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FURNACE CONTROL SYSTEM WITH DUAL SPEED BLOWER

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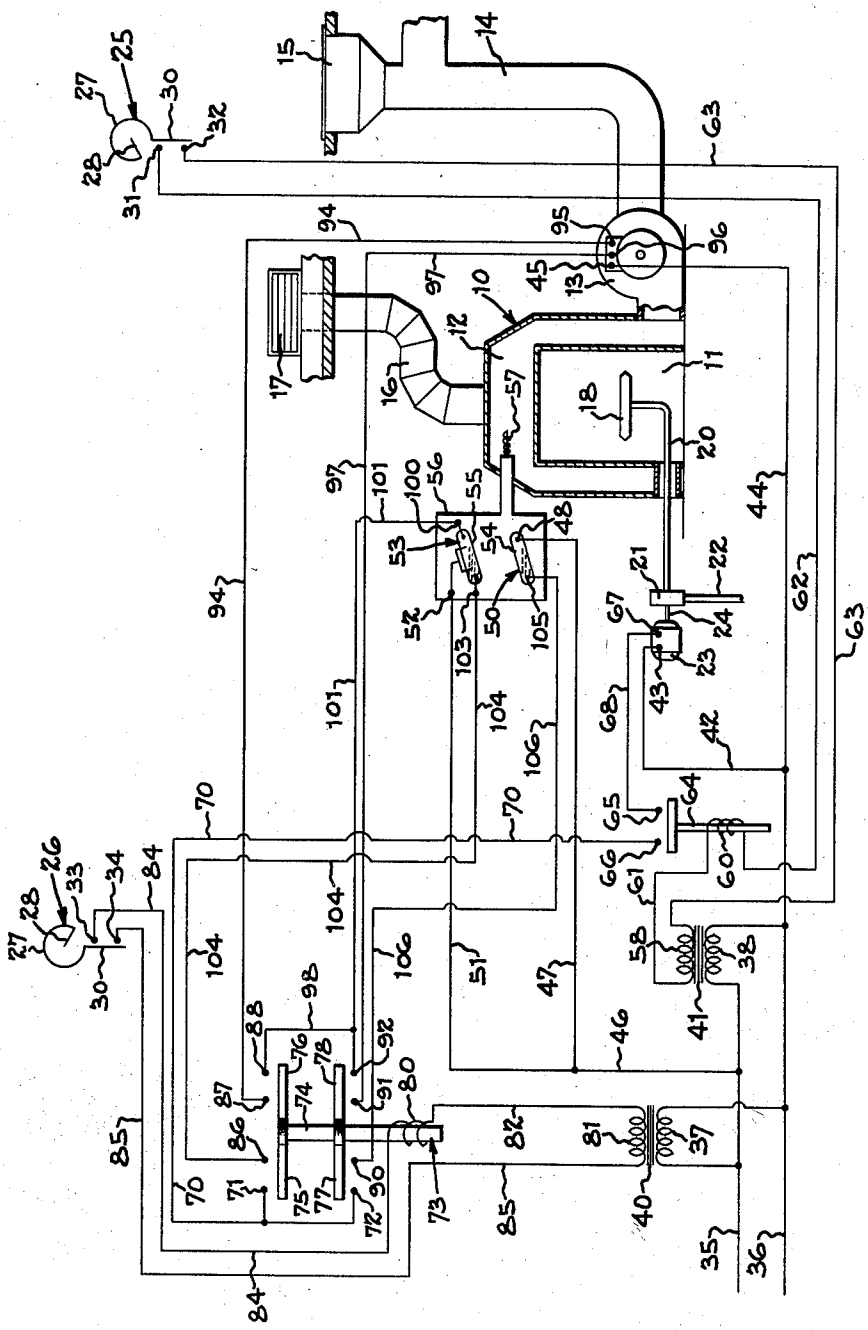


Fig. 1

INVENTOR.
William H. Calahan.
BY
Wood, Herron & Evans.
ATTORNEYS.

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FURNACE CONTROL SYSTEM WITH DUAL SPEED BLOWER

William H. Calahan, Fort Thomas, Ky., assignor to The Williamson Company, a corporation of Ohio

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The present invention relates to forced air heating apparatus, and is particularly directed to a system for automatically controlling the operation of a furnace burner and an associated blower so that the heating apparatus is effective to maintain a uniform temperature within the space being heated.

