Oct. 26, 1954 | M. O. SWENSON ET AL | 2,692,759

STEAM OPERATED HEATER SYSTEM AND/OR APPARATUS WITH CONTROL THEREFOR

Filed Sept. 27, 1951 | 3 Sheets-Sheet 1

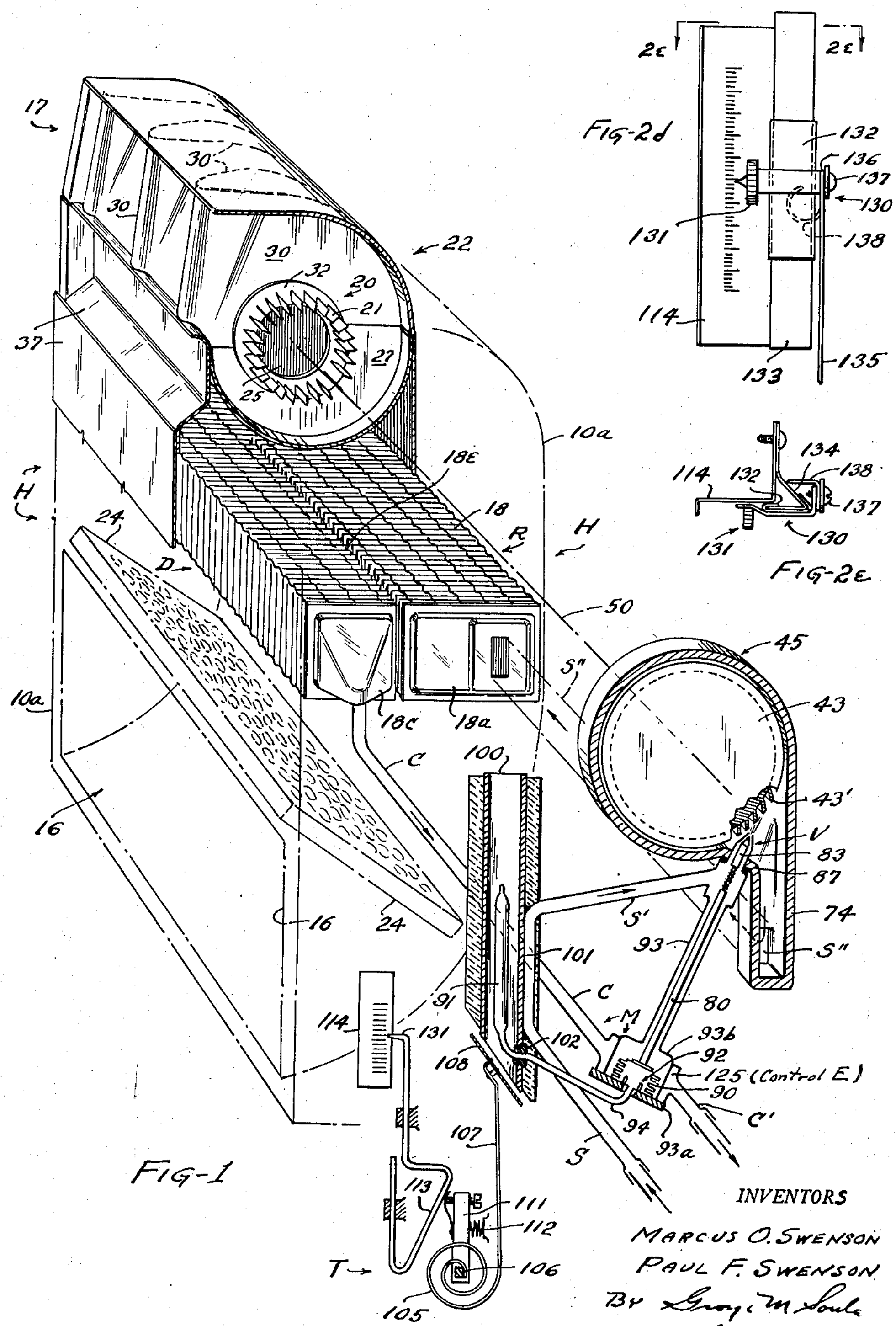

FIG-1

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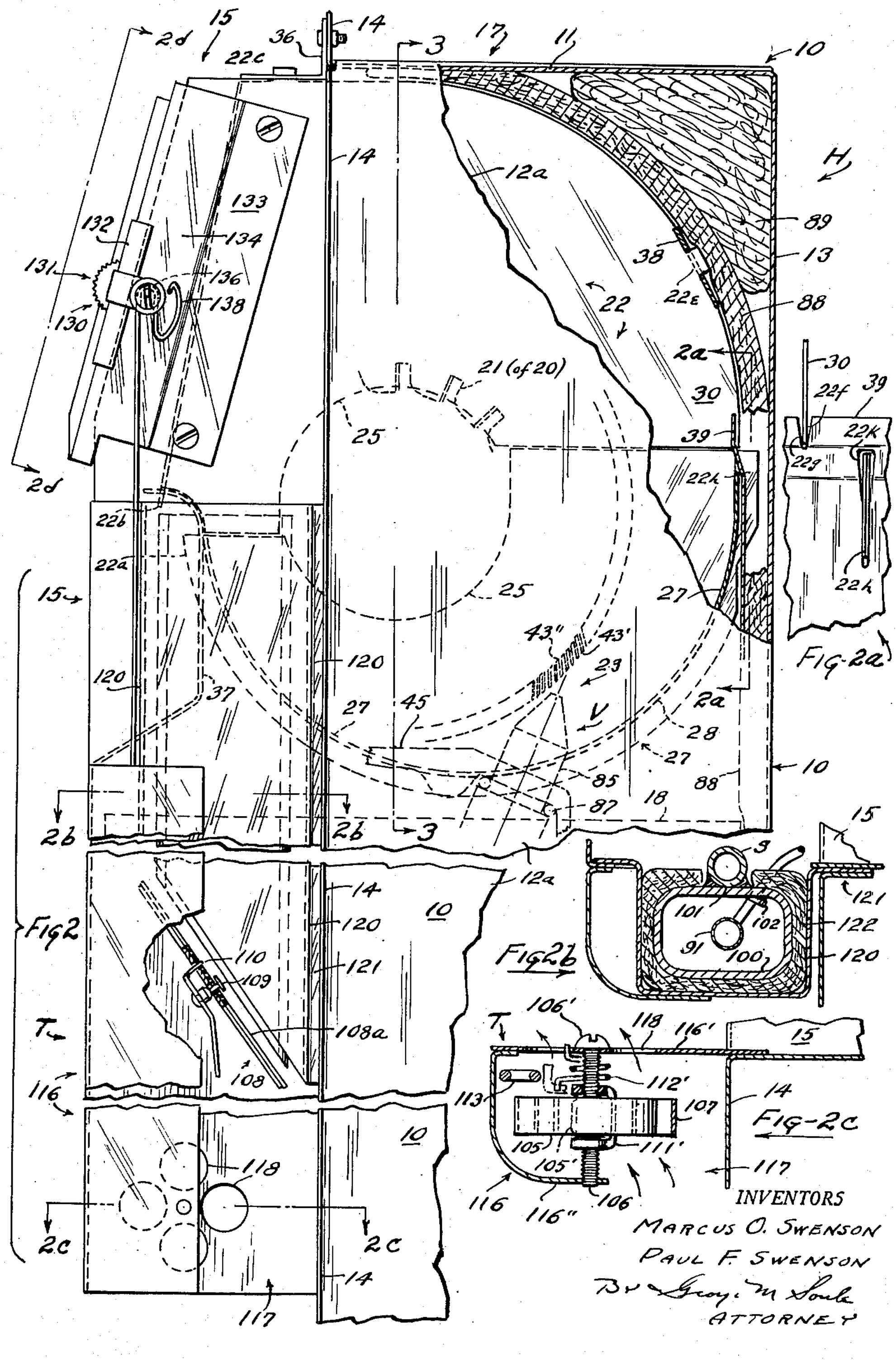
3 Sheets-Sheet 2



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Filed Sept. 27, 1951 3 Sheets-Sheet 3

