DUNHAM LLC
THE STEAM HEATING PROFESSIONALS

Manufacturers Representative For:
MEPCO
MARSHALL ENGINEERED PRODUCTS CO.
Vent-Rite VARI-VAC®
ELGE®

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CONTROL EQUIPMENT APPLICATION MANUAL

HOW TO SELECT AND APPLY VARI-VAC TEMPERATURE CONTROL EQUIPMENT - The purpose of this manual is to provide the “do’s” and “don’ts” for selecting and applying the various parts of the three basic Mepco Pump Packages Vari-Vac Heating Systems.

Products That Perform...By People Who Care

GENERAL DESCRIPTION

WHY CONTROLS ARE NECESSARY

Control of the heat carrying medium (steam or water) supplied to a heating system is necessary not only to provide comfortable and even room temperature but to obtain economical fuel consumption. Fuel consumption records have proved that a properly controlled steam system can cut fuel costs up to 40%!!

Heat is required on practically every day of the winter. By examining local weather records, one will notice on how many days of the year the temperature falls below 65 degrees F. It's on these days that most people require heat and on most of these days overheating occurs, wasting valuable fuel dollars.

The output of the heating system must be varied from 100% in coldest weather to 0% in mildest weather. In other words, it must be geared to the weather in such a manner as to prevent either overheating or under heating at all times.

There are two general methods of automatically supplying steam to the radiation in a building. One, **the "On/Off" method,** is by intermittently opening and closing a steam control valve, supplying steam under pressure which is always above atmospheric pressure when the valve is open. A modification of the "on/off" method is "cycling" control in which valve opening and closing is intermittent at intervals timed in relation to the weather. The other method is to provide a continuous flow of steam and to vary the pressure and temperature of the steam as changes occur in the outside weather.

"ON/OFF" METHOD

The only advantage of this type of system is the **low initial cost.** Only temperature or heat loss measuring devices to open or close a control valve are required.

The greater disadvantages are that the heating is uncomfortable and the system is **not economical to operate.** The two main reasons are: 1) Intermittent steam flow produces **rhythmic overheating and under heating.** Whenever steam is supplied to the system, the steam is under pressure which is above atmospheric pressure; consequently steam temperatures and thus, terminal unit temperatures are above 212 degrees F.

2) Intermittent steam flow allows piping to cool which increases the **initial rate of condensation of steam,** also causing severe overheating in mild weather.

Other disadvantages are: (1) <u>System is apt to be noisy</u> because of flow noises due to high pressure differential and expansion noises due to expansion and contraction of the piping, as well as "water hammer" as steam instantly condenses on the cooler surface of any collection of condensate. (2) **Maintenance may be costly** because frequent expansion and contraction may produce excessive strains on piping. (3) **Intermittent steam flow shortens life of heating equipment.** (4) **Flow reversals cause condensate** to "hang up" in the piping and terminal units which can result in coil freeze-up, ineffective (flooded) terminal units, and trap damage.

CONTINUOUS FLOW METHOD

The biggest advantage of this type of system is that it heats comfortably and is **economical to operate**. The three main reasons are: **1) Steam can be supplied at a rate to precisely balance the heat loss of the building** and still retain balanced steam distribution. **2)** When under vacuum, temperatures are lowered and **small quantities of steam can fill the system completely** because steam expands so greatly. At 25" vacuum steam temperatures are as cool as 133 degrees F - only during morning heat up and in extremely cold weather is "hot" steam needed. **3) Reduced pipe line heat losses** because of lower steam temperatures.

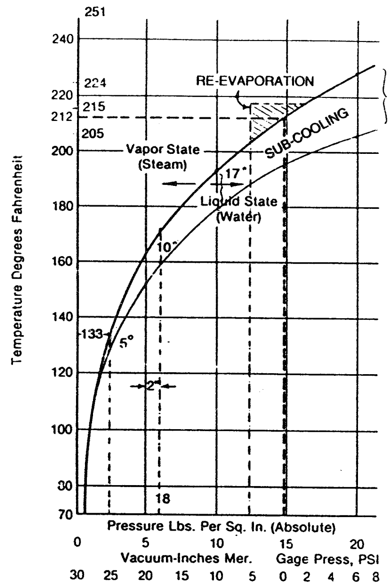
Other advantages are: **1) Better humidity and consistently comfortable room temperature.** Continuous flow of steam, at pressures and temperatures which are varied continuously with the weather, assures even room temperatures. Steam distribution is uniform because steam flow is easy to balance and the proper pressure differential between the supply and return sides of the system is maintained constantly. **2) Quiet operation.** With steam continuously flowing through the piping at a low pressure differential, steam flow noises are minimized and expansion noises eliminated. **3) Minimum maintenance cost** because continuous flow (in the correct direction) is less harmful to heating equipment (especially traps) and piping.

The continuous flow method of temperature control is practical when the heating medium is a substance whose temperature can be varied over a wide range. Water in its vapor state (steam) or in its liquid state (liquid water) can be varied over a wide temperature range.

When steam (the vapor state) is used as the medium, its temperature is varied by changing the pressure. When low steam temperatures are wanted the pressure is lowered (vacuum is increased) and when higher steam temperatures are wanted the pressure is raised (vacuum is lowered), and the temperature of the steam and the water from which it forms, change accordingly. When increasing the temperature the pressure may be raised until it is well above atmospheric pressure (zero vacuum), depending on how high a steam temperature is desired.

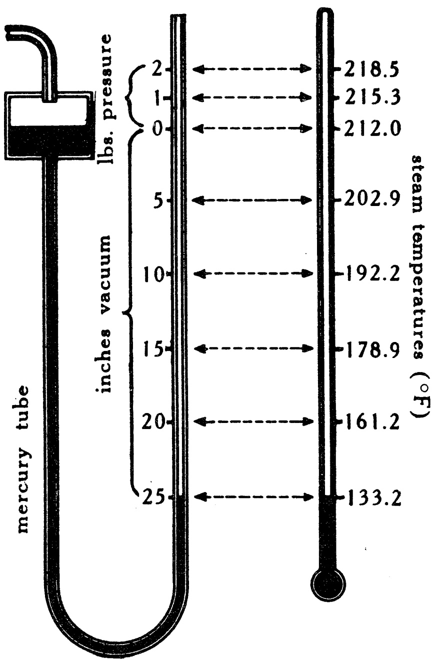
When water is used for the heating medium it must be kept at pressures higher than any at which it can vaporize (form steam) at any temperatures normally encountered.

The graph shows the effect of pressure upon keeping water at various temperatures in the liquid or vapor state. Bear in mind that a fluid condition located on the equilibrium (saturation) curve can be in a vapor or liquid or a mixture state.



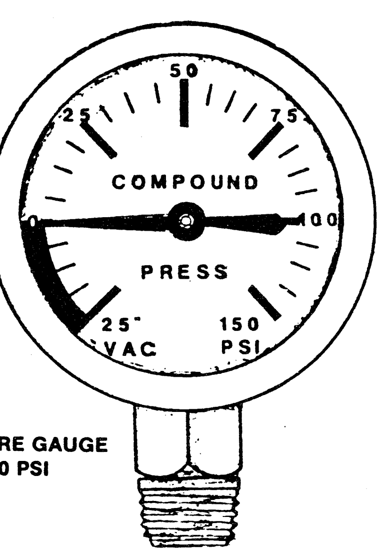
EQUALIBRIUM (SATURATION CURVE)

VARI-VAC AND HOW IT WORKS



mercury tube barometer

fahrenheit thermometer



COMPOUND PRESSURE GAUGE
25" Vacuum - 150 PSI

SUB-ATMOSPHERIC STEAM

The temperature of steam varies with the pressure upon it. Boiling an egg at a high altitude, where the air pressure is low, is an example of this fact. At sea level water boils at 212 degrees F. On top of Mt. Everest, an egg would have to be boiled considerably longer than three minutes because the temperature of boiling water at the atmospheric pressure there is only 150 degrees F. Therefore, by varying the pressure of the steam, as is done in the Vari-Vac system, the temperature of the steam is varied accordingly. At sea level, steam under a pressure of 25" vacuum has a temperature of only 133 degrees F.

In a Vari-Vac (variable vacuum) system, steam is supplied **continuously** at a rate and temperature which is varied with changes in outside temperature, wind velocity, sun, etc. During most of the heating season, the system is under a partial vacuum and steam piping and radiation temperatures are between 133 degrees F. and 212 degrees F. However, in severe weather or occasionally during morning heat-up periods, steam at 212 degrees F. may not be hot enough, so, at these times, the steam may be above atmospheric pressure. At 2 lbs. pressure, the steam temperature is 218 degrees F. The illustration above indicates the temperature of steam at various vacuums and pressures.

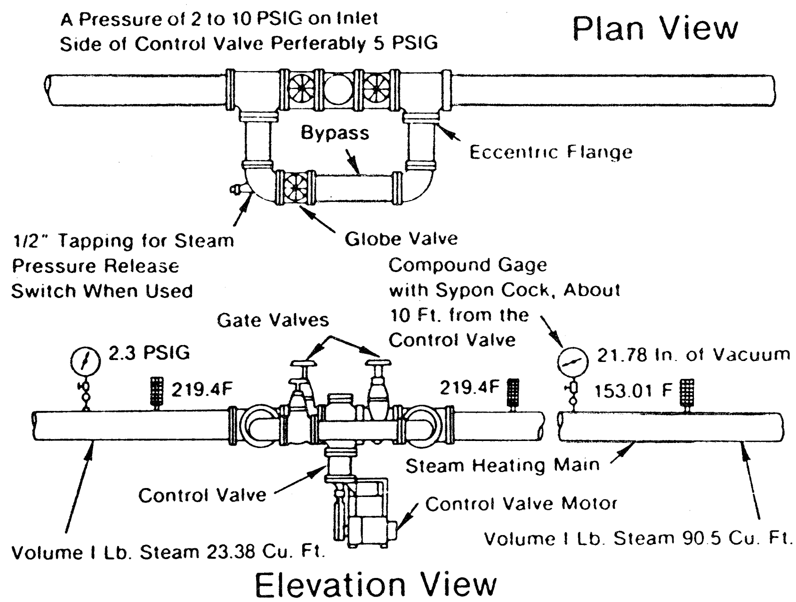
SUB-ATMOSPHERIC CYCLE

This cycle is also referred to as the variable vacuum concept of steam temperature and capacity control.

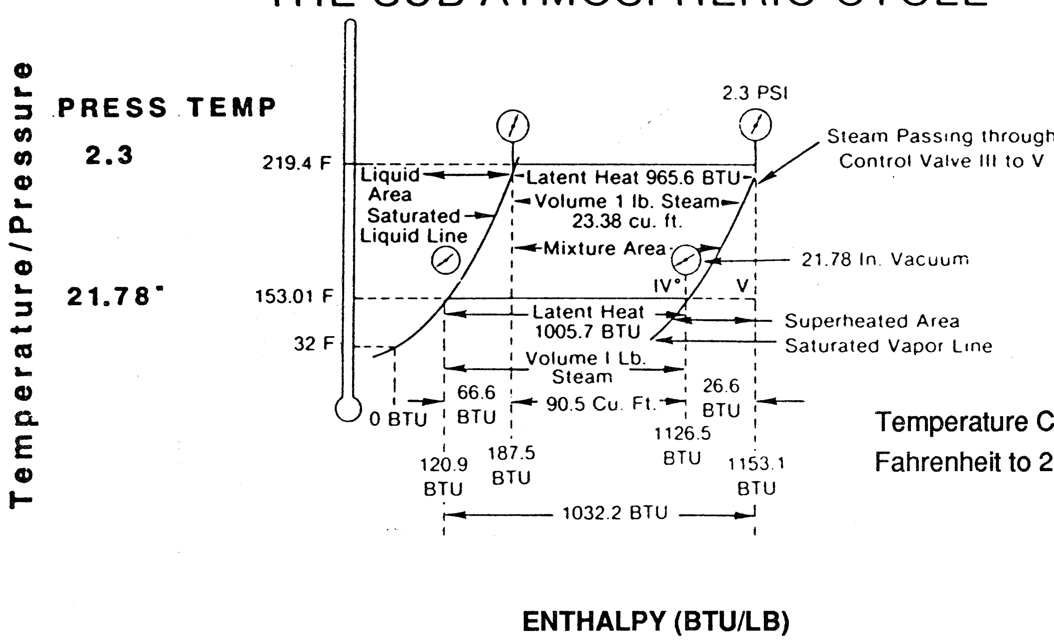
SUB-ATMOSPHERIC CYCLE CONT'D

The illustration (right) traces a pound of steam as it flows through the Vari-Vac system from the boiler through the zone flow control valve, terminal unit (heat exchange), steam trap and back to the boiler. Note the changes in state (vapor to liquid and vice versa) and the resulting changes in latent heat content, specific volume and enthalpy (total heat) as the pound of medium completes the cycle. Overall system efficiency (operating economy) depends upon full control of these characteristics over a <u>wide temperature range</u>.

