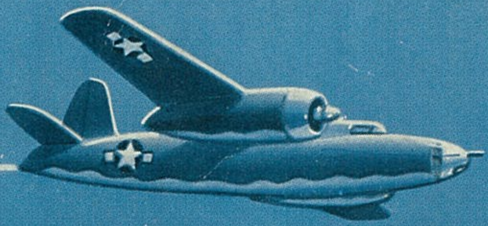


High-Altitude HEATING FOR BUILDINGS

AN EXPLANATION OF DUNHAM SUB-ATMOSPHERIC STEAM HEATING

High-Altitude HEATING FOR BUILDINGS

Brochure No. 632

C. A. DUNHAM COMPANY

450 East Ohio Street Chicago 11, Illinois

TORONTO, CANADA • LONDON, ENGLAND

An Evolution of Building Heating

EPOCH NUMBER ONE. The use of steam under pressure was replaced by an induced method of drawing steam into the radiators by suction.

EPOCH NUMBER TWO. A means of creating subatmospheric steam of varying temperature to an exact degree required for warming enclosed spaces.

EPOCH NUMBER THREE. A thermo-electric instrument for measuring and maintaining a continuous flow of rarefied steam into the heating system under a twenty-seconds interval correction check.

IT IS of interest that these three epochs of evolution were developed in the Dunham Research Laboratories and are evidenced only in Dunham Differential Heating which results in exact temperature control—no overheating, no underheating—regardless of changing weather demands.

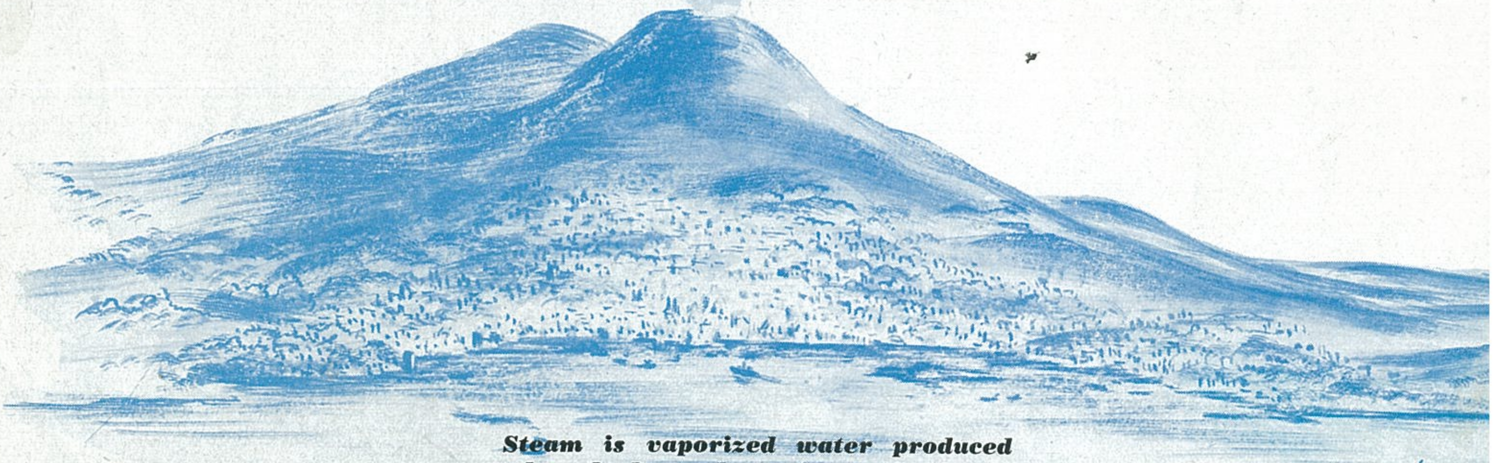
C. A. Dunham

first a word about old methods

YOU'VE probably seen drawings of "central heating" as the Romans practiced it. They located a central fire in some subterranean chamber and conveyed the heat to their rooms above through open ducts. Perhaps they designed their method after observing nearby Vesuvius! At any rate the system worked, if one didn't mind smoke, dust, fumes and soot.

BUT, as people became more fastidious, they *did* mind and in time discovered that water could be utilized as a heat-vehicle because of its remarkable ability to absorb a great extra heating load when it made the jump from water to steam. This phenomenon—"*the latent heat of vaporization*" made water an ideal medium for heating purposes. In effect, water, as steam, propelled an extra load of heat to the point of delivery, dumped the load, became water again and ran back to the boiler to recommence the entire process.

BUT steam had to fight its way to radiation—the point of delivery. Pressure and, with it, temperature built up behind the air in the pipe system forcing it ahead until the steam literally blew itself into the radiator with loud clankings and poundings and the venting of evil odors through the necessary valve on each radiator. These systems circulated *hot* steam and the scorched Sahara atmosphere they produced—relieved only by opening windows—perhaps had much to do with "popularizing" the common cold.



Steam is vaporized water produced when the latent heat of vaporization is supplied to water at its boiling point.

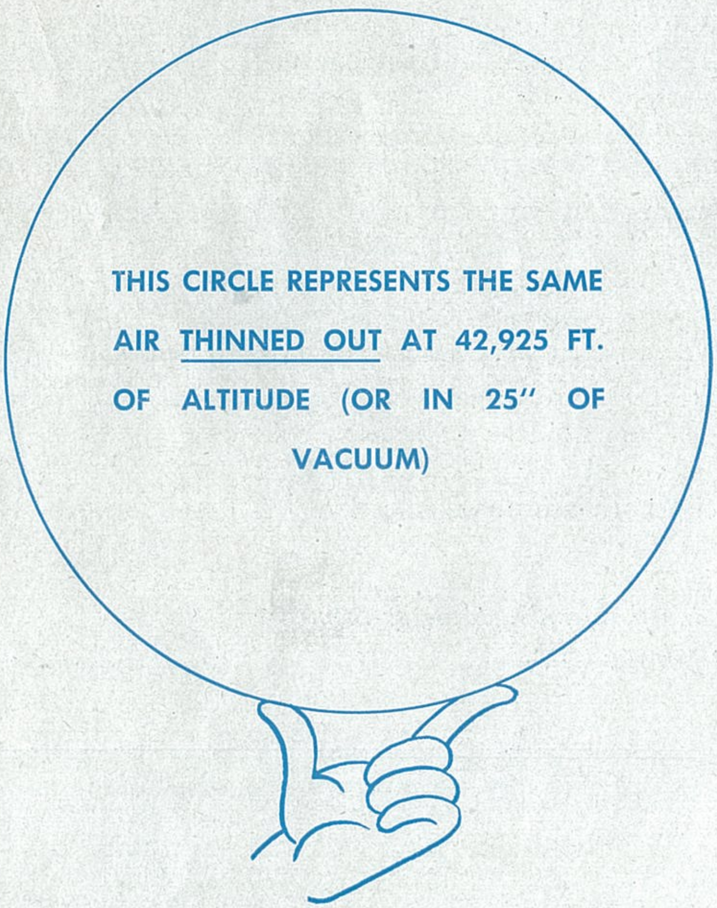
Latent Heat is that necessary to change a liquid to the gaseous state (vapor), or to change to liquid the solid substance, without effecting a change in temperature.

THE first marked advance came with the perfection of the fluid Thermostatic Radiator Trap (Dunham 1903). Then the returning condensate had its own return system and pressure could be materially lowered. And when ingenuity added the Vacuum Pump to the return line, pressure dropped still further because steam no longer had to fight its way. But pressure had not been eliminated, and pressure—even though it were no more than enough to jiggle the cover of a tea-kettle—indicated temperatures above 212 degrees F. This was a simple and satisfactory heating vehicle on the days when base or near-base temperatures were encountered, but was an overheating-problem-child to the engineer during 90% of each winter. For as meteorological records show, most of winter days are mild and any system that "cruises" only at one altitude is not only prodigal with fuel but is a highly unpleasant companion. The same discomfort, of course, is experienced even more keenly on the mildly chilly days of early Fall and late Spring. That is because when it takes pressure to get steam to the radiators the radiators are *hot* on mild as well as on cold days. On mild days there were only two choices; no heat or too much heat. Obviously, both are unsatisfactory.

