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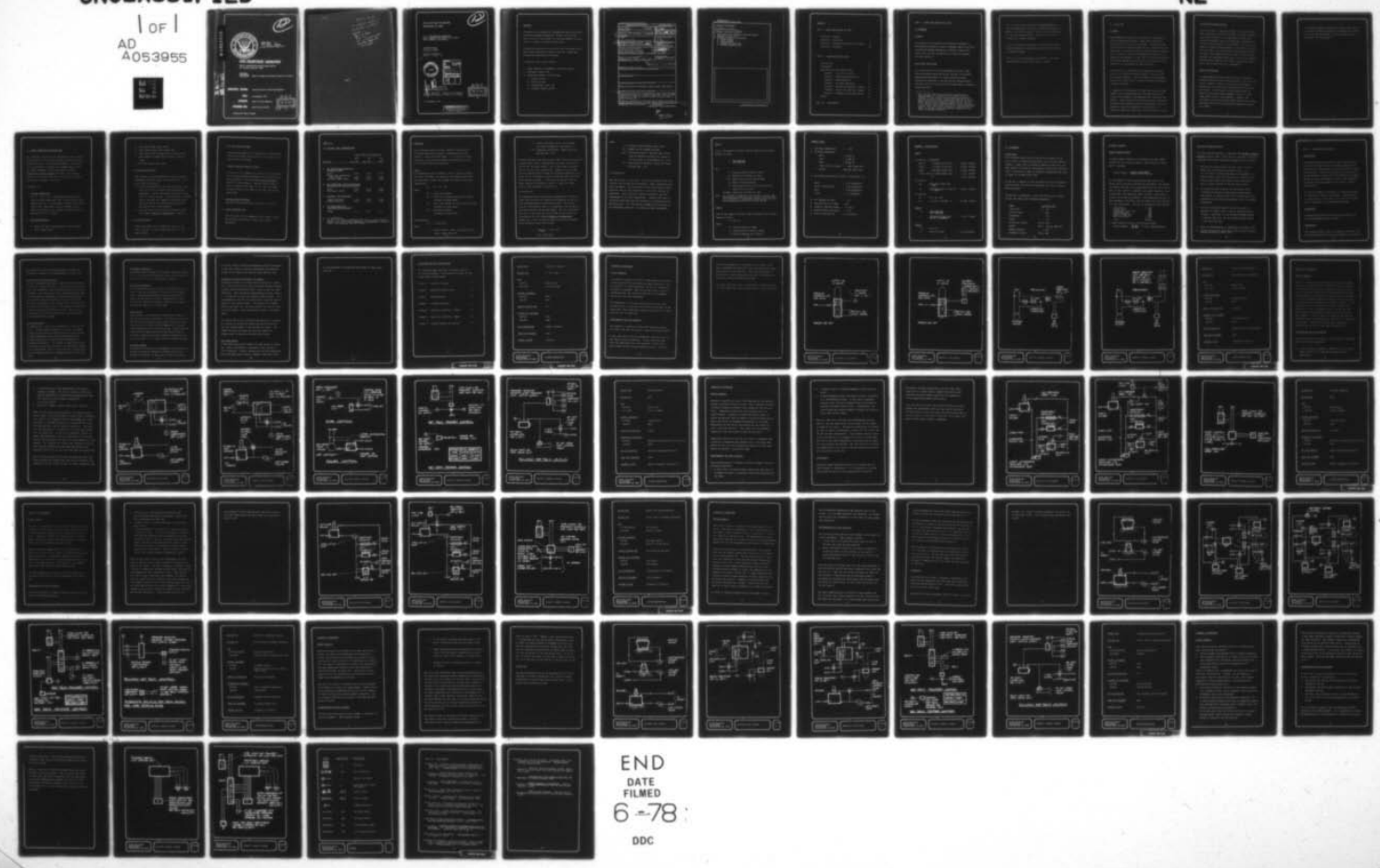

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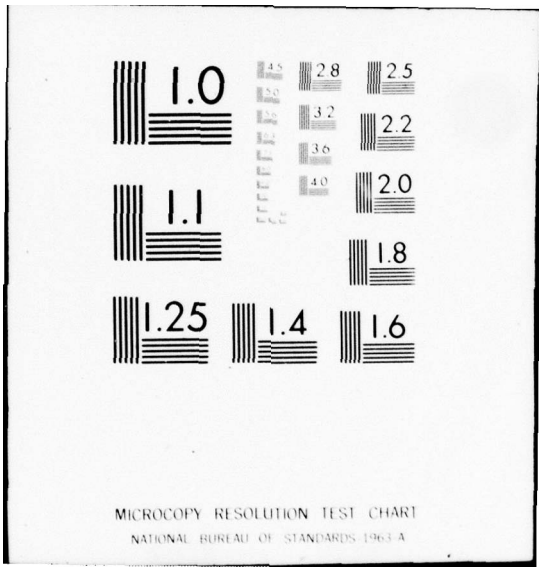
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CIVIL ENGINEERING LABORATORY

NAVAL CONSTRUCTION BATTALION CENTER
Port Hueneme, California 93043

TITLE: Guide for Night and Weekend Temperature Setback

CORPORATE AUTHOR: Joseph Paoluccio Consulting Engineers

DATE: 23 September 1977

SPONSOR: Chief of Naval Material

PROGRAM NOS. ZF57.571.001.01.003

DDC
RECEIVED
MAY 15 1978
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8/360-4252

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Proj. Eng.
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GUIDE FOR NIGHT AND WEEKEND TEMPERATURE SET BACK

CIVIL ENGINEERING LABORATORY
NAVAL CONSTRUCTION BATTALION CENTER
PORT HUENEME, CALIFORNIA

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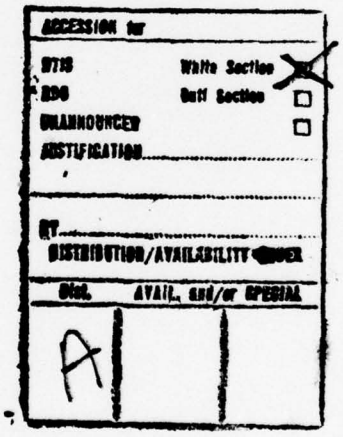

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ABSTRACT

Procedures are presented for implementing Naval Facilities Engineering Command Message No. 022124Z of March 1977, which calls for installation of night and weekend set back devices in order to conserve natural gas.

Engineering guidelines are set forth for the design of set back control systems for seven of the most common Navy heating and heating/cooling systems.

In addition, this guide includes:

1. Steps required to implement a set back project;
2. Mistakes to avoid; and
3. Simplified methods of calculating
    a. Energy savings,
    b. Dollar savings,
    c. Installation costs, and
    d. Economic payback period.

