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DRAFT FAN CONTROL CIRCUIT FOR UNDERFEED STOKER FIRED COAL FURNACES

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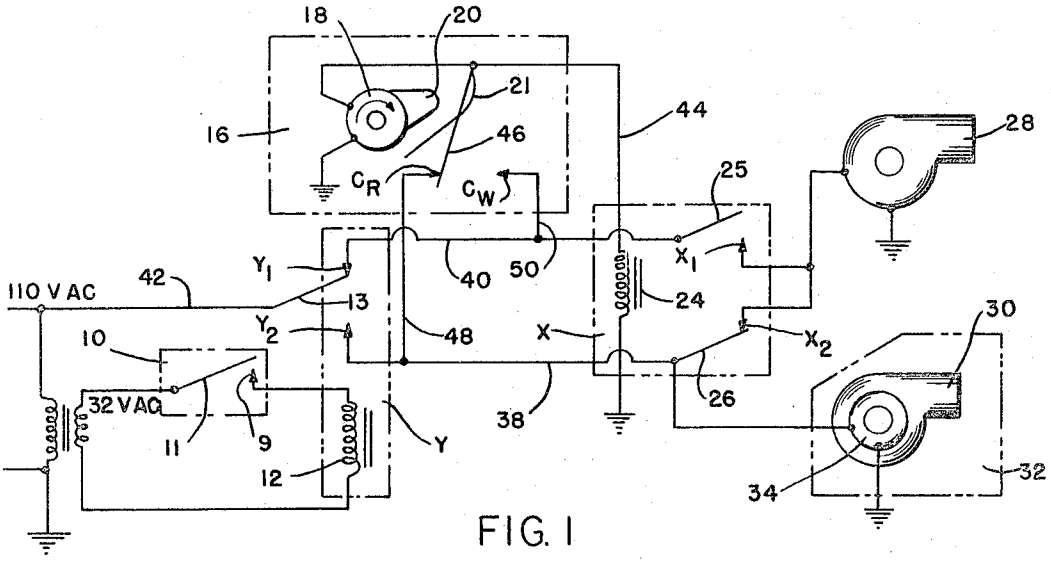

