application Serial No. 261,196, filed March 11, 1939, quick-burning coals have low electrical conductivities as compared to the conductivities of slow-burning coals. Also, I have found that the electrical conductivity of wet coal, which requires more air pressure than

dry coal, is greater than that of dry coal and increases with an increase in the moisture content. Furthermore, I have found that a mass of smaller coal, which requires more air pressure than larger size coal, has greater electrical conductivity between electrodes than the same mass of larger coal, although the apparent electrical conductivity or resistance of a single piece of coal between two fixed electrodes against which it rests or is placed does not vary much with the size of the piece.

The present invention takes care of any one or more of the three conditions named above, because in each and all of these instances the same condition or conditions which cause higher electrical conductivities of the coal also requires more air pressure under the coal bed. That is, coal beds of relatively high electrical conductivity on grates are relatively slow-burning and therefore need wider damper openings or higher air pressure to effect proper burning, and vice versa, regardless of whether this burning characteristic is due to difference in kind of coal, or difference in the size of the coal particles, or difference in the amount of moisture in or on the coal, or two of these conditions or all three of them.

By the present invention the air supply to furnaces is automatically regulated to take care of the contingencies mentioned above without interfering with the usual functioning of furnaces and without requiring new adjustments for regulating the outputs of them. The efficiency is increased and fuel is economized, in addition to a more satisfactory performance of the furnaces to which this invention is applied. The invention may be used with furnaces already installed or with new installations.

In carrying out this invention representative samples of the coal that is being burned are caused to pass two fixed electrodes, preferably in the form of parallel metal bars, such as brass, for example, in rubbing contact therewith and longitudinally thereof, to close an electrical circuit through a variable resistance that is in series with the coal, as described above. A source of potential is applied across the coal and a resistance in series therewith that is controlled by the position of the furnace damper which is in turn controlled by the apparatus described below. The degree of conductivity of the coal controls the position of a furnace damper, or otherwise controls the air pressure beneath the coal on the grate in a furnace, to provide different amounts of air according to whether the coal is slow-burn-

ing or quick-burning, that is, relatively hard or soft, wet or dry, small or large.

The invention will be specifically described in connection with the accompanying drawings, which indicate arrangements of apparatus for carrying out the invention, but it is to be understood that the invention is not limited to the particular apparatus or arrangements thereof.

In the drawings:

Fig. 1 is an abbreviated diagram to illustrate the underlying principle of the invention;

Figs. 2 and 3 are diagrammatic arrangements illustrating two ways in which the invention can be practiced; and

Fig. 4 is a side view of one of the details of Fig. 2.

The invention will first be explained in connection with Fig. 1, and two embodiments of the invention will then be described in connection with Fig. 2 and Fig. 3, respectively.

In Fig. 1, reference character A diagrammatically indicates a source of current which is connected to the ends of a resistance B. C and C' are spaced-apart electrodes or conductors that can be bridged across by the coal or a stream thereof on its way to a furnace. The electrode C is connected to a point c intermediate the ends of the resistance B, and the electrode C' is connected to the end of a variable resistance D. The pivoted arm E varies the amount of the resistance D in the circuit and is connected to the point e at the upper or negative end of the resistance B. An electromagnet or relay F is connected in a circuit between the lower or positive end f of the resistance B and the point c of this resistance through the electric valve G that is in series with the magnet F. A connection H extends from a point h, in the connection between the electrode C' and the resistance D, to the valve G to control this valve and permit current to flow through the magnet F or not, depending upon the ratio of the resistance of the coal which bridges across the electrodes C and C' and the portion of the resistance D that is in the circuit as determined by the position of the arm E.

I is a switch or circuit closer that closes when the magnet F is energized and opens when current ceases to pass through this magnet. This switch is located in a power line J that leads to a damper motor M. O indicates a connection between the motor M and the damper P of a furnace. Optionally this connection may be to an air blower or other device to determine the rate of air supply to the furnace. N indicates a connection from the motor M to the arm E to enable the motor M to move this arm E to reduce the resistance D as the damper P is opened.