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: PO No. 77MR639	2. GOVT ACCESSION NO.: DN687063
3. RECIPIENT'S CATALOG NUMBER: (9) rept.	
4. TITLE (and Subtitle): (6) Guide for Night and Weekend Temperature Setback	5. TYPE OF REPORT & PERIOD COVERED: FINAL Jul[redacted]-Sep 77
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): (20) Joseph Paoluccio Consulting Engineers	8. CONTRACT OR GRANT NUMBER(s): (12) 91 p.
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Joseph Paoluccio ~~Consulting~~ Engineers New, 407 Via Del Norte, La Jolla, CA 92037 (17)	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: 62765N, ZF57.571.001.01.003
11. CONTROLLING OFFICE NAME AND ADDRESS: Civil Engineering Laboratory, NCBC, Port Hueneme, CA 93043 (11)	12. REPORT DATE: Sep[redacted]77
	13. NUMBER OF PAGES: 88
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office): Chief of Naval Material, Washington, DC 20360 (16) F57571	15. SECURITY CLASS. (of this report): Unclassified
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

(15) N62583-77-M-R639

Approved for Public Release

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

P.E. 62765N

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Energy conservation, thermostats, night setback, HVAC Controls

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

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20. Abstract (Continued)

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   a. Energy savings,
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CONTENTS

PART I: NIGHT AND WEEKEND SET BACK

Section A: Forward 1

Section B: Discussion 3

Section C: Energy Conservation Calculations 6

Section D: Economics 16

PART II: ENGINEERING GUIDELINES

Introduction 19

Precautions 19

Guidelines for the Seven Systems 25

System 1. Forced Air Furnace 27

System 2. Heating and Ventilating 35

System 3. Steam Radiation 43

System 4. Hot Water Radiation 51

System 5. Central Air Handling - Mixing 59

System 6. Central Air Handling - Reheat 69

System 7. Packaged Heating and Cooling 79

Legend 85

PART III: BIBLIOGRAPHY

PART I: NIGHT AND WEEKEND SET BACK

A. FOREWORD

Purpose

The purpose of this guide is to provide procedures to allow Naval personnel to easily implement Naval Facilities Engineering Command Message No. 022124Z of March 1977 which calls for the installation of night and weekend set back devices.*

How to Use This Guide

This guide explains night and weekend set back, shows how to estimate energy and dollar savings, and presents engineering guidelines for common heating systems. There exist thousands of unique heating system designs, but most will fall into one of the seven general categories identified here.

---

* This message, which resulted from a Secretary of Defense memo of 7 February 1977, states, in part: "Because of the current and projected reduced availability of natural gas, actions are required to bring about immediate and long-term reductions in its use... Prior to the 1978-79 heating season, install devices in all natural gas heated facilities involving personnel comfort only, which are occupied on a nominal 40-hour week, to set back night and weekend temperatures at least 12 degrees Farenheit."

Part I of this guide discusses the night/weekend set back rationale and lists steps to take and mistakes to avoid in a retrofit project. Part I also explains how to calculate energy savings, retrofit costs, dollar savings, and economic payback.

Part II will aid in the design of the set back system. Control diagrams are shown for each of the seven types of heating systems.

Part III is a bibliography of the studies, tests and case histories on which this guide is based.

B. DISCUSSION

Set Back

Night/weekend set back can be defined as a redundant controls system which provides a lower space temperature during periods of low or no occupancy. The scheme essentially turns the heating system off at a predetermined time and allows it to stay off until a certain time has elapsed. This is usually a daily time schedule with weekends on a separate time schedule. A low limit is usually established which, when reached, activates sufficient portions of the system to provide heating to some set point.

Many studies have documented that temperature set back results in significant energy savings in both mild and more severe climates. In mild climates, the percentage savings are larger while in colder climates the absolute savings are larger.

A temperature difference of 12F (68F minus 56F) has been shown to be an optimum amount of set back according to research by Honeywell, Oak Ridge National Laboratory and others. Unique variations may exist, but any proposed set back below 55F should be carefully evaluated in terms of problems concerning temperature and performance of machinery, materials, chemicals, and fluorescent lighting.

Survey of Existing Controls

The first step in a set back project is to identify the type of heating systems involved and to survey the existing control systems. It is important to survey each system to determine the exact performance characteristic of each control element. A wide range of controls, from manual to sophisticated pneumatic or electronic controls, will be found. The survey should include obtaining manufacturers' part numbers which can lead to exact wiring diagrams and adjustment capability. It will also identify those controls which fit the retrofit scheme and those which require modification or replacement.

General Precautions

A night/weekend set back project can be and should be separate from the existing control system. Every existing control system is unique in its design and operation. Systems that have been operating successfully should not be altered. In some cases it might appear better to modify an existing control component, such as a valve, rather than install a new component. However, the inclusion of existing controls within the set back control can often lead to serious unforseen problems and should be avoided.

To minimize problems for those not familiar with controls, a consultant should be retained to interpret this guide and to provide the specific set back controls design which best fits the project.

C. ENERGY CONSERVATION CALCULATIONS

The following calculations are designed to give a reasonable analysis of yearly energy savings provided by night/weekend set back. A more detailed method of calculation can be obtained by following the recommendations within the ASHRAE Handbooks and the Department of Defense Construction Criteria Manual 4270.1-M. The following sections list the necessary data, explain the procedures, and present an example calculation.

NECESSARY DATA

1. Set Back Temperature

   Use 12F. This value is obtained by subtracting the night set back temperature, 56F, from the normal space temperature, 68F. Systems which currently use a higher normal space temperature, such as Systems 5 and 6, should be revised to use a normal set point of 68F for heating and 78F for cooling.

2. Building Dimensions

   a. Total wall area, including doors, but excluding glass; square feet.

b. Total glass area; square feet.

c. Total roof/ceiling area; square feet.

d. Total floor area in square feet, or total floor edge length in lineal feet if floor is slab-on-grade.

e. Building volume; cubic feet.

3. Building Construction

The U-factors, or heat transmission factors, must be determined for walls, glass, roof, and floors. This can be done in two ways:

a. Review DOD 4270.1-M for the correct U-factor zone based on the local climate; the winter design temperature. Select the appropriate U-factor from Table C-1, which follows. These U-factors are mandatory by DOD 4207.1-M. However, they lead to conservative results for older existing buildings that may not meet these standards.

b. Calculate the actual U-factors according to the 1972 ASHRAE Handbook of Fundamentals, Chapter 20.

4. Air Infiltration

Select the number of air changes per hour; 0.5 for tight building, 1.0 for average building or 1.5 for open building.

5. Set Back Hours Per Week

Establish the number of set back hours per week during the heating season, usually 118, or 14 per week night plus 48 over the weekend.

6. Length of Heating Season in Weeks

The local utility company can provide this information, or it can be estimated from monthly heating degree day data published in the 1976 ASHRAE Systems Handbook, Chapter 43, and elsewhere. Heating season length in weeks is approximately equal to 4.3 times the number of months during which there are at least 150 heating degree days.

7. Heating Plant Efficiency

Determine the heating plant efficiency, or use 0.75.

8. Price of Natural Gas

From the local utility company or your records, obtain the price of natural gas in dollars per therm; 100,000 BTU.

TABLE C-1

"U" FACTORS, HEAT TRANSMISSION*

Exposure	Winter Design Temperature -40F to -10F	-9F to +10F	+11F +50F
a. All Facilities Heated to a Minimum of +68F			
Walls	0.07	0.10	0.15
Floors over Ventilated Crawl Spaces	0.05	0.07	0.10
Ceilings and/or Roofs	0.05	0.05	0.05
b. All Shop Areas for Installation, Maintenance & Similar Facilities			
Walls	0.10	0.10	0.20
Ceilings or Roofs	0.17	0.10	0.10
c. Glazing - All Buildings			
Single Thickness	1.13	1.13	1.13
Double Thickness	0.65	0.65	0.65
d. All Buildings With Concrete Slab on Grade**			
Factor	7.7	8.2	1.5

* U = BTU/HR/SF/F

** Factor is in terms of BTU/HR/Linear Feet of slab perimeter, based on the 1972 ASHRAE Handbook of Fundamentals, Chapter 21, Table 2 for Unheated Slab, R = 2.50.

