May 15, 1928. 1,669,707

P. E. HAYNES

AUTOMATIC STACK OR FLUE CONTROL

Filed April 11, 1925

Fig. 1.

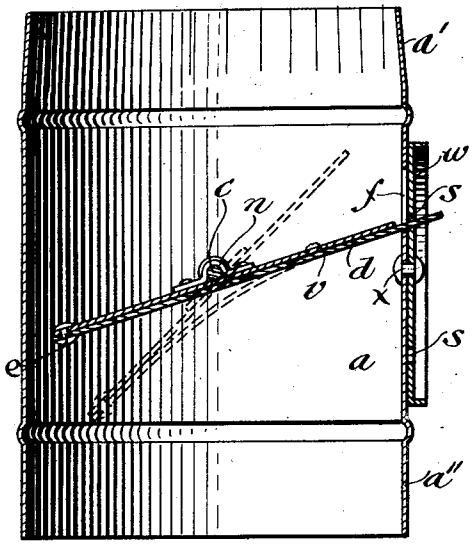


Fig. 2.

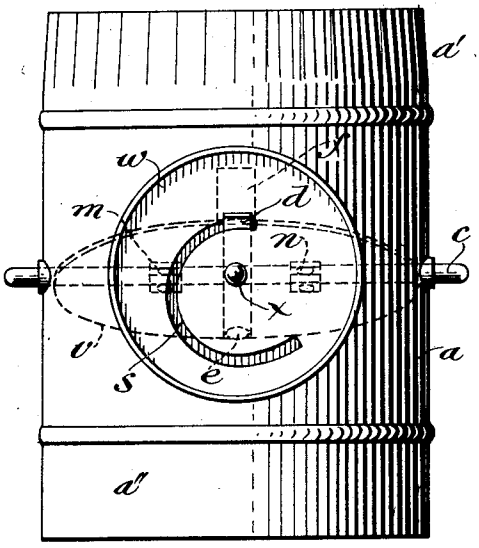


Fig. 3.

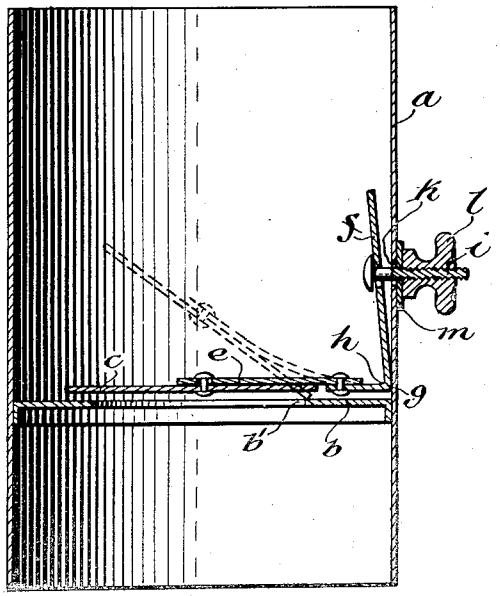
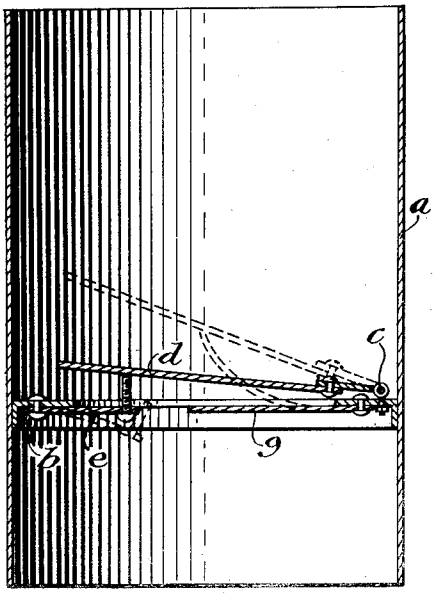


Fig. 4.



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UNITED STATES PATENT OFFICE.

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AUTOMATIC STACK OR FLUE CONTROL.

Application filed April 11, 1925. Serial No. 22,480.

The object of my invention is to provide an automatic stack or flue control which will vary the total amount of air passing through said stack or flue in some approximately fixed ratio to the heat of combustion of the fuel consumed.

