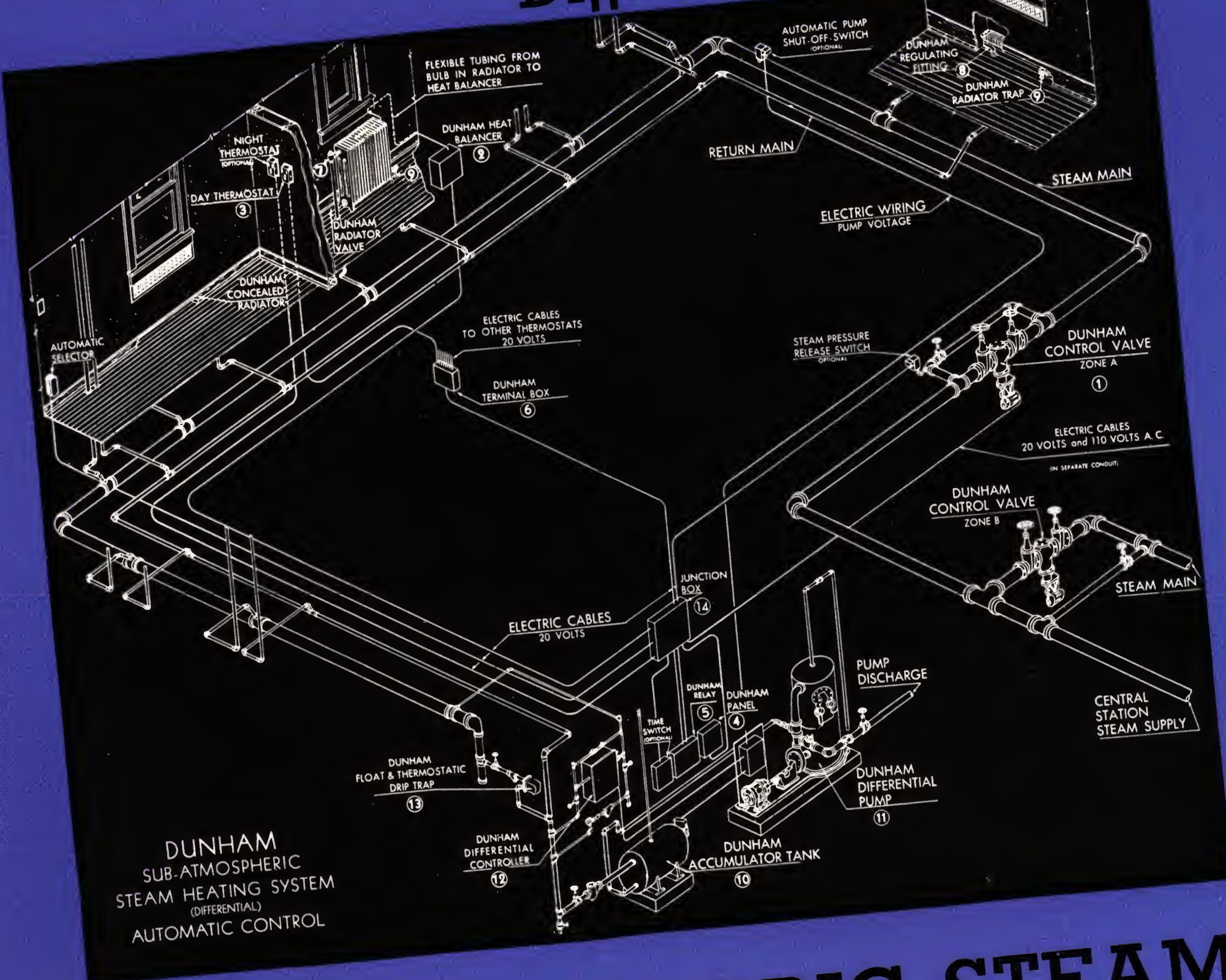
Dunham Differential Heating



SUB-ATMOSPHERIC STEAM HEATING SYSTEM

C. A. DUNHAM COMPANY
450 EAST OHIO STREET, CHICAGO, ILLINOIS

THE DUNHAM

SUB-ATMOSPHERIC STEAM HEATING SYSTEM

What It Is

The Dunham Sub-atmospheric Method of Heating is a two-pipe steam system which continuously distributes steam at a variable rate equal to the loss from the building. It unifies the function of **heat distribution** and **heat control** in the normal operation of a simple heating system by circulating steam at **variable sub-atmospheric pressures** and corresponding **low temperatures** and by controlled partial filling of the radiators with steam at the low-temperature limit of system operation.

The Differential principle, recognized now (with a satisfactory 11 year record), for its superior performance, was in 1927 a revolutionary departure from the standard vacuum return line system then regarded as the most satisfactory and economical type of steam heating system for larger and moderate-size buildings, or groups of buildings, heated from a central plant.

What It Provides

ADAPTABILITY—Sub-atmospheric Steam Heating offers to **Architects** and **Consulting Engineers** a method of controlled heating-system design adaptable to their individual plans. Piping design and sizing and radiator connections are as simple as for an uncontrolled system. They are as flexible as construction requirements are varied. No restrictions are placed upon the types or **combination of types** of radiation employed. Provision for zoning increases the precision with which steam distribution can be adapted to a wide diversity of building types, sizes and services.

TEMPERATURE CONTROL—The Dunham Sub-atmospheric Steam Heating System gives controlled heating comfort without adding control devices as "Extras." The control may be either manual or fully automatic, as hereinafter described. In either case a continuous (not "off" and "on") heat supply is provided which may be reduced to a rate which is in relation to weather conditions without interruption of circulation. In one stage of its control it utilizes steam temperature variation which covers a wide range of conditions. In the second stage it **limits steam volume** (at sub-atmospheric conditions) controlling **partial filling** of radiators thus continuing the reduction of heat output.

AUTOMATIC CONTROL— In this method the control is fully automatic and is incorporated as a normal function of the system operation itself.

1. It provides the radiators with steam at a temperature and in the amount required to meet heating demands of the existing weather conditions. Beginning with a maximum heat output obtained by steam circulation at a pressure of 2 pounds and a temperature of 218°F, **or more, as required,** the output is progressively reduced according to the demands of the weather by a reduction in the rate of steam admission to the system, which automatically causes a reduction in steam pressure and temperature until steam is being circulated at a temperature of about 133°F.
2. Further reduction in heat-output is obtained by partial filling of radiators with sub-atmospheric steam until the point is reached at which the need for heat ceases and the supply of heat is completely shut off.
3. A positive circulation is maintained as a fundamental function of the system. This tends to maintain unusually constant temperature levels throughout the building.

MANUAL CONTROL—This method is adaptable to many types of buildings and is particularly attractive for projects in which first cost for the heating installation must be held to a minimum and in which precise temperature regulation governed by thermostat may not be warranted by nature of occupancy, service or layout.

The designing and installation of the system is as simple as for a return line vacuum heating system. The installation requirements are substantially the same.

The Low Duty System and the High Duty System are the same except that in the latter, the traps will function up to 25″ of vacuum (as against 15″ for the standard traps used in Low Duty service). In Low Duty service, standard packless radiator valves can be used, but for High Duty Systems, the Dunham "Oriflex" self-adjusting type is required.