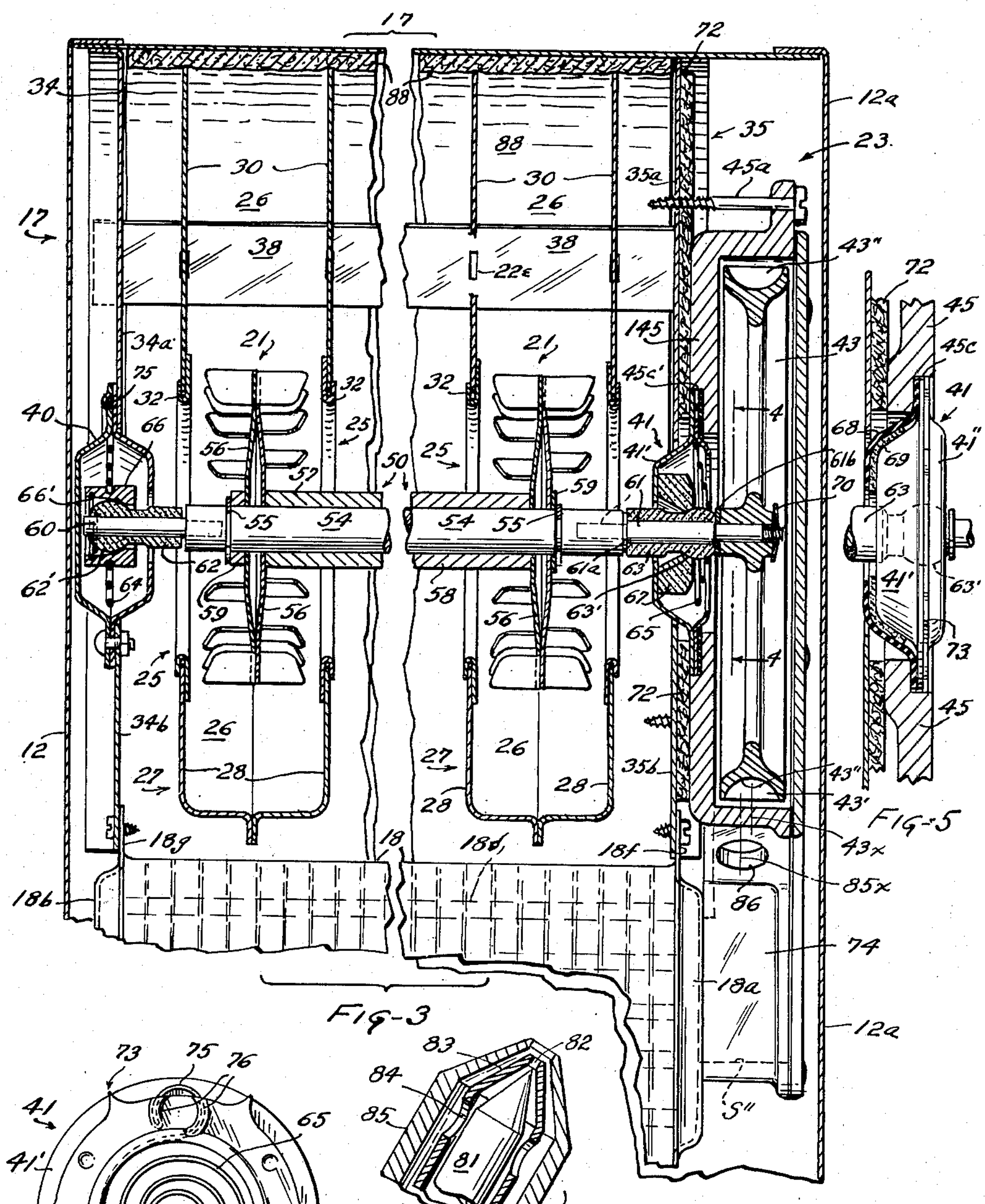

FIG-3 FIG-5

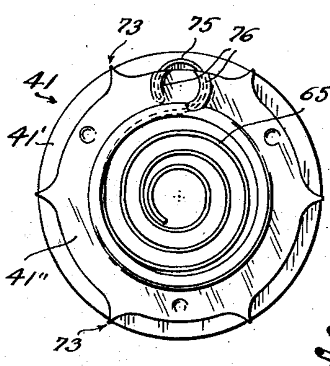

FIG-4

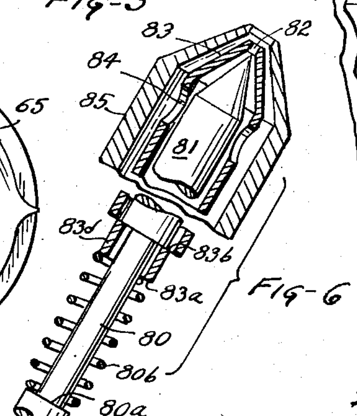

FIG-6

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Patented Oct. 26, 1954 2,692,759

UNITED STATES PATENT OFFICE

2,692,759

STEAM OPERATED HEATER SYSTEM AND/OR APPARATUS WITH CONTROL THEREFOR

Marcus O. Swenson and Paul F. Swenson, Cleveland Heights, Ohio, assignors, by mesne assignments, of thirty-seven per cent to Otto Wanek, two per cent to Kenneth J. Kitchen, ten per cent to Paul F. Swenson, ten per cent to Marcus O. Swenson, four per cent to Myron T. Cooperrider, eleven per cent to Wilma G. Stupka, eleven per cent to Wilma G. Stupka, trustee, ten per cent to J. A. Weeks, and five per cent to Earl P. Schneider, trustee

Application September 27, 1951, Serial No. 248,592

17 Claims. (Cl. 257—2)

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The invention, as specifically shown herewith, relates to a steam heater and an automatic control mechanism for it.

The objects include provision of a new or improved mechanism, system, method and/or apparatus for heating generally enclosed spaces, particularly through the use of steam, a steam/air heat exchanger and positively moved or forced space air; a new or improved modulating or gradually acting heater control, as against an "on-off" control; a new or improved exhaust-temperature-operated emergency control particularly for a steam heater; a new or improved, self-contained, wholly steam-powered heater unit with provision for positive air movement and fully automatic concurrent control of steam and air flow; a new or improved turbine and blower mechanism for a forced-air steam-powered heater; a new or improved heat exchange element or radiator unit for a heater; a new or improved throttle valve mechanism for a heating fluid medium; a new or improved temperature amplifying or thermal relay apparatus operative for effecting modulated control of a heating fluid medium input; a new or improved air-space-temperature-responsive or primary thermostat mechanism for a heater control of the illustrated type; a new or improved rotary air blower assembly and free floating support for it, a new or improved air blower and turbine assembly including novel casing, framework and other constructional features applicable generally to space heater units of the disclosed type.

Other objects and novel features will become apparent from the following description of the illustrative embodiment shown in the accompanying drawings, wherein:

Fig. 1 is a schematic largely perspective view of the principal heater and control elements.

Fig. 2 is a full scale fragmentary side elevation of the main heater cabinet or framework including a primary control assembly housing, portions being broken away and shown in cross section.

Figs. 2*a*, 2*b*, 2*c* and 2*d* are detail sectional or elevational views taken as conventionally indicated on Fig. 2, Fig. 2*e* being a top view of the assembly shown in Fig. 2*d*.

Fig. 3 is a fragmentary sectional assembly view principally showing the turbine wheel-blower assembly and its shaft support, the principal plane of the section being indicated at **3—3** on Fig. 2.

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Fig. 4 is an end or main face view of one of two shaft bearing case assemblies for the blower and turbine wheel.

Fig. 5 is a slightly enlarged scale view of a preferred form of bearing case assembly mounting, being a modified arrangement in relation to the corresponding portions of Fig. 3.

Fig. 6 is a greatly enlarged scale central sectional fragmentary view of the preferred throttling valve V for controlling steam input to the heat exchanger via the turbine casing.

GENERAL ARRANGEMENT

Heat exchanger; blower-turbine; framework

Subject mechanism, as shown, is particularly adapted for use in dwelling spaces, i. e. homes, workrooms and other such generally enclosed spaces, wherefore the illustrated physical embodiment is represented as a unit H, applicable to ordinary frame building constructions, for wall-inset-installation as between studding. The units are provided in various horizontal lengths, as determined by room size and shape, and of uniform heights and depths. Heating capacity is generally proportional to unit length. Because of using forced air at relatively low velocity, and modulating control, as will be explained and described, subject units H require only a fraction of the space usually occupied by conventional steam radiators of comparable capacity (convection type) and practically no otherwise-useful room space, providing the units H are largely wall-contained as they are designed to be used. The automatic modulating control requires no special power source, hence no fire hazard is involved; installation expense is very low and service expense is negligible or absent.