More specifically, the object is to provide a thermostatically controlled damper or valve which maintains approximately optimum combustion conditions at all rates of fuel consumption.

In the accompanying drawing:

Figures 1 and 2 are, respectively, a vertical sectional view and an elevation showing the preferred embodiment of the invention.

Figures 3 and 4 are sectional views showing modified constructions.

Carbon and carbonaceous fuels are burned in air in two distinct stages or steps. The first step consists in burning carbon or hydrocarbons to carbon monoxide and hydrogen according to the following reactions.

$$2C+O_2=2CO$$
$$2CH_4+O_2=2CO+4H_2$$

The second step consists in further consuming carbon monoxide and hydrogen to carbon dioxide and water respectively according to the following reactions.

$$2CO+4H_2+3O_2=2CO_2+4H_2O$$

In all ordinary combustion appliances, air which contains approximately 21% oxygen is used as the oxidizing agent and there is an unavoidable dilution of the products of combustion due to atmospheric nitrogen.

This nitrogen dilution causes a very material reduction in the temperature of combustion because of its heat absorbing capacity between atmospheric temperature and the temperature at which the products of combustion are finally discarded. As long as air is used for the support of combustion, this loss is to a large extent, unavoidable.

In all combustion appliances it is advisable and frequently necessary to vent the waste combustion gases through a flue or chimney and frequently a mechanically or electrically operated blower is added to support combustion. When the combustion device and flue are cold, the draft or suction is less than when warm or hot, and it is therefore necessary to provide sufficient chimney area for starting as well as for the maximum fuel consumption to which the equipment will be liable.

It is therefore obvious and furthermore well known that efficient combustion of carbonaceous fuels necessitates a variable flue opening or area which may be altered to suit the combustion conditions desired. This requirement has been partially met but not completely so by installing dampers in the flue pipes which may be adjusted manually. Due, however, to errors in judgement, variations in fuel supply, and variations in stack draft as a result of weather conditions, it is impossible for an operator to determine the exact setting. If it were possible to determine such setting, a variation in external conditions would soon render the manual damper setting incorrect.

If said damper setting is incorrect, there is a loss of efficiency due either to incomplete combustion or to the absorption of heat by excess air.

In practically all heating devices using carbonaceous or hydrocarbon fuel, the products of combustion are cooled by the absorption of heat in the device so that the temperature of the waste gases is determined by the final temperature equilibrium in the device rather than the initial or so-called flame temperature. The amount of heat absorbed, however, is determined by the average temperature equilibrium in the device because the transfer of heat is approximately proportional to the average temperature difference between the source of heat and the heat absorbing area.

It is customary in the operation of most devices, to increase the quantity of heat produced when more useful heat is desired. Thus, in a coal heating device we burn coal more rapidly to boil more water. In a gas or oil heater, we supply more fuel. In both cases the increased effect is produced by an elevation of the temperature of the products of combustion which in turn is responsible for the transfer of more useful heat to the device.

In all such equipment it seldom happens that the ratio air to fuel is correct and in most cases there is only one or at best a very narrow range of fuel consumption rates where the combustion is truly correct and the efficiency of heat utilization maximum. The failure to attain such maximum efficiency through a broad range of fuel consumption is due largely to incorrect air supply.

I propose to remedy this faulty condition

by installing in the flue or chimney a thermostatically controlled damper device which will maintain optimum conditions for the generation and absorption of heat at all rates of fuel consumption and which, in addition will be relatively cheap, and automatic in its operation.

I have made the axiomatic assumption that the optimum condition for efficient combustion is that where the amount of air supplied for combustion is barely sufficient for the complete conversion of the fuel to CO_2 and H_2O. I have made a second axiomatic assumption that the optimum condition for the transfer of heat from the products of the combustion to the heat absorber is that where the temperature of the products of combustion remain maximum from the beginning to the end of their contact with the heat absorbing area. I have made a third axiomatic assumption that the loss of heat in escaping combustion products is not dependent upon their temperature but upon the numerical product of their weight and temperature.