TEMPERATURE CONTROL OF THE SUPPLY PIPING—Sub-atmospheric Heating governs the heat output of all supply piping as well as that of the radiation itself. This means control of the usually uncontrolled heat output of supply piping which frequently would be sufficient, if equitably distributed, to heat the whole building, and which becomes an increasingly greater proportion of the total output of the system as the weather moderates. This steam supply piping output is never equitably distributed in ordinary practice, and as the steam supply cannot be shut off, building areas near the supply are overheated. By a progressive reduction in steam temperature the Sub-atmospheric System reduces supply piping heat output approximately 60% as the weather moderates.

FUEL OR STEAM ECONOMIES—The vitality, efficiency and health values of controlled heating, while readily demonstrable in tests, are normally regarded as intangibles difficult to evaluate.

The Fuel Saving which results from temperature control is, in contrast, a tangible advantage which can be measured in terms of dollars required to buy steam, oil, gas or coal.

The most conclusive and unassailable evidence, however, is the "before" and "after" data and tenant reaction from buildings heated by ordinary systems and "changed over" to Sub-atmospheric Heating. In percentages these annual savings run from 25% to 50% and in dollars they represent a rather large fraction of the cost of converting the installation.

Economies may be summarized:

1. Control of building temperature extending over the entire heating season with accuracy under mild weather conditions.
2. Control of heat loss from supply piping.
3. System control is not upset by abnormal demands such as opening windows.
4. Normally no injurious corrosion is encountered in low pressure steam heating systems. Where there is such corrosion, Sub-atmospheric Steam Heating has a distinct value. In Sub-atmospheric steam the rate of penetration by corrosion in the piping system is reduced approximately 50% from that obtaining in systems operated at atmospheric pressure. Data on tests conducted at the Michigan College of Mining and Technology will be found in the Proceedings of the A. S. H. V. E.

SATISFACTORY WINTER AIR CONDITIONS—Air Conditioning is defined as the maintenance of definite relations of temperature, humidity, air motion and freedom from dust and odors.

The Sub-atmospheric System provides a relatively large measure of the functions contemplated in air conditioning for the eight months of the year in which heat may be necessary.

1. It continually maintains a comfortable temperature level.
2. Continuous steam supply at variable temperatures prevents chilly drafts.
3. It avoids the objectionable "burnt odor" which characterizes space served by high temperature radiation.
4. The lower velocities of convection reduce the dust content of the air.
5. It does not overheat or overexpand the air, consequently natural humidity is conserved.

Where It Applies

The fact that Dunham Sub-atmospheric Steam Heating is giving satisfying heat comfort today in buildings whose requirements range from the whole group of skyscrapers of Rockefeller Center in New York and of commercial buildings in practically every state of the Union to those of fine large private residences, affords sufficient proof of its complete adaptability to heating requirements.

DUNHAM COOPERATION

For more than thirty years the Company, through a national organization of research and specialized engineering, has been engaged solely in the problem of making steam an easily managed and economical heating servant in every size and type of building. The accumulated experience of the Dunham organization is put at the disposal of the Heating and Ventilating Engineer. This cooperation is available for Modernization Work, as well as for new construction in industrial, commercial and other projects.

Over eighty sales engineers who sell and service Dunham Products in the United States, Canada and the United Kingdom bring Dunham Heating Service as close to you as your telephone. Consult your classified telephone directory for address in your city. These sales engineers are capable of selecting the correct Dunham System and Appliances for any type of building.

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Administrative and General Offices
450 E. Ohio Street, Chicago, Ill.
Factories: Marshalltown, Iowa; Michigan City, Ind.

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Look for "Dunham Heating Service" in the Classified Telephone Directory

C. A. DUNHAM COMPANY, LTD.
General Offices and Factory
1523 Davenport Road,
Toronto, Ontario, Canada

C. A. DUNHAM COMPANY, LTD.
(of the United Kingdom)
General Offices and Factory
Morden Road, London, S.W. 19, England

THE SYSTEM

DIFFERENTIAL PRINCIPLES

STEAM TEMPERATURE VARIATION—That the temperature of steam varies with its pressure is an old established fact.

Then why not **Control the Pressure or Vacuum** of the steam in the supply piping and radiators and in so doing **Control the Temperature** of the steam in the radiators and thereby the building?

An illustration—If steam at 2 pounds pressure (218° F.) provides sufficient heat to maintain a building temperature of 70° F. with an outside temperature of 0° F., a reduction in steam pressure to 25 inches vacuum giving a steam temperature of 133° F. would be sufficient for much warmer weather, since the radiation surface is fixed.

Reduction in steam temperature as employed in the Differential System thus in itself affords complete control of building temperature over a large range of the outside temperatures usually encountered.

Further control is obtained through control of steam volume.

STEAM VOLUME VARIATION—The heat output of the radiation is further reduced by the partial filling of radiators with sub-atmospheric steam, the amount of partial filling being reducible to the point at which the need for heat ceases entirely.

These two fundamentals form the basis upon which the system was developed. See illustration, Fig. 1813, below.

PRINCIPLES APPLIED—If steam was to be circulated at pressure, varying from 2 pounds gauge to 25 inches of vacuum and at variable volumes under high vacuum condition, appliances had to be developed and correlated to perform the necessary functions of distribution and control.

Control valves were developed to govern the rate of steam admission to the heating system. Valves which can be automatically governed by the heat demand of the building, and manually regulated valves are available.

Equal filling of radiators under continuous steam circulation was obtained by the development of regulating devices designed to interpose measured resistance and to proportion steam flow to each radiator.

Radiator and Drip traps, preventing steam passage while permitting condensate and air to flow to the return piping, were designed.

To provide the range of vacua under which this system functions, a vacuum pump was designed which is amply capable of producing and maintaining the necessary wide range of vacua.

The "Pull" on the return end of the system must at all times be slightly greater than the "Push" established by the rate of steam admission through the control valve. This requirement is met with a Differential Controller. Both supply and return pressures act upon the Differential Controller which starts and stops the vacuum pump to maintain the return pressure continuously lower within fixed limits than the supply pressure under all rates of steam admission to, and condensation within, the system.

In the Sub-Automatic System under automatic control, a basic rate of heat supply is established closely in accord with the requirements of the building. This basic rate is further modified. The room thermostats maintain the room temperatures at the desired point. The basic rate of heat supply is established by the Automatic Selector through the Heat Balancer. Under manual control the rate of supply is determined by the operator.

THE TOTAL FUNCTION—The total function of the Differential System is to deliver steam uninterruptedly to the radiation at pressures and temperatures and in volumes which vary in response to weather demands.

It is attained simply and effectively by the cooperative action of all parts of the equipment.

To appreciate the full value of Differential Heating it is necessary to understand not only the operation of each part but to realize the results of their cooperative action.

This can readily be done by tracing the complete cycle of automatic system operation which is indicated in Figure 1639C on Page 5.

THE CYCLE OF OPERATION—Fig. 1639C illustrates schematically the cycle of steam distribution and control. Steam from the boiler (9) flows through the Dunham Control Valve (5) and on to the radiators (6) into which it is admitted through a Dunham Radiator Valve equipped with a Regulator Plate* (10). The Dunham Radiator Trap (11) prevents passage of steam but allows air and condensation to flow into the return piping and back to the Differential Pump (8) from which the air is vented and the condensation returned to the boiler. The Differential Controller (7) actuates the pump to maintain the pressure (vacuum), in the return piping always slightly lower than the pressure in the steam supply piping insuring continuous circulation. The Automatic Selector (12) determines the maximum rate of heat supply and adjusts the Heat Balancer (2) accordingly. The Thermostat(s) (1) modify the rate established by the Selector insuring continuous circulation. *The resultant demand is transmitted through* the Junction Box (13). The Panel (4) affords complete operator-control of the entire system.