The direction of current is indicated by the full-line arrows, and when current flows through the valve G its direction is indicated by the dotted arrows. When coal electrically connects the electrodes C and C', a part of the current from A flows from the point c through this coal, thence through the resistance D to the point e due to the difference in potential between these points c and e when current from the source A flows through the resistance B. Different positions of the arm E correspond to different positions of the damper opening or other means that controls the supply of air to the furnace. If the coal passing across the electrodes C and C' has a higher conductivity and therefore requires more air than that which

would be furnished by the setting of the damper P, or other air control device for the furnace, corresponding to the setting of the arm E of the resistance D, then the current passing through these electrodes C, C' and the resistance D causes the potential of the connection H to permit the valve G to open, thus permitting current to pass through the magnet F and close the switch I, whereupon the motor M moves the damper P or other device until the rate of supply of the air to the furnace is increased until it corresponds to the conductivity of the coal passing across the electrodes C, C', whereupon the valve G closes, cutting off the current to magnet F so that the switch I opens and the motor M stops. The damper P is returned to closed position by gravity.

Suppose, for example, that it takes 30 volts negative potential to stop the flow of current through the magnet F so that switch I would open. D has a total resistance of a little over 6 megohms, tapered geometrically. As is shown by the formula:

$$E_{grid} = \frac{R_{coal}}{R_{coal} + R_D} \times E_{neg}$$

in which E_{grid} and E_{neg} are the potential differences between the tap of B that is being used and the grid and the negative end of B, respectively, R_{coal} and R_D are the resistances of the coal and D in the circuit respectively. With a given coal, the greater the resistance of D in the circuit, the less will be the grid potential. Therefore, by causing the damper motor to reduce the resistance of D in the circuit, the grid potential can be brought up to equal the negative potential at the end of resistance B. If $R_{coal}=100,000$ and $E_{neg}=60$, the grid potential will be brought up to 30 volts when the resistance in D has been reduced to 100,000 ohms. On the other hand, with the same coal, if $E_{neg}=40$, D must be changed to 33,333 ohms; and if $E_{neg}=120$ volts, D must be changed to 300,000 ohms.

Having arrived at this condition, the grid potential being high enough to stop the plate current, the motor M stops and the draft setting remains fixed until the stoker is stopped, or until a lower resistance coal reduces the grid potential. Assuming again an E_{neg} value of 60 volts, and a D value of 100,000 ohms, a drop in the value of the resistance of the coal to 50,000 ohms would reduce the grid potential to 20 volts, and the motor would operate until the D resistance was reduced to 50,000 ohms.

For any setting of the resistance D there is a corresponding setting of the damper, because they are directly connected. The lower the resistance, the wider the damper is open. As has been shown, the lower the resistance of the coal with a given value of E_{neg} , the lower will be the setting of B and so the wider open will be the draft setting.

Suppose the drop in resistance is due to wetness of the coal. The draft is opened wider to compensate for the added resistance to the flow of air. On the other hand, if a smaller size of coal is introduced, the greater number of pieces in contact with the electrodes will reduce the resistance across electrodes C and C' and so cause the damper to open wider.

The arrangement to vary the value of E_{neg} is for the purpose of adjusting the draft setting to fit different rates of feed. This variation can be made automatic; for example, it may be controlled by an outside thermostat, or a steam flow

meter, or it can be controlled by a room thermostat in case of the continuous type of stoker. In manual setting, the contact arm may be either attached to the lever that controls the rate of feed, as in the case of automatic regulation, or the positions may be marked to correspond to appropriate pulley arrangements or lever positions.

In the embodiment of the invention illustrated in Fig. 2, the electrodes over which the coal passes are designated 1 and 2. They may be parallel rods about two inches long spaced about a quarter of an inch apart and a number of pairs of them may be arranged in series-parallel relation for the coal to pass over them. The primary 3 of a transformer is connected to an alternating current supply S. There are three secondaries 4, 5 and 6 of the transformer. The low voltage secondary 4 heats the filament 7 of a rectifier 8. The plates 9 of this rectifier are connected to the ends of the high voltage secondary 5. A connection 10 extends from the filament 7 to the positive end of a voltage dividing resistance 11, and a connection 12 extends from the negative end of this resistance through a filter choke coil 13 to the middle point of the secondary 5. Condensers 13' are connected to the ends of the choke coil 13 as shown and to the connection 10. The parts 3, 4, 5, 7, 8, 9, 10, 12, 13 and 13' of Fig. 2 correspond to the source A of current in Fig. 1, the resistance 11 corresponds to the resistance B, and the electrodes 1 and 2 correspond to the electrodes C and C'.