FIG. 1

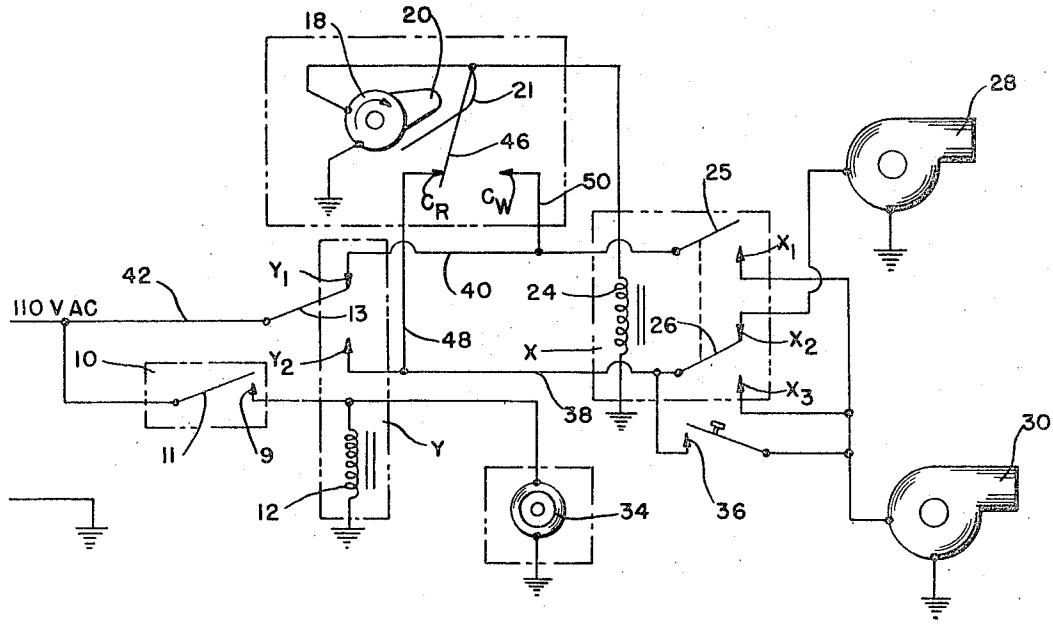

FIG. 2

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DRAFT FAN CONTROL CIRCUIT FOR UNDERFEED STOKER FIRED COAL FURNACES

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This invention relates to an improved draft arrangement and control for solid fuel consuming furnaces and more particularly to automatically timing and varying the furnace draft in relation to the "on" and "off" and heat demand cycles of the furnace.

Coal burning furnaces with underfeed stokers are generally equipped with a draft fan that is generally driven by the stoker motor so that the draft is delivered constantly at full capacity simultaneously with the delivery of the fuel to the fire bed.

It is known that the draft supplied to the fire bed for combustion should be enough to support complete combustion yet be kept low enough in velocity to reduce as much as possible the tendency of fine particles of ash and partially consumed coal to be carried over into the boiler or hot air ducts.

Also, since the widespread introduction and enforcement of strict air polution ordinances, the amount of smoke and soot given off by coal fired furances is critical. Such usually occurs immediately after each start-up and shut-down of the stoker.

In automatically controlled coal fired heating units the feed of the fuel is generally controlled by a temperature sensitive switch such as a thermostat. When significant temperatures fall below a required level heat is demanded of the furnace by the thermostat starting the stoker motor and when temperatures have been restored the thermostat stops the stoker. During the interval that the room is above this predetermined temperature the fire bed is generally kept at a very low fire by the natural draft through the dampers and the fire bed burns down, and the longer the intervals between the demands for fuel feed the thinner the fire bed becomes. Consequently, when the stoker feed is started and simultaneously therewith the full draft is also applied, there is little resistance to the draft as it goes through the thin fire bed. The speed of the air of the draft as it passes through the fire bed permits the air to pick up the small particles of "fly ash" that have not fallen through the fire bed to the ash floor and also allows it to pick up the soot and small coal particles that are introduced with coal and have not had a chance to become fused to the bigger coal. The unrestricted draft blows these particles into the boiler and out the chimney producing a smoke cloud of "fly ash" and unburned particles of the coal.

Along with producing the cloud of particles, the full draft at start-up blows an excess of relative cool air into the furnace, chilling the fire and also reducing the effective temperature within the furnace. This heat potential is carried by the draft out the chimney and wasted to the atmosphere. This lowers the efficiency of the furnace and the heat loss has to ultimately be made up by the additional combustion of more coal.

After the fire bed is built back to its working thickness and the fire is at full capacity, the full draft is required as the fire needs the air supplied by the full draft to support it is in complete combustion as mentioned before. This phase continues until the demand control by the thermostat has been satisfied and the fuel feed is turned off.

As the coal feed stoker and fan are driven by the same motor, a turning off of the stoker also stops the forced draft fan. The only draft remaining is the natural draft

of the furnace. But as the fire bed is still thick with unburned coal at this time, there is a high resistance to the natural draft and it does not supply enough air to support complete combustion. This means that the heat of the burning fire bed on the raw coal that was introduced immediately before the feed was shut off, will heat the coal without burning it, thereby boiling off the volatile gases and coking the coal. The unburned volatile gases pass to the atmosphere through the chimney and produce a dense smoke.

Again the efficiency of the furnace is reduced because the burnable volatile gases are allowed to escape to the atmosphere without utilizing their heating ability and smoke ordinances are further violated.