"THE CONTROL VALVE"

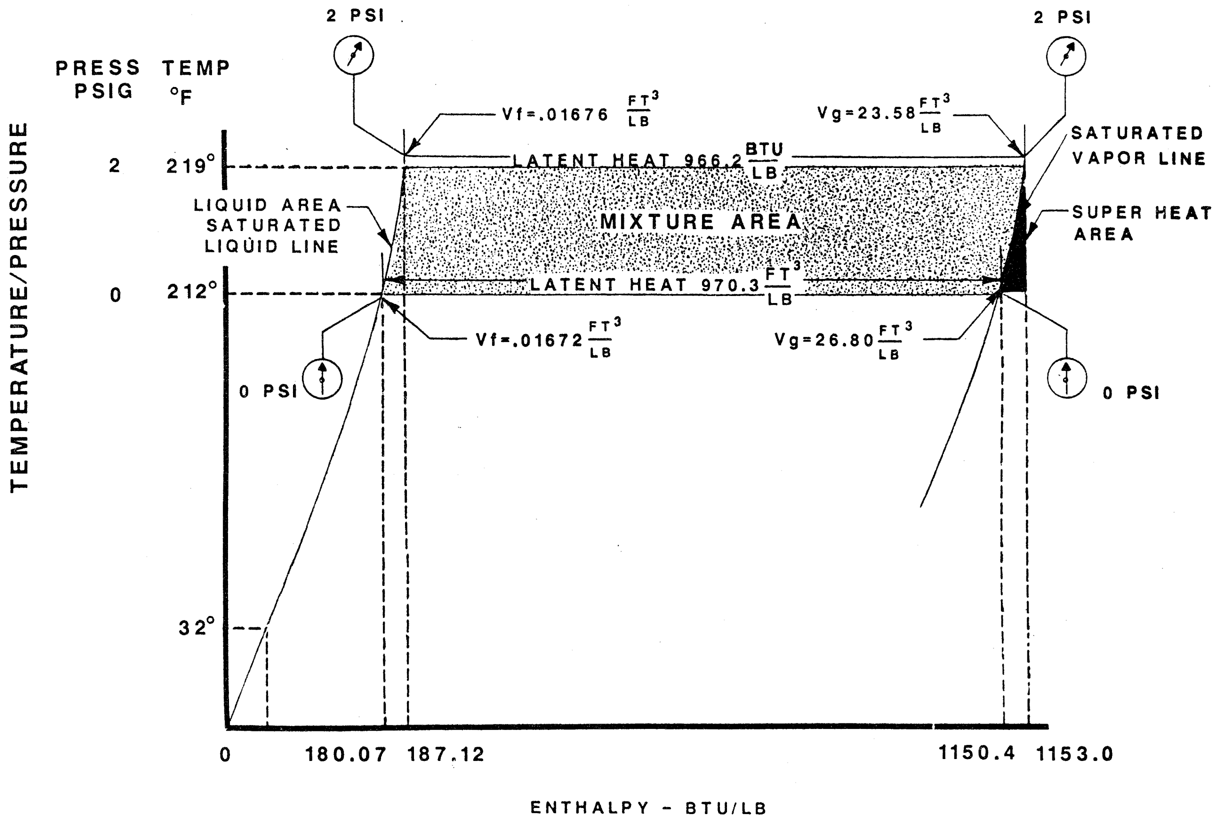


"THE SUB-ATMOSPHERIC CYCLE"



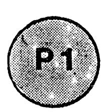
Temperature Control Range: 219 degre Fahrenheit to 212 degrees

ATMOSPHERIC RETURN CYCLE

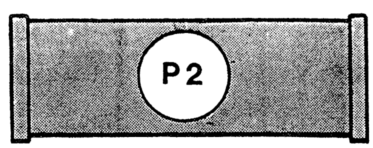


Atmospheric (pressure) return cycle - This cycle is restricted in the degree of temperature and capacity control because the return piping is vented (at the condensate return pump and sometimes by the use of vacuum breakers) to the atmosphere. Overheating in mild weather (waste) is common in such systems.

VACUUM SYSTEMS PERSPECTUS



= ATMOSPHERE



SEALED PIPE

RELATIVE PRESSURES | ABSOLUTE

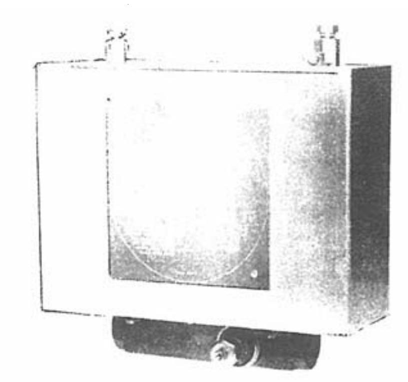
GAGE(PSI)	**ABS.**(PSI)	**VAC.**(IN.HG.)	**Pressure Ratio P1/P2**	
0	20	---	---	---
5	15	0	---	---
---	10	10"	15/10	1.5 : 1
---	5	20"	15/5	3 : 1
---	3	24"	15/3	5 : 1
---	2	26"	15/2	7.5 : 1
---	1	28"	15/1	15 : 1 (A)
---	0	30"	15/0	∞

***A)** Ratio not to be confused with pressure difference across pipe wall.*
Absolute pressures below 1 PSI not commercially recommended.

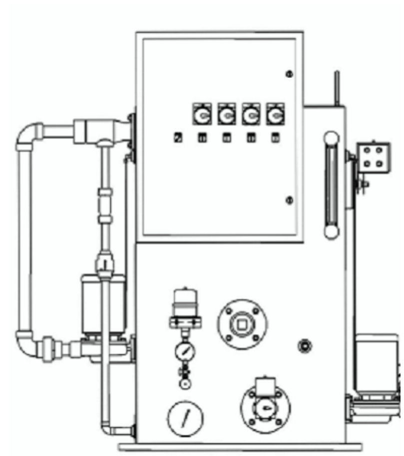
SYSTEM TIGHTNESS
Maximum operating efficiency will be obtained from piping systems capable of sustaining from 20" Hg Vac. to 18" Hg Vac. (cold test) over a period of 2 hours. Relatively large leaks can be audibly detected.

Smaller leaks can be found by either pressure testing (15 PSI) or vacuum testing the piping. Experience has shown that the 5:1 ratio shown in the above reference chart is a practical goal and relatively easy to attain.

PRESSURE DIFFERENTIAL
To obtain steam circulation, the pressure in the return piping must be less than that in the supply piping.



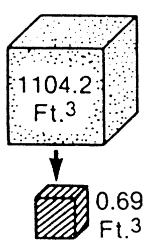
Proper pressure differential is maintained by a vacuum pump controlled by a differential controller. Ordinarily a pressure differential of not more than 1 lb. or 2" (mercury) vacuum is required to assure proper steam circulation. So, if the controller is set for such and the vacuum in the supply piping is 10", the pump operates to produce 12" vacuum in the return piping, thus proper circulation continues all the way to the highest vacuum obtained in the supply piping - 25" or higher.



PRODUCING THE VACUUM
The common misconception is that a system vacuum is **produced** by the vacuum pump. <u>The following example</u> clearly explains that the collapsing action of condensing steam produces the vacuum (void) and that it is **sustained** by the vacuum pump.

STEAM HEATING SYSTEM
10,000 E.D.R. or 2,400,000 BTU/Hr. Capacity and Saturated Steam at Atmospheric Pressure

Prevailing Conditions:

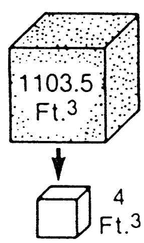


— Rate of Steam Flow:
2473 Lb./Hr. or 41.2 Lb./Min.

— Space Occupied by Flow Rate:
1104.2 Ft.^{3}/Min.

— Space Occupied After Condensing:
0.69 Ft.^{3}/Min.

— Space (Volume) Reduction Ratio:
1600 to 1



— Rate of Volume, Reduction by System:
1103.5 Ft.^{3}/Min.

— Rate of Volume (Air) Capacity of Jet Type Vacuum Pump:
Simplex Model — 4.0 Ft.^{3}/Min.
Duplex Model — 8.0 Ft.^{3}/Min.

— System/Vacuum Pump Ratio:
Simplex — 276 to 1
Duplex — 138 to 1

HEATING IN MILD WEATHER AND BALANCING STEAM FLOW

The vacuum pump is capable of maintaining 25" or more vacuum which means that the temperature of the steam in the system may be 133 degrees F. or lower. **The heating capacity or output of the radiation is reduced as the temperature of the heating medium is reduced. The heat output of convectors varies with the 1.5 power of the steam and air temperature difference - with direct radiation, the 1.3 power.** Tabulated below is the heat output variation (in percent) for convectors and direct radiators with steam at various pressures and temperatures.

STEAM

Pressure	Temperature
1 lb.	215° F.
10" vacuum	192° F.
15" vacuum	179° F.
20" vacuum	161° F.
25" vacuum	133° F.

HEAT OUTPUT

Convectors	Radiators
100%	100%
78%	80%
66%	69%
51%	55%
31%	34%

Note that the heat output of convectors drops off faster than that of radiators. At 25" vacuum the heat emission of a convector is only 31% of its rated output. If the heating system has been designed for an outside design temperature of 0 degrees F and an indoor temperature of 70 degrees F (a 70 degree design temperature difference), then circulation of steam at 25" will theoretically give the right amount of heat for an outdoor temperature of 48.3 degrees F.

SOLUTION: The mathematical solution is: 70 - (70 x .31) = 48.3 degrees. In other words, in this instance as the outside temperature increases from 0 degrees F to 48.3 degrees F, comfort temperatures are maintained with continuous steam flow, by reducing the pressure to various vacuums until a 25" vacuum is reached.

However, there remains the problem of controlling the heat all the way to 65 degrees F outdoor temperature. Since it would be commercially impractical to readily maintain a vacuum exceeding 25", other means of heat control are needed. This extra control is obtained by **partially filling the radiation with steam.** Balanced distribution of this restricted steam supply is maintained by introducing a slight resistance to flow at each radiator inlet by means of regulating valve, regulating fitting or regulating plate. Thus, the heat output can be reduced to the vanishing point (65 degrees F outside temperature). How the filling of a convector heating element takes place at approximate outside temperatures is illustrated (Base Temperature 0 degrees F) See Comparison Chart, page 10.

PARTIAL FILLING
(see chart next page)

NOTE: Partial filling caused by restricting steam flow in this manner occurs only in mild weather. Therefore, steam is never restricted to the point of causing discomfort to occupants.

The extent to which radiation will partially fill in a properly designed system depends mainly on its tightness. In a well installed and maintained system, partial filling will usually not start (in a Vari-Vac system) until a vacuum of at least 15" in the system has been obtained.

NOTE: In old heating systems partial filling of radiation may start immediately upon throttling, due to the fact that radiation is apt to be oversized.