An arm 14 is adapted to connect any one of the taps 14' of the resistance 11 to a connection 15 that leads to the electrode 1 over which the coal passes, and a connection 16 extends from this electrode to the middle of the low voltage secondary 6, which heats the filament 17' of an amplifier 17 whose plate 18 is connected by a connection 19 through the electromagnet of a relay 20 to the positive end of the resistance 11.

A connection 21 extends from the grid 22 of the amplifier 17 to the electrode 2 with which the coal contacts, and a connection 23 therefrom extends to one end of a variable resistance 24. The pivoted arm 25 of this resistance is connected by a connection 26 to the negative end of the resistance 11.

A pair of leads 30 and 31 lead from the power line 3 to a damper motor 32, one of these leads having a switch 33 therein that is closed and opened when the relay or magnet 20 is energized and deenergized. The motor 32 may, for example, be connected by a connection 34 to a damper 35 that carries the resistance arm 25, so that when this motor 32 turns to move the damper, the arm 25 is moved to change the resistance 24. This damper may control the admission of air, for example, to an air duct 36, that furnishes air to a furnace, or this motor may control other devices for controlling the supply of air to the furnace. Such air-controlling devices are old and well known, and since they constitute no part of this invention they are not shown or described in detail.

A portion of the current passes from a tap 14' through the connection 15, electrodes 1 and 2 and coal thereon, connection 23, portion of resistance 24, arm 25 and connection 26 to connection 12 and thence through secondary winding 5, plates 9 of rectifier 8, filament 7, connection 10, and resistance 11 back to said tap 14'.

In this embodiment of the invention, the primary 3 of the transformer is preferably so con-

nected to a source of current that it is energized whenever a thermostat or other control device closes a circuit to cause the stoker motor S. M. and air feed of a furnace to operate. Therefore, when the stoker motor starts, current flows through the primary 3 and energizes the secondaries 4, 5 and 6, causing direct current to flow through the secondary 5, plates 9, filament 7, connection 10, resistance 11 and filter choke coil 13, back to secondary 5. Unless the potential of grid 22 in amplifier 17 is too high, current from secondary 5 flows through rectifier 8, connections 10 and 19 and magnet 20, plate 18, filament 17', secondary 6, connections 16, 15, arm 14, tap 14', part of resistance 11, connection 12, choke coil 13, back to secondary 5, thus causing the magnet 20 to close the switch 33 and start the air control motor 32. A motor separate from the stoker motor is usually preferable to a clutch or other device for accomplishing the same purpose. The filter 13, 13' is to reduce the vibration of the relay 20.

However, if the arm 25 is in such a position that the proportion of the resistance 24 that is in the circuit at that time to the resistance of the coal across the electrodes 1 and 2 is concomitant with the air feed needed for that particular sort of coal, the potential of the grid 22 is thereby caused to be such as to prevent current from flowing through the amplifier 17 and magnet 20, and therefore the switch 33 remains open and the air feed is not changed.

When the damper 35 is in its closed position as indicated in Fig. 2, the arm 25 is in the position at which the maximum resistance of 24 is in the circuit. When the stoker motor S. M. starts, the damper motor 32 also starts and the damper 35 and resistance arm 25 are turned together until the portion of the resistance 24 left in the circuit is so proportioned to the resistance of the coal passing over the electrodes 1 and 2 that the potential at grid 22 stops current from passing through magnet 20, whereupon switch 33 opens and the motor 32, damper 35, and arm 25 stop until coal of higher conductivity passes over the electrodes 1 and 2 causing a corresponding further opening or setting of the damper 35.

The damper 35 may be returned to its closed position in any convenient way or in any of the well known ways, when the stoker motor stops. For example, as indicated in Fig. 4, the damper 35 may be hinged at 37 so that when the air fan starts sweep of the air entering the air conduit 36 turns the damper 35 on the hinge 37 and causes a pin 38 on the damper to enter a hole in a disc 39 that is driven by the motor 32. When the air fan stops, the damper 35 is turned by gravity on its hinge 37 to withdraw its pin 38 and it then returns by gravity to its closing position. This damper may be so adjusted that in one position it will permit enough air to enter the furnace under the fuel bed to burn the largest dry free burning coal that the stoker will be expected to burn, and in its further open position will allow just enough air to enter to burn efficiently the smallest wet slow-burning coal for which the stoker is built.