PROCEDURE

The following section provides a method of determining the energy and dollars saved by night/weekend set back controls. There are three steps: (1) to find the BTU/HR heat loss, (2) to find the energy saved annually, and (3) to find the dollars saved annually.

Step 1

The standard heat loss formula is used to compute building heat loss in BTU/HR. As used here, the formula deals with the difference in heat loss between the normal and set back temperatures.

$$HL = HT + HI - HG$$

where

HL = Heat Loss; BTU/HR

HT = Heat Loss Through Transmission; BTU/HR
Evaluate as shown below.

HI = Heat Loss Through Air Infiltration; BTU/HR
Evaluate as shown below.

HG = Heat Gain; BTU/HR.
Evaluate as shown below.

To Evaluate HT:

$$HT = (A)\ (U)\ (TD)$$

where

A = Areas of Walls, Glass, Ceiling/Roof, and Floor; square feet (SF)

U = Factors for Walls, Glass, Ceiling/Roof, and Floor; BTU/HR/SF/F. See Table C-1.

TD = Temperature Difference: Normal 68F minus Set Back 56F = 12F

Multiply the area times the U-factor times TD for each building element--walls, glass, ceiling/roof, and floor--and sum the results for the total BTU/HR. This is the normal procedure used in all heat loss calculations. However, by using the set back temperature TD instead of the design temperature, we arrive at the difference in heating required rather than the total heating required. If the floor is concrete slab-on-grade, multiply the factor in Table C-1 times the linear feet of floor perimeter to get BTU/HR.

To evaluate HI:

The night/weekend set back design recommendations include a tight-fitting outside air damper which prevents outside air from being processed by the heating system. This leaves only air infiltration, which is a function of the building's airtight integrity and the wind speed. The air infiltration rate (Q) in cubic feet per minute (CFM) can be calculated according to the 1972 ASHRAE Handbook of Fundamentals, Chapter 19, or the infiltration heat loss can be estimated by the following simplified formula:

$$HI = \frac{(V)\ (AC)}{60}\ (1.08)\ (TD)$$

$$= (Q)\ (1.08)\ (TD)$$

where

V = Volume of the Building; cubic feet.

AC = Number of Air Changes per Hour

1.08 = Conversion Factor: Specific heat of air times 60 MIN/HR divided by the volume of air per pound, or (0.24)(60)/13.33 = 1.08

TD = Temperature Difference: Normal 68F minus Set Back 56F = 12F

To Evaluate HG:

Heat gain occurs in two ways: from solar radiation and from internal heat production from people, lights, appliances and other equipment. The difference in heat gain between normal operation and set back operation is very small and can be neglected. Solar radiation remains essentially constant, independent of set back temperature. Internal heat gain is virtually eliminated when the building is unoccupied during set back hours. For the purpose intended by this Guide, we can reasonably reduce HG = 0 without serious consequence.

Step 2

Find E, the amount of energy saved per season due to night/ weekend set back.

$$E = \frac{(HL)\ (WH)\ (W)}{(N)\ (100{,}000)}$$

where

E = Energy Saved per Season; Therms

HL = BTU/HR as calculated in Step 1

WH = Weekly Hours of Set Back/Hr/Week

W = Weeks of Heating Season

N = Rated Heating Plant Efficiency; decimal. Usually 0.70 to 0.80.

100,000 = Conversion from BTU to Therm

NOTE: This method is generally true for most climates, but may overestimate the set back savings in mild climates if the ambient air temperature often exceeds the set back temperature during the set back period.

Step 3

Find D; the number of dollars saved per season, due to night/ weekend set back.

$$D = (E)\ (F)$$

where

D = Dollars Saved per Season

E = Energy Saved per Season; Therms

F = Price of Natural Gas; $/Therm

EXAMPLE: Data

1. Set Back Temperature = 12F
2. Building Dimensions
   - Walls = 11,040 SF
   - Glass = 2,760 SF
   - Roof = 26,700 SF
   - Floor (slab on grade) = 690 Linear Feet
   - V Volume = 801,000 Cubic Feet
3. Building Construction U-Factors (From Table C-1):
   - Walls = 0.15 BTU/HR/SF/F
   - Glass (single pane) = 1.13 BTU/HR/SF/F
   - Roof = 0.05 BTU/HR/SF/F
   - Floor = 1.5 BTU/HR/LF
4. Air Changes Per Hour = 1.0
5. Set Back Hours Per Week = 118
6. Length of Heating Season = 21 weeks
7. Heating Plant Efficiency = 0.75
8. Price of Natural Gas = $ 0.25/Therm

EXAMPLE: Calculations

Step 1

To find HT = (A)(U)(TD):

Walls:	(11,040) (0.15) (12)	=	19,872	BTU/HR
Glass:	(2,760) (1.13) (12)	=	37,426	BTU/HR
Roof:	(26,700) (0.05) (12)	=	16,020	BTU/HR
Floor (slab on grade):	(690) (1.5)	=	1,035	BTU/HR
	HT	=	74,353	BTU/HR

To find HI:

$$HI = \frac{(V)\ (AC)}{60}\ (1.08)\ (TD)$$

$$HI = \frac{(801,000)(1.0)}{60}\ (1.08)(12) = 173,016 \text{ BTU/HR}$$

To find HL:

$$HL = HT + HI - HG$$

$$HL = 74,353 + 173,016 - 0 = 247,369 \text{ BTU/HR}$$

Step 2

$$E = \frac{(HL)\ (WH)\ (W)}{(N)\ (100,000)}$$

$$E = \frac{(247,369)\ (118)\ (21)}{(0.75)\ (100,000)} = 8,173 \text{ Therms}$$

Step 3

$$D = (E)\ (F)$$

$$D = (8,173)\ (0.25) = \$\ 2,043/\text{Season}$$

D. ECONOMICS

First Costs

The following values may be used for an estimate of the first costs, including installation, of a set back retrofit project. These costs are based on general conditions, and many factors can lead to a difference in the final installed cost. Each facility must be surveyed to determine the type or types of systems which exist.

System No. 1 employs an "off the shelf" set back thermostat which replaces the existing thermostat at a cost of about $100 installed.