At the present time many furnaces are provided with apparatus for automatically supplying a fuel such as oil, gas or coal to a furnace whenever the room temperature drops below a predetermined level and for stopping the input of fuel when the room temperature again reaches the predetermined level. One of the principal differences inherent in these systems is that the temperature is not kept uniform throughout the space being heated. This is especially true during warm weather when conventional heating apparatus supplies a short blast of very hot air to the room, opening the room thermostat before the air in many parts of the room has become heated. With previous heating systems these cool areas must be tolerated or else the temperature of other parts of the room must be raised to an uncomfortable level.

A further disadvantage of previous heating control systems is that there is a tendency for the temperature in the room to overshoot the desired level during each operating cycle of the furnace. The wide temperature fluctuations which thus result not only cause substantial discomfort to the occupants of the room, but also cause very inefficient operation of the heating system. It will readily be appreciated that while a certain amount of heat is dissipated from a room kept at a predetermined temperature, 72° for example, a very much larger amount of heat is lost when the room temperature overruns the desired level and rises to 80° for instance.

The principal object of the present invention is to provide a control system for a furnace and blower unit which is effective to regulate the operation of the furnace and blower so that the temperature within the space being heated is maintained at all times at substantially the desired level. Consequently, the air within the room never becomes overheated to cause either discomfort to the occupants or excessive heat loss to the outside air.

The present invention is predicated upon the concept of providing a control system for a forced air furnace which in mild weather terminates the burner operating cycle whenever the temperature of the heated air reaches a moderate preselected, or "low limit," value, for example 150°. The burner operating cycle is thus terminated, even though the heat requirements of the room have not been filled and the room has not reached the desired temperature. The blower, during mild weather, is operated at its lower speed and supplies a moderate volume of warm air to the room. In the present system, the blower continues to operate for a period after the burner has been shut off, more particularly, until the air temperature in the furnace drops to a relatively low level, such as 110°.

I have found that often during this period, when only the blower is operating, sufficient heat is supplied to the room to satisfy its requirements; whereas, if the

burner were operated until the room heat requirements were satisfied, the blower, during its period of operation, would then deliver a substantial surplus of heat to the room, causing the room temperature to overrun its desired value by an appreciable amount. In cold weather, however, the burner operation is terminated only when the room temperature is satisfied, or the air temperature exceeds a high safety limit, and the blower is operated at its higher speed to supply a large volume of very warm air to the room. During cold weather the heat losses of the room are sufficiently large so that the heat supplied by the blower after the burner ceases operation is not greatly in excess of the heat loss of the room, and consequently, no large temperature overrun is caused.

More specifically, a heating system constructed in accordance with the present invention comprises a furnace including a burner, such as an oil burner or a gas burner, and a blower operable at either of two speeds. The blower preferably draws cold air from the room and forces it through the plenum chamber of the furnace where it is heated and from which it passes into the rooms of the house. A control circuit is provided for regulating the operation of the burner and blower, or more precisely, the blower and the supply of fuel to the burner.

The control circuit includes two thermostats, an outdoor thermostat and a room thermostat. The outdoor thermostat is adjusted to close at a selected outdoor temperature, for example 20°. This particular temperature, as will be explained below, is the temperature at which the manner of operation of the heating system is changed from one particularly adapted for mild weather to one particularly adapted for very cold weather. In any installation the optimum temperature at which this change should be made depends upon may factors, such as the size of the house being heated, the size of the furnace and the capacity of the blower. The room thermostat is readily adjustable and can be set to close whenever the temperature in the room drops below a comfortable level, such as 72°. The room thermostat functions to close a circuit for operating the burner and consequently the blower. The outdoor thermostat conditions the control circuit so that in mild weather the operation of the burner, which is initiated by the closure of the room thermostat, is terminated whenever the air in the plenum chamber reaches a moderate value, while in extreme weather the operation of the blower is terminated only when the room temperature reaches the selected level, or the air in the furnace exceeds a maximum safe value. The outdoor thermostat also conditions the blower circuit so that the blower is operated at low speed in mild weather and at high speed in cold weather.

In mild weather, if the room temperature is not satisfied when the burner operating cycle is terminated by the temperature rise within the plenum chamber, the blower will continue to operate, transfering heat stored in the furnace to the room. If the room temperature is not raised sufficiently by this additional heat, the fuel supply means is re-energized when the plenum chamber temperature drops to a value somewhat below the moderate, or low limit, value at which the fuel supply means was de-energized.