These systems still exist by the thousands. Most of them are susceptible to modernization rather easily.

Let's look at what High Altitude does to air

Most everyone knows that the weight (pressure) of atmosphere at sea-level is slightly less than 15 pounds per square inch. Because most of us live close to sea-level that atmospheric pressure seems normal to us. But if we lived on Pike's Peak we'd adjust ourselves to the light touch of seven and one-half pounds per square inch and our three minute eggs would take 4½ minutes to cook because the water would boil at approximately 186° F. That pressure, of course, is the norm for the 14,108 feet of altitude which is the height of Pike's Peak.



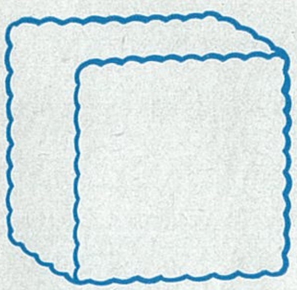
When the atmospheric pressure is less than the sea-level pressure, the difference is called a partial vacuum and the degree of rarefaction is measured in inches of mercury. For example: The rarefaction of the air at Pike's Peak is approximately the atmospheric pressure in 15 inches of vacuum. In 25 inches of vacuum the pressure of air per square inch is only 2½ pounds and water will boil at 133° F.

In other words, air under vacuum *increases in volume* in direct relation to its *decrease in pressure*. Consequently we can express 42,925 feet of altitude as 25 inches of vacuum. The upper diagram on this page represents a space enclosing a certain volume of air at sea-level atmospheric pressure. The larger diagram represents the size of the space that the same air would occupy in a 25 inch vacuum—an increase of approximately 5½ times in volume.

Air is a compressible and elastic mixture of gases. In its pure state it cannot be seen, tasted or smelled. It decreases rapidly in density as its altitude increases.

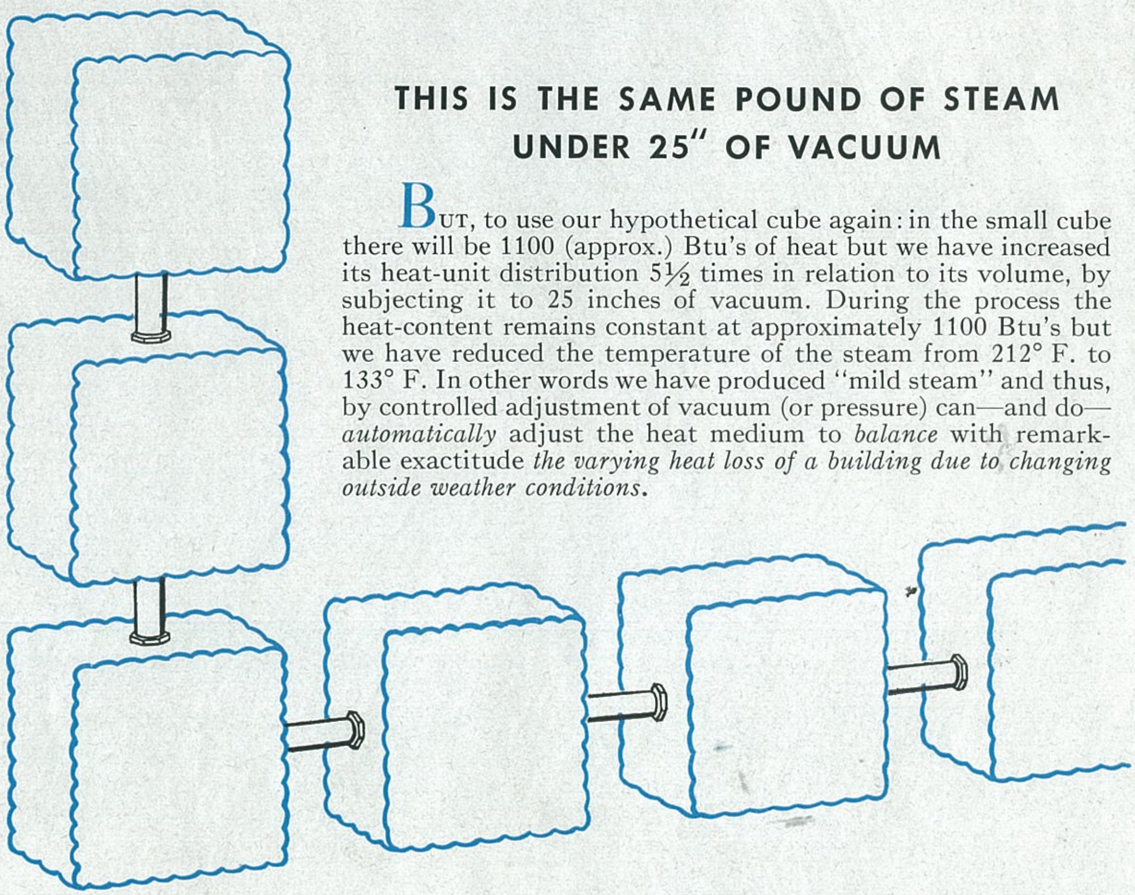
What happens to steam under High Altitude

THIS REPRESENTS ONE POUND OF STEAM AT ATMOSPHERIC PRESSURE



STEAM is interesting! In its pure state it is a dry invisible gas. Steam that we can see is rendered visible by minute particles of water in the steam produced by condensation of portions of the gas.

STEAM's physical properties have occupied the attention of scientists and inventors since the time of Hero of Alexandria who, about 130 B.C., invented a sort of primitive steam turbine engine depending for its power on steam's expansion in response to a rise in temperature. However, expansion also occurs under a decrease in pressure and it is this property which makes the Dunham Differential Sub-atmospheric Heating System possible. For example: a cube containing one pound of steam in weight at atmospheric pressure would contain, in volume, 26.79 cubic feet of steam. Under 25 inches of vacuum (or at 42,925 feet of altitude) our cube would have to increase five and a half times in size to hold that same one pound of steam which then will have expanded in volume from 26.79 cubic feet to approximately 145 cubic feet.