*Valves with regulating device built into them and which may be adjusted without breaking pipe connections are now available, (see page 11).

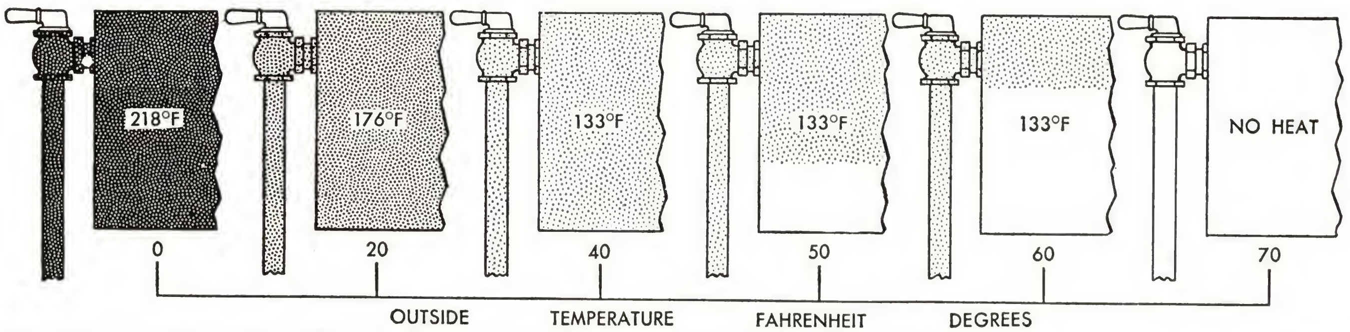


Fig. 1813—Illustrating the Differential Method of reducing heat output by reducing first the steam pressure and temperature and finally the volume.

EXPLAINED

DESIGN FUNDAMENTALS

SOURCE OF STEAM—The System requires a continuous supply of steam from any dependable source to the control valve at a pressure of 2 pounds gauge and not exceeding 10 pounds. The typical illustration on front cover indicates use of central station steam with automatic control, that on the back cover, an individual boiler plant with manual control.

PIPING—The piping must be designed and installed to free itself entirely of water by gravity flow to the Accumulator Tank of the Differential Pump. It must be properly graded, anchored and supported.

PIPE SIZING—Pipe sizes are the same as those used in standard practice for vacuum return line heating systems.

GRADING—The steam and return mains must be carefully and uniformly graded in the direction of flow with a fall of not less than ½ inch in 10 feet.

LIFT CONNECTIONS—These must not be used in the steam and return piping because of the small pressure differential which maintains steam flow in the System.

CONTROL VALVE—The Control Valve regulates the continuous admission of steam into the heating mains. It is not an "on and off" but a "graduated operation" valve controlled at various percentages of its full opening by an electric motor in response to the demands of the thermostatic appliances.

RADIATION—Concealed radiators, cast iron direct radiators, unit heaters and unit ventilators are commonly used on Sub-atmospheric installations. Continuous steam circulation eliminates difficulties due to the unequal heat storage capacity of these various types of radiation.

RADIATOR VALVES—Dunham Bellows Type Packless Radiator Valves are particularly recommended for Sub-atmospheric installations because their bellows construction makes them leak-proof. Freedom from air leakage is a factor affecting the high vacuum limit of operation of a sub-atmospheric steam installation.

FLOW REGULATING DEVICES—These devices provide control of distribution of steam within the system. They establish a reservoir condition in the steam supply piping which causes the radiators to be filled proportionate to their capacities. They are available as a complete valve including regulating feature, plates for use with ordinary types of valves, or fittings. Special fittings for use on Concealed Radiators are also available.

TRAPS—The Dunham thermostatic trap maintains radiators at maximum efficiency by draining water and venting air from them while preventing the passage of steam into the return piping. The trap does not alternately open and close but adjusts itself to a position determined by the prevailing temperature and pressure conditions.

VACUUM PUMP—The function of the pump is to remove air and condensable gases from the heating system and to return water of condensation automatically to the boiler while maintaining steam circulation. It is designed upon the "kinetic exhauster principle" which has proved its ability to perform consistently and quietly over long periods with a minimum of attention and maintenance.

DIFFERENTIAL CONTROLLER—The Differential Controller automatically controls the pump to maintain steam circulation under conditions corresponding to the rate of steam supply through the control valve. It is connected to both the supply and return piping and is actuated by the difference in pressure between them.

HEAT BALANCER AND AUTOMATIC SELECTOR—Control of a heat supply solely from room thermostats has certain weaknesses recognized as "hunting," "seeking" and "overshooting and undershooting." The Automatic Selector and the Heat Balancer overcomes these difficulties by limiting the rate of heat supply to a basic value in accordance with the building heat losses.

THERMOSTATS—The thermostat (s) evaluates room temperature and modifies the basic rate established by the Heat Balancer.

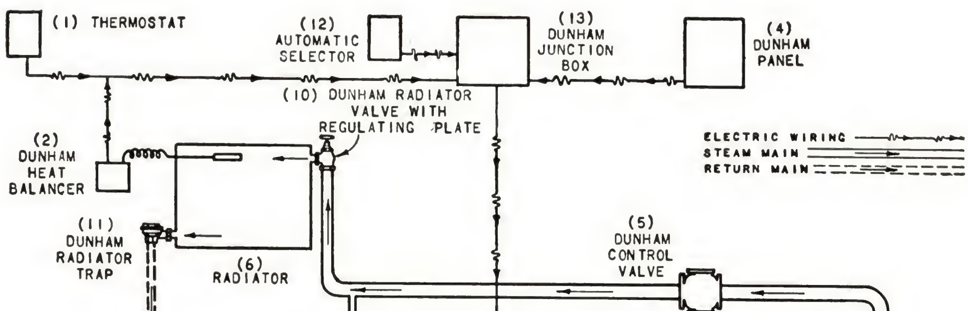


FIG. 1639C

TYPES OF

For good heating the heat supply must be both variable as to rate and responsive as to control to compensate continuously for the vagaries of the weather.

In addition to meeting this fundamental requirement the system must have adaptability of design to a wide diversity of building types, sizes and services.

The System is as flexible as construction requirements are varied. The equipment which governs steam distribution is as simple and as easy to install as that required for uncontrolled systems. The adaptability of the design is also particularly true of the control appliances.

AVERAGE TEMPERATURE CONTROL—Dunham Subatmospheric Steam Heating employs the elastic qualities of steam to provide a smoothly variable supply of heat. Average-Temperature Control has been perfected as an integral part of the system to link the variable supply to the fluctuating requirements for heat. **It gives accurate, automatic and continuous regulation of building temperature.**

Average Temperature Control is a descriptive name for the following functions:

(1) A continuous evaluation of the average of heat requirements at a number of thermostat locations in a building or zone of a building.