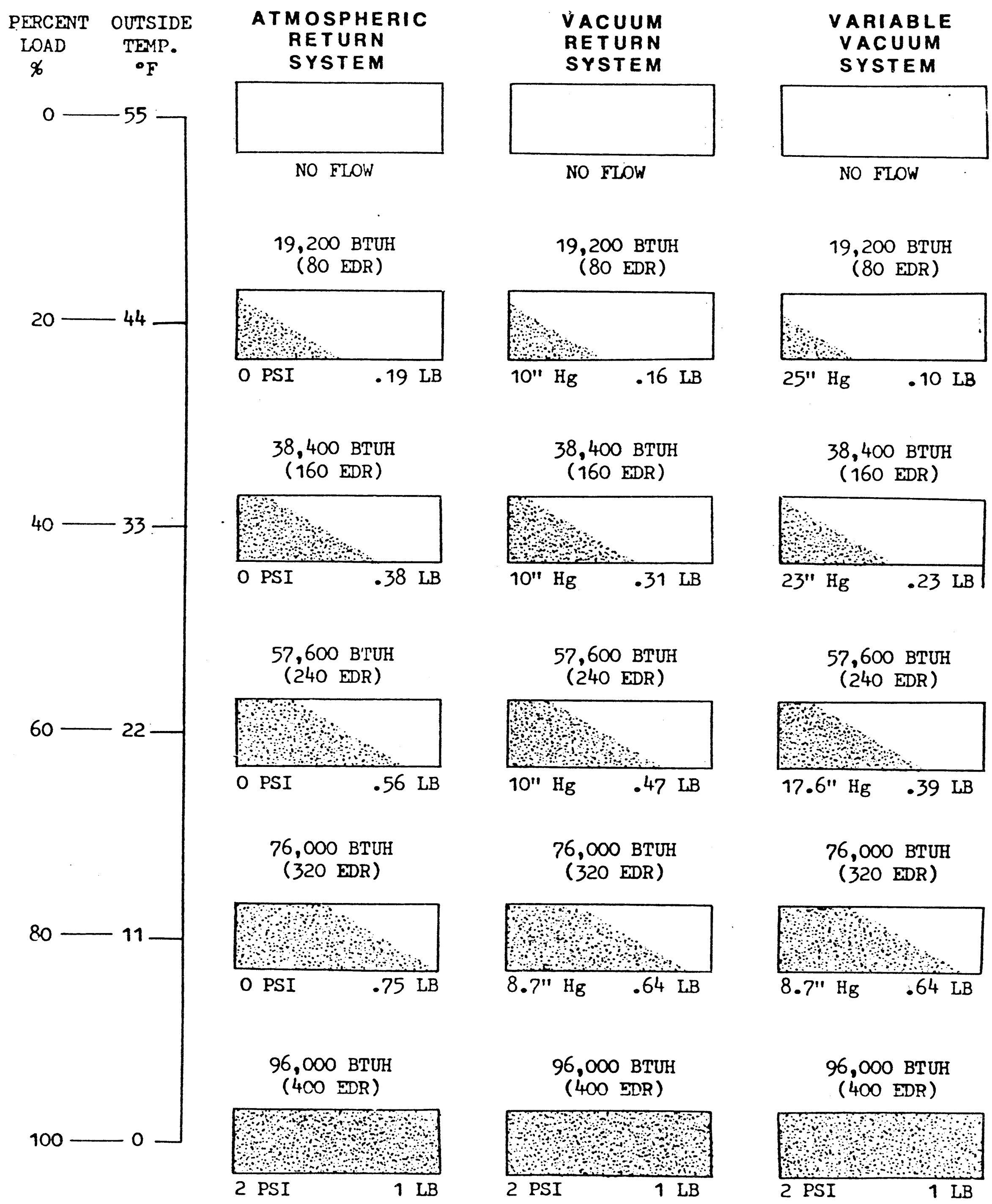
Since by circulating steam at 25" vacuum or higher, more than 60% of the desired control has been obtained, extreme accuracy in regulating steam flow for partial filling of radiation is not required. For example, if a regulating plate were improperly sized, it would only effect the convector's heat output in mild weather.

In a pressure system where regulating plates are used for balancing steam distribution, incorrect sizing of a plate means serious unbalance of steam supply to that convector.

Partial filling - graph, see next page.

COMPARISON CHART:
This chart assumes modulating (throttling) type valves are used at the entrance of each terminal unit for atmospheric and vacuum return systems and that 2 psig steam exists on supply side of such valve, whereas the steam supplied to the terminal units in a Vari-Vac system is variable. *<u>NOTE:</u> On/off cycling of the control valves in atmospheric and vacuum return systems can cause complete filling of terminal units in mild weather (overheating) due to a constant source of 2 psig steam upon valve opening.*

PARTIAL FILLING

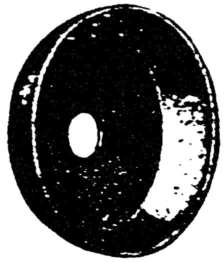


TERMINAL UNIT PERFORMANCE COMPARISON

(Theoretical Valves - Continuous Flow)

REGULATING VALVES AND FITTINGS

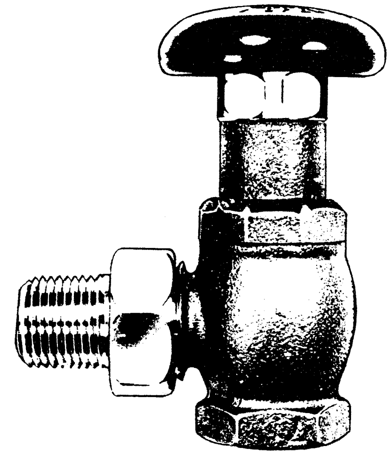
These are flow metering devices and for given pressure differences pass definite quantities of steam. Due to the greater flexibility and convenience of externally adjustable regulating valves and fittings their use is supplanting that of regulating orifice plates to balance steam flow.



REGULATING PLATE
For convectors, wall fin radiators, and branch supply connections.
Model 192

The advantage of regulating valves and fittings are: (1) Adjustment can be matched to either radiator capacity or heat loss. (2) Valve unions need not be disconnected in order to make adjustment. (3) Fewer tools and less labor required for making adjustments, particularly with convectors and concealed piping. (4) No loose parts to be lost as in the case of painters, carpet layers or others disconnecting radiators to change orifice plates.

MEPCO PUMP has developed an externally adjustable regulating valve. The orifice may be adjusted from the outside of the valve or fitting without breaking piping connections.



COMBINATION REGULATING VALVE AND ADJUST. REGULATING FITTING — For radiators
Model C, type SWRF
Bulletin #2147D

Vari-Vac steam heating systems are job-scaled into three basic systems with options:

(1) **CUSTOMARY** - ERS
- ERST

(2) **COMBINATION**- ETRS-1, ETRS-2
- ETRST-1, ETRST-2

(3) **NON-CUSTOMARY** - ERT-1, ERT-2
- ETRT-1, ETRT-2

Each system is designed for a certain need and are completely automatic.

In addition to steam temperature control equipment, all Vari-Vac systems include a vacuum pump, radiator traps, drip traps, differential controllers, and either regulating radiator valves, regulating fittings or radiator valves with regulating plates.

VARI-VAC SYSTEMS

JOB-SCALED VARI-VAC STEAM SYSTEMS
CUSTOMARY SYSTEM

Temperature control equipment used with this system consists of a differential controller, control valve, control panel, selector and a heat balancer. Optional equipment includes a digital programmable time switch and an outdoor type selector (demand sensor).

The selector evaluates the heat loss and sets the demand for heat. It is mounted against the inside surface of a glass windowpane. The temperature sensitive resistance coil of the selector is affected slightly by the room temperature, but primarily by the varying weather conditions. The temperature conditions at the selector are transmitted to the control panel from which control valve movement is regulated.

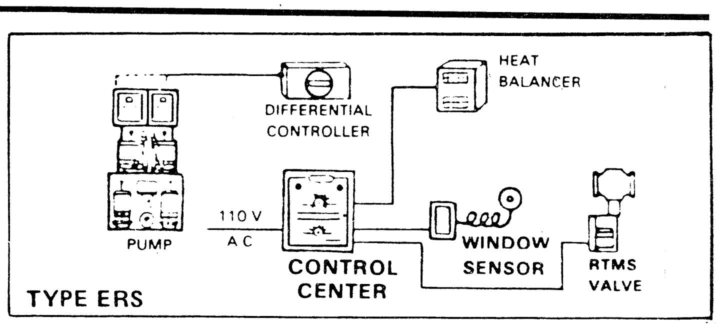
The *"heat balancer"* measures the heat supply rate. It is a specially constructed convector with its heating element connected to the supply and return piping. Two resistance coils, one located below the heating element and the other located above, measure the temperature of the air entering and leaving. Any variation in steam supply to the system is thus measured and the extent of control valve opening is changed automatically to balance the heat supply to the heat demand. (see diagram next page)

A Programmable Timer may be used to provide for an accelerated steam flow during the morning heat-up period and a decreased flow for lower night temperatures. This timer also contains an omitting device which keeps the control at "night" control when reduced building temperature is desired, such as over a weekend or a holiday.

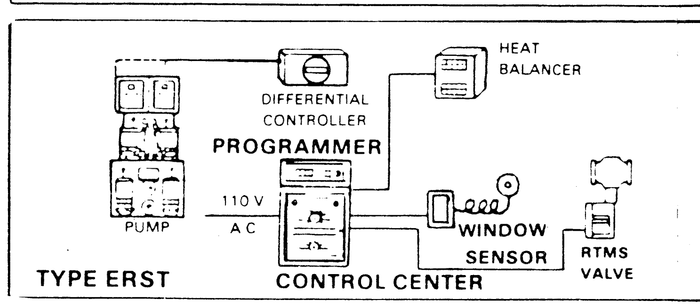
Since unusual wind velocities, rain, blowing snow or sunlight may demand a slight adjustment of heat input, the control panel is equipped with a compensator which may be used to increase or decrease the heat supply as desired. Thus the operator can, if he wishes, adjust the heat input but still have fully automatic control of the system.

CUSTOMARY SYSTEM:

THE TYPE ERS is used where continuous temperature is desireable without variations for nights or weekends. A typical use would be an apartment house where it is important to balance the heat input to the heat demand for comfort in the occupied space. The system consists of a control center, control valve, heat balancer and window sensor or outdoor sensor. The demand for heat is measured at the window sensor and the heat input to the system is measured by the heat balancer.



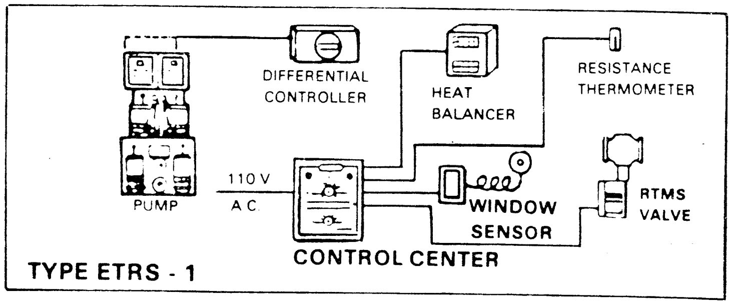
THE TYPE ERST system is identical to the ERS except that it has a digital programmer that can be programmed to automatically set-back the temperature for the night, weekend or holiday. It is also capable of pre-heating the building the following day.



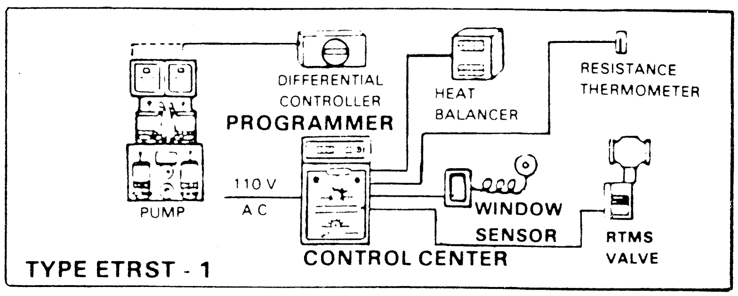
COMBINATION SYSTEM:

Includes all components of the Customary System plus the room resistance thermometer which acts as a high and low temperature limiting device. It consists of a temperature sensitive coil of fine wire mounted on a composition base and protected by a metal shield. The flow of electricity through the coil varies the surrounding air temperature, making it an excellent means for measuring room temperature. One resistance thermometer is usually installed in each zone although two may be used if desired. Where two are used, the average temperature at the two locations affects the steam supply.