One of the principal advantages of the present system is that temperature overruns are substantially eliminated, especially during mild weather when they are normally most noticeable. The elimination of appreciable overruns is largely due to the fact that in mild weather the plenum temperature is kept at relatively low values. Consequently, only a small amount of heat is stored in the furnace walls during the periods of burner operation, and there is no accumulation of a tremendous quantity

of heat which must either be supplied to the room or wasted when the burner is shut off.

Furthermore, the burner operation is terminated in response to a rise in the temperature of the plenum chamber, independently of the room temperature. Consequently, a large portion of whatever heat is stored in the furnace is supplied to the room by the blower before the burner can again be operated. I have found that even though the burner is shut off while the room is still below the desired temperature, it often has already produced all of the required heat and when the heat stored in the furnace is supplied to the room it is effective to raise the room temperature the final amount needed to bring it to the desired level. If, on the other hand, the burner had operated until the room was at the desired temperature, this stored heat could only cause an appreciable temperature overrun.

A still further advantage of the present invention is that it provides extremely efficient operation of the heating system. A maximum amount of the total heat generated by the burner is utilized. For not only is the heat produced by the burner during its operation transferred to the room; but at the end of each burner operating cycle a maximum amount of the heat stored in the furnace is utilized to heat the room. Moreover, in the present heating system the delivery of this heat to the room does not result in an appreciable temperature overrun, so that the heat is not wasted through accelerated heat loss from the room.

Another advantage of the present heating system is that in moderate, as well as in cold weather, the temperature within all portions of the space being heated remains uniform. That is, during moderate weather a small volume of air is supplied to the room so that the air has time to circulate thoroughly throughout the room, heating all portions of it at the same rate at which the thermostat is heated. The room is thus free from any cold areas, since by the time the room thermostat has closed, the entire room has been evenly heated to the desired temperature.

A still further advantage of the present invention is that the control system comprises a minimum number of control elements and hence is both economical to install and is extremely reliable in operation.

These and other advantages of the present invention will be apparent from a consideration of the following detailed description of the drawings illustrating a preferred embodiment of the invention.

In the drawings:

Figure 1 is a diagrammatic view of a heating system constructed in accordance with the present invention, together with a superimposed schematic circuit diagram of the control apparatus.

As shown in Figure 1, a heating system constructed in accordance with the present invention includes a furnace **10** having combustion chamber **11** disposed interiorly of a warm air duct or bonnet **12**. Warm air is supplied to bonnet **12** by a blower **13** which draws air through a cold air return air duct **14** having a register **15** opening into a room. The air discharged into the bonnet from blower **13** is heated and forced through warm air duct **16** to register **17** disposed within the rooms being heated.

Combustion chamber **11** houses a burner **18** which may be of any conventional construction adapted to burn a fuel such as gas or oil. In the present embodiment burner **18** is an oil burner supplied with fuel oil by means of pipe **20** interconnecting the burner with a pump **21**. The pump is effective to draw oil from a reservoir (not shown) through pipe **22** and supply it to the burner **18** under the proper pressure. Pump **21** is driven by means of an electric motor **23** mechanically connected to the pump through any suitable coupling **24**.

The control apparatus for the furnace includes a room thermostat **25** located within the room being heated and an outdoor thermostat **26** located exteriorly of the building, preferably along a north wall thereof. These thermostats can be of any suitable type comprising for example a bimetallic strip **27** having a stationary portion **28** and a movable contact arm **30** which shifts toward and away from two stationary contacts in accordance with temperature changes of the surrounding air. The contact arm **30** of the room thermostat is adapted to complete a circuit across contacts **31** and **32** when the temperature drops below a selected value, for example 72°. Similarly, outdoor thermostat **26** is adapted to close a circuit between contacts **33** and **34** whenever the outdoor temperature drops below a predetermined value, for example 20°.

Voltage for the control system is taken from house main lines **35** and **36**, line **36** preferably being the grounded connection. Primary windings **37** and **38** of step down transformers **40** and **41** are connected across these lines. Line **36** is also connected through lead **42** to terminal **43** of motor **23** and through lead **44** to common terminal **45** of blower **13**. Line **35** is joined through leads **46** and **47** to terminal **48** of high limit switch **50** and through lead **51** to terminal **52** of combined low limit and blower switch **53**.