This invention is particularly useful with a stoker that operates intermittently as heat is demanded by a thermostat or other control device and the damper is returned to a closing position when the motor stops, but is also applicable to a continuously operating stoker. In the latter case a device such as a magnetic clutch, for example, may be provided to permit the damper

to return to its closing position at intervals, say, of a few hours.

The taps 14' provided along the resistance 11 for the connection 14, are to provide for various potential differences between the leads 15 and 26 so that the supply of air to the furnace can be readily adjusted to suit different rates of feed of coal to the furnace. The changes of connection of the lead wire 14 to the different taps 14' can be made manually, as by pivoting the contact arm 14 at one end and causing its other end to sweep over the contacts 14' by being attached to the usual lever (not shown) that is set in different positions to control the rates of feed to the furnace, or its positions may be automatically controlled by a thermostat that is exposed to outside temperatures or by a steam flow meter, for example.

In the embodiment of the invention shown in Fig. 3 the parts that are common to Fig. 2 are indicated by the same reference characters.

The rectangle 40 represents diagrammatically a damper motor of the well known type that is used to regulate the air feed to furnaces. The damper motor 40 has five binding posts or terminals as represented in this rectangle. When it is used in the regular way the terminals designated 41 and 42 are connected to a source of power, and terminal 51 is connected to an arm that is moved by a metallic coil which causes this arm to touch a contact point that is connected to the terminal 50 when it is too hot and to the terminal 52 when it is too cold. When either contact is closed, the motor revolves 180° and stops until the other contact is closed, whereupon the motor revolves 180° back to the starting point. When this damper motor 40 is used in the present invention, the terminals 41 and 42 are connected by connections 43 and 44 to the secondary 45 of a transformer that is kept connected to a power supply, the switch 33 being interposed in the connection 43. A connection 43' is provided for short circuiting the switch 33 for a purpose to be described below. The terminals or posts 51 and 52 are connected together electrically when the motor 40 is used in the present invention, because such a connection is needed to cause the motor to return to the starting point. In view of the fact that this sort of damper motor is well known and constitutes no part of this invention, further description is not deemed necessary.

A magnetic relay 46 having a switch 47 is connected in parallel with the stoker motor S. M. When the stoker motor is operating, the switch 33 is controlled as described in connection with Fig. 2, because the magnet 46 is energized and the switch 47 is raised to disconnect the upper ends of the connections 43 and 43', making the operation of the damper motor 40 depend upon the closing of the switch 33 in the power connection 43 to this motor as described in connection with Fig. 2.

When the thermostat causes the stoker motor S. M. to start, the conditions for causing the relay 20 to operate are the same as in Fig. 2, so that the damper motor 40 starts when the resistance of the coal across the electrodes 1 and 2 is so related to the resistance 24 as to cause the potential of the grid 22 to be low enough, as in Fig. 2.

When the stoker motor S. M. stops due to power being shut off from it, the switch 47 drops, due to deenergization of magnet 46, and connects the connections 43 and 43', thereby short circuiting

the switch 33 and causing power from the transformer 45 to drive the motor 40 and return the damper to its closing position. The connection 48 which is connected to the contact 50, and the connection 49 which is connected to the contacts 51 and 52 are the ones that are ordinarily connected to a wall thermostat. These connections 48 and 49 are connected together by the switch 47 when the stoker motor S. M. starts and causes the damper motor 40 to start so as to open the damper 60 or air feed to the furnace when the stoker motor starts. In this illustration the resistance 24 is indicated as being stationary and the arm 25 is caused to sweep over it as it is attached to the damper motor 40.

The damper 60 is indicated as being connected by a chain 61 to a lever 62, one end 63 of which is adjustable in a slot 64 and the other end of which is connected by a chain 65 to an arm 66 that is provided with a slot 67 for adjusting the damper control, this arm being attached to the damper motor in the usual way, and also being connected to the arm 25 that sweeps over the resistance 24.

When coal of higher electrical conductivity comes into contact with the electrodes 1 and 2, the potential at the grid 22 drops so that current passes through the magnet 20 and the switch 33 closes, thus causing the damper motor to start and shift the arm 25. The movement of the arm 25 causes the arm 66 to move, thus turning the lever 62 and opening the damper 60 further to admit more air for burning the coal of higher electrical conductivity or slower burning quality. When the amount of resistance 24 remaining in series with the coal is reduced to the point where the grid 22 potential stops the current through magnet 20, then the switch 33 is caused to open and cut off power from the damper motor 40 so that it stops in position to cause the proper amount of air to enter the furnace to burn the particular coal that is in contact with the electrodes 1 and 2 at that time.