The foregoing problems produced by the full draft running simultaneously with the feed are well known. Most methods attempting to diminish the problem involve various types of numerous controls that adjust the open and closed position of the dampers to regulate the forced draft. But all damper control devices have the disadvantage of employing some mechanical linkage for positioning the dampers, and as the dampers must be positioned somewhat close to the fire bed, they are easily corroded by the surrounding atmosphere making the small adjustments more difficult and harder to control. Also, no manner of control of the opening and closing of the dampers can provide a sufficient amount of draft to support combustion of the unburned coal after the forced draft has been turned off. Therefore the problem of boiling off volatile gases producing smoke cannot be solved by damper controls.

Accordingly, it is an object of this present invention to provide an improved draft control employing draft fans of a predetermined capacity regulated by an electrical timing circuit to provide a light but firm draft when the coal feed starts and until the fire bed attains its working thickness, then provide a full draft for the duration of the fuel feed, and finally to provide another light but positive draft after the feed stops and until the volatile gases in the remaining coal have been ignited.

It is another object of this invention to povide a draft fan control system that will vary the draft to the fire bed and provide the most efficient conditions for combustion and heat transfer at any and all given times with a minimum amount of heat lost through the chimney the overall efficiency of the furnace is greatly increased without creating smoke and without coking of the coal.

It is another object of the invention to provide a method of producing a variable draft automatically controlled that will reduce the soot and "fly ash" entering the boiler or blown up the chimney and also reduce the amount of volatile gases escaping unburned to the atmosphere, thereby reducing the contamination entering the atmosphere.

It is another object of this invention to provide a draft fan control system which has no movable parts to corrode or become fouled yet will provide a simple, inexpensive, and universal modification of equipment presently in use that will increase their efficiency and provide a method of reducing their exhaust contamination so they can conform to the stricter contamination ordinances.

It is a still further object of this invention to provide a draft control that has a minimum of moving parts and is completely independent of damper control operation so that the controls can be placed at any convenient location and be free from the highly corrosive atmospheres surrounding a furnace.

These being the objects of the invention, other and further objects will be noted from the description to follow

taken in conjunction with the accompanying figures in which:

FIG. 1 is a schematic drawing of the control circuit of the present invention, and

FIG. 2 is a schematic drawing of a modification of the control circuit of FIG. 1.

A draft fan control circuit of the present invention as shown in FIG. 1 can be electrically connected to an underfeed stoker unit conventionally having a forced draft fan that runs when the stoker feed motor is also running. In adapting furnace units presently in use to embody the invention a slight but fixed modification of the present units is made, namely a reduction in the capacity of the draft fan to a fan of approximately 50% capacity, and the provision of an inexpensive second draft fan matching the reciprocal of said approximately 50% capacity. These fans are then controlled as shown in the circuit diagram of FIG. 1. The percentages may be varied as desired to sharpen the results with equipment of various suppliers.

As shown in FIG. 1, the stoker mechanism **32** and one draft fan **30** may be driven by the same motor **34** as is conventional. The draft fan **30** can either be the original equipment regular large fan but with its output cut down or can be a replacement fan for the regular large fan having the desired fraction of the capacity of the large fan replaced. This means that the modifications required to change equipment presently in operation to the automatic control of the draft fans of the present invention is minimal namely cutting down on a fan already there or replacing it and the addition of a small draft fan with an independent motor drive. Provision of a low draft concurrent with the stoker operation is particularly advantageous where automatically timed intermittent feed is employed for sustaining the fire bed during long "off" periods.

The operation of this circuit is as follows:

A thermostat or temperature controlled normally open switch **10** has a switch armature **11** which is closed when the controlling temperature drops below a predetermined minimum. This allows current to pass it and through the coil **12** of an electromagnetic relay switch Y, energizing the coil **12** and thereby closing the switch arm **13** against contact Y_2. Closed switch Y_2 contact passes current from the power line **42** through contact Y_2 and into line **38** from which it flows through the drive motor **34** for both the stoker **32** and the cut down draft fan **30**. This starts both the coal feed and the cut down draft and provides the fire bed with a small initial start-up draft that will not be strong enough to blow the soot and "fly ash" out the chimney but will provide sufficient air for complete combustion.