THE ETRS-1 is designed for schools, office buildings or areas where abnormal sun loads and/or internal sensible heat gains may exist. This system consists of a control center, control valve, heat balancer, window sensor or an optional outdoor sensor, and a resistance thermometer. The demand for heat is measured by the window sensor and the heat input is measured by the heat balancer. The resistance thermometer serves as both a high and low limit temperature control.



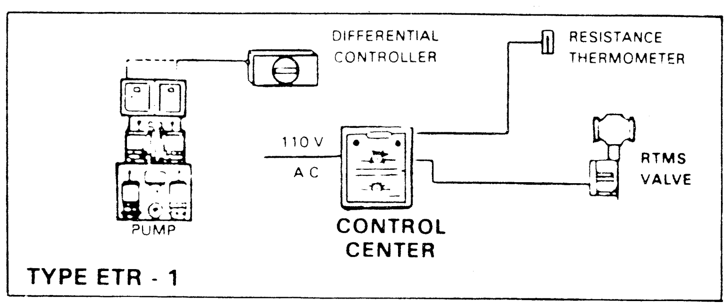
THE ETRST-1 is identical to the ETRS-1 system, but includes a digital programmer which will set-back the temperature during periods of little use.



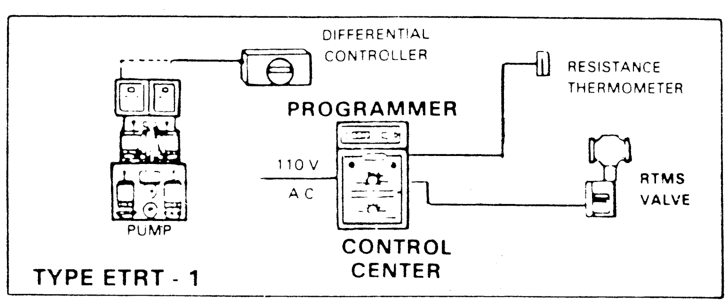
NON-CUSTOMARY SYSTEM:

CONTROL ASSEMBLY - Room Resistance Thermometer Control. If control from Room Resistance Thermometer only is desired, this assembly is preferred. It is best suited for use in factories or other installations where unit heaters are all or the greater part of the heating load. Heat input into the system is checked three times each minute and corrections in Control Valve openings are made if found necessary.

THE ETR-1 system is designed for areas where undivided space is to be heated and internal sensible heat gains are paramount. A factory is a good example where these are encountered. This system consists of a control center, control valve, and resistance thermometer. The demand for heat is measured at the resistance thermometer; the temperature in the space can be read at the control center.



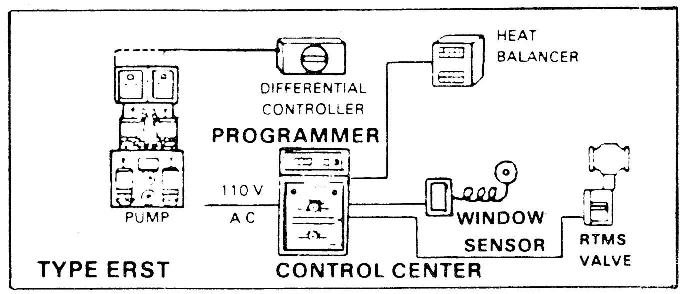
THE ETRT-1 system is identical to the ETR-1 except that a digital programer is incorporated into the system to setback the temperature during periods of shutdown, such as nights, weekends and holidays. It is also capable of pre-heating the space prior to the work period.



OPTIONS:

TEMPERATURE CONTROL ASSEMBLIES - There are two variations of various basic temeprature control systems. The selection of the equipment for an installation is dependent upon location of control panel and other parts of the control assembly. These assemblies are: (a) CONTROL ASSEMBLY #1. This assembly is used where all parts of the control assembly are located close to one another and usually within the same building. (b) CONTROL ASSEMBLY # 2. Used when the Control Panel or the Control Panel and Selector are not located close to one another in the same building as the Control Valve and Heat Balancer. A reduction in the number of conductors is required in control cable for connection to the Control Panel is affected by use of CRS 22 Terminal Box. Also, compensation for lengths of runs of cable exceeding 1800 ft. is provided in this Terminal Box. *Consult factory for additional applications.*

THE TYPE ERST system is identical to the ERS except that it has a digital programmer that can be programmed to automatically set-back the temperature for the night, weekend or holiday. It is also capable of pre-heating the building the following day.



SELECTING THE PROPER SYSTEM

In addition to considering the various performance features of job-scaled Vari-Vac when selecting the proper assembly, it is important to consider the following things:

Size of building	**Hours** of operating shift
Height of building	**Zoning** requirements
Type of occupancy	**Location** of equipment
Hours of occupancy	

SIZE OF BUILDING

The larger the building, the bigger the dollar value of fuel savings and the greater the difficulty in maintaining uniform temperatures in all rooms. It is difficult to draw a line and say that one of the automatic systems should be selected for buildings with a specific number of square feet EDR. However, it is usually true that buildings with less than 2500 square feet EDR are not good prospects for the automatic systems unless there are special requirements such as extremely accurate temperature control, as in a school, hospital or laboratory.

For buildings with 6000 square feet EDR or more, possible dollar value of fuel savings amount to a large percent of the control cost and therefore automatic control is a worthwhile investment. Any of these systems can be selected for this size building, but if extremely accurate room temperature control is important, the selection should be the Combination System as this assembly with the resistance thermometer can maintain temperatures within a very close range.

HEIGHT OF BUILDING

Skyscrapers may require zoning due to varying demands for heat at different levels. Here it is usually advisable to use combination control so that the temperature sensitive resistance thermometers, etc., located at various levels, can compensate for stack effect.

TYPE OF OCCUPANCY

When considering type of occupancy no specific rules for selection of the proper Vari-Vac system can be made. However, hospitals, schools, laboratories, etc., usually require the Combination System because of the need for extremely accurate room temperature control. High internal sensible heat gain areas pose specific solutions.

HOURS OF OPERATING STAFF

Since Vari-Vac is job-scaled according to degree of automatic control desired, the working hours of the operating staff must be considered when selecting the proper system. For example, when the staff works only during the day time, the functions provided by Programmable Timers are essential and therefore the Timer Options are recommended.

HOURS OF OCCUPANCY

Some buildings are heated only occasionally, other require only low heat for days at a time, and still others need full heat "around the clock". Where buildings are unattended for a long time it is important to have some type of automatic control to prevent freezing and prevent overheating.

ZONING REQUIREMENTS

The fact that the building requires more than one zone usually indicates that it is probably a sizable building. For such buildings any one of the assemblies are recommended as these systems automatically respond to the requirements of the zone served.

LOCATION OF EQUIPMENT

Occasionally it is difficult to find a good location for the room resistance thermometer. Customary Control is recommended in this case and is ideal for hotels or housing projects. Control is obtained from the selector and heat balancer.

When using Customary Control and all parts of the control assembly are located close to one another, Assembly No. 1 is recommended, otherwise Assembly No. 2.

SELECTING THE CONTROL VALVE AND VACUUM PUMP

SELECTING THE CONTROL VALVE

The Vari-Vac Product Catalog pictures and describes in detail the control valve and lists sizes and capacities. Control valve capacities include an allowance for heat given off by covered piping. However, if steam mains and/or steam risers are used for heating, such as in a bathroom or kitchen, the condensing capacity of these heat risers should be included in the total radiation load on the basis of 300 BTU per square ft. of actual pipe surface. Therefore, if a building has 12,000 square feet EDR in convectors or radiators, plus an additional 3,000 square feet EDR in exposed piping, the control valve should be selected on the basis of 15,000 square feet EDR capacity.

Control Valve Size Inches	Capacity Sq. Ft. E D R*	Size of Bypass Inches
1½	1,3000	1
2	2,000	1¼
2½	3,000	1½
3	4,500	2
4	8,000	3
5	12,000	3
6	18,000	4
8	32,000	5
10	50,000	6

*For 5 PSIG initial supply pressure and 2 PSIG system pressure.

SELECTING THE VACUUM PUMP

The vacuum pump should be selected on the basis of total square feet EDR which includes total connected radiation (convectors, unit heaters, etc.) plus bare steam piping. This piping condensing capacity can be figured as 300 BTU square feet of actual pipe surface.

When determining the size vacuum pump required, it is important to review the following procedure: Equipment which is not supplied with steam by the Vari-Vac system cannot be connected to the Vari-Vac vacuum pump unless the condensate is run through a heat exchanger or flash tank. If heat exchangers or flash tanks are not used, condensate must be handled through a separate vacuum pump or condensation pump.

NOTE: For more details on proper selection of vacuum pumps, see the PUMP APPLICATION MANUAL #1495B. For information on applying vacuum pumps to a zoned Vari-Vac system, see page 16.

SELECTING THE RADIATION

With Vari-Vac continuous steam flow both convector and cast iron radiation can be used on the same zone more satisfactorily than with other types of steam systems. For further details on selecting radiation, see the #2695 APPLICATION MANUAL.

Radiation should not be oversized. Excess radiation makes any heating system more difficult to control. Radiation is rated on the basis of 2 psig steam pressure and it is usually possible to raise the pressure of 5 lbs. (or more) to increase the heat output.

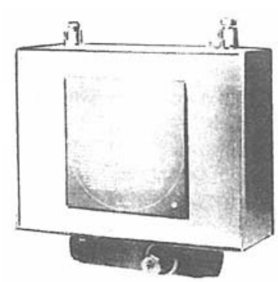
APPLICATION

WHERE TO INSTALL CONTROL EQUIPMENT

There are certain principles related to the function of control equipment which dictate the manner of applying the system components. However, it would be impossible to cover every situation here that will occur in determining the correct location for each piece of Vari-Vac control equipment. Occasionally, there is not a good location to be found and special arrangements must be made. However, there are many "do's" and "do not's" which cover most situations. They are listed here:

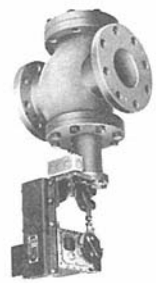
DIFFERENTIAL CONTROLLER

The preferred location for the differential controller is near the end of the steam main farthest from the control valve but it may, if necessary, be located nearer the vacuum pump. When installing the controller, two precautions must be taken: (1) The steam connection to the controller should be taken off the steam main at least 20' beyond the control valve. (2) The connection between the return main and the controller should be taken off the return main at least 20' ahead of the pump.

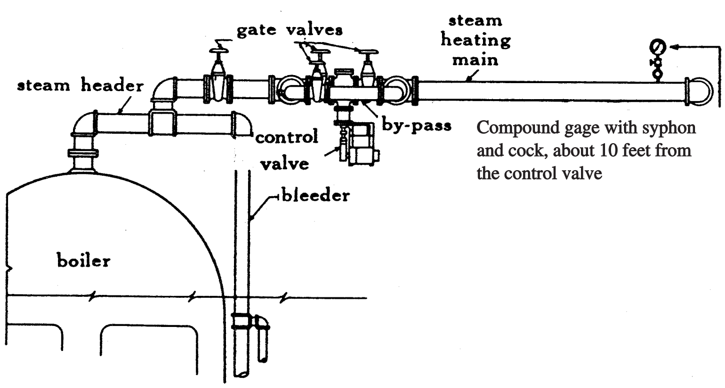


When one vacuum pump serves more than one zone of a multi-zone installation, a differential controller should be installed in each zone. However, if this cannot be done, one differential controller can be used for as many as three zones. It should be installed in the zone which is expected to require the highest vacuum (the one having the warmest exposure), usually the south zone. If one pump serves more than (3) three zones, at least two differential controllers should be installed. The second controller should be located in the zone in which the heating requirements differ from the remainder of the building - for example, in the operating room zone of a hospital or the first floor store zone of an office building.