(2) The continuous averaging of this demand for heat with that established by the Heat Balancer and Automatic Selector, and the continuous transmission of the resultant demand to the Control Valve in the steam main.

(3) The automatic operation of the Control Valve to deliver steam at a rate continuously in correspondence to the average heat demand.

The Thermostats perform the function of evaluating and averaging the heat requirements. They produce a "graduated" rather than an "on-and-off" demand for heat. They are located throughout the building, or zone, in relation to its height, exposures and orientation to give an average thermostat demand in step with the actual building demand for heat. The demand from these Thermostats is transmitted electrically to the motor of the Control Valve to increase or decrease the basic rate of steam supply established by the Automatic Selector and Heat Balancer.

The System automatically adjusts itself to maintain steam circulation under pressure, temperature and volume conditions which correspond to the rate of heat supply called for by the average demand.

Sub-Atmospheric Steam Heating with Average-Temperature Control is adaptable to all types of buildings in which occupancy requires a relatively high degree of human comfort and efficiency.

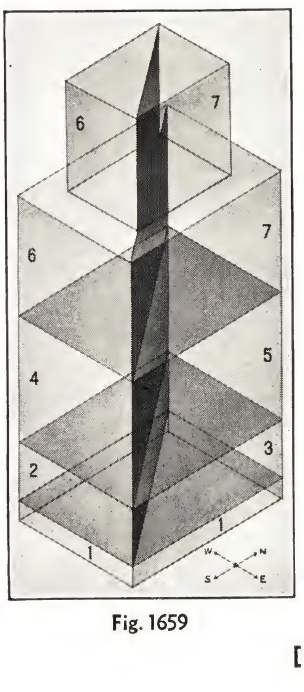


Fig. 1659

REMOTE CONTROL—The Dunham Panel is equipped with switches to change the system from automatic operation, which is normal practice, to remote control as may be desired for night service or emergencies. Under remote control, the rate of steam admission to the system is adjusted at the will of the operator from the Panel.

MANUAL CONTROL—Manual Control provides a major portion of the advantages of sub-atmospheric steam for buildings in which, by reason of financing, occupancy, service or layout, the ultimate precision of Automatic Control is not warranted. This type of installation is also economically adaptable to many existing buildings in which operating costs should be reduced and heating service improved.

Manual Control is suitable for all types of buildings. The service and occupancy of some types of structures may warrant a substantial measure of control upon the basis of comfort and operating economy, but may not make the finest precision in temperature regulation imperative. Here, also, and in buildings in which consideration of first costs outweigh the benefits of complete temperature regulation, Manual Control may be applied advantageously.

Manual Control may be used either with individual boiler plant or with central station steam. The heat output reduction effected by steam temperature variation is from 25% to 50% of the total system capacity and is obtained by utilizing a range of pressure from 2 lbs., or more, above that of the atmosphere down to as low as 25″ of mercury vacuum, with corresponding steam temperature variation. Further reduction in output is secured without interruption of steam supply, through progressively **reducing the volume** of steam in circulation and thereby producing a condition of partial filling in the radiation.

ZONE CONTROL—To insure the finest degree of precision in temperature regulation and the lowest possible heating costs, it may be advisable to divide large buildings into a number of heating zones, each having an individual system of supply piping and each being controllable in accordance with the particular heat requirements of the section it serves.

This practice is called zoning. It is used in buildings serving more than one purpose, such as an office building containing stores or a theatre; in institutional buildings housing various departments and services with varying temperatures and time requirements for heat; and in tall buildings with sectional variations of wind and sun exposure and subject to the phenomena of "stack (chimney) effect." Obviously each zoning project must be dealt with individually. This should be done in the light of the factors of service requirements, occupancy, exposures (wind and sun) and the construction, size and shape of the building.

Typical zoning practice is illustrated schematically in Fig. 1659. Zone 1 comprises the main floors including foyers, mezzanines and frequently shops, banks and other types of establishments. Above this zone, the building may be divided, as in this case, both with respect to exposures and to height.

CONTROL

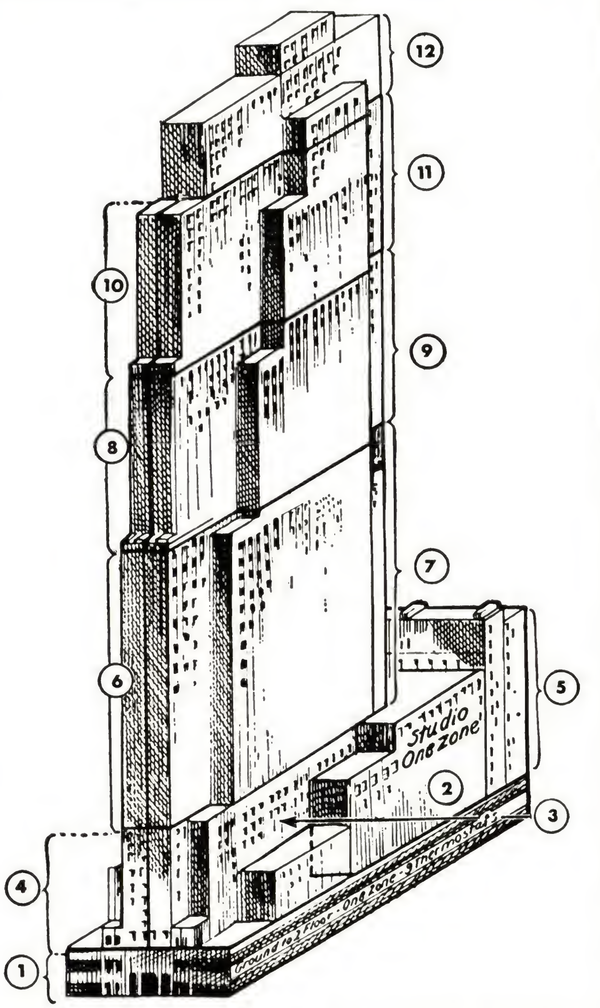
Zones 2, 4 and 6 serve the south and west sides of the building at various heights and Zones 3, 5 and 7 serve the north and east sides with the same subdivision as to height.

When a Sub-atmospheric installation is zoned, each zone is regarded as an individual system. Each zone requires a separate system of steam supply piping. Each also requires separate regulating equipment, including a Control Valve, a Heat Balancer, Automatic Selector, Thermostats and a Differential Controller. Where the radiation load of two or more zones does not exceed the capacity of a single Differential Pump, one pump may serve a plurality of zones.

Under certain conditions, one Differential Controller only may be necessary for several zones. Where one zone comprises blast radiation, a separate pump is usually required for this load.

THE ZONING OF ROCKEFELLER CENTER FOR SUB-ATMOSPHERIC STEAM HEATING

Architects: Reinhard & Hofmeister; Corbett, Harrison & MacMurray; Hood & Fouilhoux. Consulting Engineer: Clyde R. Place



1—Ground to 2 Floor, One Zone.
2—Studio, One Zone.
3—3 to 11 Floor, North Zone, 9 Thermostats.
4—3 to 11 Floor, South Zone, 9 Thermostats.
5—Building No. 9, One Zone, 9 Thermostats.
6—12 to 32 Floor, South Zone, 9 Thermostats.
7—12 to 32 Floor, North Zone, 9 Thermostats.
8—32 to 45 Floor, South Zone, 9 Thermostats.
9—32 to 45 Floor, North Zone, 9 Thermostats.
10—45 to 64 Floor, South Zone, 9 Thermostats.
11—45 to 64 Floor, North Zone, 9 Thermostats.
12—64 to 70 Floor, One Zone, 4 Thermostats.