THIS IS THE SAME POUND OF STEAM UNDER 25" OF VACUUM

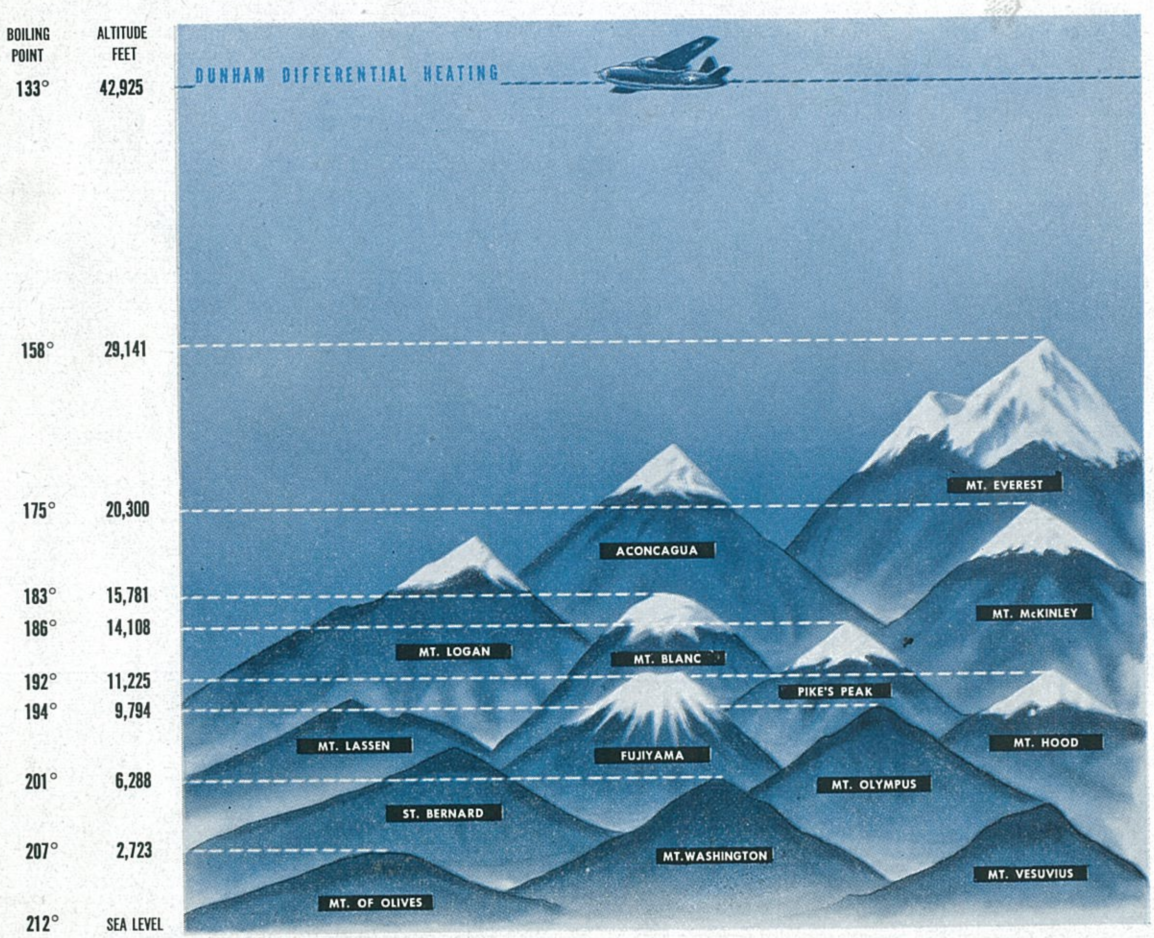
BUT, to use our hypothetical cube again: in the small cube there will be 1100 (approx.) Btu's of heat but we have increased its heat-unit distribution 5½ times in relation to its volume, by subjecting it to 25 inches of vacuum. During the process the heat-content remains constant at approximately 1100 Btu's but we have reduced the temperature of the steam from 212° F. to 133° F. In other words we have produced "mild steam" and thus, by controlled adjustment of vacuum (or pressure) can—and do—*automatically* adjust the heat medium to *balance* with remarkable exactitude *the varying heat loss of a building due to changing outside weather conditions.*

Expansion is dimensional increase in a body due, usually, to a decrease in pressure or an increase in temperature.

The basis of High Altitude heating

JUST as air thins out progressively at higher altitudes, so steam thins out its distribution of heat-units progressively—in relation to its volume—as the vacuum in which it is produced increases. Note that 25 inches of vacuum has an atmospheric pressure slightly thinner than that found when flying eight miles high.

THIS produces, in effect, mild steam which has a known, fixed degree of temperature declination for every inch of rise in vacuum.



Partial Vacuum is a region in which the gas (air) pressure is less than atmosphere which averages 14.7 pounds per square inch at sea level.

We present

High Altitude HEATING

THE advantages of Dunham Differential Heating are manifold and, in its field, are as important to the comfort and convenience of man as the stratosphere passenger plane which is looming on our travel horizon. High altitude heating is merely the result of man's understanding and harnessing of natural laws.

THERE is a close parallel between the use of high altitudes for improved flying and the use of sub-atmospheric pressures for a more efficacious circulation of steam for heating purposes.

ALL the world has been indoctrinated in the flights of progress made by machines, and awaits, impatiently, for their benefits. Indeed, the impatience is whetted since much of the fruits of progress has already been made available, and much more has been promised.

THE attitude of eagerness, intensified even in pre-war days by our great mechanical advances, spurred Industry to outstrip the layman's imagination. One result was High Altitude Heating—the System of Sub-atmospheric Steam Heating—known since 1927 as Dunham Differential Heating.

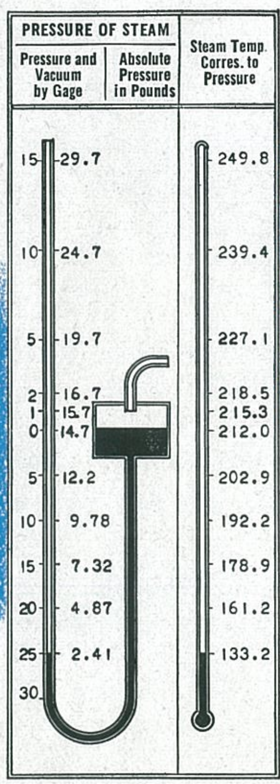
BUT before we discuss the advantages of Dunham Differential Heating let us first contemplate certain disadvantages of ordinary pressure steam heating.

Gas is a state of matter wherein a substance, no matter how small the amount, will expand until no part of the entire region in which it is contained is free from its presence.

CONSIDER a building in Rochester, N. Y., as a mental heating problem under the old pressure steam heating method. It gets cold in Rochester — sometimes below zero. So, to be sure of your comfort during the extreme cold you will select a radiator capable of heating the rooms in the "comfortable seventies" when Rochester is at its coldest.

AND, by the same token, you will make sure that your boiler is large enough for such cold snaps, too.

BUT—"snaps" is exactly the right word because in Rochester, as in so many other places in the United States, the extremely cold spells represent only a very short part of the time "winter is upon us". Indeed, according to U. S. Weather Bureau statistics, the average winter temperature in Rochester is 3 degrees *above* freezing point!



WHAT are you going to do about that building on a 35 degree morning? You will stoke your boiler *gently*. You want a little heat. In fact, you want just the "comfortable seventies". So you go easy on the boiler. If nothing happens, you fire up a little more and a little more until you drive the steam up to your radiators. You get heat—hot heat—just about as much in volume as in that zero weather—but you discover, that the cold-weather-radiator is too large when supplied with that too-hot, cold-weather steam. You open windows letting in a lot of that 35 degree outside air—then you turn off the radiator and presently the room cools down to a comfort level. The trouble is it keeps on cooling down, cooler—cooler, and so you turn on the radiator, close the window, and the same cycle begins all over again.

AND don't overlook the fact that when you turn off the radiator you do *not* "turn-off" fuel consumption. The steam is there, behind the valve, just the same. The only difference is that you're not using it. All you've done is to imprison it to keep it from working and that is waste unmitigated.

UNTIL the white man mingled with esquimaux, it is said the latter never experienced the "common cold" though they live most of the year in intense cold. This

Temperature is the measurement of "hotness" in relation to an arbitrary zero as shown in the Fahrenheit and Centigrade scales or to absolute zero.

appears to confirm the opinion of most authorities that over-heating rather than under-heating is the more frequent cause of "colds". Between the extremes lies an ideal heating condition which Dunham Differential Heating achieves.

OVERHEATING has been endured and its economic waste in man-hours and fuel has been condoned long and needlessly principally because the public generally has not understood how simply and effectively such wasteful extravagance and discomfort has been outmoded by the Differential system.

NOW, let's return to Rochester and suppose that you decide to heat the same space with High-Altitude Steam. You have the same boiler and the same radiator but instead of the discomfort of unhealthy over-heating, you are *conscious only of comfort —not of heat!* High-Altitude Heating, like high-altitude flying, maintains a level of much better performance and at markedly reduced fuel consumption. The *desired* comfort load of 70°, 72° or more is maintained regardless of frequent changes in the weather.

ON a bitter cold morning when the wheels on the milk wagon are creaking in the snow your High-Altitude Heat will be cruising close to ground level with pressure on the positive side—ounces, half a pound, a pound or two—and you will be *comfortably* warm. That will be because the pressure you are using and the temperature it maintains will exactly balance the heat loss of your building.

THEN, little by little, that day or maybe in a few days, the cold snap passes. That's when the virtues of High-Altitude Heating begin really to impress you, for as the outside temperature rises the temperature of the steam in your radiator declines. Thus over the entire range of outside winter weather, from bitter cold to occasional spring-like days when only a little heat is required, you will be comfortable. You will have no special boiler attention, no opening and closing of windows, no turning on and off of radiators. You will never be chilly because you will be in a balanced, healthful temperature at all times.

THE utter simplicity of High-Altitude Heating as it is provided by the Dunham Differential System is one of its immediate recommendations. It resembles the older vacuum return line system in layout, and such systems are frequently changed to Differential Heating.