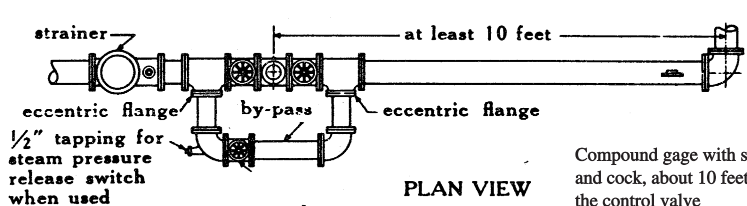
CONTROL VALVE



Control valves must be installed in a horizontal main and never in a vertical pipe (see illustrations). There should be at least 10' of straight pipe beyond the control valve, to allow steam flow to become steady, before pipe bends or branches are installed. The control valve can be mounted with the motor above the steam main but in this case the valve body should be dripped. The control valve must not be mounted in vertical piping because there will be excessive erosion on the bottom side of the inner valve and seats.

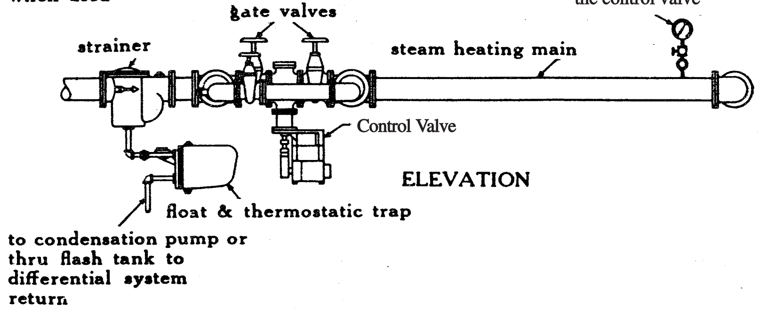


Compound gage with syphon and cock, about 10 feet from the control valve



PLAN VIEW

Compound gage with syphon and cock, about 10 feet from the control valve



ELEVATION

A strainer should be installed ahead of the control valve unless the valve is in the boiler room close to the boiler header. This strainer must be dripped.

On large multi-building projects, it is advisable to install the control valve, vacuum pump and hot water generator in a service building designed for that purpose. No vacuum pump operates quietly and the pump, the control valve, the hot water generator and piping all give off heat. So, in consideration to first floor tenants, the service building is a worthwhile consideration.

CONTROL PANEL

Since the control panel is the central control station for the heating system, it should be installed at a location convenient for the operator or supervisor of the system and where it is not subject to tampering by unauthorized persons. The location should also be one where there is not excessive heat, dust, dirt, moisture or danger of damage from boiler fire cleaning tools or passing traffic.

NOTE: The control panel must not be installed near steam pipes - never under uncovered cold water pipes because the pipes sweat in warm weather.

RESISTANCE THERMOMETERS

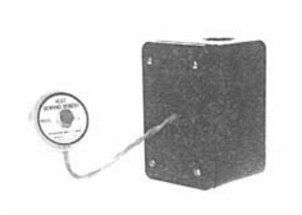
These devices must be located in their own zone and mounted on inside walls, preferably on columns away from drafts and direct sunlight - also away from convectors, radiators, air ducts and hot water, steam or refrigeration piping. They should not be located where normal air circulation will be obstructed by building

construction or furniture - that is, away from file cabinets, shelves, doors and corridors and not in small rooms or alcoves. The room in which the thermostat or resistance thermometer is located should also be an appreciable distance from the control valve.

NOTE: It is essential that these devices be located in a "typical" room - typical as to size, use, hours of occupancy, etc. - a room which will cool down at night in line with the rest of the zone. The room must not be one in which there is excessive window opening or uncontrolled heat.

WINDOW SELECTOR

The window selector should be placed in a room which is in the zone the selector is to govern - a room located so that its heat loss is most severe and in which temperature conditions are typical. In a single zone controlled building or in a north zone, it should be mounted on a north facing window with a single thickness of plain, clear glass. The glass surface must be smooth and level. Although the selector is designed so that it can be mounted to a window which is to be raised or lowered, it is preferable to mount it on a fixed window or on a transom above an outside door. If a north window is not available, one facing west or northwest can be used. A northwest window is the next best location. The selector must be mounted on the easterly side of a northwest window and on the westerly side of a northwest window so as to be protected from early or late sun.



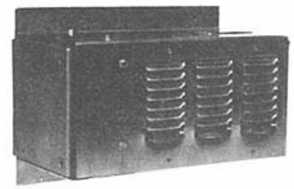
This sensor is no longer being offered by factory.

If it is necessary to mount the selector on a window facing from northeast through south to northwest, a sun shade must be provided. Locating the selector on a south facing window even with a sun shade is not recommended; usually a west window in a southwest room is available. The room chosen should be a normally heated room - not one that is aired out frequently, such as a bedroom, conference room, etc.

The selector should not be located higher than the fifth floor of a building because of the rising air currents along the building wall; however, if there is a complete zone or zones above the fifth floor, selector(s) should be located in each zone(s).

It is best to avoid mounting a selector on a window over a convector or radiator. It is also best to avoid a window near an air duct, exhaust fan, boiler, washing machine or any such equipment which gives off heat or causes air movement. However, if the selector must be installed in one of these locations, it may be necessary to insulate the back side (room side) with mineral wool and enclose the selector in a box. The control panel will then have to be re-calibrated to compensate for the lower selector temperature and greater range.

If the selector cannot be located in a normally heated room, then a basement window in a heated room may be selected. However, this window must be well above grade where it will not be blocked by snow or shrubbery. It should not be a window facing a ramp for fear of shielding the selector from the full effect of the wind.



OUTDOOR SENSOR

The location of the outdoor selector is governed by the building (see zoning) and positioned on the outside of the building to best serve the climatic exposure of that particular part of the building. Sun shields should be used for east, south and west exposures.

HEAT BALANCER

The heat balancer should be located at some point 1/4 or 1/2 the distance from the control valve to the end of the longest steam main. It should not be located close to the control valve and not closer than 5' to an elbow or bend in the main.

The heat balancer should be installed in a room with a normal air temperature of not less than 60 degrees Fahrenheit or more than 80 degrees F. The location must be where the surrounding air temperature is steady - not near outside doors or any kind of draft - not in room where stored materials or cabinets would obstruct free air flow - not in a closet where there is no ventilation - not near a ceiling where the air may become stagnant - not in a place where the sun will hit it.

NOTE: If it is necessary to install the heat balancer near steam or return piping, the adjacent piping must be insulated. The heat balancer must never be installed so close to steam piping that the inlet air temperature would be affected.

After it is installed and adjusted, the heat balancer will add approximately 5 square feet EDR heat output to a room. This heat output should not be considered part of the heat required for that room nor should it amount to more than 20% of the total heat loss.

All steam pressure reducing valves (such as a Vari-Vac valve) and all pumps make some noise. They also generate heat. If such equipment must be located directly below an apartment, for instance, steps should be taken to minimize the noise by using cork or similar pads under the pump and spring hangers for all piping. A hung ceiling with ventilating fan will prevent transmission of heat to the floor above.

VACUUM PUMP

REASONS FOR ZONING

There are four basic things to consider when determining the proper arrangement of multiple zones in a building.

Occupancy

Physical Size

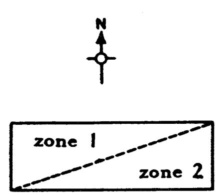
Stack effect

Exposure

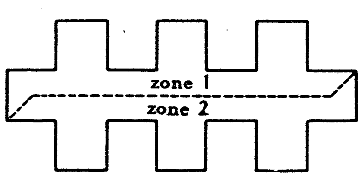
Occupancy - There are many needs for occupancy zoning all of which could not be discussed here. However, some of the most common needs are: (1) A school building having a gymnasium heated for special events - the gym should be on a separate zone. (2) An office building in which the office heat may be shut off or reduced at five or six o'clock but stores on the ground floor which would require heat until later - the stores should be on a separate zone. (3) In an industrial building having warehouse space heated to 40-50 degrees F. - a manufacturing portion heated to 60-65 degrees and offices requiring 70-75 degrees - each should be on a separate zone.

Physical Size - It would be impossible to heat an extremely large building evenly from one zone because the heat losses of all sides vary from time to time. Furthermore since the control valve, piping, vacuum pump, etc., would be of larger size, splitting the system into two or more zones may actually reduce the installation cost. Also, a building may cover such a great area that distributing steam entirely at low pressure may require excessive pipe sizes. By zoning, so that steam may be distributed at higher pressures, pipe and control valve sizes may be materially reduced.

Stack effect - A very tall building must be zoned at various levels because of the different heat load requirements. The up-draft in the building may cause excessive infiltration on the lower floors and outward flow of air on the upper floors.



Exposure - Various sides of almost any building re-



quire different amounts of heat at different times according to the state of the weather. In most localities one side of the building is exposed to cold winds to a greater extent than another side, as local weather reports will show. In most sections of this country, the northwest is usually the cold side, and that is also the side which gets little sun during December, January and February. Other sides of the building are exposed to winds of varying velocity and duration so that on some days the southeast side may actually need more heat than the northwest.

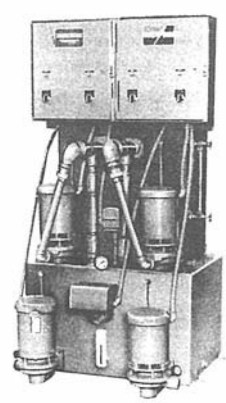
Generally, the solution is to have a separate zone for each major or dominant exposure. Thus if four sides of a building are each about the same dimension, four zones may be indicated. However, if the building is long and narrow so that two sides dominate in influencing the heat loss, two zones would be indicated. In such an instance the short sides would not need a separate zone, so by splitting the building diagonally into two zones the exposure requirements would be satisfied and the expenditure for heating held to a minimum (see illustration).

The majority of buildings are not of regular shape but are built with ells, wings and bays. With this design, it would be an economic impossibility to zone each wall. Here again, dividing the heating system into two zones along a diagonal line would be a practical solution to care for wind effect (see illustration).

With buildings of conventional design with windows of average size, the sun effect during the heating season may not be important enough to warrant zoning. During the heating season, the number of hours the sun affects the heat loss of this type of building frequently is not sufficient to cause serious overheating. However, with continuous window construction the sun effect is more of a factor and zoning should definitely be planned when the heating system is designed.

LOCATING VACUUM PUMPS

It is always best to install one vacuum pump and one differential controller in each zone of the heating system. Wherever this cannot be done, the following should govern the vacuum pump and differential controller application:

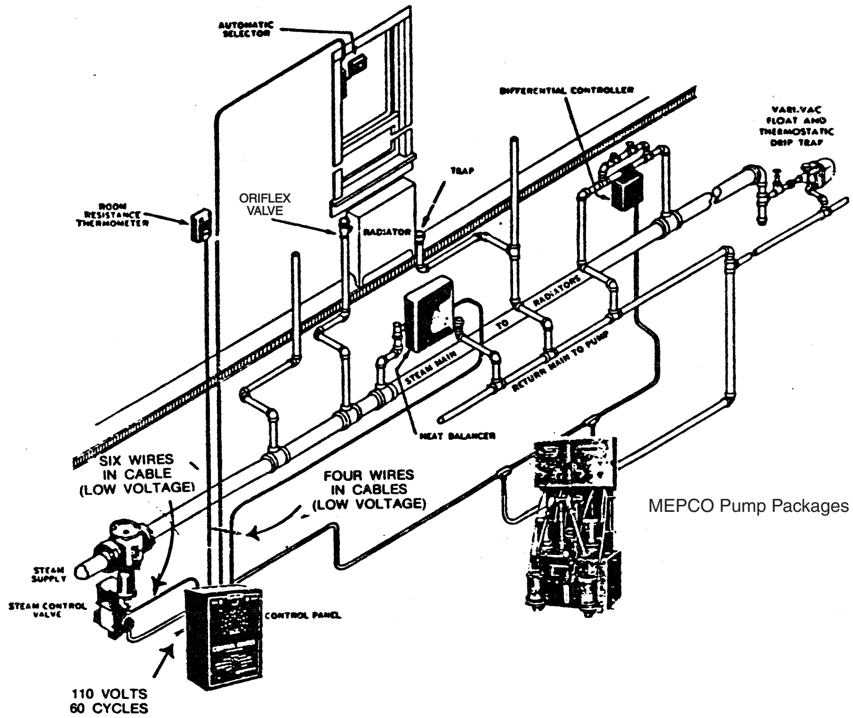


(1) If zoning is for exposure. If one vacuum pump and one differential controller must serve two or three zones, the steam connection to the controller must be made into the steam supply of the zone expected to require the highest vacuum.