Systems No. 2 through No. 7 are very similar with respect to cost and employ the following components:

Item	Installed Cost
Time Clock	$ 50
Control Valve	400
Thermostat	35
Relay	25
Wiring and Conduit	100 to 1000
Damper	500 + 20 per 1000 CFM
Damper Operator	250
Pneumatic Tubing	100 to 500

Economic Payback

Simple Payback Method

A simple payback analysis is sufficient for most night/weekend set back projects where a rapid return on investment is apparent.

$$\text{Simple Payback} = \frac{\text{Capital Investment}}{\text{Annual Dollar Savings}}$$

In the example in the Energy Calculations Section, an Annual Dollar Savings of $2,043 was estimated. The Capital Investment required can be determined from the "First Costs" part of this section. Assuming a hot water system is to be retrofitted, the components might include a time clock, a control valve and an economizer. By estimating the cost of the components separately, one can obtain the total retrofit cost for the project. The cost is determined to be $2,100:

Time Clock	$ 50
Control Valve	400
Thermostat - Low Limit	35
Damper Operator	250
Damper (7,000 CFM)	640
Wire and Conduit	725
Total	$2,100

A simple payback analysis can now be performed:

$$\text{Simple Payback} = \frac{\$2,100}{\$2,043} = 1.0 \text{ Year (Approximately)}$$

Discounted Payback Period

If a more detailed analysis is desired, the Economic Analysis Handbook, NavFac P-442, can be used to calculate a Savings/Investment Ratio and a Discounted Payback Period in Years:

1. Multiply the Annual Dollar Savings times 13.113 to obtain the discounted net present value. This 13.113 factor is taken from Table 8 of Appendix E, ** NavFac P-442, using a 8% differential inflation rate (natural gas prices over general price escalation) and a 15-year lifetime of the set back system.*

2. Divide Net Present Value by the estimated Capital Investment to obtain the SAvings/Investment Ratio. See Section II, NavFac P-442, for a discussion of the importance of the Savings/Investment RAtio in economic evaluations.

3. Find the Discounted Payback Period from Table C, Appendix D, NavFac P-442, using an economic life of 25 years. Note that if the Savings/Investment Ratio is greater than 10.0, the Discounted Payback Period is less than one year.

* Refer to NavFacEngCom Ltr 1023B/JNW of 23 August 1976.

** Energy Conservation Investment Program (ECIP) Guidance Memorandum dated 24 March 1977.

PART II: ENGINEERING GUIDELINES

INTRODUCTION

The guidelines shown are based on simplified and representative versions of seven of the most common natural gas heating or heating and cooling systems found in Naval installations. A verbal and informal survey with Naval Design personnel at Naval Facilities Engineering Command, Western Division, San Bruno, California, was conducted to determine the most commonly used systems in Naval installations.

The infinite number of variations in system design make it impossible to show all conditions. Trade practices in various parts of the country also affect the arrangement of components of a representative system.

PRECAUTIONS

Following are precautions which must be considered in the night/weekend set back retrofit.

Thermostats:

Each system retrofit shown is arranged to interface with an existing installation with the exception of System No. 1.

New thermostats and associated sub-control systems are required to accomplish the night/weekend set point; 56F.

Heating and Cooling Thermostats:

Improper thermostat adjustment can waste energy by turning on the space cooling in winter. This can occur in systems which have thermostats controlling both heating and cooling equipment. This error still occurs today when people lower their thermostats attempting to conserve heating energy; such was the reported situation last winter in the 65F White House adjustment. This problem can be avoided easily by having the cooling portion of the equipment automatically turned off during night/weekend set back. More detailed instructions are given in the technical sections dealing with heating/cooling systems.

Space Thermostats:

The temptation to adjust space thermostats is difficult to resist. Unauthorized adjustments will result in reduced savings and may defeat an otherwise sound set back design. Set back thermostats which must be located within the building should be of a type that defy adjustment by unauthorized personnel. For example, a remote bulb thermostat could be used, with the body of the thermostat located in an inconspicuous closet or attic, and the non-adjustable bulb with guard located in an appropriate place within the space.

Equipment Thermostats:

Thermostats may be located in the central return air ducts. This is the preferred arrangement because only authorized personnel have access to the equipment spaces.

Multiple Thermostats:

In buildings where several smaller air handling units are used, it may not be convenient to use return air thermostats. Space thermostats may be placed strategically within the building to initiate night/weekend set back. The controls should be arranged so that the first space to reach 56F starts the set back mode.

Steam System:

Steam systems involve potential problems with respect to the existing piping installation. The control valves used must be of the slow-opening and slow-closing type. Rapid valve action can result in water hammer due to residual steam condensate within the steam piping. Steam condensate traps should be added upstream of the control valve to eliminate conveying the steam condensate through the control valve when it is re-opened after a prolonged shutdown.

Hot Water System:

Examination of the physical arrangement of the piping must be made to determine exposure to freezing during long periods of shutdown. In some cases, it may be necessary

to install freeze protection thermostats within the piping. In the event freeze protection thermostats are required, locate to turn pump on and control valve open to flow.

Economizer Systems and Outdoor Air Damper:

Economizer systems which allow varying outdoor air quantities into the building during mild weather become an energy consumer during the heating mode if they do not shut down completely. When employing night/weekend set back control, it is necessary to close the outdoor damper tightly. It is recommended to retrofit the system with a new high quality damper of low leakage design. Pre-energy crisis damper designs have been less than satisfactory in terms of tight shut-off; however a more substantial product is available today.

All systems which use a fixed minimum outside air quantity as a source of ventilation should be retrofitted with a new low-leakage damper in the outside air intake. The damper should be arranged to close the outdoor air dampers upon initiation of the set back control.

Heat Pump System

A heat pump system would employ the same design as System No. 7 and is considered a variation of that system in this discussion. Studies conducted by Carrier Corporation have indicated some technical problems involving "icing"

of the evaporator at conditions with night set back lower than 55F.

GUIDELINES FOR THE SEVEN SYSTEMS

The following page identifies the symbols used in the control diagrams. The technical sections for each system begin on these pages:

System 1.	Forced Air Furnace	27
System 2.	Heating and Ventilating	35
System 3.	Steam Radiation	43
System 4.	Hot Water Radiation	51
System 5.	Central Air Handling - Mixing	59
System 6.	Central Air Handling - Reheat	69
System 7.	Packaged Heating and Cooling	79

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SYSTEM TYPE	Forced Air Furnace
OUTSIDE AIR	0 - 15% Fixed
FUEL	
HEATING	Natural Gas
AUXILIARY	Electric Blower
CENTRAL EQUIPMENT	
HEATING	None
COOLING	None
ENERGY DISTRIBUTION	Air
PRIMARY AIR TREATMENT	
HEATING	None
COOLING	None
AIR DISTRIBUTION	Blower, Ductwork
ZONE AIR TREATMENT	None
CONTROL SYSTEM	Electric

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SEQUENCE OF OPERATION

Normal Sequence:

The system functions as a result of the manually positioning of the system OFF-ON switch and the space thermostat. When the switch is in the OFF position, the unit is secured and no energy is expended. When the system switch is placed in the ON position, the cycling of the unit is an automatic function of the space thermostat.

The thermostat is a two-position device which when below set point turns on the unit and continues to add heat to the space until space temperature exceeds the set point, at which time the unit is turned off.