Because of its size, height and the diversity of services housed, the 70-story Central Tower of Rockefeller Center (Radio City), New York, provides an instructive example of zoning. It also illustrates the range of adaptability of the Differential Vacuum Heating System and the flexibility of control obtainable. The heating installation was designed by Clyde R. Place, Consulting Engineer. In zoning, the major portion of the building was divided vertically to take care of exposures and horizontally to take care of stack effect. Additional zones were established to take care of special requirements.

The vertical division of zones makes it possible to supply heat at a higher rate to the zones on the north side than to those on the south. The horizontal division makes it possible to supply heat to the upper zones at a rate lower than to the lower zones.

Zone 1, comprising the ground and second floors, is mainly banking quarters and shops. Here zoning for exposure is not important because of the protection provided by neighboring buildings. Building 9, comprising Zone 5, which adjoins the Central Tower, will be given over to occupancy of special type; here also the protection of neighboring buildings makes zoning for exposure unnecessary. Zone 2 is the studio of the National Broadcasting Company.

Steam is carried to the supply point of each zone at 50 pounds pressure and there reduced by means of a reducing valve to 2 pounds for supplying the Control Valve which is a part of the Dunham Differential Vacuum Heating System.

One return main leads from the South Zones 4, 6, 8, 10 to a Dunham Differential Pump in the basement of the Tower Building.

Another return main leads from the North Zones 3, 7, 9, 11 and the top zone 12 to a second Differential Pump, which with an additional pump for stand-by service is also located in the basement of the Tower Building.

Returns from Zones 1 and 5 lead to a Differential Pump in the basement of Building 9.

Returns from Zone 2 lead to another Differential Pump, also located in the basement of Building 9.

FUEL OR STEAM ECONOMIES

FIRST COSTS—A Sub-atmospheric System is a complete heating system which incorporates temperature regulation. Its first cost is greater than that of an uncontrolled heating system such as the ordinary vacuum return line system. For this greater first cost, the owner receives over the life of the building, greater heating satisfaction in terms of comfort and health, plus an annual reduction in fuel consumption of from 20 to 30 per cent below an ordinary heating installation.

In this system the owner buys low cost heating plus temperature regulation. The purchase of an ordinary system requires the additional purchase of temperature control equipment. A cost comparison on these purchases substantially favors the Sub-atmospheric System and reveals its true value as a heating investment.

HEATING COSTS—Convincing proof of fuel savings by Sub-atmospheric Steam Heating is to be found in the operating records of the heating plants of buildings from coast to coast which have been converted from ordinary heating to a Sub-atmospheric System.

Fuel consumption rates in new buildings are as low (and usually lower by reason of better control of design and installation) as in buildings changed over to Sub-atmospheric operation. Comparison is, however, more difficult in view of the variable factors encountered between different buildings, localities and seasons.

This system controlling, as it does, the supply and distribution of heat makes its fuel saving in temperature control.

Outside weather conditions determine inside heat requirements. The one is the cause, the other the effect, and while there is a time-lag between cause and effect, the need for a heat supply which can be varied to follow weather fluctuations is none the less imperative for satisfactory heating. This need is met in the Dunham Sub-atmospheric Steam Heating System.

The calculated maximum heat loss from a building at "design basis" conditions determines the amount of radiation which must be installed. This radiation is usually sufficient to keep the building warm during coldest winter weather when filled with steam at 2 pounds pressure. Heat losses may be reduced 50, 75, or 90 per cent below this maximum during mild weather, yet no reduction can be made in the radiation, therefore, **unless the system provides control of the heat output from the radiators,** the results are overheating, discomfort and extensive window opening during most of the heating season. Overheating increases fuel consumption for the entire season from 25 to 50 per cent (or more) in excess of that which should actually be supplied to maintain a desirable inside temperature.

APPLIED TO EXISTING BUILDINGS

The System is applicable to existing buildings as well as to new projects. Excessive heating costs, unsatisfactory heating service or wear and tear on present equipment may make the consideration of a "change-over" worthwhile in such buildings.

The survey of a consulting engineer or contractor may indicate that a "change-over" is a better investment than a straight replacement. In many instances a "change-over" proves to be the economical and permanent solution of such problems as uneven heating, faulty circulation, necessity for excessive steam pressures, noise or other operating difficulties.

The cost of "change-over" installations varies with the type of heating system already in service. The fact that fuel or steam costs are considerably higher than they would be under Sub-atmospheric operation is not in itself sufficient reason for a "change-over" recommendation. The important consideration—to the owner—is the ratio of savings to the cost of making the "change-over."

We will gladly co-operate with architects, consulting engineers and contractors in supplying data as the basis for the surveys upon which modernizing recommendations can be made to clients.

APPLYING THE SUB-ATMOSPHERIC PRINCIPLE—In "change-over" work the effort is made to use as much of the existing equipment as will permit satisfactory operation and thus to reduce the extent and costs of alterations.

Existing piping and radiation throughout the building can normally be utilized without change after being checked for tightness and grading and proper distribution of radiation. In such cases a practical and economical approximation of "Differential" standards of comfort and savings is secured by adopting the Sub-atmospheric principle and method of steam heating.

Dunham Sub-atmospheric Steam Heating standards are sufficiently flexible for practical application to obsolete two-pipe vacuum return line systems, gravity steam systems and to one-pipe steam systems.

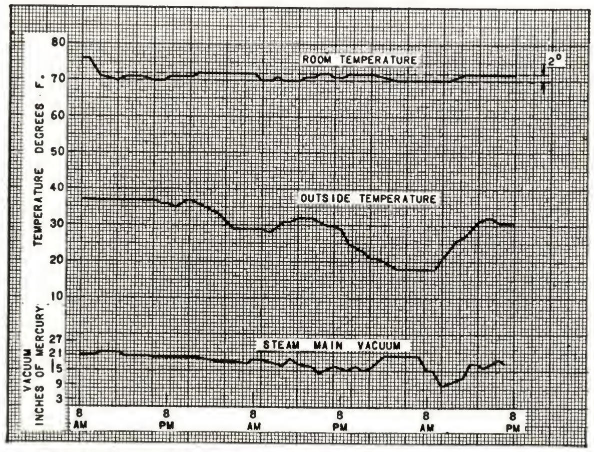
APPLIED TO

AIR CONDITIONING AND VENTILATION

The Differential principle of a variable rate of heat transfer by variation in the steam temperature and volume is well adapted for application to the air (blast) heating equipment systems for institutional and other types of buildings.

Satisfactory control of the rate of heat transfer to the air distributed by such a system is the prime requisite for satisfactory operation.

The application of Sub-atmospheric Heating to this type of service gives a basic control of the heat output from 100 per cent capacity to zero by its inherent ability to reduce heat emission.