WASTEFUL steam heating systems may be changed over to Differential operation which automatically governs the heat supply and its distribution to give improved heating.

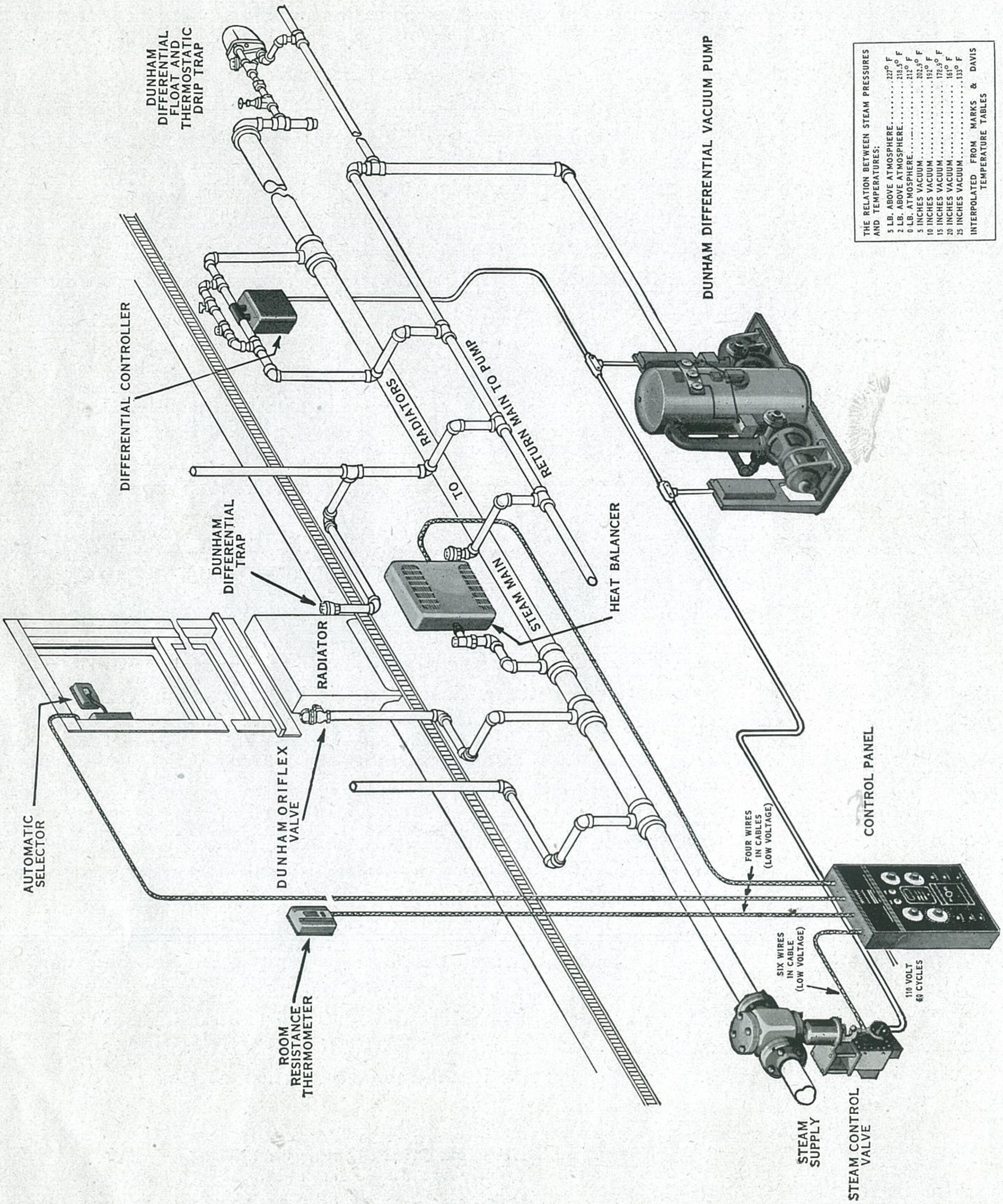
THE modernizing work can be done without difficulty by your own heating contractor with a minimum of expenditure and of inconvenience to you.

EXISTING boilers, piping and radiation are used, but the method of steam distribution and control is altered to make the original installation operate more efficiently and more economically.

Heat is a form of energy which when applied to or removed from an absorbing body respectively raises or lowers its temperature.

The Dunham Differential Vacuum Heating System

Fully Automatic



THE RELATION BETWEEN STEAM PRESSURES AND TEMPERATURES:

5 LB. ABOVE ATMOSPHERE	227° F
2 LB. ABOVE ATMOSPHERE	218.5° F
0 LB. ATMOSPHERE	212° F
5 INCHES VACUUM	202.9° F
10 INCHES VACUUM	192° F
15 INCHES VACUUM	178.9° F
20 INCHES VACUUM	161° F
25 INCHES VACUUM	133° F

INTERPOLATED FROM MARKS & DAVIS TEMPERATURE TABLES

Fig. 3437

Functions of Differential Equipment

In order to appraise the full value of Differential Heating, using sub-atmospheric steam, it is necessary to understand the functions performed by each of the operative items of heating equipment comprising the System. The simplicity and effectiveness of the Dunham Differential Vacuum Heating System is attained through their coordinated action. The functions of the various units, indicated on opposite page, are as follows:

Radiators

Radiation and piping may be any of the types and sizes in common use with other steam heating systems.

Control Panel

The Control Panel is the centralized operating station at which all control adjustments and settings are made and from which remote readings of room temperatures, control valve openings and percentage of heat output as measured by the Heat Balancer may be obtained.

Temperature Control Equipment

The Temperature Control Equipment appraises the heat demand of the building utilizing the resistance thermometer principle of operation. The Resistance Thermometers comprise coils of metal conductors whose electrical resistance varies with variations in their temperature connected in a Wheatstone Bridge circuit. Such temperature sensitive elements have no moving parts, nothing to wear out, clog, or to require—or get out of—adjustment. All moving parts are contained in the Panel and in the Control Valve.

The basic control of the Differential Temperature Control Equipment balances the heat supply (measured by the Heat Balancer) with the heat demand (measured by the Selector). Compensating or limiting features are provided by the room Resistance Thermometer units. Since this room thermometer is not depended upon to perform the function of the conventional room thermostat, it is not as limited in its application. It can be used to register room temperatures from any location regardless of the type of occupancy of the room.

Control Valve

The Control Valve regulates the admission of a *continuous* flow of steam into the heating main, and the Differential System equipment distributes this steam proportionately to all radiators. When the requirements for heat are great, the quantity of steam admitted is sufficient to fill the system with pressure up to two pound gage with corresponding steam temperature to approximately 218° F. When heat requirements are less, the smaller quantities of steam admitted are expanded into larger volumes at pressures below that of the atmosphere and, due to the relatively constant differential in pressures between the steam and return lines, the radiators are filled with steam. The expansion of the steam at sub-atmospheric pressure is accompanied by a lowering of the temperature, thereby resulting in a reduction in the heat given off by the radiators.

Partial Filling

When the admission of steam into the system has been reduced to the point at which the maximum operating vacuum is reached, then any additional reduction in the supply of steam results in the radiators being partially filled. As partial filling progresses with the reduction in the steam supply, each radiator receives less steam, in proportion to its capacity, up to the point at which the demand for heat ceases and the Control Valve closes off completely.

Packless Radiator Inlet Valve

Radiator Inlet Valves with externally adjustable or internally fixed orifices at each radiator inlet give balanced steam distribution throughout the building. The resistance to flow at the orifice of these regulating devices results in the small pressure gradient essential to balance distribution under partial filling conditions.

Thermostatic Radiator Trap

Radiator Traps allow air and water to leave radiators and prevent steam from entering the returns under the entire range of sub-atmospheric pressures employed. The thermostatic disc is at all times exposed to and controlled by the conditions of pressure and temperature within the radiator, whether trap is open or closed.