High limit switch **50** and low limit-blower switch **53** are thermostatic switches including a temperature sensitive element in communication with the plenum chamber of the furnace. These switches may be of any suitable construction including, for example, stationary contacts and a movable bimetallic element. However, in the embodiment shown, high limit switch **50** and low limit-blower switch **53** include mercury filled bulbs **54**, **55**, mounted on a frame **56** connected to a helical thermostatic strip **57**. As the temperature within the plenum chamber rises, helical strip **57** causes mercury bulbs **54** and **55** to tilt, closing the switches in a manner to be explained later.

The secondary winding **58** of transformer **41** is connected through lead **61** to relay coil **60** which is in turn joined to contact **31** of the room thermostat **25** through lead **62**. The other contact **32** of the room thermostat is returned to primary **58** through lead **63**. The energization of relay coil **60** controls the movement of armature **64** which is adapted to bridge contacts **65** and **66** when the relay coil is energized by the closure of the room thermostat. Contact **65** is joined to terminal **67** of motor **23** through line **68**, while contact **66** is connected through line **70** to contacts **71** and **72** of conditioning relay **73**. Relay **73** comprises armature **74** carrying four insulated contact arms **75**, **76**, **77**, and **78**. Control coil **80** of the relay is connected to secondary **81** of transformer **40** through lead **82** and to contact **33** of the outdoor thermostat **26** through lead **84**. Contact **34** of the room thermostat is returned to the opposite side of secondary winding **81** through connector **85**. Conditioning relay **73** is constructed so that when coil **80** is de-energized, arms **75** and **76** respectively bridge contacts **71** and **86**, **87** and **88**; and when coil **80** is energized, arms **77** and **78** respectively bridge contacts **72** and **90**, and **91** and **92**.

The function of relay **73**, as will be explained in greater detail below, is to condition the control apparatus so that when the outdoor temperature is mild, that is, above a predetermined value, such as 20°, the low limit switch de-energizes the pump motor **23**, stopping the operation of burner **18** whenever the air temperature in the plenum chamber reaches a predetermined value. Relay **73** also functions to condition the blower energization circuit so that the blower operates at low speed whenever the air in the plenum chamber is warm enough to close the blower switch. On the other hand, when the outdoor temperature is below 20°, relay **73** conditions the circuit so that the blower **13** is operated at a high rate whenever the blower switch is closed, and additionally, the low limit switch is removed from the pump motor circuit so that for practical purposes the burner is operated until the room thermostat is satisfied, or alternatively until the air temperature in the plenum exceeds the setting of the

high limit safety switch, which setting is generally in the neighborhood of 250°.

The circuit arrangement by which relay **73** is effective to cause the described operation includes lead **94** interconnecting contact **87** and low terminal **95** of the blower. High terminal **96** of the blower is joined to contact **91** through connector **97**. Contacts **88** and **92** are tied together by conductor **98** and are joined to contact **100** of the low limit-blower switch through lead **101**. The third terminal **103** of the low limit-fan switch is joined to contact **86** by connector **104**; and terminal **105** of the high limit switch is connected to contact **90** through lead **106**.

The low limit portion of switch **53**, including contacts **103** and **52**, is normally closed and should be set to open when the air temperature within the plenum chamber reaches a value at which it is effective to convey a moderate amount of heat into the room. This value is not absolutely critical, but preferably is generally of the order of 50 percent of the maximum air temperature which the furnace can produce. It have found that a temperature setting of approximately 150°, provides very effective operation. Once the low limit switch has opened it preferably does not close again until the plenum temperature drops approximately 15° below the temperature at which the switch is set to open; in the present embodiment this temperature is 135°. The blower controlling portion of switch **53** including contacts **103** and **52** should be set to close at a plenum chamber temperature some what less than the low limit temperature, for example 110°. That switch should also be adjusted so that it opens when the temperature in the plenum chamber drops to a still lower value, for example 90°, following operation of the burner. The high limit safety switch is preferably adjusted so that it opens at around 250°.

When both the room thermostat and outdoor thermostat are open, it can be seen that neither the pump nor blower is energized. The motor circuit is open at relay armature **64** since coil **60** of that relay is de-energized because of the condition of room thermostat **25**. Similarly, since the air temperature in the bonnet **12** is below 110°, the blower circuit is open at blower switch **53**. However, when the room thermostat is closed, the circuit to relay coil **60** is completed and armature **64** bridges contacts **65** and **66**. This completes the circuit to motor **23** through leads **42**, **68**, **70**, relay arm **75** bridging contacts **71** and **86**, lead **104**, low limit switch **53**, and leads **51** and **46**.