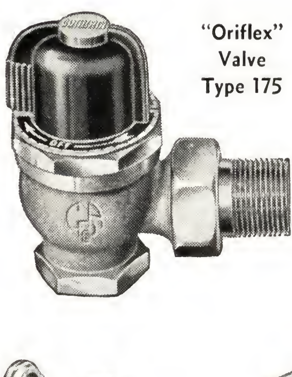


CONTROL RECORD OF AIR CONDITIONED BUILDING USING THE DIFFERENTIAL SYSTEM

TYPE "ME" UNIT HEATER AND CIRCULATING UNIT

Styled for tomorrow—available today—incorporating many innovations—developed from the eminently successful Type "M" heater introduced seven years ago. Cabinet completely conceals all piping, wiring and operating parts, yet all are easily accessible. Essentially a refined recirculating type unit heater, it may also be used to perform the functions of air conditioning—heating, cooling, circulating, cleaning, de-humidifying, and humidifying the air which it handles noiselessly. Recent research in air-movement equipment provides this Type "ME" unit heater, rounding out a complete line of heating and cooling units in this field.

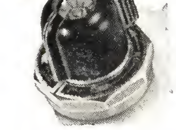
THE ORIFLEX VALVE



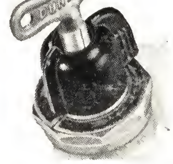
"Oriflex" Valve Type 175

Prior to the development of the Dunham self contained adjustable orifice valve, balancing the heating system required a series of time-consuming operations—(1) the valve had to be disconnected from the radiator. (2) A regulating plate (orifice) inserted. (3) The valve reconnected to radiator—before testing for "balance" could be made. With "Oriflex" the valve does not have to be disconnected: merely remove medallion, insert key on adjustment stem thus made accessible and adjust the orifice (calibrated guide surrounds the stem), replace the medallion—that's all.

Where costs demand a lower priced valve, a standard Type 200 valve with regulating plate may be used on low duty systems.

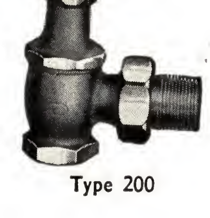


Remove Medallion

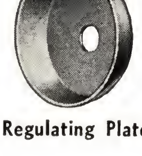


Insert Key and Turn to Desired Setting

Adjustment Completed, Replace Medallion



Type 200



Regulating Plate

Dunham Sub-atmospheric Steam Heating may be utilized for either High Duty or Low Duty service and be either automatically or manually controlled as described on page two.

A TYPICAL SPECIFICATION

1. **THE GENERAL CONDITIONS** governing this work shall be those established as standard by the American Institute of Architects.

2. **CONSTRUCTION AND MATERIALS.** The heating installation proposed includes the furnishing, delivery and erection of all necessary material, which shall be first class in all particulars and in accordance with the specifications, heating plans and manufacturer's details.

3. **INSPECTION.** The contractor shall allow the C. A. Dunham Company's representative to inspect the installation and shall lend any assistance necessary to expedite and perfect the work.

4. **SCOPE OF WORK.** The contractor shall furnish and install a Dunham Sub-atmospheric Steam Heating System in accordance with these specifications, the accompanying plans and instructions issued by the manufacturer.

5. **PATENTS.** The contractor shall obtain and furnish owner with a license to install and operate the system specified above under U. S. Lettters Patent Nos. 1,644,114; 1,771,077; 1,983,218; 1,802,383 and 1,802,384.

NOTE: Use either (the following) 6A, 6K, 6M as required.

6A. **AUTOMATIC CONTROL EQUIPMENT** (Average Temperature Control). The contractor shall furnish and install in the supply main in the boiler room at the point shown on the plans, an electrically operated Dunham Sub-atmospheric Steam Control Valve governed by the average of Thermostats, a Heat Balancer, an Automatic Selector, all to be furnished installed and electrically connected with a Terminal Box, Junction Box, Differential Controller and Panel according to manufacturer's instructions. He shall also furnish and install an Automatic Pump Shut-off Switch.

6K. **AUTOMATIC CONTROL EQUIPMENT** (Key Room Control). The contractor shall furnish and install in the supply main in the boiler room at the point shown on the plans, an electrically operated Dunham Sub-atmospheric Steam Control Valve governed by *Thermostats, a Heat Balancer, an Automatic Selector, all to be furnished, installed and electrically connected with a Terminal Box**, Junction Box, Differential Controller and Panel according to manufacturer's instructions.

*Specify 1, 2, or 4 Thermostats as required.
**Omit Terminal Box when only 1 or 2 Thermostats are used.

6M. **MANUAL CONTROL EQUIPMENT.** The contractor shall furnish and install in the supply main in the boiler room at the point shown on the plans a Dunham Sub-atmospheric Pressure Reducing Valve and shall insert additional rods in the weight arms so that the weights will hang to a point six feet above the boiler room floor (to facilitate valve adjustment).

7. **DIFFERENTIAL VACUUM PUMP.** Furnish and install on a suitable foundation a size Dunham Differential Vacuum Pump with size accumulator tank equipped with float switch. The pump shall have the capacity to handle sq. ft. equivalent direct radiation under operating conditions of 2 lbs. gauge steam pressure to * of vacuum within the radiators. The suction of pump to be connected to accumulator tank outlet and discharge of pump connected to boiler (or other apparatus) as directed by the architect. Pump to have automatic starting equipment mounted on pump base. Pump is direct connected to a Motor wound for volts, phase, cycle. Pump impeller to be of bronze and capable of discharge head of lbs. at pump.

*25″ for high duty system; 15″ for low duty.

8. **DIFFERENTIAL CONTROLLER.** Furnish and install where directed and in accordance with manufacturer's installation and wiring instructions, a Dunham Differential Controller to govern differential vacuum pump operation to maintain a pressure differential between the steam and return piping.

9. **AUTOMATIC PUMP SHUT-OFF SWITCH** (for Automatic Control System). Furnish and install in heating system steam main approximately 50 feet from control valve a Dunham Automatic Pump Shut-Off Switch according to manufacturer's installation and wiring instructions.

NOTE: Automatic Pump Shut-Off Switch is optional on Key-Room Control installations. It is not used on Manual Control.

10. **WIRING INSTALLATION.** The Heating Contractor shall obtain from the C. A. Dunham Company detailed wiring diagrams of the control equipment and Differential Pump to be used on this installation. Service wiring will be brought to within 10 feet of both the Control Valve and the Differential Vacuum Pump from which point this contractor must arrange for the complete installation of all wiring circuits of control equipment and pump in accordance with C. A. Dunham Company's instructions. All wiring must be installed in accordance with local regulations governing this work.

NOTE: This (complete) paragraph applies only when 6A or 6K is used. On Manual Control (6M) installation omit the words "both the Control Valve and" in the 4th line (of paragraph 10).

11. **BOILER.** The steam boiler shall be a with guaranteed rating for at least sq. ft. of equivalent direct radiation. It shall be installed upon a suitable foundation and in accordance with boiler manufacturer's instructions. It shall be equipped with all necessary connections and trimmings, including a safety valve set to blow at 10 pounds pressure, a Dunham Compound Gauge 15 pounds by 30 inches vacuum, and a sensitive Damper Regulator. (Omit Regulator on gas-fired and automatic oil-fired installations.)

12. **SMOKE PIPE.** Connect boiler to chimney with suitable black iron smoke pipe gauge. Size to be as recommended by Boiler Manufacturer. Smoke pipe must be provided with hand stop damper. (Omit hand stop damper on gas or oil-fired installations.)