Drip Trap

The trap is installed at drip points to which large volumes of condensate flow, it is a combination of a thermostatic trap and a float trap. It keeps steam mains and risers free from water and air, and return mains free from steam, thus making circulation rapid and noiseless. It has high water handling and air venting capacity for heating-up periods.

Differential Pump

The Differential Vacuum Pump exhausts air and vapor from the return piping, keeping the pressures therein below that in the supply, as required to maintain the pressure difference necessary to cause a positive circulation of steam throughout the system. The Differential Vacuum Pump also operates to handle the condensate from the System. This water gravitates to the accumulator tank from which it is lifted and returned to the boiler by the pump.

Differential Controller

The Pump is controlled by the Differential Controller which is connected to the supply and return piping and is actuated by the pressure differential. The Controller starts the pump when the pressure difference between the supply and return tends to fall or disappear, and stops it when this pressure differential is restored.

Method of Differential Control

Model RSTT—Fully Automatic

Consisting of a Panel, a Control Valve, one or more Resistance Thermometer Units, a Selector and a Heat Balancer, for indicating and controlling steam supply in proportion to the demand as measured by weather conditions and limited by room temperatures.

(Recommended for all heating systems using direct radiators or convectors.)

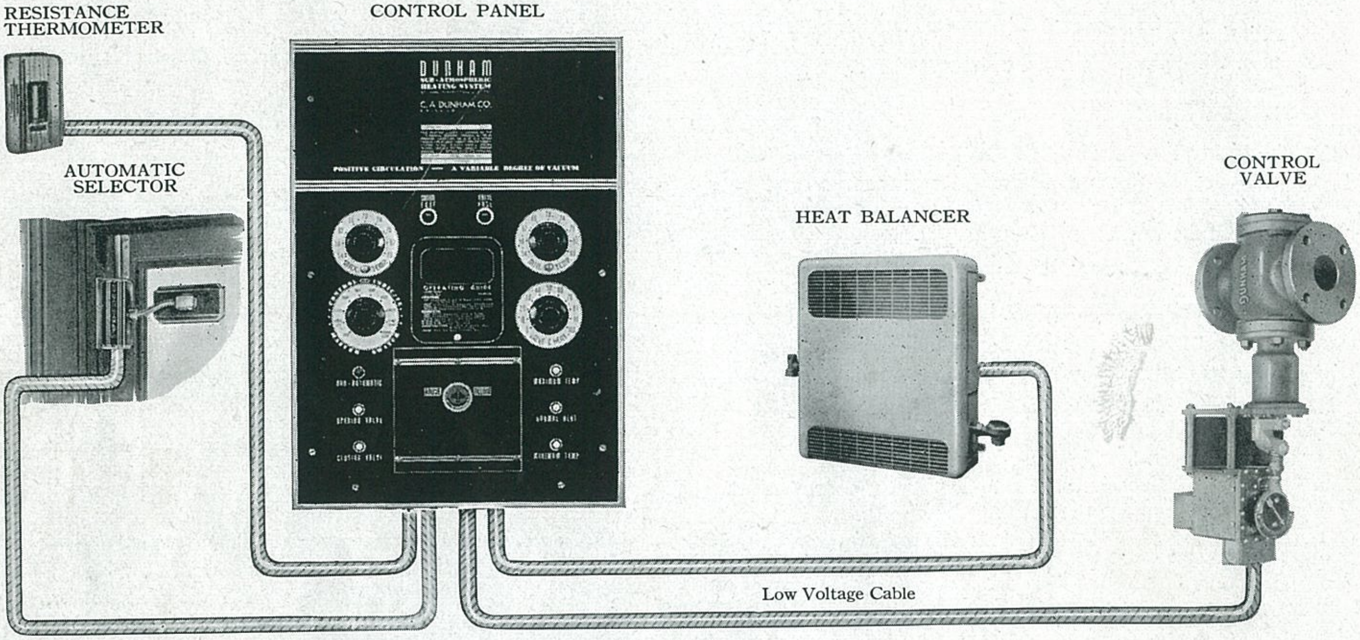


Fig. 1962A

Dunham Model RSTT Control

The Model RSTT insures continuous heat supply in exact accordance to outside weather conditions. This supply is checked in cycles of three different measurements of the demand.

The "Normal Heat" measurement is the basic control and provides a check of the heat supply as measured by the Heat Balancer in comparison with the demand as measured by the Selector. In this phase of the control, the relay can either open or close the Control Valve depending on whether a greater or less supply of heat is required.

The Selector is a window mounted Resistance Thermometer Unit, the temperatures surrounding which are affected by outside temperature, wind velocity and other weather conditions. It provides a measure of heat demand.

The Heat Balancer, which is a control radiator, measures the actual heat supply. There are two Resistance Thermometer coils, one—below the heating element—measures the average temperature of the incoming air while the second —above the heating element—measures the average temperature of the air after it has been heated. The difference between these two temperatures is a measure of the heat supply.

The Control Panel includes a measuring or weighing device for determining the balance between the heat demand (Selector) and heat supply (Heat Balancer). This device is the Galvanometer which governs through a relay the opening and closing of the Control Valve which is made in small increments. When the heat supply is less than the demand, the Valve is slightly opened to increase the supply. When the supply is greater than the demand, the reverse occurs. As stated above this is the basic control feature.

The Panel also functions to check the actual room temperatures and determines if they are within definite established limits.

The "Maximum Temperature" measurement provides a check of the heat supply as determined by the Valve opening with the demand as measured by the room Resistance Thermometer Unit(s). This phase of the operation is a maximum limiting control and the relay can close the Valve only if temperatures are high; it cannot open it.

The "Minimum Temperature" measurement also provides a check of the heat supply as determined by the Valve opening with the demand as measured by the room Resistance Thermometer Unit(s). This phase of the operation is a minimum limiting control and the relay can open the Valve only if temperatures are low; it cannot close it. This phase of the control is particularly effective during the heating-up period.

Only Dunham meets all control needs

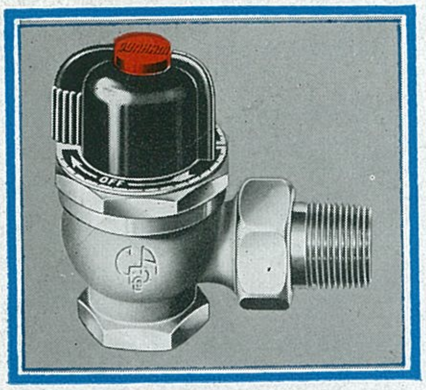
HIGH-ALTITUDE HEATING takes on the whole burden of maintaining comfort-level temperatures at *all times*, in *all parts of a building*, in *all weather conditions*—under variables in service and occupancy.

HEAT-COMFORT requires a constant balance of the steam supply against the requirements for warmth. The requirement is variable, the steam supply should likewise be variable, *but not intermittent*. Only High-Altitude Heating has the necessary flexibility to fully meet this variable requirement because no other system is capable of a *continuous flow*, giving a feeling of "warmth" through *automatic control of both steam temperatures and steam volume.*

VARIOUS temperatures can be carried in various rooms or sections as desired without recourse to individual control devices in each room or section.

THERE is no stratification of the warmed air at the ceiling, floor or breathing levels. Overheating either the room air, floors or walls is avoided and no carbonized dust results.

"ZONING" is sometimes used in buildings having both exposed and sheltered exposures requiring varying temperatures and heat-time periods. In many cases, however, where zoning would be suggested with ordinary heating equipment, extreme zoning may be found entirely unnecessary with the Dunham method.



The polished black air-foil design plastic handle of Oriflex is topped with an inset cardinal medallion. When this medallion is removed it provides access to an interior adjustment stem to which a key may be fitted. A turn of the key provides minute or extensive adjustment of the stem orifice to meet the particular requirement of each radiator. When adjustment is completed the key is removed and the cardinal medallion snapped back in place. There is no similar method of balancing which reduces labor, saves time and permits minutely accurate adjustments.

The ORIFLEX *valve*

ONE fundamental of good heating requires that all radiators should heat simultaneously regardless of their size or distance from the steam source. Adjustment to meet this need is called "balancing the system", a time-consuming routine prior to the invention of the Oriflex Valve. Neither steam, water or sediment can contact the mechanism of Oriflex, its operation is always smooth and positive.