When the air within the plenum chamber is heated, to 110° due to the operation of burner **18**, a circuit is completed through contacts **103—52** of fan switch **53**, low limit contacts **100—52** remaining closed. The closure of the fan switch completes the circuit to the low speed terminal **95** of the blower **13**. It will be understood that blower **13** is provided with a two speed motor which operates at one speed when the circuit to terminal **95** is completed and is operated at an appreciably higher speed when the circuit to terminal **96** is completed. The blower is thus effective to supply either a moderate or a large volume of heated air to register **17**, depending upon which of the motor terminals is energized. When the blower switch is closed the circuit to terminal **95** is completed through lead **94**, relay arm-bridging contacts **87** and **88**, lead **93**, blower switch **53** and conductor **51**. The other blower terminal **45** is connected to ground power line **36** at all times.

When the outdoor thermostat is closed, energizing coil **80** of circuit conditioning relay coil **73**, armature **74** is urged downwardly so that arms **77** and **78** engage their respective sets of contacts. With the relay armature in this position and the room thermostat closed, the circuit to motor **23** is completed through lead **68**, relay arm **64**, line **70**, relay arm **77** bridging contacts **72** and **90**, connector **106**, high limit switch **50** and leads **47** and **46**.

When the burner **18** has heated the air in plenum chamber **11** to 110°, the blower switch closes, completing the circuit to the high speed blower terminal **96**, it being noted that the circuit to the low speed blower terminal remains open at contacts **87** and **88** of the conditioning relay. The circuit to high speed terminal **96** includes lead **97**, relay arm **78**, line **101**, blower switch **53**, and leads **51** and **46**. With the outdoor thermostat closed, the burner continues to operate until the room thermostat opens or until the air within the plenum chamber reaches the high limit setting, preferably of the order of 250°. At this time high limit switch **50** is actuated, opening the circuit to pump motor **23**. However, the blower continues to operate at high speed until the temperature in the plenum chamber drops below 90° at which time the blower circuit will be opened at blower switch **53**.

In operation, so long as the room temperature is above the desired level, for example 72°, neither the blower nor the pump motor is operated, the circuit to the blower being open at fan switch **53** and the circuit to the pump motor being open at relay armature **64**. Assuming that it is a relatively mild day with the outdoor temperature above the 20° setting of thermostat **26**, the outdoor thermostat is open, relay coil **80** is de-energized, and the armature **74** of circuit conditioning relay **73** is in its upper position.

When the temperature within the room drops below the room thermostat setting of 72°, room thermostat **25** closes, completing the circuit to relay coil **60**, thus forcing armature **64** into engagement with contacts **65** and **66**. This completes the circuit to pump motor **23** and burner **18** is thereby provided with fuel. Operation of burner **18** causes the temperature of the air within the plenum chamber to rise and when this air reaches a temperature of 110° corresponding to the setting of blower switch **53**, that switch is tripped, completing the circuit through relay **73** to the low speed terminal of the blower. The blower thus begins to supply a moderate quantity of warm air to the room. Burner **18** will continue to operate until the occurrence of either one of two events. In the first place, if the heat requirements of the room are not met, that is the room temperature is not raised above 72°, continued operation of the burner causes the temperature in the plenum chamber to rise until it reaches the low limit setting of 150°. At this temperature, the low limit switch is actuated, opening the circuit to motor **23**. This terminates the operation of burner **18**. However, during its period of operation the burner has been effective to generate a quantity of heat now stored in chamber **11** and in the furnace walls. This heat is effectively supplied to the room by the continued operation of the blower, which is terminated only when the temperature in the plenum chamber drops below 90°, opening the blower switch.

However, if the room temperature is not raised to the desired level by the time the plenum chamber temperature drops below 135°, low limit switch **53** is again closed to restore the circuit to the pump motor and start burner **18** in operation again. The operation of the burner will continue until either the air temperature in the plenum rises above 150°, or alternatively, until the heat requirements of the room are satisfied and thermostat **25** opens to break the motor circuit at relay armature **64**. It has been found that frequently the room thermostat, which is still closed when the burner operation is stopped by switch **53**, will be opened by the time the plenum temperature drops to 135° indicating that a sufficient amount of heat has been supplied to the room by the blower. In this case the burner is not re-energized when the plenum temperature drops, but nevertheless a small amount of heat is still supplied to the room by the continued blower operation. In mild weather this small amount of heat only slightly exceeds the rate of heat loss from the room so that no excessive temperature fluctuation is caused, although a maximum amount of the

heat produced by the burner during its period of operation is utilized.