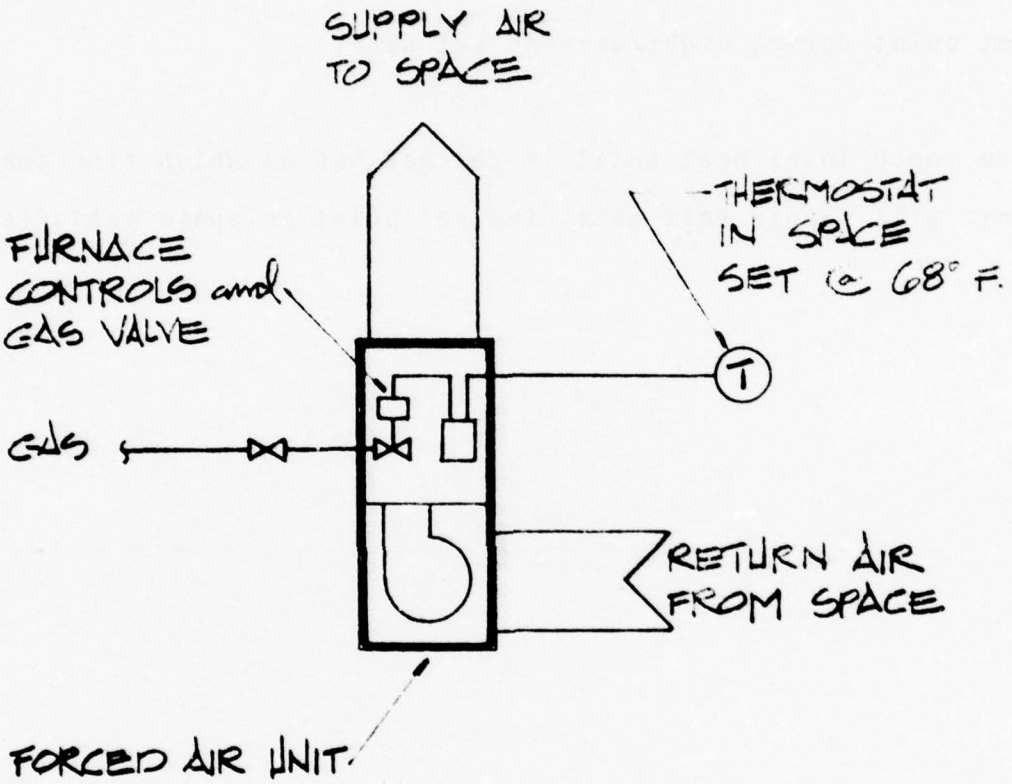
Night/Weekend Set Back Sequence

The sequence is identical to the normal operation during the time of day when the system is used for personal comfort.

A time clock device with two thermostats takes the place of the single existing thermostat. In most cases the time clock and thermostats are "off-the-shelf" controls which easily adapt to the existing thermostat wiring. The first

of the two thermostats is adjusted to a set point of 68F and it commands the operation of the unit during the regular working hours of the facility. The second thermostat is adjusted to a lower temperature, 56F, and this becomes the set point during night/weekend set back.

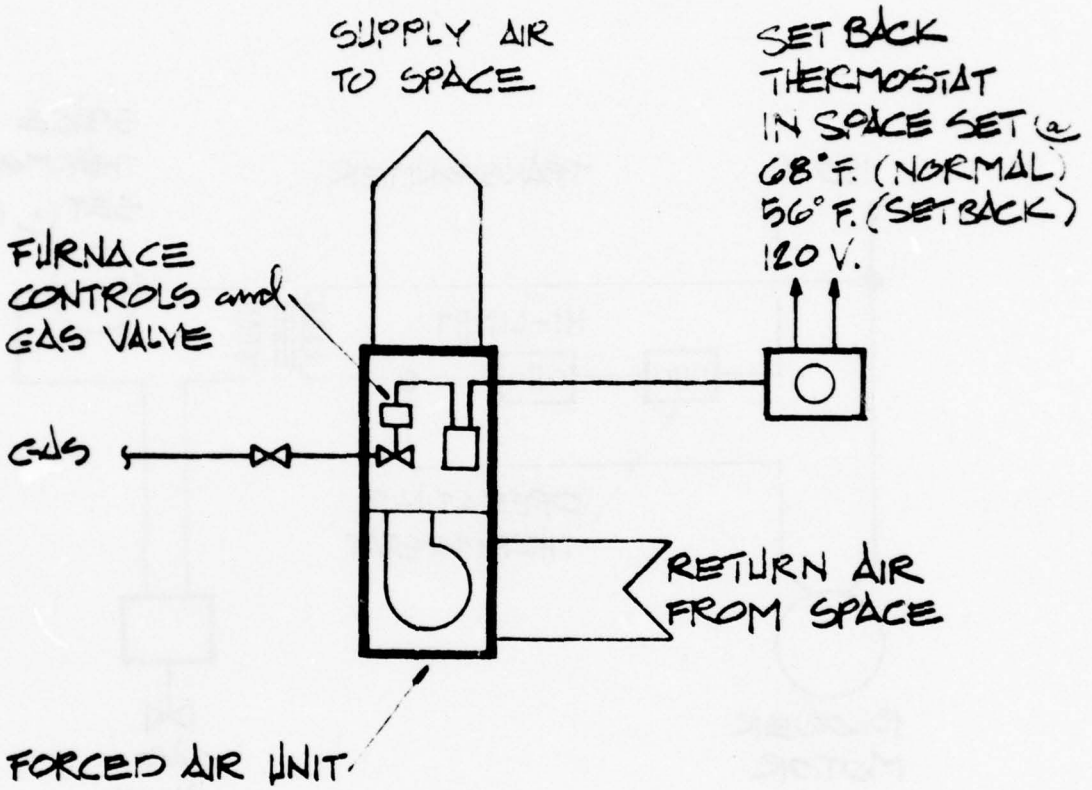
The space loses heat until it reaches 56F at which time the unit will supply heat until the set point is again satisfied.