Unit H, for the use mentioned, and, as shown particularly in Figs. 2 and 3, has a generally rectangular, box-like, sheet metal casing or framework **10** (**10***a*, Fig. 1) including a top wall **11**, sides **12** and **12***a*, a back wall **13** (Fig. 2), a bottom wall (not shown), and all-around front flanges **14** for attachment to the building in which the unit is installed. Frontal portions **15** (Fig. 2) of the unit which extend forwardly of casing **10**, rigid therewith, usually project into the room or space to be heated in which case those portions are conventionally covered by a decorative or protective sheet metal or other facing and grill structure (not shown) which, in that event, would provide the air inlet opening 16, Fig. 1, preferably near the floor, for reception of room air into the unit.

A diffuser unit or assembly 17 (shown more or less schematically in Fig. 1) contains or supports the steam-air heat exchanger 18 (hereinafter, for convenience, sometimes called "radiator"), also the blower assembly 20 with vanes 21 and an air receiving and directing scroll cell structure generally indicated at 22, Fig. 1.

Various constructional features of the diffuser and casing assembly, parts or portions indicated by characters 22a through 22k, Figs. 2, 2a and 3, are intended to form the subject matter of a separate or divisional application; and, since the parts or features so indicated are made self evident in the drawings, they will not be further discussed herein.

The blower apparatus, except as hereinafter especially qualified, operates as a conventional multicell, scroll type centrifugal blower which discharges into the room space served the air which is received into grill opening 16 and is then warmed by the radiator.

Power for operating the blower is preferably supplied through a steam turbine mechanism or assembly 23, Figs. 1 and 3, operated by heat input steam from line S, S', Fig. 1, en route to the radiator through line S''.

The radiator 18, Figs. 1 and 3 has hollow, steam-inlet and condensate-outlet headers 18a and 18b respectively (Fig. 3 only) and a similar, steam and/or condensate return header 18c (Fig. 1 only), which headers interconnect the horizontal steam passages 18d (Fig. 3) of the radiator. As shown the radiator comprises an appropriately cut section of conventional radiator core stock and, for part of its length, as indicated 18e the air-contacting fin structure is divided (between horizontally adjacent steam passages 18d) into a steam-receiving portion R and a condensate-discharging or heating-medium-return portion D as will later be discussed more in detail. Condensate return line or exhaust from the radiator as indicated at C, C_1, Fig. 1.

The room air, received at grill opening 16, is filtered through a conventional, readily replaceable, filter unit or frame 24 placed obliquely between the principal plane of the inlet or grill opening 16 and that of the radiator 18 in or on a suitable guide or attaching frame not shown.

By comparison of Figs. 1 and 3 it is apparent that room air entering unit H through grill opening 16, passes through the filter 24 to and through the radiator 18 and into lateral circular openings 25 of the individual scroll cells 26 containing the fans or air-impellers 21. The fans and cell walls diffuse and expel the warmed air into the room horizontally of the unit H.

Bottom scroll cell sections 27, each comprising two rigidly joined mutually complementary half shells 28 are vertically aligned with the defining walls of top scroll-forming elements 30. Elements 30 are generally U-shaped metal stampings (cf. Fig. 1) the bottom edge margins of which align with associated top edge margins of the half-scroll, composite bottom sections 27. All around the rotational axis of the fans 21 the upper and lower scroll shell elements 27 and 30 are detachably joined together by parallel-flanged coupling rings 32 whose rounded inner peripheral surfaces (defining the air-inlet openings 25 of the scroll cells) conduct the air, which necessarily travels through the effective restrictions of openings 25 at relatively increased speed, smoothly and with little or no tendency to whistle even at maximum impeller speed.

The supports for the scroll cell parts 28, 30 described above comprise, as shown, main, oppositely flanged diffuser frame end or header members 34 and 35 (Fig. 3) which, in order to facilitate assembly of the blower etc. into the diffuser unit, may be formed as separate upper and lower sheet metal sections 34a, 34b and 35a, 35b.

The flanges of the frame end members 34, 35 support front cross connectors shown at 36, 37, Figs. 1 and 2, and rear cross connectors 38, 39, Figs. 2, 2a and 3, which can be joined to the end frames in any suitable manner, e. g. by welding or so called "sheet metal" screws (neither shown).

The heat exchange radiator 18 is detachably supported by the flanged end members 34b and 35b of the diffuser frame, as clearly shown by Fig. 3. The sheet metal header members 18a, 18b and 18c of the radiator have upstanding flange extensions 18f and 18g, as partially shown in Fig. 3 only, for attachment to the diffuser frame elements as by screws.

The flanged end members 34 and 35 of the diffuser frame also support, respectively, bearing cases 40 and 41 for the fan rotor shaft assembly 42 which is extended to the right, Fig. 3, beyond bearing case 41 to carry the impeller wheel 43 of turbine assembly 23. Casing 45 of the turbine assembly is also carried by frame end wall 35 as will be more fully described later herein.

ROTOR ASSEMBLY, FLOATING SUPPORTS, SEAL, ETC.

As shown particularly by Figs. 3, 4 and 5 the rotary parts of the blower and turbine assemblies 20, 23 are made of very light weight materials and unitarily mounted for free turning and laterally floating movement, as has been found highly desirable, if not practically essential, in order to minimize generation or transmission of sound vibrations and to minimize power requirement. Power saving is especially important when the power is borrowed from the heating steam supply as in the present embodiment. It is also practically necessary that the bearings for the rotor shaft shall operate indefinitely without deterioration under relatively high surrounding temperature conditions and without requiring attention, e. g. for lubrication or adjustment.

Rotor shaft 50 as shown in Fig. 3, has a relatively large diameter fan-supporting portion 54, preferably aluminum, grooved for receiving snap rings 55, between which axially resilient (concave-convex) fan-forming (e. g. aluminum) stampings 56 (mirror images of each other as assembled) are secured in axially compressed, i. e. flexed, condition through provision of spacer sleeves 57, 58 slid onto the shaft between adjacent pairs of fan stampings 56, and, further, of dimensionally appropriate clearance-takeup washers 59 at one end or both ends of the fan blade and spacer sleeve assembly.

The reduced-diameter cylindrical end portions 60, 61 of the shaft 50 are made separately from the main body 54 of the shaft, as stainless steel pins or stubs pressed into place in end sockets of the aluminum body. The pins 60, 61 provide adequately hard and polished surfaces for contact with polished bores of carbon bearing sleeves 62, 63 which are used because of proven long life, oil-free service. The pressed-in portions of the pins 60, 61 are of reduced diameter relative to the carbon-sleeve-contacting surfaces of the pins. In the case of pin 61 the reduced diameter provides a shoulder which clamps a stainless steel washer 61*a* tightly in place on the shaft. A similar stainless steel washer 61*b* is tightly held on the shaft by the turbine wheel and its attaching means, nut 70; and the two washers by alternate abutment with the ends of the carbon sleeve 63 locates the shaft 50 and all parts carried by it axially in position.

The carbon sleeves 62, 63 are resiliently supported on light gage spiral springs 64, 65 in the respective bearing cases or housings 40 and 41, see Fig. 4. The carbon sleeves 62, 63 have generally spherical head portions 62′ and 63′, shown as seated respectively in a metal collar 66 and a carbon sealing ring 67 (described later) for universal movement (hence free self-alignment) relative to those members and the bearing cases. An inner shoulder of collar 66 bears leftwardly (Fig. 3) against the spherical head portion 62′ under the influence of a very light retaining coil spring 66′ seated like a snap ring in an internal groove of the collar. The inner coil of the bearing-supporting spiral spring 64 is expanded into an external groove of collar 66 and the various spiral coils thereby hold the carbon sleeve 63 in free floating position axially on the shaft stub or pin 60 while permitting lateral floating movement of the associated end of the shaft assembly. The spiral spring 65 in casing 41 is, by engagement of its inner coil with spherical head 63′ of the associated sleeve, sprung slightly out of the normal plane in which the spring is originally coiled or formed; and, since the axially opposite portion of the spherical head 63′ bears against the carbon ring 67, the latter is always maintained in sealing contact with the inner smooth face of the adjacent case part 41′.