13. **PIPE AND FITTINGS.** Furnish and erect a system of steam supply and return piping. All piping to have tight connections, be properly supported and graded to insure free and noiseless circulation. Use wrought steelpipe (or wrought iron) and cast iron fittings of standard weight and quality. The ends of all pipes shall be reamed or filed. Use graphite and oil applied to male thread only for making up all pipe joints. Provide for expansion of mains and rises by using loop type expansion joints and swing connections wherever possible. In other cases provide approved all-metal packless expansion joints. Piping to be properly anchored.

14. All steam tappings in boiler shall be connected full size of tapping into a steam header which shall be dripped to the return header through a bleeder. Springpieces to steam and return mains shall be taken off the top of mains at 45 degrees. On down-feed systems take the springpieces from the bottom of overhead steam main at 90 degrees.

15. The end of each steam main, down-feed riser and drip point shall be drained into return main using a gate valve, Dunham Strainer and Dunham Trap as indicated on plans. Each drip shall flow by gravity into the return main. No lift connection shall be used.

16. Grade steam mains, return mains and drip piping ½″ in 10 ft. down with flow. All steam supply springpieces, offsets in steam risers and runouts to radiators which grade in a direction opposite to steam flow shall in each case be installed not less than one size larger than the vertical pipe to which they connect and graded ½″ per foot. Grade return springpieces ½″ per foot.

17. Return mains shall be connected to the Accumulator Tank of Dunham Differential Vacuum Pump as shown in detail furnished by manufacturer. Lift connections must not be used except between pump and accumulator tank. There must be gravity flow of water and air from all drip and radiator traps and drip points to the accumulator tank.

18. Risers are to be run concealed or in the open as directed by the architect. All concealed piping must be tested and made tight at 15 lbs. water pressure before being concealed and covered.

19. All union connections, flanges, packing nuts on gate and globe valves and on gauge glass of boiler must be drawn up tight so as to prevent air leakage into system when under a vacuum. This work must be performed after system is completed and while it is working with a vacuum in both steam and return lines.

20. **FLOOR PLATES, SLEEVES.** Furnish approved floor and ceiling plates and sleeves on all pipes passing through floors or partitions.

21. **VALVES AND CHECK VALVES.** All shut-off valves in steam and return piping (excepting radiator inlet valves) shall be gate valves of approved make. Valves 2″ and under shall be brass; 2½″ and larger to be iron bodies, brass trimmed; 5″ and larger shall be flanged. Check valves shall be horizontal or angle swing type of approved make with light weight brass disc, tested for tightness. Check valves shall be installed where shown on plans or details, and wherever necessary.

22. **RADIATION.** Furnish and install Dunham Concealed Radiators (or cast iron direct radiation) of type and size shown on plans.

23. **RADIATOR TRAPS AND VALVES.** Each radiator shall be provided at its return outlet with a Dunham D Series Radiator Trap of suitable size for satisfactory operation. The outlet of these traps to be connected to the return piping. A Dunham "Oriflex" Packless Radiator Valve of proper size, shall be installed at inlet connection of each exposed radiator. Each concealed radiator shall be equipped with a Dunham Adjustable Regulating Fitting, or with a Packless Valve and a Dunham Regulating Plate in accordance with instructions furnished by manufacturer.

24. **PAINTING.** All Exposed Piping, and parts of Boiler and radiators shall be painted as directed by the architect. The paint must be applied when the entire system is under vacuum.

25. **COVERING.** Cover all steam mains and their springpieces with four-ply, 1″ thick asbestos sectional covering secured in place with metal bands. Fittings to be covered with asbestos cement. Cover all steam and return risers and other piping run concealed in outside walls or concealed in partition within 18″ of outside wall, with two-ply, ½″ thick asbestos sectional covering. Cover boiler as specified by boiler manufacturer.

26. **FINISHING UP.** Thoroughly blow down and clean out the System under 5 lb. steam pressure, wasting condensate to sewer. After this, close valve in steam main and surface blow off the boiler through sfety valve tapping at 5 lb. pressure, supplying make up water constantly, for at least two hours. Then, extinguish the fire, entirely drain the boiler and allow it to cool before filling with fresh water.

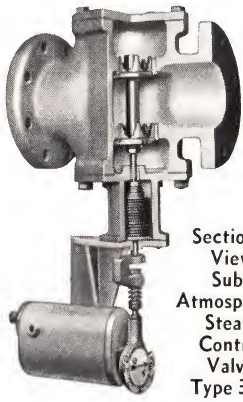
27. **TEST.** When System is finished and cleaned, but prior to covering of pipes, it shall be tested for tightness by the Contractor who shall furnish labor and materials for performing the following test: obtain a vacuum of 15 inches on a cold system by operating the Differential Vacuum pump. Stop the pump. After two hours, there shall remain ten inches vacuum on the system. System shall be considered cold five hours after steam was last on the system.

28. **GUARANTEE.** The Heating Contractor shall guarantee the apparatus installed to circulate steam thoroughly through every radiator without noise, with a vacuum of * in steam main. If the installation shall fail to accomplish this guarantee by reason of any defect developing within the first heating season due to faulty material or workmanship, The Contractor shall remedy such defect at his expense within reasonable time after notice.

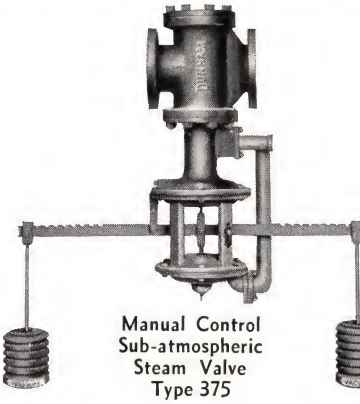
*25″ for high duty system; 15″ for low duty.

29. **FINALLY.** Nothing herein contained shall be construed to relieve the Contractor from making good and perfect work in all details of construction.

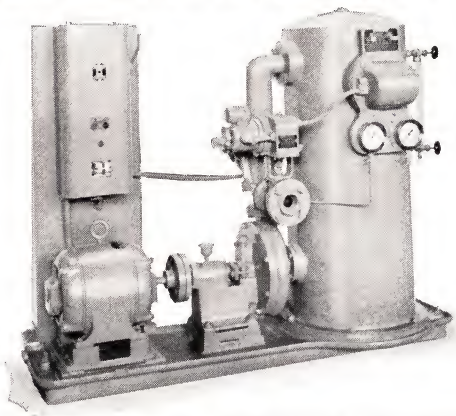
MAJOR PARTS OF A SUB-ATMOSPHERIC SYSTEM



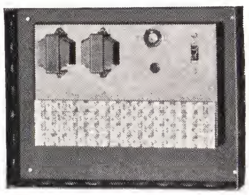
Sectional View Sub-Atmospheric Steam Control Valve Type 379



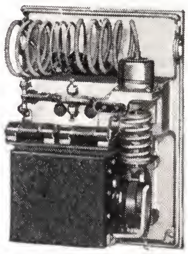
Manual Control Sub-atmospheric Steam Valve Type 375



Differential Pump, Type DV Which Is Supplied with Accumulator Tank (not shown)