The current in line **38** also goes to a time switch **16**, such as a Tork Time Switch, model Number 1163–12M 8001, through line **48**. The current in line **48** flows through a time controlled switch arm **46** disposed at rest on contact CR of line **48** and from there through the clock element **18** of the time switch **16**. As long as the switch arm **46** is resting on contact CR the clock is energized and also current can flow to the coil **24** of another electromagnetic relay switch X energizing the coil **24** thereof. Therewith the normally closed switch arm **26** is opened from contact with X_2 and does not allow any current to reach the motor of the second fan **28**. Accordingly at demand start-up the only forced draft supplied to the fire is from the 50% capacity draft fan **30**.

As the demand switch **10** remains closed the time switch **16** receives current through contact CR until the cam **20** driven by the clock motor **18** rotates sufficiently to force the switch arm **46** from contact CR to engagement with the contact *Cw*. The contact *Cw* is not yet supplied with current so the switch arm **46** does not receive any current and the time switch **16** stops. As no current is flowing through the switch arm **46**, the current to the relay switch X is also cut off, de-energizing the coil **24** thereof, allowing the switch arm **26** of the relay switch X to close on the contact X_2, to pass current from the line **38** through the switch arm **26** and into the motor of the second draft fan **28**. With both fans running, a full draft is supplied to the fire bed.

The time switch **16** can be adjusted to provide a predetermined time lapse between closure of the demand switch **10** and the opening of the switch arm **46** of the time switch **16** from engagement with contact CR and making engagement with the contact *Cw*. This provides time for the incoming coal particles to ignite or fuse to larger particles; for the "fly ash" to be shaken to the ash floor by the motion of the incoming coal; and, for the fire bed to recover its working depth. Both fans are then placed in operation to provide the full capacity draft necessary to support the combustion of coal being fed to the fire box as long as the demand switch is closed regardless of the length of time this occurs.

As soon as the heat demand is satisfied, the switch **11** is opened by the thermostat control, thereby stopping the current flow through the coil **12** to de-energize the electromagnetic relay switch Y. The switch arm **13** of the relay Y breaks away from Y_2 and returns to its normal position against contact Y_1 and line **38** does not receive any more current and therefore the motor drive **34** of the stoker **32** and the draft fan **30** does not receive any current and both stop running. Engagement with contact Y_1 by the switch arm **46** of the time switch **16** simultaneously supplies current through lines **40** and **50** to contact *Cw* and the clock element **18** and cam **20** of the time switch **16** are again activated. Also, current again flows to the coil **24** of the electromagnetic relay switch X, energizing the coil **24** and opening the switch arm **26** of the X relay and closing the switch arm **25** on the contact X_1 of the X relay. This allows the current in the line **40** to flow through the X relay switch at X_1 and into the second draft fan **28** so that a small draft is provided to support combustion of volatile gases emitted from the fresh coal that had entered the fire bed just prior to the feed being turned off.

Again the clock element **18** of the time switch **16** is set for a predetermined lapse of time for burning the escaping volatile gases before the cam **20** has turned sufficiently to allow the switch arm **46** of the time switch **16** to open at the contact *Cw* and close at the contact CR. The time lapse can be manually adjusted so that the switching occurs at the average time it requires for the volatile gases of the fresh coal to have been burned. After the switch arm **46** of the time switch snaps back to the contact CR the clock element **18** is stopped and the coil **24** of the electromagnetic relay switch X is de-energized as the contact CR is connected to an open line **38**. When the coil **24** of the X relay is de-energized the switch arm **25** opens from the contact X_1 and stops the draft fan **28**. Thus, at this point no fuel feed or forced draft is supplied to the fire bed and it is allowed to burn at its low rate as supported by the natural drafts until the thermostatic demand switch **10** again is closed and the cycle explained is repeated.