The bearing case part 41′ (see Fig. 5 for preferred assembly and construction) is appropriately sealed and sound-proofed as by a compound gasket 68, 69, against and around an inner circular margin of the turbine housing 45; hence air around the fan shaft within the diffuser head 17 is prevented from entering the turbine chamber, by way of the right hand floating bearing assembly, when there is a considerable pressure differential between turbine chamber and diffuser. Such differential tends to be created centrifugally by the turbine wheel. Gasket 69 is prefereably of cork or other cellular cushioning material and is provided to absorb whatever sound the carbon ring 67 may make (in event of slight unbalance in the rotor assembly) in sliding against bearing case stamping 41′.

NOTE.—Turbine housing 145 as shown in Fig. 3, except for the location of its bearing-case-receiving counterbore 45*c*′ (corresponding to 45*c*′, Fig. 5), is intended to complement Fig. 5 in showing the turbine housing features which are omitted from Fig. 5.

The turbine housing 45 (or 145), when attached to the diffuser frame end wall 35 as by screws 45*a*, preferably holds a loose-fiber asbestos sheet 72 tightly against the diffuser frame. The sheet 72 serves principally as a sound absorptive, cushioning pad for the turbine assembly and a vibration damper for the diffuser wall 35 which would otherwise tend to amplify sound generated by turbine operation at certain critical speeds. Bearing case 40 (left Fig. 3), is shown as bolted to diffuser wall 34. The other bearing case 41 (cf. Figs. 3, 4, and 5) has one of its sheet metal parts (41″ as shown) formed to provide a circular series of relatively sharp points 73 projecting beyond the outer rim of the complementary part (41′) so that the entire case 41 and the bearing members supported thereby will be held securely in place in the illustrated position (see Fig. 5 especially) by over-center toggle spring or snubbing action of the points 73 as forced into place in the relatively smaller, receiving circular depression or counterbore 45*c* (or 45*c*′, Fig. 3) formed in the turbine housing.

Fig. 4 illustrates the preferred manner of securing the spiral springs 64 and 65 in the bearing cases 40 and 41, essentially the same construction being used for both. An anchor loop 75 of the spiral spring is designed to be held securely between the embracing parts of the two stampings (i. e. composing the cases 40 or 41) when those stampings are finally secured together as by spot welding. For example, part 41″ is recessed as at 76 (Fig. 4 only) to receive the spring loop 75, and the loop is especially held securely by local welding not shown. Thereby the center carbon-sleeve-supporting loops of the two spiral springs 64 and 65 are yieldingly maintained centrally of the respective bearing cases.

STEAM-AIR HEAT EXCHANGER (*continued*)

It has been mentioned that the exchanger 18 is a single section of conventional radiator core stock with certain ones of the horizontal steam inlet passages divided, principally by headers 18*a*, 18*b* and 18*c* from the passages which communicate directly with the condensate outlet pipe C; and, in effect, that for part of the horizontal length of the exchanger, in the direction of steam passage therethrough, cross conduction of heat from portion R to portion D is interrupted by separation of the heat radiating fin structure into two parts, as by the vertical through slot 18*e* (Fig. 1) in the core structure. Such slotting has the effect of producing: (*a*) an approximately uniform average air temperature at the diffuser unit outlets from blower cells 26; (*b*) minimized cross or lateral conduction of heat from the inlet larger area portion R to outlet smaller area portion D, thus allowing a relatively low heating-medium-exhaust temperature; (*c*) an inlet radiator section and an outlet radiator section (comparable, in operation, to superposed, serially connected sections) but in a single inexpensive and vertically compact arrangement with the necessary heating fluid connections at a common end, and (*d*) an economically manufactured, operatively integral, multiple fin and tubing radiator core or exchanger structure of proven type which is not subject to destructive strains when relatively large portions of it operate with a high temperature differential therebetween. Such portions are represented (Fig. 1) by the steam inlet side R and condensate or outlet side D.

TURBINE AND NOZZLE; STEAM THROTTLE VALVE

Valve mechanism V, Figs. 1, 2, and 6, as already mentioned, is the thermal-amplifier-controlled or adjusted throttling valve for fluid heating medium input to the heater H and operates as a two stage steam turbine nozzle which (inter alia) insures that at low heat requirements of the heater, when the volume of steam flow is minimized, the steam will be caused to impinge on the turbine blades at sufficient velocity to insure turning of the turbine impeller and air blower assembly **20**. The compound nozzle tends to maintain uniform rotor-blade-driving effective force in the various throttling positions of the valve.

Motor device or bellows M, Fig. 1, operates the throttle valve, as will be still further described later, through friction-free stem **80** connected to a central needle valve pin or plug **81** of the throttle valve, see Fig. 6. Needle or pin **81** variably closes a tapered seat intersecting port **82** in a sleeve-needle **83** the interior of which is always in communication with steam input line S as through lateral passages **84**, Fig. 6, in the sleeve. Sleeve needle **83**, in turn, seats against a tapered inner face of a main nozzle fitting or thimble **85** which enters an opening **86**, Fig. 3, of the turbine case **45** or **145** and is sealed around that opening as by an elastic O-ring **87**, Fig. 2. Fitting **85** is held firmly against the turbine case, around the opening **86** by appropriate means not shown.

Control needle valve part or valve pin **81** is constrained to open its port **82** in sleeve-needle **83** before the sleeve-needle can open its relatively larger port in the fitting **85**. For that purpose a lost motion yielding connection is provided between the operating stem **80** and the sleeve-needle **83**. As shown the stem **80** has a shoulder **80***a* and the sleeve-needle a shoulder **83***a* between which shoulders a light gage helical spring **80***b* is held in compression at all times. Thereby, as the stem **80** moves in the valve-opening direction, its first operation is to unseat the central valve needle **81**. Upon further valve-opening movement of the stem the head formed by the valve pin **81** abuts a shoulder **83***b* of the sleeve **83** thereby withdrawing the sleeve-needle from contact with its seat in fitting **85**. To minimize valve seating areas, and further to contribute to freedom of operation, the tapers of the needle plugs (**81** and **83**), in the described order of unseating, are of increasingly divergent relationship with respect to their seating surfaces, as illustrated. Shoulders **83***a* and **83***b* are provided by radially distorting the wall of the shell which forms the sleeve-needle **83** (portion **83***d*) after the stem, spring and sleeve needle are relatively assembled.

The needle valve parts **81**, **83**, **85** are normally coaxial with turbine housing case opening **86**; and the nozzle axis thereby established (see **85***x*, Fig. 3) is preferably eccentric to the principal central plane **43***x* (Fig. 3) of the turbine impeller wheel **43** about which plane the impeller blade and bucket formations **43′**, **43″** are symmetrically disposed.

The turbine wheel **43** is preferably an aluminum casting having its blades and buckets formed as tangential cuts intersecting the originally cylindrical periphery as shown by comparison of Figs. 2 and 3. Since noise and required air flow limit air impeller diameter and speed the turbine wheel is made adequately larger than the fans **21** to nevertheless achieve efficient turbine blade velocity at average available steam velocity. The selected proportions, as illustrated tend to insure rotation of the impeller assembly at very low steam flow.

At relatively high turbine speeds which result from correspondingly high steam jet velocity, the individual jet impacts on the blades will be relatively small. In practice we provide 180 blades on the approximately 4″ impeller wheel illustrated with approximately .005″ thick blades and .040″ wide, uniformly tangential slots to form the buckets. The high frequency sound waves generated in operation of the turbine at maximum speed, being highly directional are easily muffled by appropriate sound damping provision discussed below. The large number of blades causes the individual sound waves emitted by the turbine to be of low amplitude and at a frequency above the audible range.