PRIOR to the invention of the Oriflex Valve, "Balancing" was accomplished by orifice plates, with openings calibrated in steps of 5, 10, 15 square feet, and so on. Oriflex provides increments of ONE square foot and is regulated as minutely and as simply as the diaphragm in a camera.

THE Oriflex handle is polished black, set off with a cardinal medallion, designed to compliment any interior decorative motive. The valve is a pleasing expression of the engineering thoroughness which distinguishes the Differential System throughout.

The chromium plated cast bronze cover, topped with an inset cardinal medallion name plate, beneath a convex plastic lens makes the trap a joint contribution of the engineer, artist and industrial designer. The body is sand blast finish cast bronze, also chromium finished.

All working parts are made of non-corrosive metals especially adapted for the service. The valve seat is raised slightly and rounded to minimize the depositing of incrustants. The valve is attached to the thermostatic disc with a flexible joint to insure it seating squarely, like a globe valve. Its position and design make it self-cleaning as well as tight-closing. The valve opening is exceptionally large and the flow of water out of the trap is not restricted by a guide, as none is necessary with the Dunham Thermostatic Disc.

The DIFFERENTIAL *trap*

THE "High Duty" (D Series) trap designed for use exclusively on Differential Systems operates over a pressure range from 15 pounds gage down to 25 inches of vacuum. It adjusts itself to a position determined by the temperature and pressure conditions encountered within the radiator (as a thermometer does to room temperature) and insures continuous passage of air and condensate from the radiators automatically, without permitting the passage of steam. It thus maintains radiators at maximum heating efficiency, it conserves heat and saves fuel.

THE design of the trap is such that the thermostatic disc is *at all times* exposed to and controlled by the steam pressure and temperature *within the radiator* whether the trap is open or closed.

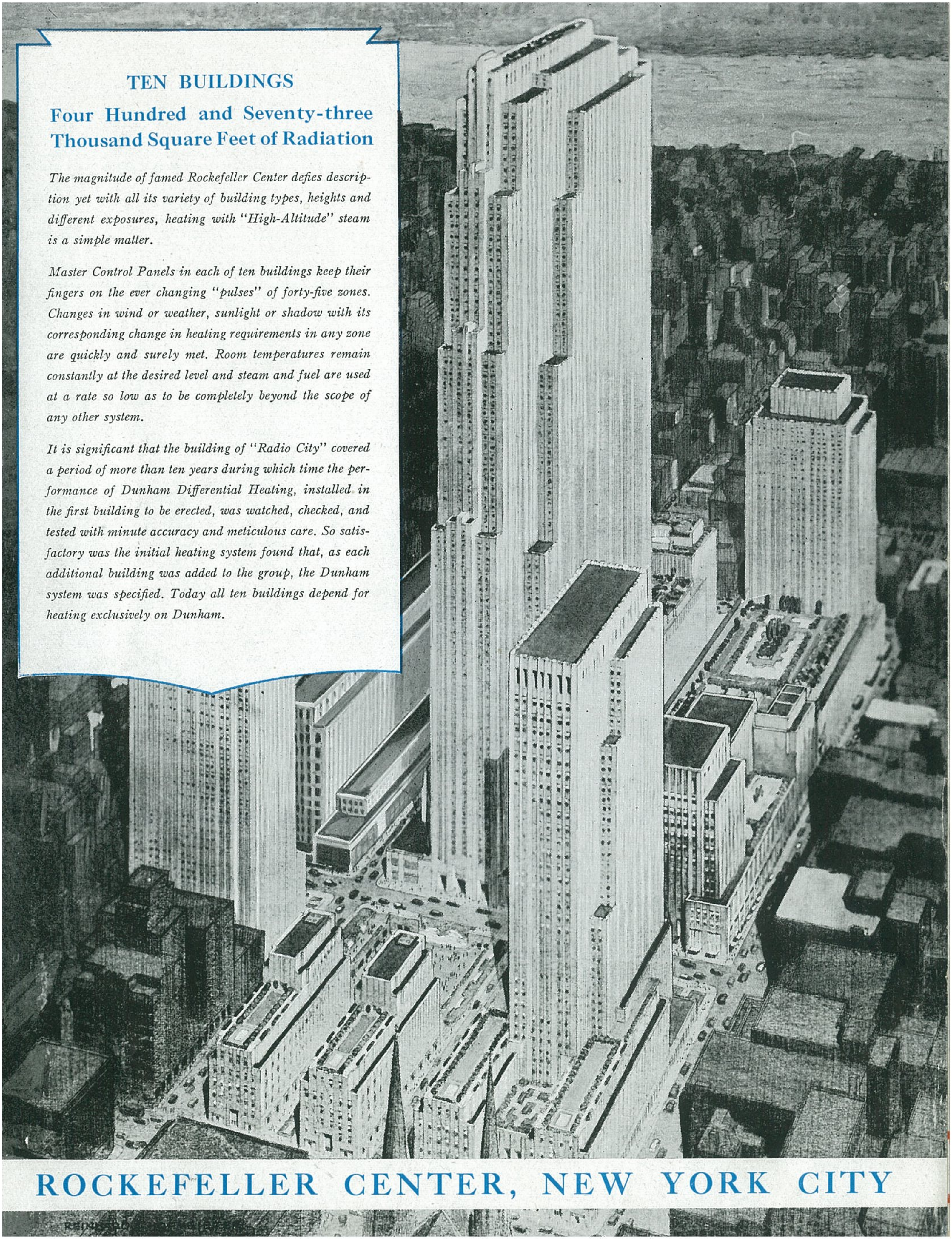
TEN BUILDINGS

Four Hundred and Seventy-three Thousand Square Feet of Radiation

The magnitude of famed Rockefeller Center defies description yet with all its variety of building types, heights and different exposures, heating with "High-Altitude" steam is a simple matter.

Master Control Panels in each of ten buildings keep their fingers on the ever changing "pulses" of forty-five zones. Changes in wind or weather, sunlight or shadow with its corresponding change in heating requirements in any zone are quickly and surely met. Room temperatures remain constantly at the desired level and steam and fuel are used at a rate so low as to be completely beyond the scope of any other system.

It is significant that the building of "Radio City" covered a period of more than ten years during which time the performance of Dunham Differential Heating, installed in the first building to be erected, was watched, checked, and tested with minute accuracy and meticulous care. So satisfactory was the initial heating system found that, as each additional building was added to the group, the Dunham system was specified. Today all ten buildings depend for heating exclusively on Dunham.