GUIDE FOR NIGHT AND WEEKEND TEMPERATURE SET BACK

EXISTING FLOW DIAGRAM

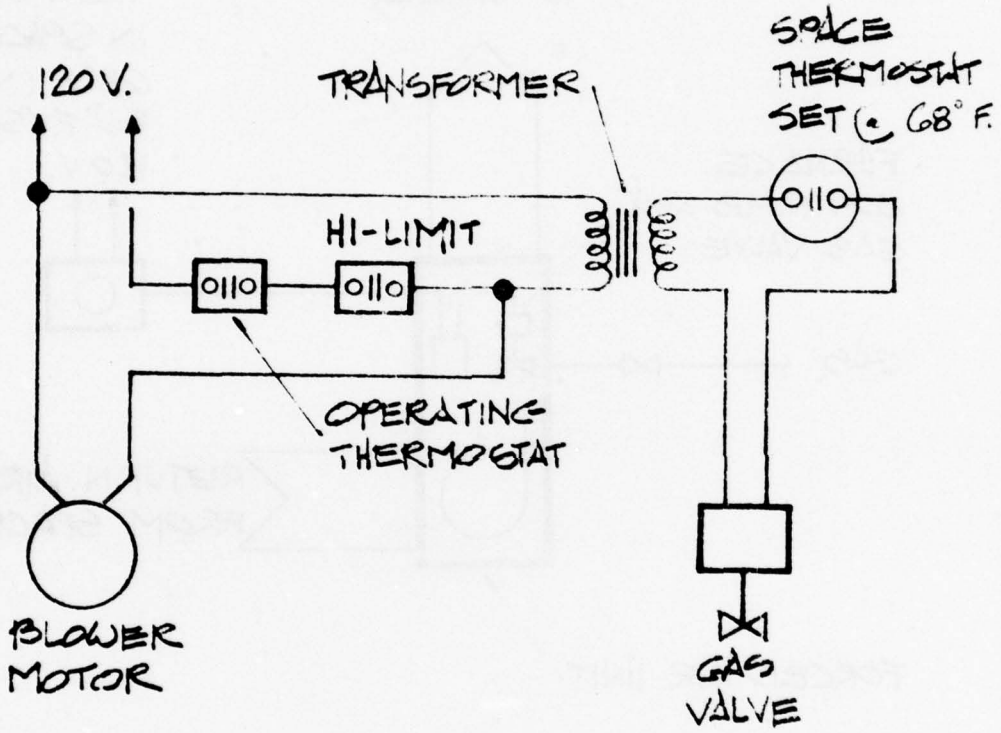
SYSTEM 1



GUIDE FOR NIGHT AND WEEKEND TEMPERATURE SET BACK

RETROFIT FLOW DIAGRAM

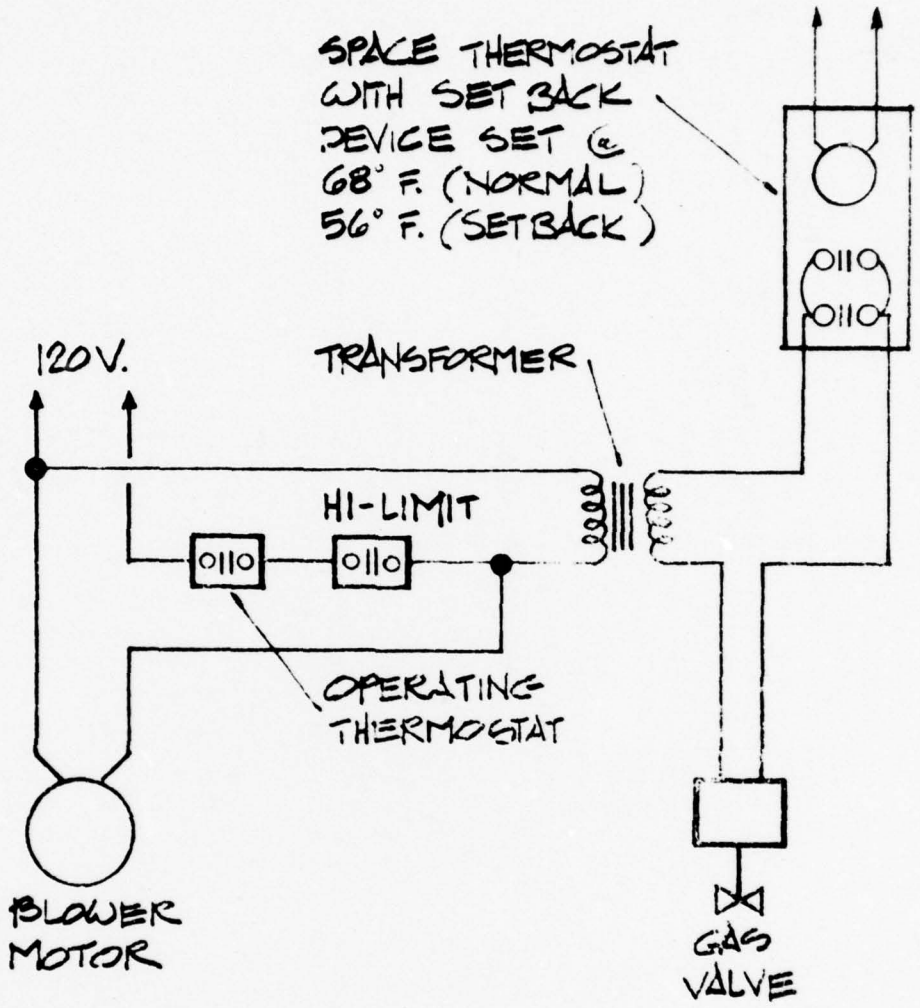
SYSTEM 1



GUIDE FOR NIGHT AND WEEKEND TEMPERATURE SET BACK

EXISTING CONTROL DIAGRAM

SYSTEM 1



GUIDE FOR NIGHT AND WEEKEND TEMPERATURE SET BACK

RETROFIT CONTROL DIAGRAM

SYSTEM 1

SYSTEM TYPE	Heating and Ventilating
OUTSIDE AIR	Fixed Minimum or Economizer
FUEL	
HEATING	Natural Gas
AUXILIARY	Electric Blower
CENTRAL EQUIPMENT	
HEATING	Hot Water Boiler
COOLING	None
ENERGY DISTRIBUTION	Hot Water
PRIMARY AIR TREATMENT	
HEATING	Air Handling Unit
COOLING	None
AIR DISTRIBUTION	Ductwork and Air Distribution
ZONE AIR TREATMENT	None
CONTROL SYSTEM	Pneumatic or Electric

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SEQUENCE OF OPERATION

Normal Sequence:

Heating is supplied by a gas-fired water boiler and pumped through insulated piping to air handling equipment located within the facility. In this particular system the boiler controls maintain a specified supply water temperature; the boiler produces supply water at a rate defined by the pumps to a point of maximum capacity; therefore, the boiler load is dictated by the peripheral air handling equipment. Local controls for the air handling unit usually consist of a pneumatic or electric thermostat with a set point of 68F that automatically positions a control valve to maintain that setpoint. Upon full demand for heating, the valve is positioned open to the heating coil and hot air is delivered to the space. The behavior of the valve, therefore, is based on the set point of the space thermostat, 68F.

Night/Weekend Set Back Sequence:

The existing system is allowed to function exactly as before with the following exceptions:

a. A new time clock introduces a secondary level of control whose function is to lower the building set point temperature.