From these three axiomatic assumptions, I have deduced the following:

a. Excess air reduces the efficiency of combustion.

b. Excess air reduces the average temperature of combustion products and thereby reduces the amount of useful heat transferred.

c. Excess air increases the weight of combustion products and therefore increases the heat loss per degree elevation of the flue gas temperature.

I wish to make these points absolutely plain because my device actually increases the temperature of the exit waste gases, although the gain in heat absorption is as high as 58%.

The simplest application of my device is that made to an ordinary domestic gas fired water heater of the circulating type. In this type of heater, the gas burns continuously at an approximately fixed rate. Usually the gas burns under a coiled metallic pipe which connects between the top and bottom of a storage tank. The water being heated in the coil, rises, fills the top of the storage tank and displaces the colder water in the tank which descends and enters the heating coil. This circulation continues until the tank is in some temperature equilibrium with the air surrounding it after which all heat transferred to the water in the coil is lost by conduction and radiation, although circulation continues indefinitely,

The final equilibrium obtainable in such a system is determined by the amount of heat which may be transferred when the average tank temperature is maximum. Obviously, with combustion gases at higher temperatures, more heat may be transferred and an ultimately higher tank temperature reached than is possible if the combustion gases are at some reduced temperature.

When the withdrawal of hot water from the system is intermittent but regular, the storage tank never reaches its maximum temperature equilibrium and the transfer of heat is determined by the difference in the temperature between the cold water and the hot combustion gases.

Tests with my device show that the temperature of the exit gases from a typical water heater is increased 60° F. at the very lowest gas consumption to more than 200° F. at greater gas consumptions. The efficiency of heat absorption under these conditions varies from 42% to 52%, depending on the rate of gas consumption. Under the same conditions but without my device, the efficiency of heat absorption varies from 28% to 38%.

As an example of the preferred means whereby the principle of my device is applied, I show in Figs. 1 and 2, diagrams of the thermostatic control, as applied to gas or oil heated devices.

In Figs. 1 and 2, *a* is a housing with connections *a'* and *a''* at top and bottom to fit standard flue connections. *c* is a shaft which has two bearings in casing *a* and turning freely in such bearings. Secured upon said shaft *c* by straps *m* and *n* is valve or damper *v* which turns with shaft *c*. *d* is a blade of thermostatic metal or bimetallic strip which is riveted to *c* and *e* and extends through slot *f* in casing *a*. The bimetallic strip expands more rapidly on its upper side so that as the temperature rises strip *d* tends to curl downward causing valve *v* to turn contra-clockwise on axis *c*, assuming positions shown by dotted lines.

Water heaters and other combustion devices vary in size and air requirement and there is a considerable variation in temperatures of flue gases where the fuel consumption is the same. In general, smaller devices use less fuel and require less air. In the cases of water heaters and similar devices, the smaller units have lower heat absorbing capacity because of the reduction in heat absorbing area. When such is the case, the wasted heat escapes with the flue gases which leave the apparatus at a higher temperature.

Due to these as well as other obvious reasons, it is desirable and frequently necessary to vary the free opening of a damper throughout the temperature range so that the amount of air drawn through the apparatus will be sufficient to completely burn the fuel.

For such cases wheel *w* is provided with a certain slot *s* through which the end of thermostatic strip *d* extends. By turning the wheel *w* on an axis *x*, the end of thermo-

static strip is caused to rise or fall and the angular setting of the valve definitely established at any point within the range of slots *f* and *s* in the casing and wheel respectively. By this means the free opening of the valve is varied independently of the thermostatic strip and in effect the free opening is increased or decreased throughout the entire temperature range as desired.

I do not wish this invention to be confined to the method just described since I have devised other means of practising my invention without departing from the spirit of my claims. As examples of these alternative methods I show Figures 3 and 4. In Figure 3, *a* is a casing or conduit through which the hot gases pass. *b* is a stage or annular ring slightly restricting casing *a*. *c* is a valve for closing or opening the passage through the annular ring *b* and is attached by a loose rivet or similar means to thermostatic strip *e* which is a bimetallic strip and bends upward when heated. The bimetallic strip is riveted tightly to angle support *f* which because of its weight bears against casing *a* at *g*. Angle *h* is less than a right angle. Screw *i* fits loosely in a hole in the upper portions of *f* and extends through hole *k* in casing *a*. Thumb nut *l* and washer *m* on screw *i* may be used to adjust support *f* so that the *a* angle between the support and the casing may be varied between desired limits and by so doing the opening *b'* may be blocked and the free opening between *b* and *c* adjusted. When cold the valve stands as indicated by the solid lines but when heated, bimetallic strip *e* bends upward and lifts valve *c* to some height corresponding to the temperature as indicated by the broken lines.