FIG. 2 refers to a circuit diagram basically the same as that shown in FIG. 1 except the position of the draft fan contacts within the X relay switch have been changed to provide more versitility for the circuit with two motor fans separate from the stoker motor. As will be seen by following this circuit, one fan can be used to provide a forced draft during the initial feed period; the full combustion period; and, during a short period of time after the feed has stopped so that a fan of any desired percentage of a theoretical full draft down to the minimum draft can be employed with the remaining fan running only during the full combustion period to bring the draft capacity up to the full 100% capacity draft during the full combustion period.

The circuit as shown in FIG. 2 first with the manual switch **36** closed operates in the following manner:

As previously explained, closing the temperature con-

trolled demand switch **10** starts the cycle by energizing the Y relay switch and in this circuit, the stoker motor **34** is connected directly to the demand switch **10** and begins the feed of coal with the closing of the demand switch **10**. Closing the contact switch arm **13** on the contact Y_2 of the Y relay allows current to flow through the line **38** and with the manual switch **36** closed, the small capacity draft fan **30** also starts simultaneously with the feed. At this time, as explained in FIG. 1, the coil **24** of the X relay is also energized, opening the switch arm **26** and the contact X_2 of the X relay. This status continues and the draft fan **28** is the only draft fan operating until the cam **20** of the time switch **16** snaps the switch arm **46** of the time switch **16** from the contact CR to contact *Cw*. When the switch arm **46** of the time switch **16** is cammed to engage the contact *Cw* the X relay is de-energized and the switch arm **26** of the X relay closes on the contact X_2 and current will flow to the second draft fan **28**. Current is still flowing through the manual switch to the draft fan **30** so that during this period both fans **28** and **30** are running to provide in combination a full draft to the fire bed.

Camming the switch arm **46** of the time switch **16** from the contact CR to the contact *Cw* shuts off the current to the clock elements **18** stopping it so that the cam **20** holds the switch arm **46** of the time switch **16** on the contact *Cw*. Therefore the full draft and fuel feed as just explained continues until the heat demand is satisfied and the switch arm **11** of the switch **10** opens to de-energize the coil **12** of the Y relay switch and also stop the flow of current to the stoker motor **34** whereby fuel feed is stopped. The switch arm **13** of the Y relay returns to its normal position on the contact Y_1 thereby stopping the current in the line **38**; in turn stopping the draft fan **28**; and directing the current flow through the line **40**. With the current flowing through line **40** and the switch arm **46** of the time switch **16** on the contact *Cw* as explained above; the time switch **16** again starts to run; the coil **24** of the X relay is again energized; and the switch arm **25** closes on the contact X_1 of the X relay allowing the current in line **40** to go to the draft fan **30**, making it continue to run.

The draft fan **30** and the clock **18** of the time switch **16** continue to run a pre-determined length of time controlled by the cam **20** of the time switch **16**. When the cam **20** has rotated sufficiently to allow the switch arm **46** of the time switch **16** to snap back to the contact CR the current to the time switch **16** and current to the coil **24** of the X relay is stopped, de-energizing the coil **24**. Thus, the switch arm **25** of the X relay is opened from the contact X_1 and the draft fan **30** stops. At the end of this period the circuit is at its initial position, ready for a repeat of the cycle when further demand is made by the thermostat **10**.

Using the circuit of FIG. 2 with the manual switch **36** closed as explained above permits the use of one draft fan **30** to provide the initial draft at the beginning of the fuel feed; a part of the full draft during full combustion; and the partial draft continuing for a short period after the fuel feed has stopped.