(2) If zoning is for occupancy with like hours of heating for each zone. If one vacuum pump and one differential controller must serve two or three zones, the steam connection to the controller must be made into the zone containing the longest run of supply pipe.

(3) If zoning is for occupancy with different hours of heating for each zone. A separate vacuum pump should be installed in the zone operating the longest hours. This is especially important if that zone is small, the reason being that it is not economical to operate a large pump overtime to heat a small zone.

NOTE: *Vacuum pumps should always be isolated from tenant quarters where possible. (See "Control Valve," last paragraph, page 14)*



Sometimes due to building construction it is not possible to locate a vacuum pump at the low point in the return piping. For example, the construction may be such that the two ends of a long building are low with a high section in the middle, the boiler plant being at one end. Consequently, the condensate cannot flow by gravity from the far end of the building to the vacuum pump. This situation can be remedied in two ways:

(1) By installing a condensation pump at the far end of the building (opposite the boiler room), discharging into the return main at the higher elevation. An air-loop must be connected from the vent of the condensation pump tank to the high point in the return piping (see illustration). The disadvantage of this arrangement is that the condensation pump is under a vacuum and special shaft packing is required. Packing must be checked frequently for leakage. If packing leaks, the pump may "air bind" and fail to pump the water back to the return main. This arrangement is, therefore, recommended only for jobs having constant supervision and maintenance. Mechanically sealed pumps have proven satisfactory.

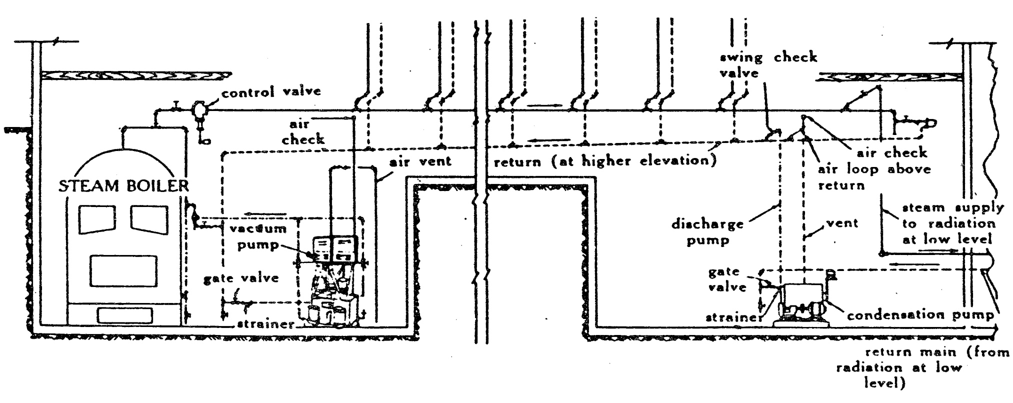
NOTE: *Regardless of using the condensation pump in the return piping the vacuum pump must be sized according to the entire EDR load.*

CONDENSATE PUMP BOOSTER ARRANGEMENT

(2) By installing a vacuum pump at each end of the building. The advantage is that there is no condensation pump shaft packing subjected to a vacuum. With this arrangement, a differential controller should be used with each pump, and each pump should be sized for the EDR load it will handle.

When two vacuum pumps are used on the same zone, the two return lines must be connected together at the high point through an equalizer pipe.

When a vacuum pump is located some distance from the control valve (perhaps even in another building)

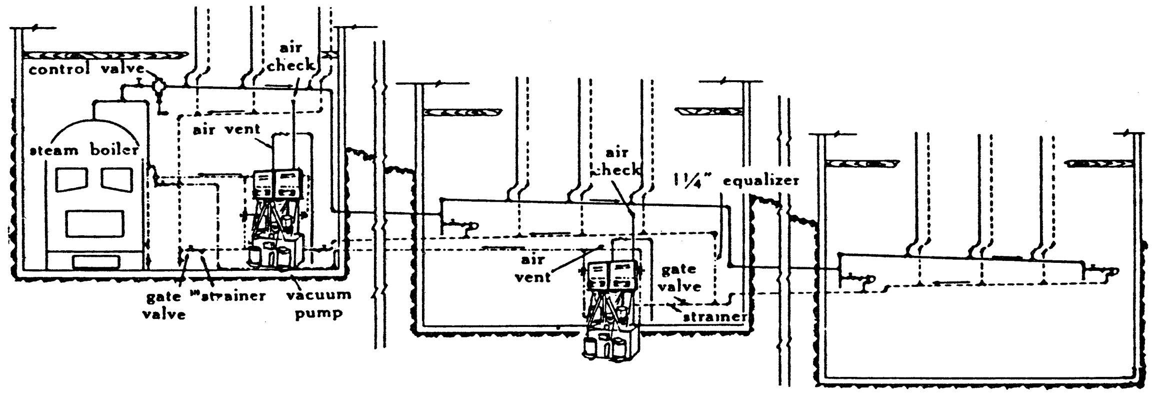


CONDENSATE PUMP BOOSTER ARRANGEMENT

and it is desired to have the pump operate on float control when there is no steam flowing into the system, the following procedure may be followed:

(1) The auxiliary switch on the Control Valve can be wired to the pump panel so that the vacuum control is cut out when the control valve is closed, or

(2) A reverse acting temperature switch (often called an "aquastat") can be inserted into the steam main near the pump location and wired to the control panel of the vacuum pump. When the control valve closes, the drop in temperature in the steam main breaks the pump automatic control circuits and the pump will operate only on float control. When steam again flows into the system, the rise in steam main temperature "makes" these automatic control circuits and automatic control of the pump is restored.



NOTE: The disadvantage of this arrangement is that the pump does not start when the control valve starts to open. The pump will be idle until steam circulates through the main and comes in contact with the switch.

PIPE SIZING

The following pipe sizes are based on the same pressure drop for each length of run of steam piping between the low pressure boiler, pressure reducing or control valve and the remote end of the system and on the basis of an overall pressure drop of 1 lb. from the boiler or control valve to the end of the steam pipe run. An allowance has been made for heat losses from covered piping and the effect of pipe cutting and reaming. The pressure drop per unit of pipe length is thus varied systematically according to the length of the pipe line. This tends to make the pressure drop the same between the source of steam supply and the last convectors or radiators for each length of run.

A detailed procedure for determining the piping design of an ordinary two-pipe vacuum return line system is described below. This procedure should be followed in determining the piping design of a Vari-Vac system.

STEAM MAINS

Pipe Sizes (inches)	Capacities in Square Feet EDR										
	Equivalent Length* of Runs in Feet										
	100	200	300	400	500	600	800	1,000	1,500	2,000	3,000
2	1,130	800	650	570	500	450	400	350	300	250	200
2½	2,100	1,470	1,200	1,050	925	840	735	650	550	460	380
3	3,800	2,660	2,160	1,900	1,670	1,520	1,330	1,180	990	830	680
3½	5,500	3,850	3,140	2,750	2,420	2,200	1,920	1,700	1,430	1,210	990
4	7,750	5,400	4,400	3,900	3,400	3,100	2,700	2,400	2,000	1,700	1,400
5	13,800	9,650	7,800	6.900	6,100	5,500	4,800	4,300	3,600	3,040	2,480
6	22,200	15,500	12,600	11,000	9,800	8,900	7,800	6,900	5,700	4,900	4,000
8	46,000	32,000	26,200	23,000	20,200	18,400	16,100	14,200	12,000	10,100	8,300
10	80,700	56,500	46,000	40,300	35,500	32,200	28,200	25,000	21,000	17,700	14,500
12	127,000	89,000	72,500	63,500	56,000	51,000	44,500	39,400	33,000	28,000	23,000
14	164,000	115,000	93,500	82,000	72,000	65,600	57,400	51,000	42,600	36,100	29,500
16	234,000	164,000	133,400	117,000	103,000	93,600	82,000	72,600	61,000	51,500	42,100

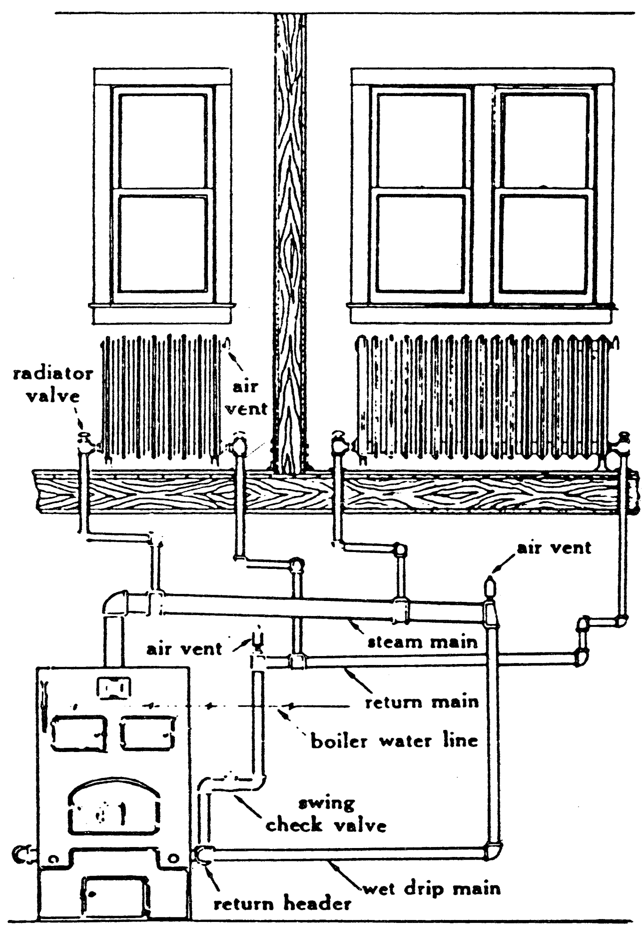
**The equivalent length is the distance along piping from the boiler or control valve to the farthest radiator plus allowances for elbows and valves, plus 25 feet allowance for last radiator connection. Do not reduce any steam main below 2 inches in size at its end.*

TWO-PIPE GRAVITY SYSTEM

In an effort to overcome the difficulty of steam and water flowing against one another in the same pipe, the two-pipe system was developed. This system can be used in buildings of moderate size where radiation can be installed at least 24" above the boiler water line.

Except for eliminating the counterflow of steam and water in the supply piping, disadvantages of the one-pipe system are all present. Other disadvantages include: **(1) A valve must be installed** at each end of a radiator in order to shut off the steam; otherwise steam may be present in both supply and return piping. **(2) The return from each radiator must be connected** separately into a wet return or otherwise water sealed (which is costly and often impractical). **(3) The mid-portion of the radiator is** apt to become air bound (if the radiator return is not water sealed). This occurs particularly during the "heat-up" period, when steam fills the radiators nearest the boiler and flows through them into the return piping and then into the outlet connection of more distant radiators.

Two-pipe, two-valve gravity steam system piping connections. Steam flows through the supply main to radiators and returns to the boiler through a separate return main.