Figure 4 is the second alternative method by which my invention may be practised. *a* is a casing as before and *b* is an annular ring or stage. *c* is a hinge attached to stage *b* and supporting valve *d*. *e* is a thermostatic or bimetallic strip riveted to stage *b* and having at its other end an adjustable screw. When cold this screw serves to maintain valve *d* at some predetermined point. *g* is another bimetallic strip riveted to stage *b* also. When heated bimetallic strip *e* bends downward and strip *g* bends upward. As heating continues, valve *d* lowers until it contacts with the free end of strip *g* and then strip *g* lifts valve *d* to some point corresponding to the temperature of the gas passing over it.

In operation the position of the flue valve is adjusted until the flue opening is such as to permit the passage of a quantity of air just sufficient to effect the complete conversion of the fuel at the lowest rate of fuel consumption. This setting is obtained by suitably adjusting the position of the bimetallic member as, for instance, by turning the wheel *w* of Figure 1 to the desired point. The proper setting will, of course, depend on the size of the heater and other circumstances as explained heretofore. When the rate of fuel consumption is increased the flue gas temperature is increased and in order that there may be complete combustion the amount of air required is correspondingly increased. An increased flue gas temperature causes the bimetallic member to expand and in expanding this member effects a corresponding further opening of the valve thereby automatically increasing the amount of air to the extent necessary. In this manner the correct ratio of air to fuel is approximately maintained throughout the range of fuel consumption. If a further adjustment is desired at some point along the range of fuel consumption, it may be obtained by suitably manipulating the wheel *w* or its equivalent.

Having fully described my invention, I claim:

1. A thermostatic draft control for combustion processes comprising a valve, a shaft supporting said valve, a bimetallic strip rigidly attached at one end to said valve, a casing enclosing the previously described mechanism and slotted to receive the free end of the bimetallic strip.

2. A thermostatic draft control for combustion processes comprising a valve, a shaft supporting said valve, a casing enclosing the previously described mechanism and having a slot, a bimetallic strip secured to said valve with its free end projecting through said slot, and means attached to said casing by which the free end of the thermostatic strip may be adjusted to vary the free opening of the valve at any temperature.

3. A thermostatic draft control for combustion processes comprising a casing to confine the products of combustion, a valve or damper in said casing, a bimetallic strip which bends when heated, said bimetallic strip being fastened at one end to said valve, a shaft supporting said valve and one end of said bimetallic strip, which assembly turns freely in said casing when said bimetallic strip bends under the influence of heat, and an adjustment on said casing for securing the bimetallic strip and for adjusting the free opening of said valve at any temperature.

4. A thermostatic draft control for combustion processes which comprises a casing for confining the products of combustion, a valve or damper in said casing, a bimetallic strip attached to said valve, a slot in said casing through which the free end of the bimetallic strip extends, and an external adjustment by which the free opening of the valve may be varied at any temperature.

5. A thermostatic draft control for com-

bustion processes comprising the combination of a casing through which the products of combustion escape, a valve or damper in said casing having a normal position determined to prevent an excessive air supply at the start of the combustion process, and thermally responsive means subject to the heat of the gases of combustion for varying the position of said valve or damper, thereby causing the same to open beyond its normal position in proportion to the heat of the combustion products.

6. A thermostatic draft control for combustion processes comprising the combination of a casing through which the products of combustion escape, a valve or damper in said casing having a normal position determined to prevent an excessive air supply at the start of the combustion process, thermally responsive means subject to the heat of the gases of combustion for varying the position of said valve or damper, thereby causing the same to open beyond its normal position in proportion to the heat of the combustion products and means for adjustably varying the free opening of said valve or damper at any temperature.

In testimony whereof I affix my signature.

PIERRE E. HAYNES.