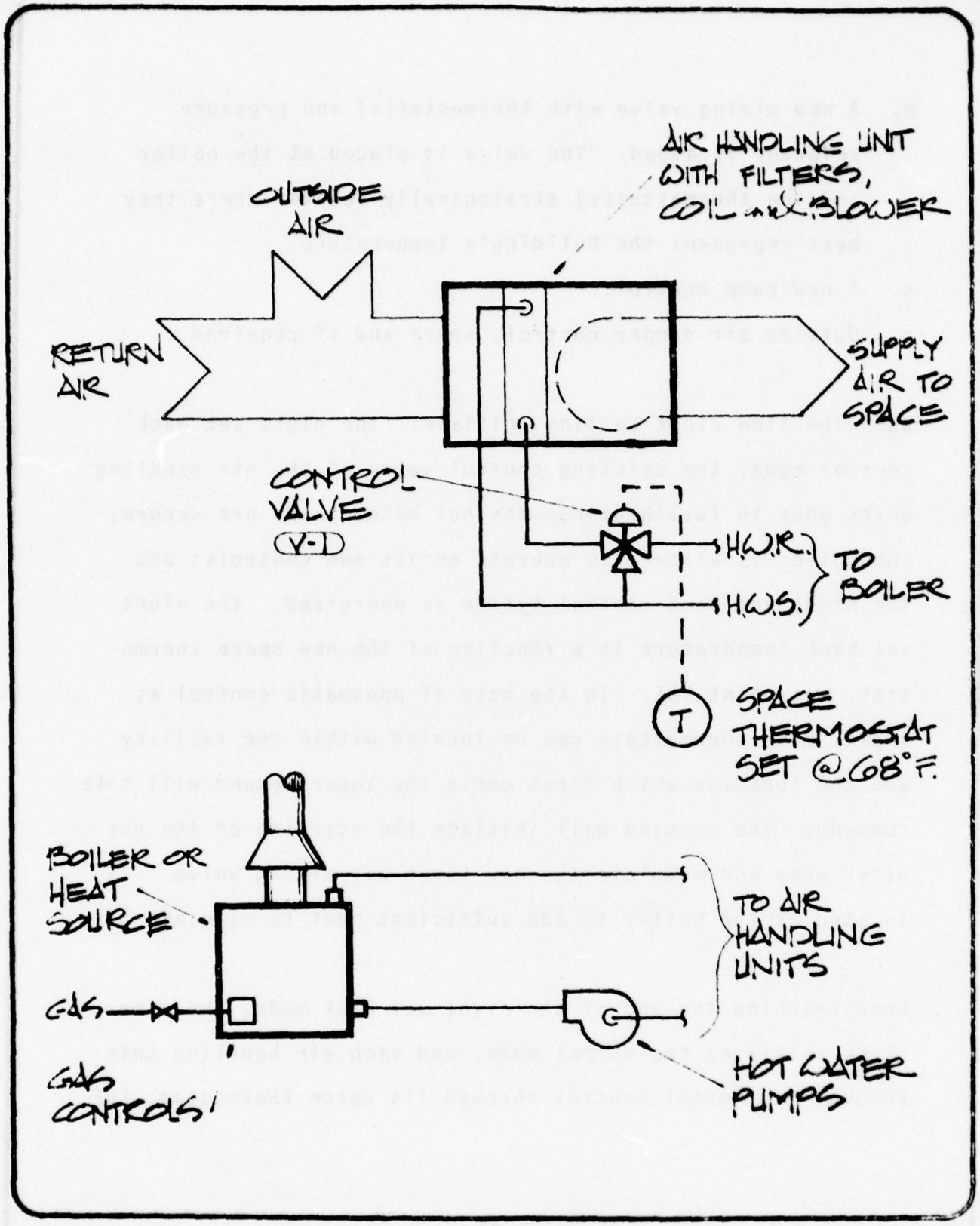
b. A new mixing valve with thermostat(s) and pressure selector is added. The valve is placed at the boiler and the thermostat(s) strategically located where they best represent the building's temperature.

c. A new pump control.

d. Outside air damper control, where and if required.

When the time clock setting initiates the night set back control mode, the existing control valve at the air handling units open to full heating; the hot water pumps are secure; the boiler is allowed to operate on its own controls; and the night set back control system is energized. The night set back temperature is a function of the new space thermostat, set point 56F. In the case of pneumatic control as shown, many thermostats can be located within the facility and the location which first meets the lower demand will take command. The command will initiate the starting of the hot water pump and modulate the new three-way mixing valve located at the boiler to add sufficient heat to maintain 56F.

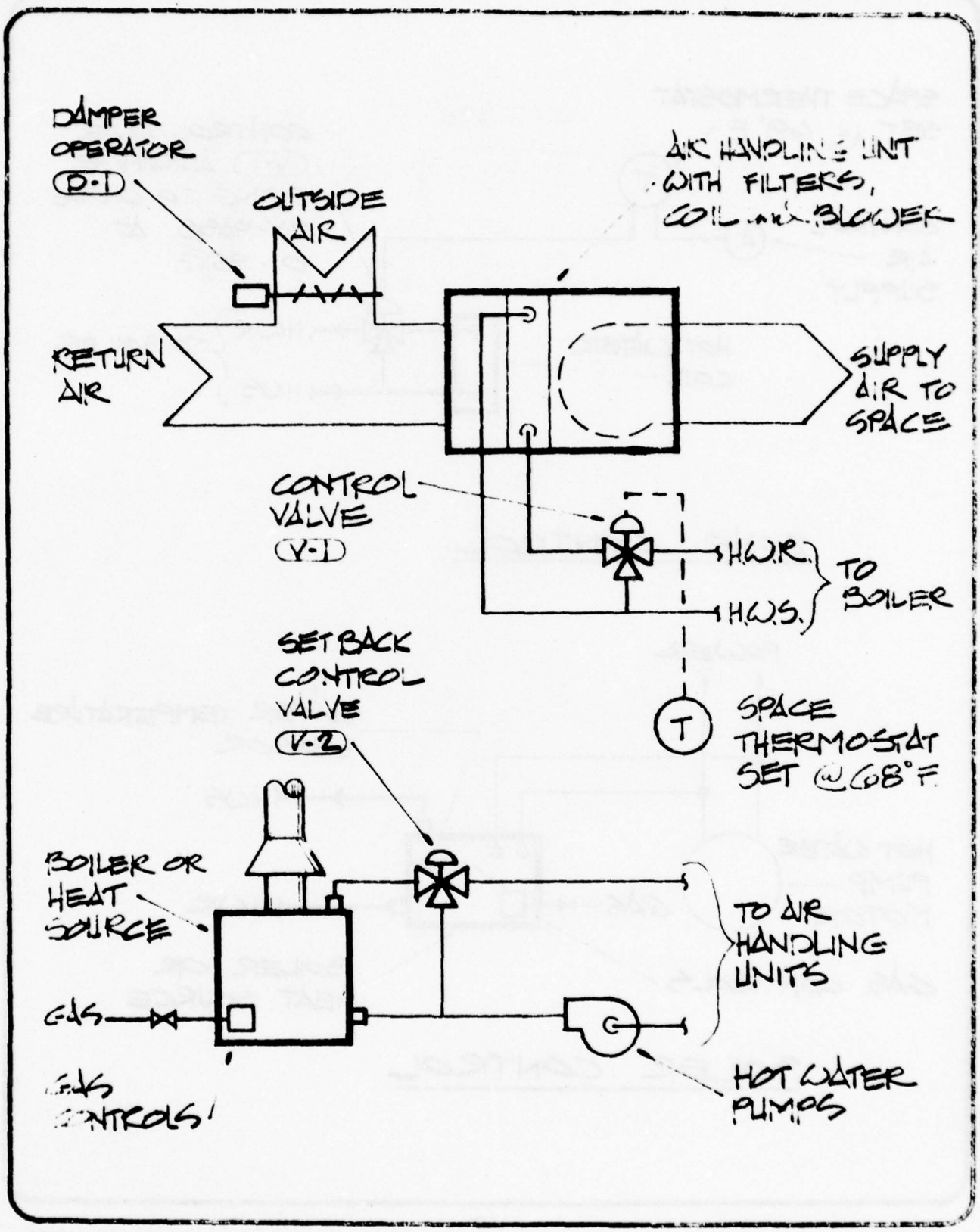
Upon reaching the end of the night set back mode, the time clock initiates the normal mode, and each air handling unit resumes its normal control through its space thermostat, 68F.