RETURN MAINS

Pipe Sizes (inches)		1	1¼	1½	2	2½	3	3½	4	5	6
Capacity in Square Feet per equivalent length* of Run in Feet	400 ft.	800	1,600	4,000	11,000	21,000	38,000	55,000	78,000	138,000	220,000
	1,000 ft.	500	1,000	2,500	7,000	13,000	23,500	34,000	48,000	86,000	138,000
	2,000 ft.	350	800	1,800	5,000	9,000	16,000	24,000	34,000	60,000	98,000
	3,000 ft.	300	600	1,500	4,000	7,500	13,500	20,000	28,000	50,000	80,000

**The equivalent length is the distance along piping from the pump to the farthest radiator plus allowances for elbows and valves.*

VERTICAL RISERS

Pipe Sizes (inches)		Steam Risers									Return Risers		
		¾	1	1¼	1½	2	2½	3	3½	4	¾	1	1¼
Capacity in Square Feet per equivalent length* of Run in Feet	200 ft.	66	133	290	450	920	1,510	2,660	3,850	5,400	1,000	2,000	4,500
	400 ft.	47	95	210	325	655	1,080	1,900	2,750	3,900	800	1,600	3,400
	600 ft.	38	76	166	260	525	865	1,520	2,200	3,100	640	1,200	2,500
	1,000 ft.	29	59	129	200	410	670	1,180	1,700	2,400	500	1,000	2,100
	2,000 ft.	20	42	92	143	290	475	830	1,210	1,700	350	700	1,500

**Determine the equivalent length of run for each riser exactly the same as for steam mains, that is from the boiler or control valve to the farthest radiator supplied by the riser.*

CONVECTOR OR RADIATOR CONNECTIONS

Square Feet EDR	Supply			Return		
	Size Inlet Valve (inches)	Vertical Pipe to Inlet Valve (inches)	Horizontal Runout to Riser or Springpiece to Main from a First Floor Radiator (inches)	Trap Size (inches)	Stub to Trap and Size of Trap (inches)	Horizontal Runout to Riser or First Floor Radiator (inches)
1- 25	½	½	¾	½	½	¾
26- 80	¾	¾	1	½	½	¾
81-100	¾	¾	1¼	½	½	¾
101-140	¾	¾	1¼	½	½	¾
141-170	¾	¾	1½	½	½	¾

ALLOWANCE FOR FITTINGS

PIPE SIZE	LENGTH IN FEET TO BE ADDED TO ACTUAL LENGTH OF RUN TO OBTAIN EQUIVALENT LENGTH					PIPE SIZE	LENGTH IN FEET TO BE ADDED TO ACTUAL LENGTH OF RUN TO OBTAIN EQUIVALENT LENGTH				
	Standard Elbow	Side Outlet Tee	Gate Valve*	Globe Valve*	Angle Valve*		Standard Elbow	Side Outlet Tee	Gate Valve*	Globe Valve*	Angle Valve*
½"	1.3	3	0.3	14	7	3½"	8	15	1.6	80	40
¾"	1.8	4	0.4	18	10	4"	9	18	1.9	92	45
1"	2.2	5	0.5	23	12	5"	11	22	2.2	112	56
1¼"	3.0	6	0.6	29	15	6"	13	27	2.8	136	67
1½"	3.5	7	0.8	34	18	8"	17	35	3.7	180	92
2"	4.3	8	1.0	46	22	10"	21	45	4.6	230	112
2½"	5.0	11	1.1	54	27	12"	27	53	5.5	270	132
3"	6.5	13	1.4	66	34	14"	30	63	6.4	310	152

**Valve in full open position.*

APPLICATIONS

VARI-VAC IN SCHOOLS

This section will deal only with Vari-Vac Control as applied to systems using Unit Ventilators.
When applying Vari-Vac control to heating systems in schools, there are the following main considerations:

- introduction of outside air for ventilation.
- varying occupancy and "Heat Gain" in rooms.
- occasional need for large quantities of outside air during mild weather.
- prevention of drafts.

VENTILATION

The quantity of outside air required for ventilation varies according to building codes, state laws, city ordinances or local customs. Generally, the quantity must be from 10 to 30 cubic feet per minute per pupil. This fresh air may be introduced in several ways:

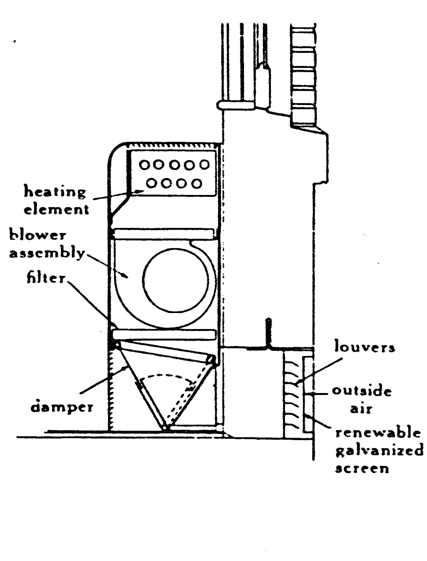
(1) By a unit ventilator in each classroom. This unit consists of a cabinet containing a heating element, a fan, dampers, filter and an outside duct connection through the wall.

(2) By a central fan system discharging heated fresh air through ducts to classrooms.

(3) By exhausting room air through roof fans with ducts connected to classrooms, allowing fresh air to enter open windows and by infiltration.

UNIT VENTILATORS

The first method, the use of unit ventilators, is the most common in northern latitudes. A typical unit of this type is shown below.



The unit ventilators should be selected for a final temperature at design basis such that with the required amount of outside air, air will not be delivered to the roorns at temperatures less than 70 degrees. Best results are obtained when the unit ventilator is sized to provide only the heat required by the air to satisfy the above requirements; the part of the heat loss not supplied by the unit ventilator "surplus heat" being supplied by baseboard, Fin-vector or Thermo Vector radiation.

Vari-Vac Control can be applied in any of the following ways. The arrangements are given in the order of preference based on performance as to comfort and operating economy.

(1) Design the system into two or more zones for exposure and hours of occupancy. Select COMBINATION control for each zone and install one or two resistance thermometers in each zone. Install these thermometers in rooms which do not have unit ventilators, such as offices or libraries. Install in each classroom one unit ventilator equipped with the following type automatic damper control:

A proportioning thermostat with spring return proportioning type damper operator. The amount of outside air supplied is varied according to room temperature. When temperature is above the desired point, an increased amount of outside air is admitted. If the room temperature is lower, less outside air is admitted. If the building codes do not require year round ventilation, during extreme cold weather room air may be re-circulated 100%

(2) Design the system with the required number of zones and select CUSTOMARY control. In each classroom install one unit ventilator equipped with automatic damper control as described above.

(3) For the small schools or where initial cost is the predominant factor, select CUSTOMARY control and zone if required. Install one unit ventilator in each classroom and omit automatic damper control - provide a manual fresh air damper control for teachers to operate.

Individual unit ventilator control may be electric or pneumatic, the deciding factor in the choice being the comparative cost of installation and maintenance for the particular installation. Even if a complete electric or pneumatic control system has already been installed, super-imposing Vari-Vac control will offer many benefits. **All radiation and also the heat output of the steam piping will be controlled.** With any system except the continuous flow variable vacuum type, the piping is giving off much unwanted, uncontrolled heat.

Maintenance required on the electric or pneumatic control equipment will be greatly lessened since Vari-Vac alone will perform about 75% of the control requirement, leaving only 25% to the other control equipment.

CLASSROOMS

The school building code, the state law or the city ordinance may require a specific volume of fresh air for ventilation at all times regardless of the outside weather. Therefore, during school hours the unit ventilator damper must not close beyond the position which will violate this regulation. But in order to shorten the heating up period in the morning before school opens, it is necessary to keep the damper closed. Consequently, it is recommended to install a proportioning thermostat with spring return proportioning type damper operation. The spring return closes the damper whenever the power is turned off, as in the evening after school hours. By so doing, no outside air enters the building during the night. As the room temperature rises after the morning heat-up period, the damper is opened to admit outside air, thereby supplying required ventilation during school hours.

NOTE: It is not necessary for the unit ventilator fresh air damper to be opened at any time beyond the position which will supply the code-specified minimum ventilation. Opening the damper beyond this point means heating additional outside air which wastes fuel.

The danger of freezing unit ventilators on a properly installed and operated Vari-Vac system is no greater than on any other type of controlled system even during extremely cold weather. The reason is with that Vari-Vac control, steam is continuously flowing through the element, the steam temperature being increased automatically as the outside temperature drops.

Underheating will not occur with Vari-Vac due to the steam supply being regulated automatically as outside weather changes. However, the following provisions should be made when designing and installing the system to assure proper results:

(1) Properly size the unit ventilators according to ventilation requirements only. Do not oversize to increase "surplus heat". Use supplementary radiation to make up heating capacity needed to balance heat loss.

(2) Make sure the system is installed so that the piping is tight.

(3) Install an air stream temperature control switch in the unit ventilator located farthest from the Vari-Vac control valve. Install the switch in the discharge air stream at the return end of the heating element. When the temperature of the outlet air from this unit ventilator drops to the temperature setting of the switch (setting should be 55-60 degrees F.), the control switch causes the Vari-Vac control valve to open.

(4) When regulating steam flow to unit ventilators (with regulating valves, fittings or plates), **do not restrict steam flow** in same proportion as with supplementary radiation and radiation in unventilated rooms. consult Mepco Pump Packages for proper regulating plate schedule.

(5) Do not install room resistance thermometer(s) or thermostat(s) controlling the system steam supply in rooms in which unit ventilators are installed.

OFFICES AND RESTROOMS

Unit ventilators are not usually used for heating school offices and restrooms. Therefore, Vari-Vac control is applied to this part of the heating system in the same manner as it is applied to a commercial or institutional type building. The room resistance thermometer or thermostat of the Vari-Vac control system should be located in this portion of the school building - not in rooms with unit ventilators.

VARI-VAC IN AUDITORIUMS

GYMNASIUMS AND AUDITORIUMS

A gymnasium or an auditorium is usually heated and ventilated by use of a combination blower unit heaters and radiation. A blower unit operates on the same principle as unit ventilators, only they have much higher heating and ventilating capacities.

Varying occupancy of this part of the school requires that this part of the heating system be designed in one of two ways:

(1) The gymnasium or auditorium on a **separate controlled zone** so that the special requirements can be met without affecting the heating and ventilating of the rest of the school.

(2) The gym or auditorium on a **separate steam supply and return line** so that the steam to it can be shut off when necessary. Install a shutoff valve in the lines so neither the rest of the heating system nor this portion need be heated when not in use.

Blower unit heaters used for heating a gymnasium or auditorium, but not piped as a zone of Vari-Vac control should contain "face and by-pass" dampers operated from thermostats located in the same area. Supplementary radiation should be controlled by the Vari-Vac control equipment rather than by additional room thermostats.

Vari-Vac may be applied to buildings with central air conditioning systems. Usually these systems admit heated air for ventilation only from ducts located on inside walls or plenum spaces. For economy, the air is heated only sufficiently to avoid chilling drafts and radiation for space heating is installed along outside walls and under windows to assure comfort conditions. This radiation is controlled by Vari-Vac as in any commercial building but one precaution must be taken: Locate the room resistance thermometer in a typical room; that is, one ventilated by the central air conditioning system and heated by supplementary radiation.

NOTE: The thermometer or thermostat must be located away from drafts and from the inlet air stream of the air conditioning system.

With only the space heating radiation controlled by Vari-Vac, the control can be applied in two ways: (1) to heat the building to a given temperature slightly less than the desired room temperature, the central air conditioning system supplying the balance of the heat; (2) to supply all of the heat by radiation, the air conditioning performing the job of ventilating only.

With both the space heating radiation and the central air conditioning system controlled by Vari-Vac, the COMBINATION JOB is recommended and can be applied to the central heating and ventilating system in two ways: (1) One resistance thermometer installed in a central duct before branches are taken off. Another resistance thermometer located in a discharge duct to act as a low limit control. (2) A room resistance thermometer located in the heated space (not in an outlet air stream). Another resistance thermometer located in a discharge duct to act as a low limit control.

NOTE: Radiation controlled by Vari-Vac must not be on the same zone as that supplying the central air conditioning system.

VARI-VAC with HOT WATER HEATING

Vari-Vac promotes operating ease, application flexibility, effectiveness and economy where both heating and cooling is required and especially where a variety of services are to be provided and individual needs satisfied by a plant requiring minimum space. A single boiler plant may supply not only the heated water for the winter heating cycle but also the domestic hot water and variable vacuum heating zones. Steam from the boiler may also serve absorption refrigeration units.

VARI-VAC WITH AIR CONDITIONING

Through the Vari-Vac controls, the operating staff may always set the condition sensing resistance thermometers or monitor the system conditions at the Control Panel. The staff may thus know general conditions without leaving the boiler room. The staff may also alter the values to be held by the controls at the panel.