The sound muffling of the apparatus as a whole includes the loose fiber asbestos sheet **72** already described and (Figs. 2 and 3) a sheet of fibrous mineral material, e. g. fiber glass **88**, backed up by a filling wad **89** of the same or similar material, all contained between the diffuser assembly **17** and the main outer casing **10**. Sheet **88**, as will be evident from comparison of Figs. 2 and 3, forms or may form an upper part of the blower scroll cell structure **22** already described in some detail. Fig. 1 is wholly schematic as to the upper scroll cell structure (top shown as though composed of a solid imperforate sheet, not used).

AUTOMATIC HEATER CONTROL

The control mechanism is principally shown in the schematic diagram, Fig. 1, complemented by Figs. 2, 2*b* and 2*c* which show an actual physical arrangement of certain of the components. The control, as designed for operation with saturated steam, is represented partly by a well known type of sealed vapor pressure generator and motor device M which, as shown, includes a flexible metal bellows or diaphragm **90**, separate vapor generator bulb **91**, and a connecting capillary tube **94**. The motor proper or bellows has its movable end wall connected directly to the throttle valve operating rod or stem **80** which is designed for movement with nearly complete freedom from friction in a generally upright light gage metal tube **93**. The relatively heavy base **93***a* of the tube **93** forms a fixed support for the bellows. The rod **80** and tube **93** are of low heat conducting metal and of such length as will thermally isolate the bellows portion of the assembly to prevent control action on the bellows directly by incoming steam.

The tube **93**, in effect, is part of the input steam line S′, ahead of the throttle valve in the direction of passage of steam to the heater. After commencement of heater operation, the tube and its enlarged base portion become filled, around the valve stem and the bellows, with trapped condensate. The water column thus maintained contributes to thermal isolation of the bellows **90** from the steam chamber or upper enlarged portion of tube **93** around the throttle valve, and at the same time transmits the steam pressure to the movable wall of the bellows.

At a given supply steam pressure, after an equilibrium point of steady operation has been reached, further opening or closing of the throttle to satisfy varying heat demand has negligible effect on the pressure in the throttle valve chamber, due principally to the fact that the effective needle valve outlet or throttling orifice for steam is very small in relation to the supply conduit cross section and to the effective area of the diaphragm or bellows **90**. The average nozzle orifice effective area, in wintertime heating of average dwellings, bears to the effective area of the diaphragm or bellows a ratio of between 1/300 and 1/400.

The control mechanism further includes an extremely delicately acting primary thermostat mechanism T which is designed for full range operation with a small room or space temperature change (around 2° F.). Mechanism T initiates steam-valve-throttling operation of the motor device M and thereafter modifies its action on the steam throttle valve in accordance with room temperature.

The control mechanism (as a further outline of arrangement and operation) is a device in which a delicately acting or highly sensitive thermostat (hence necessarily of low power) when subjected to relatively small variations of room air space temperature, is enabled to develop or cause stable operation of a relatively strong force by amplifying or magnifying the small air space temperature variations or signals to corresponding or proportional large relay output temperature variations for throttling-power-control. The amplifying ratio is desirably in the magnitude 1:5. Such temperature amplifying or thermal relay operation affords throttle-valve-positioning, modulating control through a relatively large range, and, as will be shown, is independent of steam pressure fluctuations within fairly wide limits. The relatively strong throttle-valve-operating force mentioned above is derived, in the control mechanism as illustrated, as a function of steam input heat, as a suitable source resulting in a relatively high secondary or thermal-relay-output equilibrium temperature, the acting force being gradually varied or modified by operation of the primary thermostat T.

Bulb 91, as shown, is subjected to steam input temperature by being located in a heat-reservoir and air conduit 100 formed as an externally insulated (e. g.) copper flue or chimney appropriately joined in intimate heat conductive contact with a portion of the steam inlet pipe S, S' as at 101. The bulb thus obtains its relatively high temperature principally, if not wholly, by radiation of heat thus absorbed by the chimney.

Since the primary purpose of introducing room temperature air into the chimney under the control of thermostat T is to cause variation of bulb temperature in accordance with room temperature change, it is of advantage so to design this part of the apparatus that only one of the three processes of heat transfer is effective as a function of input heat to the mechanism as a whole. Thus, preferably, the bulb is subjected steadily to radiant heat by the surrounding chimney wall and is cooled by convection.

In order that the bulb can be simultaneously sensitive both to input (steam) heat and that of space or room air (samples of which as needed for the modifying or tempering action being induced to enter the chimney by convection as will be explained) the bulb and its capillary tube are generally isolated from contact with the chimney. As shown a double flanged elastic ring or collar 102 acts to support the bulb firmly in spaced or loosely enveloped relation to the copper chimney by snug engagement with the wall of an opening or slot in the chimney and by snug embracement of the tube.

In order for the temperature of bulb 91 to accurately reflect the position of the damper valve 108, as determined by the primary thermostat, extraneous heat losses from the bulb and capillary tube must be minimized. In other words, bulb heat loss must be primarily due to the cooling effect of room air admitted to the chimney and should not be by way of the capillary tube or otherwise to air externally of the chimney. For that reason the capillary tube 94 is preferably stainless steel the heat conductivity of which is very low as compared to copper which is generally used for capillary tubes. Additionally, the capillary tube may have a barrier or insulation sheath (not illustrated), for the purpose of minimizing generator heat loss.

Since air introduced into the chimney is progressively heated by the chimney its temperature increases as it passes through the chimney. The chimney, in turn, being cooled by the passage of air therethrough, is progressively cooler from the air outlet end toward the air inlet end. Thus if the bulb is located near the outlet end it will be heated more rapidly by the high temperature end of the chimney and cooled less rapidly by the high temperature air; while if the bulb is located near the intake end of the chimney it will be heated less rapidly by the cooler chimney portion and cooled more rapidly by the cooler intake air. By properly locating the bulb between the chimney ends a desirable relationship between throttle opening rate and throttle closing rate may be selected. For example by proper location the two rates can be made approximately equal.

For installation of the capillary tube and collar 102 into the receiving chimney wall opening the bottom edge margin of the copper chimney is preferably slit (not illustrated) into intersection with the chimney wall opening which receives the collar to permit a small portion of the chimney wall metal to be bent out of place and then returned to position in engagement with the collar.

PRIMARY (ROOM AIR) THERMOSTAT

The thermostat mechanism T, as schematically shown in Fig. 1, includes a bimetal coil 105, which, as mentioned, is designed to be delicately responsive to room air temperature change (return air to the heater). The coil 105, for desired-temperature range or control point selection by room or space occupants, has in effect a pintle mounting at 106 and a wholly free arm portion 107 (not usually a bimetal member) which is the sole support for a damper or valve 108 freely pivoted on the arm (see 109, 110, Fig. 2) in normally free juxtaposition to one end of the chimney (oblique bottom end as shown) for controlling the amount or volume of room or space air (could be any other low and generally constant temperature fluid) which can enter the chimney as draft induced by its heat.

The bimetal coil support includes an arm 111 suitably biased as by a spring 112 toward an adjusting cam 113 part of which, shown as a pointer 131 in Fig. 1 is associated with a graduated temperature scale 114 (preferred, arrangement explained later in connection with Figs. 2, 2*c*, 2*e* and 2*d*).

It is important that the thermostat element 105 be isolated from operational heat of the mechanism (unit H) as much as practically possible in a self contained heater and control, hence, as shown by Figs. 2 and 2*c*, the coil is disposed in a light walled protective case or guard 116 made, as will be apparent from the views, to provide a generous sized inlet 117 for room air near the base of the unit H and at one side of it. Air usually travels over the bimetal coil in directions indicated by arrows in Fig. 2*c*, leaving principally through openings 118 and the open top of case or guard

116 as induced by recirculation of room air through operations of the blower in conjunction with the room walls.

Part of the air control damper (e. g. top plate 108a, Fig. 2) is preferably non-metallic (e. g. hard asbestos or plastic) as a partial barrier against radiation of chimney heat to the bimetal. Damper-aligning tongue or finger 110, Fig. 2, and damper-supporting pivot pin 109 are of very small cross section, hence those parts are ineffective to transmit appreciable chimney heat to the coil (lost by radiation from the relatively long arm 167 which may be of low conductive material).