When the current is cut off from the stoker motor it is also cut off from the relay 46, whereupon the switch 47, by connecting the upper ends of the connections 43 and 43', keeps the secondary 45 connected to the motor damper so that it returns to its original closing position and stops in the usual way with the damper 60 closed, ready to be opened again to the position demanded by the coal when the stoker motor S. M. starts up again.

What is claimed is:

1. The process of regulating the supply of air to a furnace, which comprises feeding coal to said furnace across a pair of separated conductors in an electrical system, and utilizing differences in the electrical resistance of different coals that are being fed to said furnace to change the rate at which air is fed to said furnace.

2. The process of regulating the supply of air to a furnace, which comprises feeding coal to said furnace across a pair of separated conductors in an electrical system in series with a variable resistance, and utilizing differences in the ratios of electrical resistances of different coals that are being fed to said furnace to change the resistance of said variable resistances thus changing the rate at which air is fed to said furnace.

3. The process of regulating the supply of air to a furnace, which comprises feeding coal to said furnace across a pair of separated conductors in an electrical system, and utilizing differ-

ences in the electrical resistance of different coals that are being fed to said furnace to decrease the rate at which air is fed to said furnace in accordance with the increase in the electrical resistance of the coal being fed thereto.

4. The process of regulating the supply of air to a furnace, which comprises feeding coal to said furnace across a pair of separated conductors in an electrical system, and utilizing differences in the electrical resistance of different coals that are being fed to said furnace to set the damper of said furnace to different positions.

5. The process of regulating the supply of air to a stoker-fired furnace, which comprises feeding coal to said stoker across a pair of separated conductors in an electrical system, connecting a source of current to said system when said stoker is operating and cutting it off when said stoker is not operating, and utilizing differences in the electrical resistance of different coals that are being fed to said furnace to change the rate at which air is fed to said furnace.

6. In a device for regulating the supply of air to a coal burning furnace, a pair of spaced-apart electrical conductors, and means connected to said conductors to regulate the air feed to said furnace in accordance with the electrical conductivity of coal bridging across said conductors.

7. In a device for regulating the supply of air to a coal burning furnace, a pair of spaced-apart electrical conductors, and means connected to said conductors to regulate the air feed to said furnace in accordance with the electrical conductivity of coal bridging across said conductors, said means including a variable resistance in series with said conductors.

8. In a device for regulating the supply of air to a coal burning furnace, a pair of spaced-apart electrical conductors, and means connected to said conductors to regulate the air feed to said furnace in accordance with the electrical conductivity of coal bridging across said conductors, said means including a variable resistance in series with said conductors and a source of current for said resistance and pair of conductors.

9. In a device for regulating the supply of air to a coal burning furnace, a pair of spaced-apart electrical conductors, and means connected to said conductors to regulate the air feed to said furnace in accordance with the electrical conductivity of coal bridging across said conductors, said means including a variable resistance in series with said conductors and a motor connected to said resistance.

10. In a device for regulating the supply of air to a coal burning furnace, a pair of spaced-apart electrical conductors, and means connected to said conductors to regulate the air feed to said furnace in accordance with the electrical conductivity of coal bridging across said conductors, said means including a variable resistance in series with said conductors and an electrical valve in parallel with said conductors.

11. In a device for regulating the supply of air to a coal burning furnace, a pair of spaced-apart electrical conductors, and means connected to said conductors to regulate the air feed to said furnace in accordance with the electrical conductivity of coal bridging across said conductors, said means including a variable resistance in series with said conductors, a motor connected to said resistance, an electrical valve in parallel with said conductors, and a relay controlled by said valve to start and stop said motor.

12. In a device for regulating the supply of air to a coal burning furnace, a pair of spaced-apart electrical conductors, and means connected to said conductors to regulate the position of the damper of said furnace in accordance with the electrical conductivity of coal bridging across said conductors.

13. In a device for regulating the supply of air to a coal burning furnace, a pair of spaced-apart electrical conductors, and means connected to said conductors to regulate the air for said furnace in accordance with the electrical conductivity of coal bridging across said conductors.

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