Employing the same circuit of FIG. 2 and opening the manual switch **36** changes this relation only in that the draft fan **30** will not run during the full combustion period. The draft fan **30** will run during the period of initial fuel feed by the current flowing through the switch arm **26** closed on the contact X_3 of the X relay, and during the period after the fuel feed has stopped receiving current through the switch arm **25** closed on the contact X_1 of the X relay. The contacts X_3 and X_1 of the X relay are both open during the period of full combustion with current flowing through the contact X_2 running only the draft fan **28** during this period. Thus the draft fan **28** can be a full draft fan allowing the original full size draft fan of the furnace to be employed at full capacity, with the secondary draft fan **30** being of any desired optimum capacity to provide a forced draft only on start-up of the fire during the initial feed and also during a short period after the fuel feed has stopped.

It is seen that by employing either of the above circuits of FIG. 1 or FIG. 2 a draft fan arrangement and control is provided, that can be incorporated with existing coal burning furnaces fed with underfeed stokers, utilizing the present equipment of the system making the modifications with some additional minor equipment, thereby simple and relatively cheap.

It is also seen that the draft fan control and arrangement just described provides an automatic regulation of the forced draft delivered to a solid fuel consuming furnace that will supply the varying draft requirement necessary to support complete combustion of the fuel without supplying an excessive forced draft that would tend to blow small particles of ash and soot out the chimney. Thus by eliminating the discharge of the fine particles of "fly ash" and soot to the atmosphere and at all times providing a sufficient quantity of air to support complete combustion, thereby reducing the discharge of unburned volatile gases to the atmosphere, the furnace units can operate within the rigid requirements of the anti-air polution ordinances. Also, the induction of air by a forced draft that is just sufficient to support complete combustion eliminates an excessive cooling of the fire bed and furnace that occurs when such is supplied with a larger draft than required. Thus the described draft fan control and arrangement will also increase the overall efficiency of a furnace unit employing it.

Having thus described the invention and the desirable characteristics and advantages thereof, it will be apparent to those skilled in the art that various and further changes can be made within the stated objects without departing from the spirit of the invention, the scope of which is commensurate with the appended claims.

What is claimed is:

1. A draft control circuit for a stoker-fed coal-fired furnace having a stoker, a plurality of fractional blowers compositely supplying a full forced draft to said furnace,

thermostat means having a two position heat demand which means including connections arranged to activate the stoker and one of the blowers in its heat demand position,

timer means having a two position switch controlled thereby including connections to the heat demand switch means arranged to activate the timer means for a predetermined period of time in one of its positions at the start of said heat demand position and for a subsequent predetermined period of time when the thermostat means and said heat demand switch means resume their other position, and

relay means including connections to the timer means arranged for energization and deenergization concurrently with activation of said timer means and including two switches and connections therefrom to the blowers arranged to activate said blowers independently,

said heat demand switch in its said other position and said timer means switch in the other one of its positions energizing said relay means to close one of its switches to activate the other of said blowers in series with said heat demand switch and timer means switch in their said other positions whereby a partial draft is supplied whenever the timer means is energized.

2. A draft control circuit for a stoker-fed coal-fired furnace having a stoker, a plurality of fractional blowers compositely supplying a full forced draft to said furnace,

a heat demand means including a relay having a switch closed when energized and a connection therefrom to said stoker and one of said draft blowers,

timer means connected to said closed switch for activation thereby and including a switch closed after a predetermined running time of the timer means,

means interconnecting said closed switches and the other one of said blowers in series to activate the latter whereby a fractional draft is supplied to the furnace during the activation of the timer means and a full forced draft is supplied to the furnace thereafter during head demand.