Referring further to chimney 100 and associated features, as shown particularly by Figs. 1, 2 and 2b, the chimney is preferably mounted in a supporting case member 120 of channel-like form attached, as at 121 to the heater housing 10, and practically the entire space around the chimney and within the case member 120 is packed with insulation material 122 for the full height of the chimney. That concentrates the chimney heat largely on the vapor generator bulb 91 and further tends to prevent chimney heat loss and radiation to the bimetal coil notwithstanding the fact that the chimney and coil are fairly near each other. Channel 120, as shown, supports part of thermostat case or guard 116.

By comparison of Figs. 1, 2 and 2c it will be apparent that with the bimetal coil supported as indicated and subject to room air return circulation the filter 24 (Fig. 1 only) isolates the coil from influence of heat radiating from the heat exchanger 18 and its associated metal parts.

PRIMARY THERMOSTAT SETTING MECHANISM

The pintle mounting 106 for the bimetal coil 105 can be very conveniently made (Fig. 2c) as a uniform diameter screw 106′ threaded for its full length. Threads of the screw engage both parallel main walls 116′ and 116″ of the thermostat guard or case 116. The bimetal coil 105 has its inner end 105′ firmly fixed to a rigid, U-shaped sheet metal arm 111′ having spaced parallel portions which are apertured to receive the screw. At least one of the apertures has internal threads mating the screw threads so that the arm 111′ is held by the threads in properly spaced position between the guard side walls 116′ and 116″ and is still free to pivot as necessary for setting or adjustment of damper position. The follower spring for holding arm 111′ in contact with cam 113 comprises, as shown in Fig. 2c, a torsion coil spring 112′ around the screw 106′ with one of its ends bearing against the arm and the opposite end hooked into one of the air openings 118 of guard wall 116′.

As shown in Figs. 2, 2d and 2e the arrangement for setting cam 113 of the thermostat mechanism in reference to graduated dial 114 includes a slider assembly 130 having a pointer and manipulator button 131 the support for which assembly is a generally C-shaped vertically elongated saddle 132 rigid with the pointer end freely slidable on a sheet metal bracket 133 which, together with the dial, is suitably secured fixedly to one side of the frontal portion 15 of the main heater casing as will be apparent from inspection of the views. The bracket 133 has a flat panel portion 134 the plane of which is oblique to its front, saddle-supporting portion as shown best in Fig. 2e.

The coil-position-adjusting cam 113 (actual production design not shown) has an adjustable operating connection with the saddle and pointer assembly 130 including a relatively stiff metal wire 135 which has an attaching loop 136 at its upper end receiving an attaching screw and clamping washer 137 and an additional, spring, loop 138 integral therewith. As shown particularly by Fig. 2 the spring loop 138 is forced out of its normal plane by contact with the oblique panel 134 of bracket 133 so that it serves as a spring friction shoe to hold the slider assembly securely in set positions.

VAPOR PRESSURE GENERATOR AND MOTOR MECHANISM

Constructional principles; operation

Metal bellows 90 (a commercial or standard part) is selected for proper spring rate for stabilization of throttle valve action and, of course, with regard to throttle valve stroke, chimney/bulb design or interrelationship, type of vapor fluid to be used and other factors generally following recognized practice. For example, the filling fluid used to charge the vapor space or chamber provided, in the illustrated arrangement, by the bellows 90, bulb 91 and capillary tube 94 of motor M must be so chosen as to have a vapor pressure/temperature relationship (rate of pressure change with temperature) such that the desired throttle valve movement will take place as the effective heat of the chimney is modified by damper valve action of the primary thermostat. Additionally, since the vapor pressure action in the bellows (tending to close the steam valve) is opposed by steam pressure which varies within certain limits, the vapor fluid pressure change with temperature must be selected to be in the same magnitude as that of the steam within the range of steam pressures to be used. Thereby the effects of such steam pressure variations on the throttling control will be minimized.

If a portion of the vapor generator and motor is to be used for condensate-temperature-operated emergency control (E, described later) this function places an additional limitation upon the selection of filling fluid and the normal bulb operating temperature range. When such condensate-temperature-operated mechanism is used then, since normal condensate temperature establishes the lower minimum operating temperature for the bulb in the chimney and emergency control temperature establishes the maximum operating temperature in the chimney the normal damper-modulated bulb temperature for throttle operation must be located within those two limits.

The vapor space or chamber (bellows, capillary tube and bulb) is preferably fully charged with a single vapor generator fluid, methyl alcohol for example, at ordinary room temperature while the bellows is retained in a partially collapsed condition (top bellows wall in contact with an appropriate stop as at 92, Fig. 1, for example) against the inherent opposing force of the bellows spring. Thereby the throttle valve will be fully open when steam is first admitted to the system as through pipe S, and immediately start heating the exchanger and circulating room air. Additionally during an idle period when room heat is not required the bellows arrangement and charging procedure provides a minimum of steam bleeding through the unit necessary to maintain the chimney at a suitable energy supplying level. Maintenance of chimney temperature during idle periods is desirable to insure rapid response to a change of room heat loss. It can be seen that as the chimney cools due to lack of steam flow the bellows filling procedure described will cause throttle opening and thereby the re-establishment of chimney temperature. Incidentally should rupture or leakage of any movable wall of the bellows occur at any time, the internal and external pressures will be equalized and the bellows spring will then close the throttle valve.

It may be noted at this point that when the assumed saturated steam is first supplied to the system through pipe S (assuming the room temperature is below the desired temperature at which the primary thermostat T is set) steam will first be supplied to the heater through the throttle valve, starting room air circulation and maximum heat supply to the heat exchanger 18. Concurrently the applied steam pressure will through the tube 93 which surrounds the valve stem exert pressure on the top side of the valve-connected wall of the bellows, biasing the valve toward open position. Since the bimetal coil 105 is sensing an assumed room temperature below its set range and thus has allowed a relatively large chimney opening, the incoming steam will be heating the chimney toward an equilibrium temperature as established by the chimney damper setting.

The bulb or vapor presssure generator located within the chimney is now heated to a temperature dependent upon chimney temperature and damper-controlled air. This, in turn, will cause vapor pressure corresponding to the modified generator temperature for the selected vapor fluid to be transmitted to the throttle valve motor bellows 90 in a throttle closing direction. As the bimetal coil senses an increase in room air temperature, caused by room heat addition from the heat exchanger 18, the chimney opening will be restricted with a resulting higher chimney temperature, a higher bulb temperature, and an increased throttle closing biasing force of the vapor fluid pressure. When the room air temperature sensed by the bimetal reaches the lower portion of the temperature control range the corresponding bulb temperature and vapor pressure force will be sufficient to cause throttle closing action to a stable point where the vapor pressure plus the remaining spring biasing force of the motor (bellows) are equal to the oppositely acting or biasing steam force.

A stable position of the throttle valve will result since the spring biasing force acting conjointly and codirectionally with the vapor pressure force decreases in the throttle closing direction while the steam pressure remains substantially constant. Thus there will be only one combination of vapor pressure force and throttle position with a net force equal to steam pressure force.

It can be seen that as the room air temperature approaches the upper portion of the control range steam throttling will be accomplished such that, within the capabilities of the unit for the steam being supplied, the room heat losses will be just equalled by the heat addition and the unit will maintain temperature, assuming that heat loss to be constant, at a point within the temperature control range corresponding to the necessary throttle valve position.

As room heat loss (e. g. by lowering of outside or weather temperature) commences to exceed heat input to the room the same action as already described takes place and the throttle valve is further opened until the rate of room heat supply again balances the rate of loss.

EMERGENCY CONTROL AND OPERATION

Condensate return from heaters of the class described is usually as a liquid to an unsealed condensate tank at atmospheric pressure. Thus any flow of steam from the condensate return line is highly undesirable, being a source of loss of boiler water and being capable of adversely influencing condensate return from other normally operating units.

The emergency control E hereof, by restricting steam flow to the heater to such a point that the condensate temperature must be appreciably below the saturated steam temperature at atmospheric pressure, operates to prevent steam flow through the return line C, C' and limits exhaust to a liquid. Control E, limits the maximum quantity of steam that can be supplied to unit H within the immediate condensing capability of the unit.

In order to prevent premature operation of the emergency control, as when the heater is required to operate at full capacity (maximum steam and air flow at maximum steam pressure) the condensing capacity of the heater should, through proper design, be adequate, under the condition mentioned, to limit return line temperature to a point well below the normal bulb temperature control range.