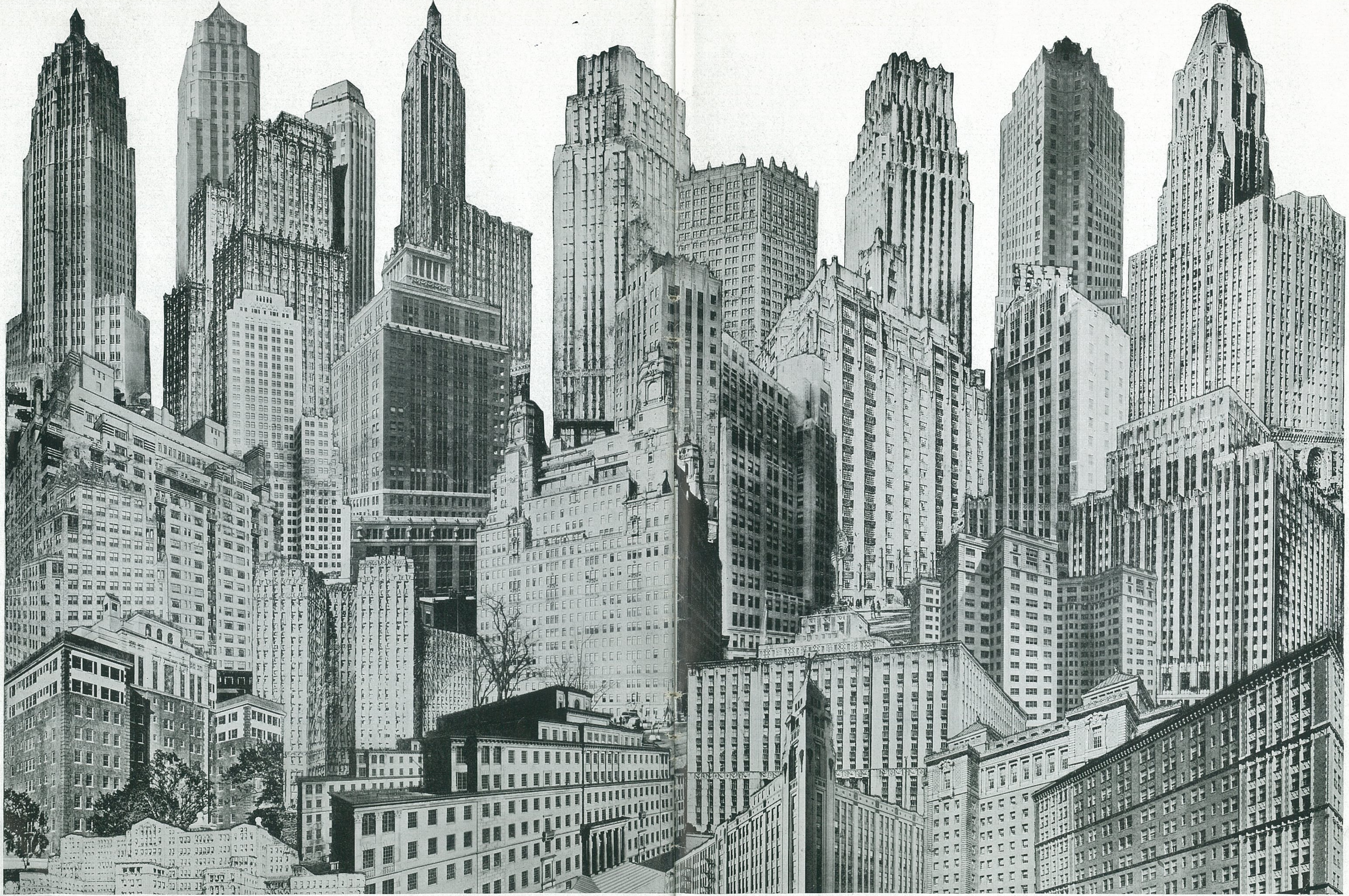
ROCKEFELLER CENTER, NEW YORK CITY

P A R K C H

Parkchester, pictured on these pages, is the physical evidence of "a dream come true". This vast garden community of 51 buildings, covering 129 acres of highly valuable land in the Borough of Bronx in the City of New York, and housing forty thousand people in its 12,272 apartments, became a reality, however, only after the most skillful engineering analysis of every factor contributing to its erection and maintenance. Among the problems presenting itself for the most exacting examination and determination was the question of satisfactorily heating the living quarters of 12,000 families, a theatre seating 2,000, five large garages, and the stores fronting on two miles of roadway. It had to be within the limits of sound economy. It had to heat all the buildings with equal efficiency from the one nearest the heating plant to the one in the farthest corner of the project. It had to meet the various heat needs of the wide variety of purposes to which the rooms and lofts were to be put. It had to have automatically controlled balance between heat requirements, as determined by weather conditions from hour to hour, and the heat loss of the buildings which also varied according to orientation and exposure. Finally, it had to conserve manpower and fuel.

After intensive study of all the problems involved the system selected as the only one that could meet all the requirements and best serve the comfort of the residents and the interests of management was the Dunham Differential Heating System. Since its installation at the time of building its successful operation has never been challenged.

E S T E R



From Coast to Coast are scattered the buildings—great and small—which enjoy the benefits and advantages of Dunham Sub-Atmospheric Differential Heating. Their names and locations are legion, their style, construction, purpose and exposure varied in the extreme. In one thing only have they a common characteristic, to wit: the desire for consistently comfortable and efficient heat at all times and under all weather conditions, automatically achieved at economies in fuel consumption and manpower beyond the capabilities of other steam heating plants. This desire is unfailingly met by High Altitude Heating as developed by the C. A. Dunham Company.

Ten Million Pounds of Steam saved per year

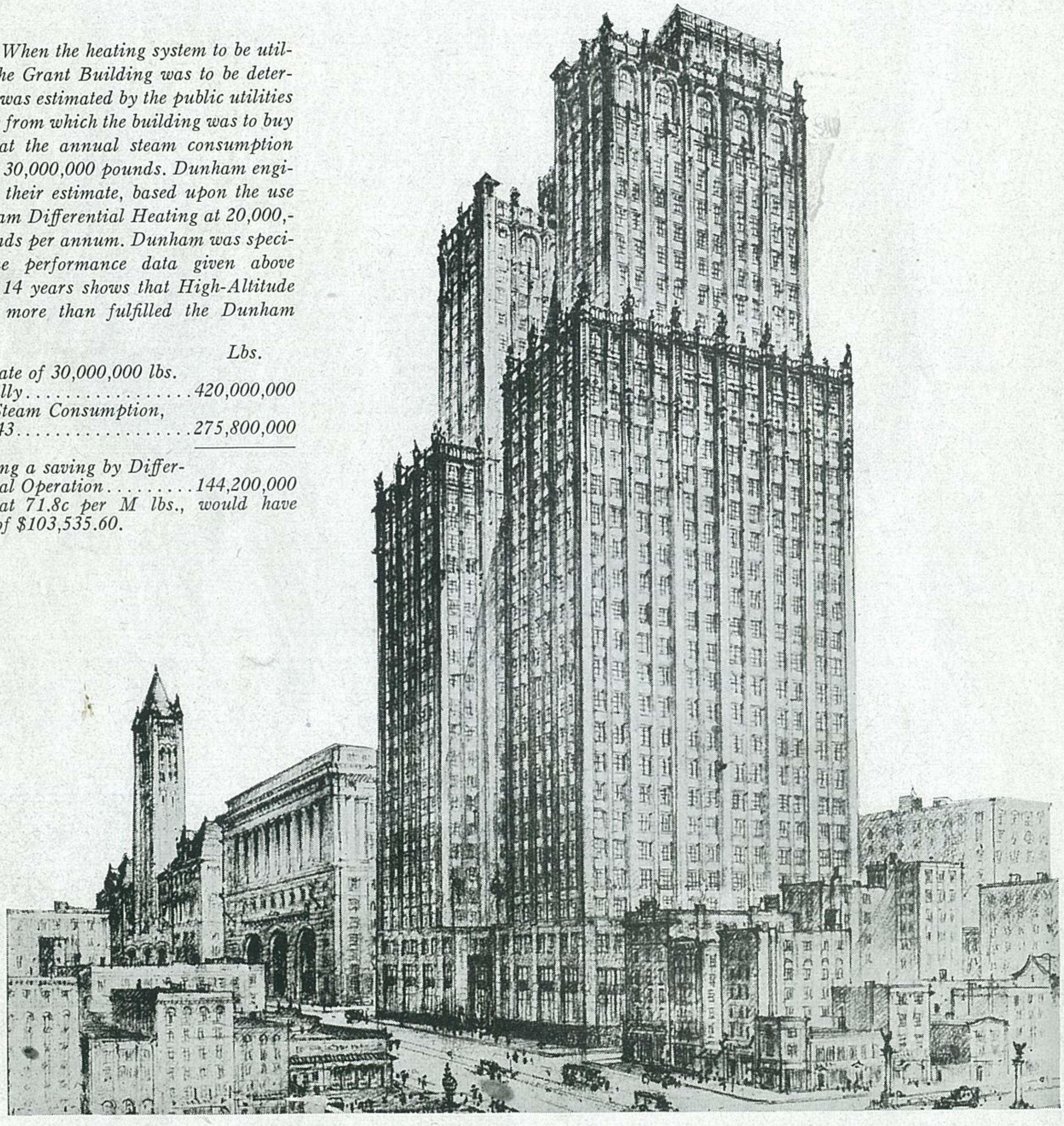
Grant Building, Pittsburgh, Pa. Heating Record