If, instead of being mild, the outdoor temperature is below 20°, thermostat **26** is closed, energizing coil **80** of the conditioning relay. When the room thermostat closes, pump motor **23** is energized, and the high speed terminal of the blower motor is connected in series with blower switch **53**. The circuit to this terminal is completed when burner **18** raises the air temperature in the plenum chamber to 110°, at which time the blower switch is closed, and the blower supplies a high volume of air to the room. Under these conditions, the burner continues to operate until either the room temperature rises above 72°, opening thermostat **25** and relay armature **64**, or the plenum chamber exceeds the high limit safety setting of 250°. However, even after the operation of the burner is terminated, the fan will continue to operate, delivering a high volume of heated air to the room until the temperature in the plenum chamber drops below 90°. Since during colder weather the heat losses from the room are large, even this increased volume of air supplied to the room after it has reached the desired temperature, does not convey heat to the room at a rate greatly in excess of the heat loss. Consequently, undue temperature fluctuations in the room are avoided in cold weather as well as in mild weather; yet substantially all of the heat generated during the operation of the burner is utilized.

From the foregoing description of the general principles of my invention and the detailed disclosure of a preferred embodiment, those skilled in the art will readily comprehend the various modifications to which my invention is susceptible. For example, while I have shown but a single outdoor thermostat controlling a single conditioning relay to place a low limit switch in the fuel pump energization circuit, several thermostats, conditioning relays, and limit switches could be employed. That is, a plurality of outdoor thermostats, each set at a different temperature, could be provided, each thermostat governing the operation of a conditioning relay effective to insert a limit switch having a unique temperature setting in circuit with the burner fuel supply pump. Consequently, burner operation would be terminated at one of a plurality of different plenum temperatures in accordance with the outdoor temperature. If desired, a multispeed fan could be used in conjunction with this arrangement so that various fan speeds could be employed to match the various plenum temperatures.

Furthermore, while in the embodiment shown the burner operation is regulated by control of a fuel pump motor, it will be appreciated that other electrically actuated control means could be used. For example, if a gaseous fuel is to be burned, leads **42** and **68** could be connected to an electrically responsive valve rather than to pump motor **23**.

Having described my invention, I claim:

1. A control system for a furnace including a burner, electrically responsive means for supplying fuel to the burner and a blower effective to force air through the furnace into a room, said blower being selectively operable at either a low speed or a high speed, said control system including a room thermostat in circuit controlling relationship with said fuel supply means, low limit switch means in circuit controlling relationship with said fuel supply means, said switch means being adapted to open at a predetermined furnace temperature and being adapted to reclose at a lower furnace temperature, an outdoor thermostat, means responsive to the condition of said outdoor thermostat for removing said low limit switch means from circuit controlling relationship with said fuel supply means when the outdoor temperature drops below a predetermined level, blower switch means in circuit controlling relationship with said blower, said blower switch means being adapted to close at a temperature lower than the temperature at which said low limit switch recloses, means responsive to the condition of said outdoor thermostat in circuit connection with said blower for conditioning said blower for operation at either a high speed or a low speed in response to the closing of said blower switch means.

2. A control system for a furnace having a burner, electrically responsive means for supplying fuel to the burner, and a blower effective to force air through said furnace and into a room, said blower being selectively operable at either a high speed or a low speed, said control system comprising a room thermostat and an outdoor thermostat, each of said thermostats having contacts respectively adapted to close when the room and outdoor temperatures drop below predetermined levels, said room thermostat being effective upon closure to energize the fuel supply means for operation of the burner, first switch means responsive to the furnace temperature for energizing said blower, low limit switch means operable at a predetermined furnace temperature higher than that at which said first switch means are actuated, high limit switch means operable at a substantially higher furnace temperature than the low level switch means, the outdoor thermostat being effective when open to place said low limit switch means in the energizing circuit of the fuel supply means whereby said fuel supply means are de-energized by the low limit switch means whenever the air in the furnace reaches said predetermined temperature, the outdoor thermostat being effective when closed to remove said low limit switch means from circuit controlling relationship with said fuel supply means and to insert the high limit switch means in the energization circuit of said fuel supply means, said outdoor thermostat further being effective when open to condition said control system whereby said blower is operated at a low speed in response to the actuation of said first temperature responsive means, said outdoor thermostat being effective when closed to condition said control system whereby said blower is operated at a high speed in response to the closing of said first switch means.

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