In event air circulation in the room served by the heater becomes restricted, as by accidental blockage of the heater air inlet or outlet passages, the emergency control mechanism E operates to reduce or cut off the supply of steam to the heater as will be described.

The emergency control mechanism, as shown schematically in Fig. 1 only, includes a heat exchange relationship between condensate return or exhaust fluid pipe C and the bellows 90 of motor M, represented by a chamber portion 125 of the return pipe around the bellows housing or hollow enlarged chamber portion 93*b* of the condensate collector tube 93 which contains the throttle valve stem. For simplicity of installation a uniform diameter return pipe is secured as by a clamp (not shown) in heat conducting contact with the metal base plate 93*a* which supports the bellows.

Complete emergency throttle closing action (shutdown) results from attainment by the vapor fluid in the bellows of a temperature as high as that to which the vapor generator bulb 91 is subjected by damper-controlled convection in order to cause movement of the throttle valve to closed position.

When room air circulation is restricted as mentioned the normal removal of the steam heat content by the room air does not take place; the room air heating is reduced, and the primary thermostat T causes opening movement of the throttle. This necessarily results in an increase of condensate temperature. If the air flow restriction is sufficient to cause the condensate to approach a temperature at which saturated steam tends to pass through the exhaust line, throttle closing movement is caused by vapor generation in the bellows. Such throttle value movement actually continues only until the steam flow is reduced to the current condensing capacity of the heat exchanger mechanism, hence for complete shutdown the air blockage or restriction would have to reduce the condensing capacity practically to zero value.

Since exhaust from the heater is limited to a liquid by the above described emergency control action, it follows, as an additional feature of control E, that pressure in the turbine chamber is prevented from rising to a value such as could cause steam leakage from the chamber into the adjacent portion of the diffuser or blower housing.

VARIATIONS

The following alternatives for the control mechanisms thus far described and as shown in the accompanying drawings while not yet fully investigated for practical application would appear to be within the spirit and scope of the present invention:

1. Reversal of the direction of operation of steam and vapor generator pressure on the throttle valve V and reversal of action of room thermostat mechanism T. In this case vapor pressure in the generator of motor M, in response to input-heating-medium temperature as modified by damper-controlled convection in the chimney 100, would oppose throttle-valve-closing steam pressure on the bellows 90 aided by a suitable stabilizing spring opposing and overcoming the inherent spring action of the bellows wall in case a metal bellows is used; and the bimetal coil 105 would then have its operation reversed so as to open the damper 108 to increase steam flow as room or space temperature falls. This arrangement would require a continually open by-pass bleeder for steam around or through the throttle valve in order to maintain an initial-throttle-opening bulb temperature. This arrangement requires a special emergency control e. g. separate vapor generator system to shut off steam or for steam throttling in response to abnormal return line temperature rise.

2. An arrangement in which the metal bellows forms a pocket inside a vapor-fluid-containing and supporting case or capsule sealed around one end of the bellows and free from the opposite end, the pocket being open to the throttle valve chamber ahead of the valve and the bellows having its free or movable end wall connected to the end of the valve stem opposite the valve plug.

The above form ("2") of vapor generator and valve assembly can (*a*) be supplemented with remote bulb and connecting capillary tube and fully substituted for the illustrated arrangement (all functions the same) or (*b*) be used as the tempering-fluid-sensitive part of the vapor fluid chamber (with or without separate bulb and capillary tube) in which case condensate is free to enter the bellows around the valve stem, the movable or free end wall of the bellows thus being subjected to steam pressure on one side and vapor pressure on the other; and, if a capillary tube and bulb are also used as mentioned, then the bulb is disposed remotely of the bellows and capsule unit (e. g. outside the tempering fluid conduit or chimney) for emergency control, heat-exchange association with exhaust (i. e. condensate) fluid.

We claim:

1. A control for a space heater operated by a heating fluid medium, comprising: a throttle valve for heating fluid input to the heater, fluid motor means operatingly connected to a movable element of the valve and including a sealed chamber for thermo-responsive vapor fluid, the chamber having two relatively isolated thermo-sensitive surface portions, means arranged to subject one of said portions to a heating medium input temperature function ahead of the valve, space-temperature-responsive means controlling the flow of a tempering fluid into heat exchange relationship to said one thermo-sensitive portion for modifying the throttling action of the motor means in accordance with space temperature changes, and emergency control means arranged to subject the other thermo-sensitive surface portion to an exhaust heating fluid temperature function for moving the same throttle valve element toward closed position in event of increase in exhaust temperature to a predetermined point.

2. A control for a space heater operated by steam, comprising: a throttle valve for steam input to the heater, fluid motor means operatingly connected to the valve and including a sealed chamber for thermo-responsive vapor fluid, the chamber having two relatively isolated thermo-sensitive surface portions, means arranged to tend to maintain one of said portions at a temperature generally in the magnitude of that of the input steam, means operating normally to maintain the other of said portions at a temperature materially less than that of the input steam, space-temperature-responsive means acting variably to cool said one thermo-sensitive portion for modifying the throttling action of the motor means in accordance with space temperature changes, and emergency control means arranged to heat the other thermo-sensitive surface portion as a condensate temperature function for limiting condensate temperature.

3. A self-contained steam-powered space heater unit and control comprising in combination: a forced air heat exchange mechanism including a radiator, a rotary air impeller, a steam turbine connected to drive the impeller, a throttle valve for input steam including a nozzle directed to operate the turbine, and means to conduct turbine exhaust steam to the radiator; the control comprising a thermal relay including a motor operatingly connected to the valve and having a first thermo-sensitive control element normally and continually subjected to approximately the temperature of the steam as supplied to the radiator for operation over a relatively large control temperature range and a second thermostatically operating control mechanism subjected to space air temperature and having a relatively small temperature control range, and means to cause the second control mechanism to vary the flow of a low temperature fluid into cooling relationship to the first thermo-sensitive control element to initiate throttle-valve-positioning operations of the motor.

4. A steam-operated space heater unit having a heat exchange radiator and an air blower mechanism including an impeller adapted to be driven by input steam en route to the radiator, a steam throttling valve and input steam passage means leading thereto, a motor mechanism including a thermo-sensitive actuator element and motor element actuated thereby and operatingly connected with the valve, an air conduit around and in spaced relation to the actuator element and comprising a tubular heat-conductive hence heat-radiating wall in intimate heat-exchange relationship to a portion of the input steam passage means, space-temperature-sensitive means arranged to control the flow of air from a portion of the space served by the unit into the conduit, said means comprising a flap valve element disposed across one end of the conduit and supported for movement wholly by a bimetal thermostat element, and means to conduct space air to the bimetal element while substantially isolating said element from operational heat of the unit.

5. A control mechanism for a room space heater adapted for operation by a heating fluid medium under pressure, comprising: a throttle valve for the heating fluid, a sealed vapor pressure motor

mechanism having a thermally sensitive surface, means operative normally to maintain said surface steadily at a temperature generally in the magnitude of that of the heating fluid medium on the way to the throttle valve, the motor mechanism having a movable wall operatingly connected to the valve, the wall being continuously exposed on one side to vapor-fluid-pressure and on the opposite side substantially uniformly to pressure of the heating fluid on the way to the throttle valve, means operatively to maintain said opposite side at a temperature considerably less than that of the heating fluid on the way to the valve, and space-temperature-responsive means controlling the flow of a relatively low temperature fluid into heat-exchange relationship to said thermally sensitive surface of the motor mechanism.

6. The mechanism according to claim 5 wherein the last mentioned means thereof comprises a space-temperature-responsive thermostat motor remotely of all previously mentioned elements, the thermostat motor having an output member forming the sole support for a damper arranged to control the flow of room space air in a manner variably to cool said thermally sensitive surface.

7. A control mechanism for a room space steam heater requiring for its operation steam input under pressure, said control comprising: a throttle valve for the steam, a sealed vapor pressure motor mechanism having a motor portion and a separate but connected thermo-sensitive generator portion, the motor portion having a movable wall connected for opening and closing the throttle valve as a vapor pressure function of the generator, the motor portion of the motor mechanism normally containing vapor fluid in liquid form only, means operative during the admission of steam to the valve to maintain the thermo-sensitive generator portion steadily at a temperature generally in the magnitude of that of the input steam, means operative to subject one side of said wall substantially to input steam pressure while simultaneously sufficiently isolating the wall from input steam temperature to insure that the vapor fluid in contact with said wall will normally remain in liquid form, and room space temperature responsive means operative to control the flow of low temperature fluid in thermal exchange relation to said generator portion.