3. A forced draft control for use with a coal-fired stoker-fed furnace having a stoker,

a plurality of fractional draft blowers for compositely supplying a full forced draft to said furnace,

a heat demand switch means,

a timer means having connections to and controlled by said switch means and including a switch having two positions,

said switch means activating said timer means through said timer switch in either position and said timer switch deactivating said timer means when moved by the timer means to its opposite position,

conductor means interconnecting said switch, switch means and blowers and arranged to control said blowers selectively,

said timer switch activating one of said blowers and said stoker while the timer means is activated with its switch in one position in series with the switch means in its heat demand position,

said switch means and said timer switch actuating both of said blowers and said stoker while the timer is deactivated by its switch being moved to its other position with the switch means in heat demand position, and

said timer switch in said other position energizing said timer means and one of said blowers alone when the switch means is deenergized whereby a partial draft is supplied when the timer is energized and another partial draft is supplied for a short period after the heat demand has ceased.

4. In a draft control for hard fuel burning furnaces having a motor driven underfeed stoker, the combination of

two blowers for supplying compositely the forced draft required for the furnace with each supplying a fraction thereof,

means for energizing said stoker motor including a two position temperature controlled heat demand switch,

a timer energized by said demand switch and having alternately closed switches one of which is closed when the demand switch is in its alternate position,

connection means arranged for energizing one of said blowers in series with said heat demand switch when in heat demand position,

connection means for energizing the other of said blowers including a relay controlled through the other of said timer switches and having a switch closed when energized, said relay being connected in series with the timer switches, and said relay switch being connected in series with the stoker, with one of the blowers and with the heat demand position of the heat demand switch.

5. In a circuit for controlling a plurality of draft blowers each providing a fraction of the full forced draft and a stoker motor for a solid fuel burning furnace the combination of

a temperature controlled means having a first switch means closed upon heat demand,

a first relay connected to and energized by said first switch when closed and having a two position second switch means with one position connected to the stoker and to one blower when the relay is energized,

a timer means operating a two position third switch means and including connections therebetween arranged to activate the timer means in both positions in combination with connections between the first and second switch means in which said one position of the second switch is connected to the open position of the third switch to deactivate the timer, said third switch being opened at the end of a predetermined prior of time in the timer cycle, and the other two switch positions of the first and second switch means being connected together, and

a second relay connected to said third switch and energized concurrently with said timer means and including a two position fourth switch means energizing said other blower whereby a full draft is supplied whenever the first means is closed upon heat demand and the timer is deactivated, said predetermined period of time being set by manual adjustment of said timer.

6. A draft control for a stoker-fed coal-fired furnace having a plurality of fractional blowers compositely supplying a full forced draft to said furnace,

a stoker,

heat demand means having a two position switch including connections with said stoker and blowers arranged to activate the stoker and both of the blowers while in its heat demand position,

timer means having a two position switch and including connections between said switches arranged to activate the timer means and deactivate one of said blowers for a predetermined period of time when said timer switch is in one position at the start of said heat demand means, and thereupon reverse the position of said timer switch to deactivate the timer means and activate said deactivated blower, said heat demand means reversing the position of its switch at the end of the heat demand prior to deactivate said stoker and blowers, and said timer means connections to said heat demand switch being arranged to activate said timer means with both said switches in their other positions and activate one of said blowers for a predetermined time whereby a partial draft is supplied whenever the timer means is energized.

7. In combination with an electrically powered coal-fired furnace having a stoker

a plurality of fractional capacity blowers compositely supplying a full forced draft to said furnace,

a plurality of motor means, one of which simultaneously operates said stoker and one of said blowers and another one of which operates the other blower,

a timer including switch means having alternate positions,

a first relay including switch means having alternate positions,

a second relay including switch means, having alternate positions,

means interconnecting said switch means in one of their respective positions and to a source of electric power and arranged to energize the second relay, said timer and both of said motor means when said first relay is energized,

means interconnecting said switch means in their alternate positions being connected together and to said source of electric power and arranged to energize said other motor means when said first relay is deenergized and said second relay is energized,

thermostat means including a switch and a connection arranged to energize said first relay during heat demand upon the furnace, and

said timer moving its switch means from its one position to its other position to deenergize itself and said second relay until said first relay is deenergized by said thermostat.

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KENNETH W. SPRAGUE, *Primary Examiner.*