Junction Box, Type 373

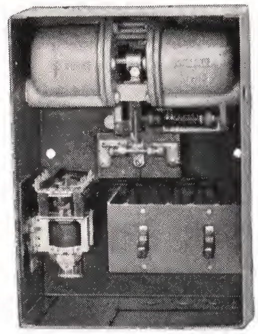


Heat Balancer, Type 386

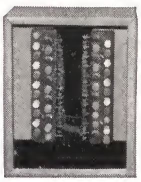
Automatic Selector, Type 261

Thermostat, Type 396

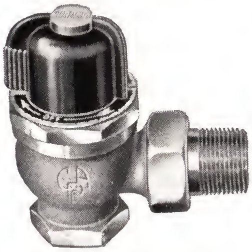
Panel



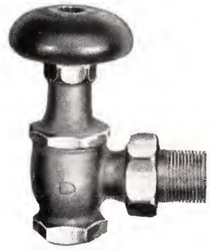
Controller, Type 389



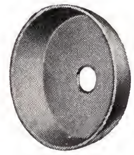
Terminal Box, Type 395



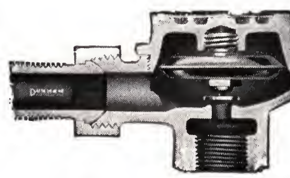
"Oriflex" (Adjustable Orifice) Radiator Valve Type 175 (See Page 9)



Wheel Handle Packless Radiator Valve, Type 200

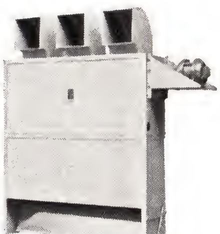


Regulating Plate, Type 192, Used with Valve 200

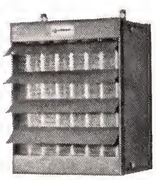


Sectional Differential Radiator Trap

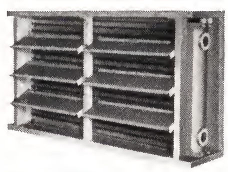
Some of the Other Products Built by Dunham



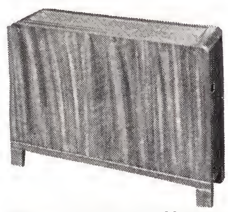
Type "R" Unit Heater



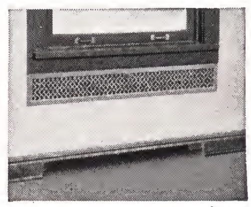
Type "V" Unit Heater



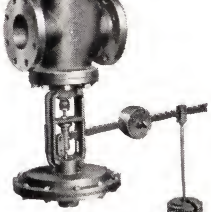
Type "D" Unit Heater



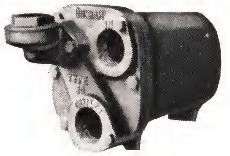
Type "M" Unit Heater



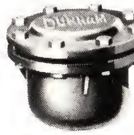
Concealed Radiator, Plaster Front



Double Seated Pressure Reducing Valve

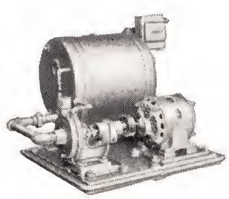


Float and Thermostatic Trap

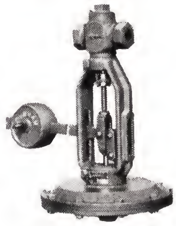


High Pressure Trap

Medium Pressure Trap

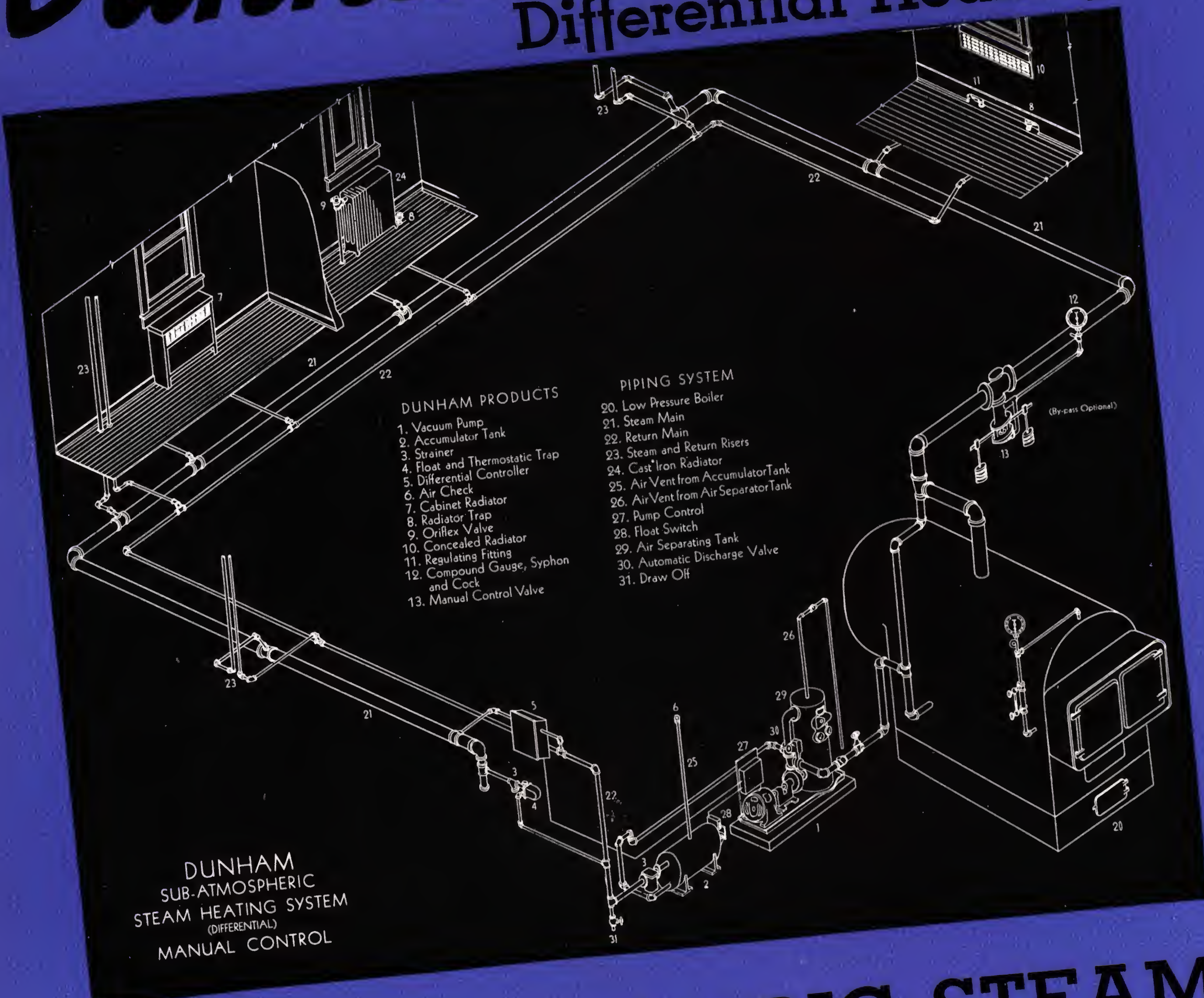


Condensation Pump and Receiver



Single Seated Pressure Reducing Valve

Dunham
Differential Heating



SUB-ATMOSPHERIC STEAM HEATING SYSTEM

C. A. DUNHAM COMPANY
450 EAST OHIO STREET, CHICAGO, ILLINOIS