8. A modulating control for a space heater operated with saturated steam, comprising: a throttle valve for the steam, a fluid motor having an element operatingly connected to the valve and having a thermosensitive vapor pressure generator portion, means for concurrently causing the generator portion to sense the temperature of the supply steam by heat transmitted to it and said motor element to sense the pressure of the supply steam substantially exclusive of its temperature, whereby the heat-induced vapor fluid pressure tending to move the valve in one direction is opposed by steam pressure tending to move the valve in the opposite direction, air space temperature responsive means controlling the flow of cooling air into contact with the generator to cause generator temperature changes in accordance with air space temperature changes, and spring means connected to oppose movement of the throttle valve in one direction with a force which varies with throttle valve position, whereby to allow establishment of an equilibrium throttling position of the valve for each air space temperature.

9. A control mechanism for a steam-operated, space heater, comprising: tubular means forming a throttle valve chamber having a steam inlet passage, a steam discharge port and an elongated condensate-collecting passage exposed to steam on the way to the port, a metal air conduit open at both ends and in thermal association with the steam-inlet-passage-forming portion of said means for heating of the conduit, a vapor pressure generator including a bulb in the conduit in spaced relationship to its metal wall, a metal bellows in said condensate-collecting passage and a capillary tube connecting the bulb and bellows and in spaced thermal-insulating relationship to the metal of the conduit, a throttle valve member in the valve chamber in steam-controlling relationship to the port and connected to the bellows by means passing loosely through the elongated condensate-collecting passage, and space-air-temperature-sensitive motor means arranged to control the flow of air through the conduit for variably cooling the bulb.

10. In and for a space heater, a control mechanism having a valve for throttling the input of a heating medium to the heater, a valve-positioning mechanism including a temperature-responsive actuator device and motor means rendered active thereby and connected to the valve to hold it in throttling positions, means to subject the actuator device steadily to relatively high temperature radiant heat during operation of the heater, and means to modify the temperature of said actuator device by the cooling effect of space air, the modifying means comprising a generally upright metal conduit containing the actuator device and having a downwardly open air inlet passage, air guiding means operative to conduct relatively low temperature air from said space to said air inlet passage, and a space-air-temperature-change-actuated mechanism for controlling the passage, the latter mechanism including a temperature sensing motor element remotely of said air inlet passage and a damper movably supported generally across the passage and normally out of contact with the conduit solely by an output portion of the temperature sensing motor element.

11. In a steam heater unit wherein steam is throttled through a steam turbine nozzle on the way to a heat exchanger, a throttle valve nozzle comprising a hollow steam-conducting body having a steam-guiding orifice converging toward the turbine along a fixed axis for delivery of the steam as a concentrated jet, a tubular plug communicating with the steam conducting interior of said body and movable within the body along said axis variably to restrict the orifice, said tubular plug having a relatively smaller discharge orifice also converging toward the turbine along said axis, an inner plug movable within and relative to said tubular plug along said axis, means providing a lost motion connection between the plugs for limiting said relative movement along said axis to predetermined extended and contracted relative positions, respectively, of the plugs and for causing movement of the tubular plug by the inner plug in a direction away from the orifice of the body after the plugs have reached said predetermined extended position, means including a spring and co-operating shoulder means on or connected with the plugs and operative during movement of the inner plug in a direction for opening the orifice of the tubular plug to hold the tubular plug in a position closing the body orifice until the inner plug has moved a predetermined distance to said relatively extended position of the plugs, and a motor con-

nected to the inner plug for axial movement of it whereby to control emission of steam successively through said orifices.

12. A modulating control for a steam heater wherein steam is supplied to a radiator under appropriate pressure to operate a steam turbine on the way to the radiator and the turbine drives an air impeller to extract heat from the radiator; the control comprising: a steam throttling valve having a closed position and various steam throttling positions in each of which the steam emerges from the valve into operating contact with an impeller element of the turbine as a concentrated stream, fluid motor means operatingly connected to the valve and including a sealed chamber for thermo-responsive vapor fluid, means tending to maintain a thermosensitive portion of the chamber at a relatively high temperature, the motor means having relatively opposed, pressure-receiving surfaces, one subjected to vapor fluid chamber pressure and the other substantially uniformly to input steam pressure in all positions of the throttle valve, spring means connected to stabilize the valve in its steam throttling positions, and space-temperature-responsive means arranged to control the flow of relatively low temperature fluid into cooling relationship to the thermosensitive portion of the vapor fluid chamber.

13. A modulating control for a space heater connected for operation by steam at substantial pressure, the control comprising a thermal relay including a primary relay input thermostat sensitive to temperature of such space, a secondary relay output thermostat mechanism including a sealed vapor pressure generator having an actuating element exposed to steam temperatures as supplied to the heater and an expansible chamber motor element connected to the actuating element and having opposed areas, one subjected to vapor pressure of the actuating element and the other subjected to steam pressure as supplied to the heater, means operating at least partially to isolate said other area from the heat of the steam, a throttle valve for the steam including a port member and a control plug member, one connected for throttling movement by the motor element, the port and plug members providing a throttling orifice for the steam of such small average area in relation to those of said opposed motor element areas as to have substantially negligible unbalancing effect on the motor areas as the valve members are relatively moved between steam throttling and closed positions, spring means connected to act on the motor-connected member of the throttle valve for stabilizing the valve in steam throttling positions, and valve means connected for operation by the primary thermostat and arranged to control the flow of cooling fluid over the actuator element of the thermal relay.

14. In a space heater operated by steam and having a heat exchange radiator with inlet conduit means for steam and outlet conduit means for condensate; a throttle valve including a valve chamber, valve port and movable port-throttling means in the chamber; means forming a generally upright tubular pocket, having one end in open communication with the valve chamber for receiving steam on the way to the port, hence capable of collecting condensate of such steam; a vapor generator system including a motor vessel in the pocket and means mechanically connecting said vessel with the throttling means and extending through the open end of the pocket out of frictional contact with its walls for full freedom of movement and so that the motor vessel will be more or less isolated from the heat of the steam by condensate in the pocket, said generator system further including an actuator vessel remotely of the pocket and arranged to derive motor-actuating heat from the steam inlet conduit means; air space temperature sensitive means arranged for controlling the flow of cooling air over the actuator vessel for thermal relay actuated control of the throttle valve; a portion of the radiator outlet conduit means being in heat-exchange relationship to said motor vessel to cause emergency throttling operation of the valve therethrough consequent upon attainment of a predetermined high temperature by said radiator outlet conduit means.

15. A self-contained steam powered space heater unit and control comprising in combination: a forced air heat exchange mechanism including a radiator, a rotary air impeller, a steam turbine connected to drive the impeller, a nozzle directed to admit steam to operate the turbine, a throttle valve for controlling the input steam, and means to conduct turbine exhaust steam to the radiator, and a control including a first thermally responsive motor means normally and continuously subjected to temperature changes of the input steam delivered to the radiator and operatively connected to the valve for moving the valve in the opening direction in response to decreases in the temperature to which the first motor means is subjected, and in the closing direction in response to increases in the last mentioned temperature, a second thermally responsive motor means subjected to space air temperature and having a smaller temperature control range than the first motor means, means to cause a flow of space air into heat exchange relationship with said first motor means, and means operated by the second motor means to decrease the flow of said space air into said relationship when the space air temperature increases and to increase the flow of space air into said relationship when the space air temperature decreases.

16. The unit and control combination according to claim 15 characterized in that said radiator has a return line for conducting fluid in the form of condensate and steam from the radiator, and means are provided for operatively subjecting the first motor means to the temperature changes of the fluid in said return line so as to urge the first motor means to operate in the valve closing direction as the temperature of the fluid increases.

17. The unit and control combination according to claim 15 characterized in that means are provided for applying the pressure of the input steam to the first motor means in opposition to the force applied for moving the valve in the closing direction by the first motor means.

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