In many buildings the size and nature of its occupancy is such that it is difficult to find a representative thermostat location in it or one of its zones. The controls utilize a heat loss index for responding to the building heating requirements in various weathers. This index is a resultant of building conditions and weather conditions - (Inside/outside temperature difference, wind velocity, wind direction, precipitation and solar radiation) and is evaluated by the "Selector".

VARI-VAC WITH HOT WATER SYSTEMS

An excellent application of Vari-Vac control is in buildings where hot water is used as the heating medium and steam is used to heat the hot water. A low pressure steam boiler can be used for generating steam; the steam supply line is connected to a heat exchanger through which the water passes. In tall buildings, heat exchangers can be located at various levels and steam easily piped to them. This avoids high static heads in lower parts of the hot water system.

HOT WATER HEATING SYSTEM WITH STEAM PIPED TO HEAT EXCHANGERS Steam from the boiler passes through the control valve to the steam space of the heat exchanger. Condensate flows from the exchanger through float and thermostatic trap(s) and back to the vacuum pump. Radiation may be baseboard, convector, Fin-vector or radiant panel type. Domestic hot water can be heated in the storage heater in the same manner, a condensation pump used to discharge condensate to the boiler.

The heat balancer is connected between the hot water supply and return piping. A manual air vent must be provided for the heat balancer. Instead of installing a regulating fitting at the outlet of the heat balancer, a needle valve should be used for balancing the hot water flow. The reason is that the regulating fitting cap cannot be removed under water pressure. COMBINATION CONTROL is recommended for this type of installation.

The differential controller, control valve, selector and room resistance thermometer are installed in the usual manner (for locations, see "Where To Install Control Equipment", pages 13 through 16).

The heat exchanger should be selected from the manufacturer's catalog. The size is based on steam at 2 lbs.* pressure and the number of gallons per minute of heated water required for the heating system. The heat exchanger should have at least a four pass coil designed for the expected water pressure.

The hot water circulating pump should pump through the exchanger and may operate continuously, being shut off by the auxiliary switch on the control valve when it closes. The circulating pump should be installed in the hot water return line (see illustration, page 24). The circulating pump is selected in the usual manner as for a hot water system. The water friction head, the heat exchanger, must be considered in selecting the pump.

*Higher as conditions may dictate.

VARI-VAC WITH UNIT HEATERS

Ordinarily, unit heaters are operated from room thermostats (Non-Customary) which start and stop the fan motors according to the heat required. Intermittent heating such as this is irritating to those subjected to it and is not economical because overheating usually occurs. With the steam flow controlled by Vari-Vac, the unit heater fans operate continuously up to the steam shut-of point, eliminating discomfort to occupants. Pipeline losses are reduced and in many cases this system will affect substantial fuel savings.

A room resistance thermometer serves as a high and low limit control.

HEATING ONLY

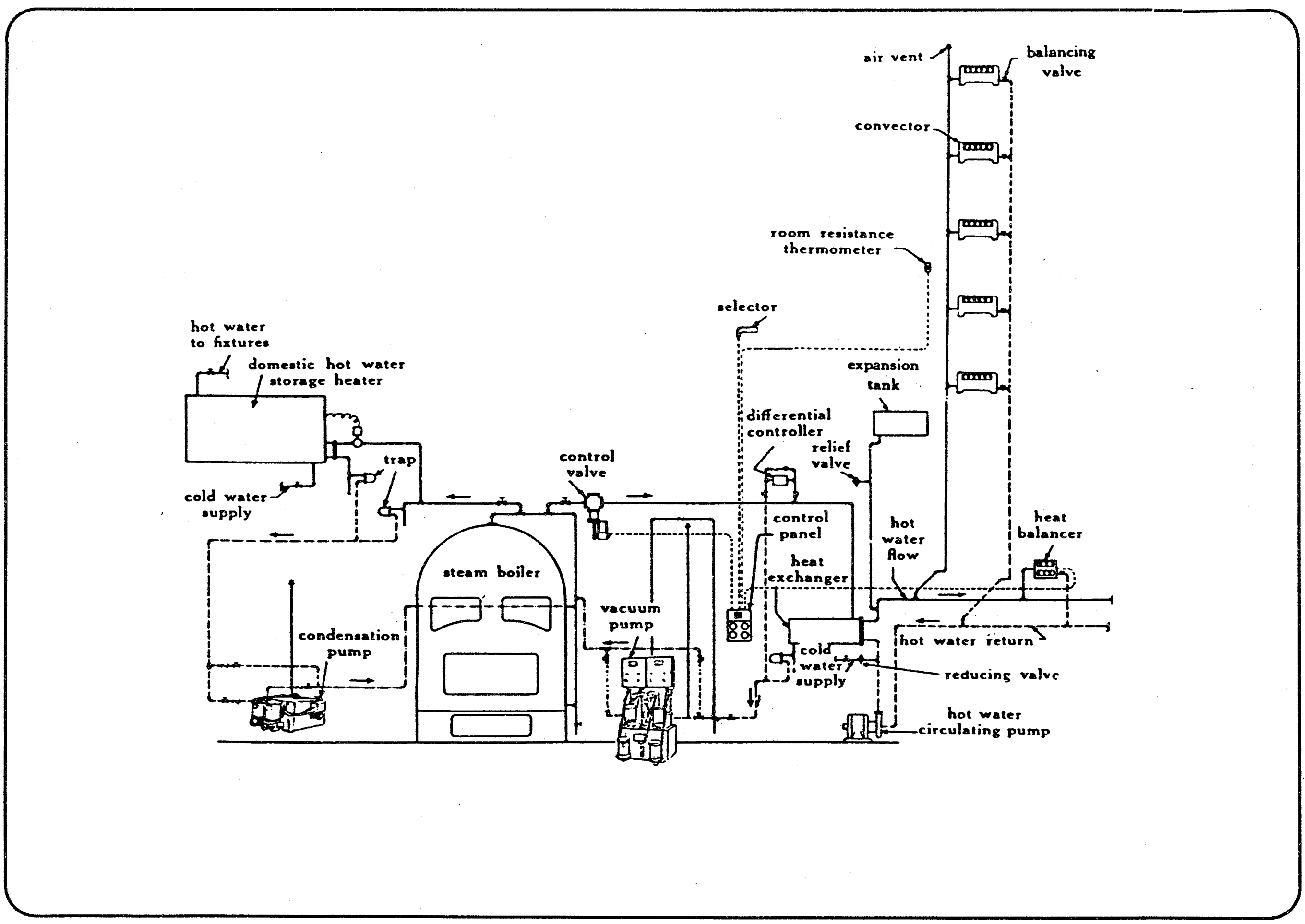
When ventilation is not required, either propeller fan or blower type unit heaters may be used for heating. *Vari-Vac Non-Customary* equipment controls the steam supply to the units. Steam flows to the system in accordance with the demand of the resistance thermometer(s).

The unit heater fans or blowers should be individually controlled by line voltage room thermostats which are set a little above the room resistance thermometer settings. For example, if the room resistance thermometers are set for a 68-70 degree temperature spread, the room thermostats would be set for say, 70-72 degrees. With this arrangement, the fans will operate continuously until shut off by the unit heater's low limit switch. As long as heat is required, steam will flow to the heating elements of the units because the steam pressure and temperature will be varied by the room resistance thermometer.

In heating weather it is necessary to prevent the discharge of cold air from the units. This is done by installing a low limit control in the piping between each unit heater and its float and thermostatic trap. When this piping cools, the circuit to the unit heater motor is broken and remains so until the temperature in the piping rises to the point where cold air would not be discharged.

When heating with blower unit heaters using by-pass dampers, the room thermostat operates the by-pass damper rather than the blower fan. Fans operate continuously with this arrangement.

NOTE: *When all unit heaters are located in one large area, it may be possible for several to be controlled by one room thermostat. However, if unit heaters are located in a separate room, individual room thermostats should be used.*



HEATING AND VENTILATING

When ventilation as well as heat is required, blower fan units rather than the propeller fan type are usually selected because of the larger air volume handled and the probability of a static pressure caused by duct systems. These units are offered in many assembly arrangements - with mixing dampers, by-pass dampers, filters, humidifiers, etc., as described in detail in the Blower Unit Heater Product Catalog.

When the steam supply is under Vari-Vac COMBINATION control, the fans usually operate continuously. The dampers may be operated by modulating spring return motors controlled by proportioning type room or duct thermostats. Mixing damper controls are arranged for full recirculation of room air for heating up.

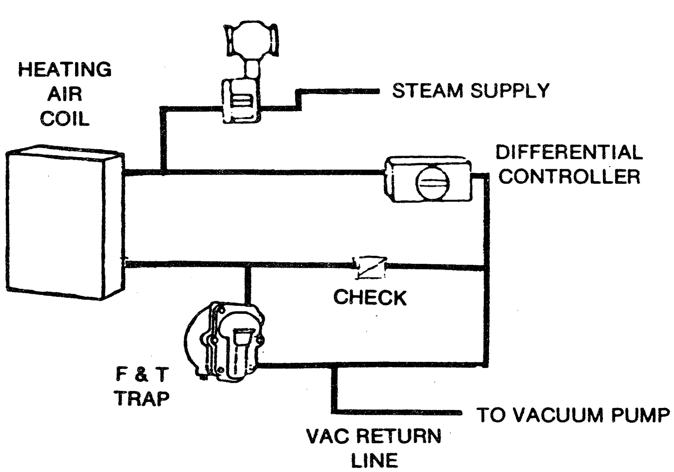
No steam control valve needs to be used (optional) because the variation of steam temperature through Vari-Vac control takes care of this and only a small part of the control cycle is left to the dampers.

NOTE: *See the Blower Unit Heater Application Manual for schematic drawings and description of Vari-Vac controlled Blower Units used for heating, heating and ventilating and ventilating only.*

VARI-VAC WITH AIR HANDLERS

AIR HANDLING UNITS

The recommended heating coil hook-up for air handling units is -



ADVANTAGES:

- Steam temperature (thus coil mean temperature) under full control down to 133 degrees Fahrenheit.
- Full face area of coil available for uniform heating of air (coil partial filling usually begins below 133 degrees F steam temperature, not before)
- No introduction of air (vacuum breaker) into heating system
- Extended trap life (up to 10 times)
- Coil freeze-up practically eliminated
- Water hammer practically eliminated
- Eliminates face and by-pass damper/controls
- Up to 30% fuel savings compared to atmospheric return system

SENSORS

The air stream sensors, before and after heating coil serve as heat balancer. Outdoor selectors, or return air duct sensors, serve as the demand sensor. Room resistance thermometers use is optional.

STEAM TO WATER CONVERTORS

- Similar advantages to air handler applications

VARI-VAC WITH ABSORPTION CHILLERS

GENERAL APPLICATION

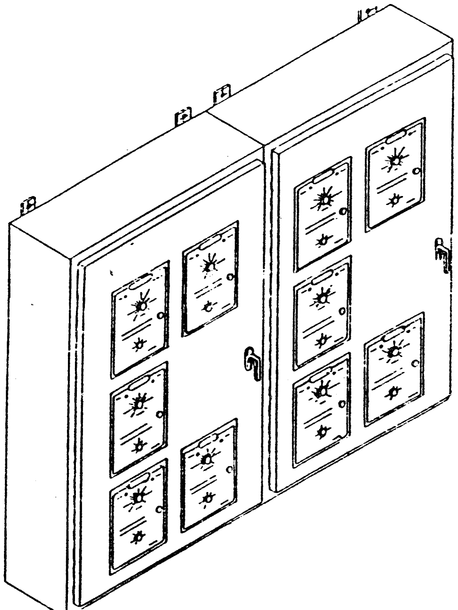
The Vari-Vac concept can be applied to any low pressure steam (comfort heating) system heat exchanger with variable load demands. This would include absorption chillers.

VARI-VAC WITH DEDICATED BOILER

DEDICATED BOILER

The steam boiler itself is a heat exchanger and can be operated under the variable vacuum concept. A 20% savings can be expected in fuel consumption. The boiler must be used for comfort heating only, because steam is actually generated at pressures down to 20"

Hg vacuum. Consult factory for further information.



CENTRAL STATION CONTROL
PANEL MOUNTING

This figure depicts optional control panel mounting for large job applications which may require many zones of control located at a central location. Consult factory for more details.