Year	Pounds Steam	Degree Days	Sq. Ft. EDR	Pounds M Sq. Ft. Degree Days
1929-30	18,227,000	5,460	72,000	46.36
1930-31	20,700,000	5,518	73,000	51.38
1931-32	18,301,000	4,305	73,000	58.23
1932-33	19,922,000	5,052	73,000	54.01
1933-34	21,072,000	5,722	73,000	50,44
1934-35	19,280,000	5,030	73,000	52.50
1935-36	20,823,000	5,735	73,000	49.73
1936-37	19,667,000	5,018	74,500	52.60
1937-38	19,161,000	5,077	74,500	50.65
1938-39	18,334,000	4,863	74,500	50.60
1939-40	21,466,000	5,788	74,500	49,78
1940-41	18,923,000	5,293	74,500	47.99
1941-42	18,249,000	4,778	74,500	51.57
1942-43	19,817,200	5,325	76,300	48.78

NOTE:—*When the heating system to be utilized in the Grant Building was to be determined it was estimated by the public utilities company from which the building was to buy steam that the annual steam consumption would be 30,000,000 pounds. Dunham engineers set their estimate, based upon the use of Dunham Differential Heating at 20,000,000 pounds per annum. Dunham was specified. The performance data given above covering 14 years shows that High-Altitude Heating more than fulfilled the Dunham estimate.*

	Lbs.
At estimate of 30,000,000 lbs. annually	*420,000,000*
Actual Steam Consumption, 1929-43	*275,800,000*
Showing a saving by Differential Operation	*144,200,000*

Which, at 71.8c per M lbs., would have a value of $103,535.60.



Heating 1/3 greater area at 2/3 former cost

110-118 N. PEORIA STREET
CHICAGO 11, ILLINOIS

April 12, 1937

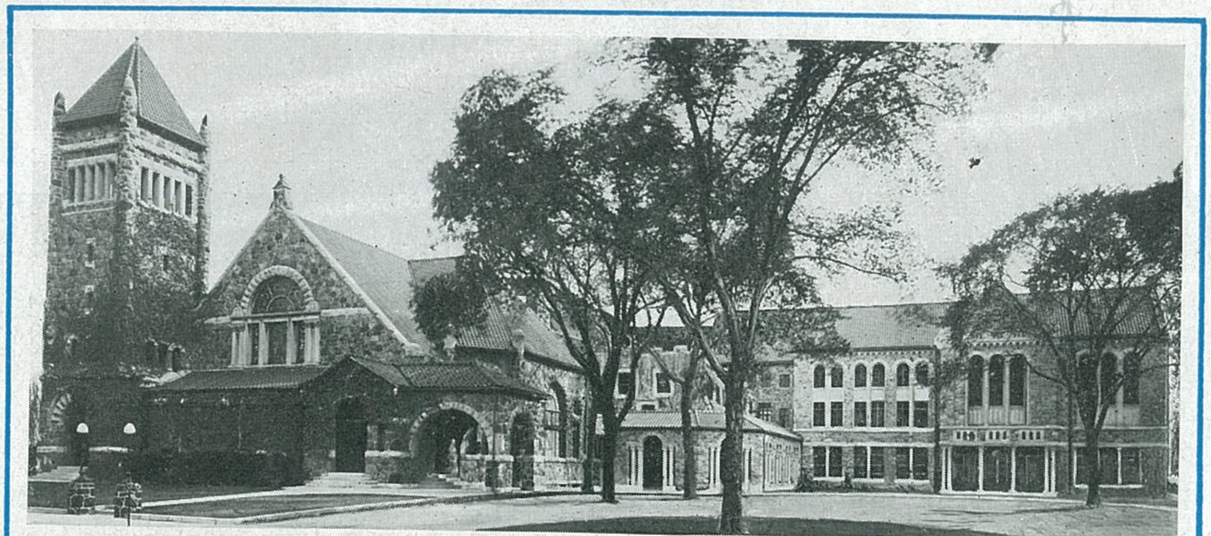
"In 1931 the writer acted as a member of the Building Committee of the First Presbyterian Church, Oak Park, Illinois, in erecting a $250,000.00 Church House. The church auditorium and Sunday School building, which had been in use for a great many years, were heated by hot water circulated from the central service station of a public utility.

"The Building Committee considered two programs. (1) To continue hot water heating in the two existing structures and install a separate heating system in the new Church House, (2) to install a complete plant in the new building to serve all three buildings. After careful investigation of both plans, and of heating systems in general, the Committee selected the Dunham Differential Vacuum Heating System to be installed in the Church House and it was decided to change the auditorium and Sunday School building from hot water to steam under Differential operation.

"Notwithstanding the fact that the heating contract with the public utility for the two buildings was $3,700.00 annually, we are now heating the three buildings (with at least 60% additional cubical contents than in the two buildings) at a heating cost which does not run over $2,000.00 a year.

J. G. Ford

J. G. Ford



First Presbyterian Church, Sunday School Building and Church House, Oak Park, Illinois.

AN UTTER NECESSITY IN THE HUGE BUILDING PROJECT

A tremendous advantage in any sizable building

DUNHAM DIFFERENTIAL HEATING

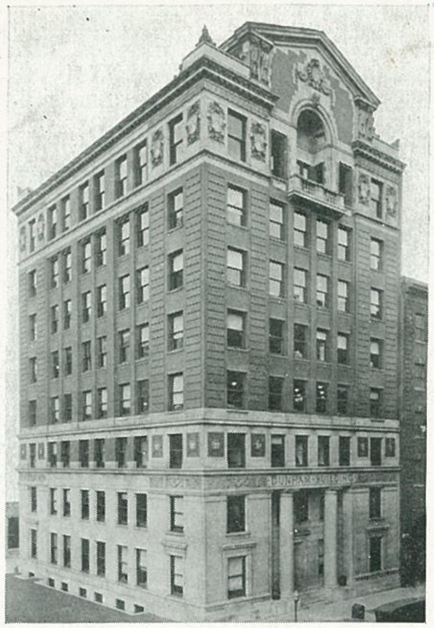
Undoubtedly, there will be a continuous upsurge of building activity during the next decade. Vast housing projects have been designed and the plans have already been finished by many leading architects and consulting engineers whose advanced ideas will find expression in the social structure of the future. Projects now on the boards will without doubt be followed by many similar undertakings which will be sponsored by Investment and Management organizations, Insurance Companies and other national groups.

High Altitude Heating will adequately heat these larger developments with a *minimum of fuel consumption*—with a *minimum of manual supervision*—and with a *maximum of comfort*. Regardless of size or number of buildings in a project, Dunham Differential Heating (the "High Altitude" system) will provide—in every room of every building in a group, a heating comfort and an economy of operation far beyond the capabilities of any "pressure steam" heating system.

Do not let the simplicity of Dunham High Altitude Heating lead to the thought that it is paralleled by any other system. It stands alone. For almost two decades it has proved its phenomenal operating economy and the surpassing comfort conditions secured with Subatmospheric Steam Heating.

No "large building" Management can justifiably ignore these advantages.

Printed in U.S.A. 7-44 GI



C. A. DUNHAM COMPANY

Administrative and General Offices

450 E. OHIO STREET, CHICAGO 11, ILLINOIS

FACTORIES: MARSHALLTOWN, IOWA MICHIGAN CITY, IND.

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

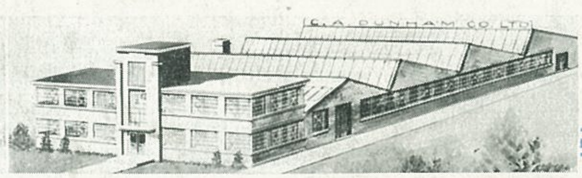
C. A. DUNHAM COMPANY, LTD.
(of the United Kingdom)
General Offices and Factory
Morden Road, London, S. W. 19, England

Marshalltown Plant, Marshalltown, Iowa

Pump and Heater Unit Plant, Michigan City, Ind.

Brass Foundry, Marshalltown, Iowa

General Offices and Plant, Toronto, Canada



Offices and Plant, London, England

HIGH ALTITUDE HEATING