GUIDE FOR NIGHT AND WEEKEND TEMPERATURE SET BACK

EXISTING FLOW DIAGRAM

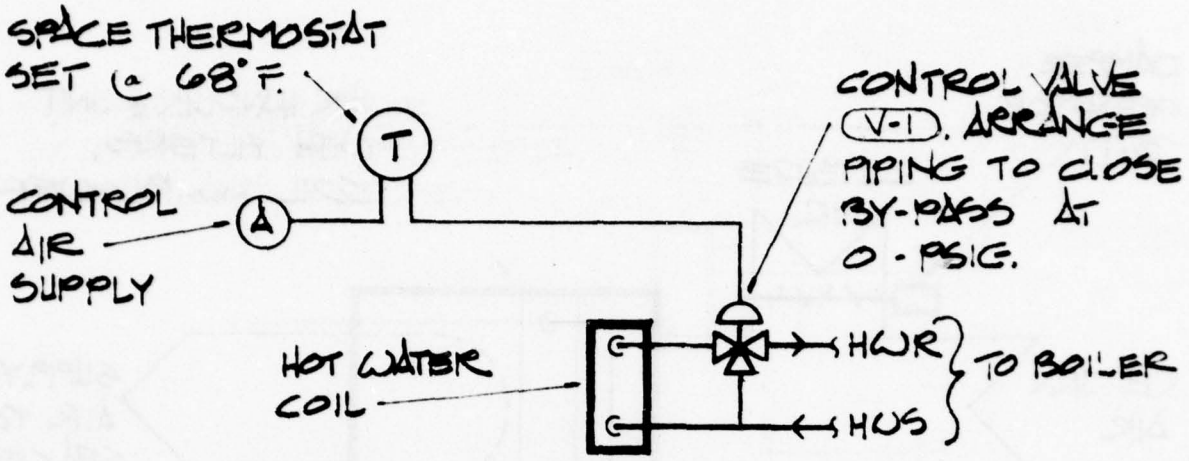
SYSTEM 2



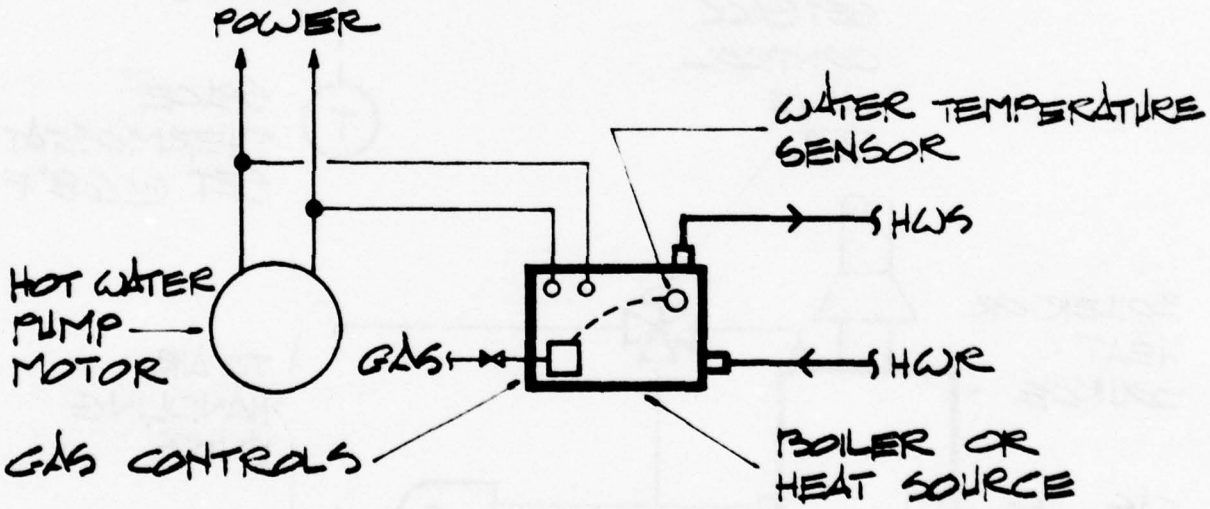
GUIDE FOR NIGHT AND WEEKEND TEMPERATURE SET BACK

RETROFIT FLOW DIAGRAM

SYSTEM 2



ZONE CONTROL

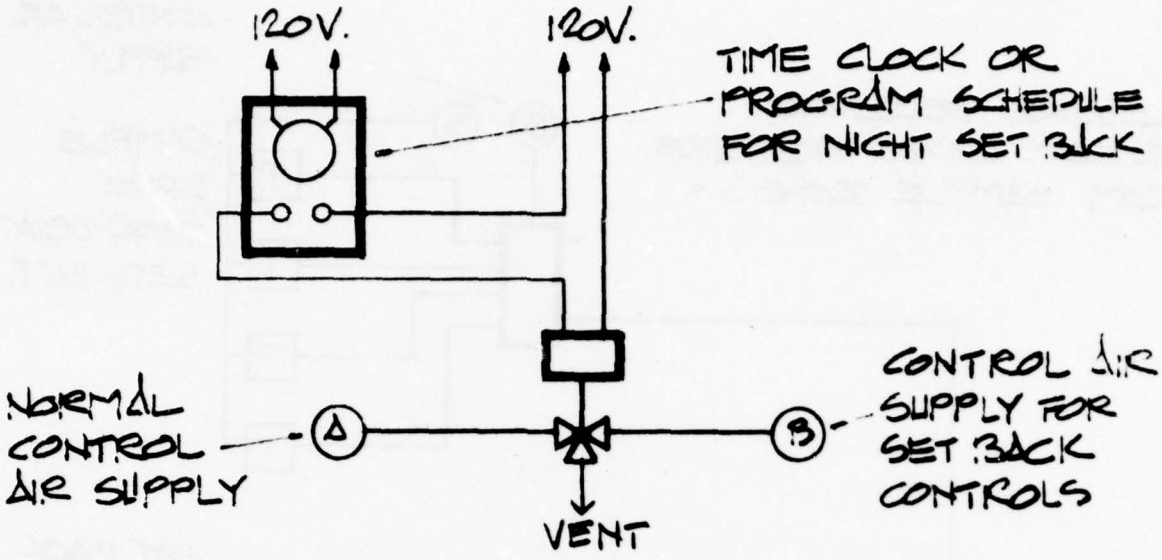


BOILER CONTROL

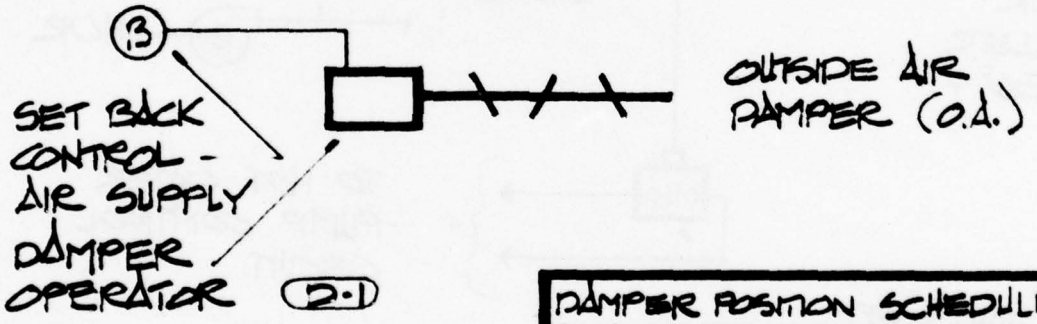
GUIDE FOR NIGHT AND WEEKEND TEMPERATURE SET BACK

EXISTING CONTROL DIAGRAM

SYSTEM 2



SET BACK PROGRAM CONTROL



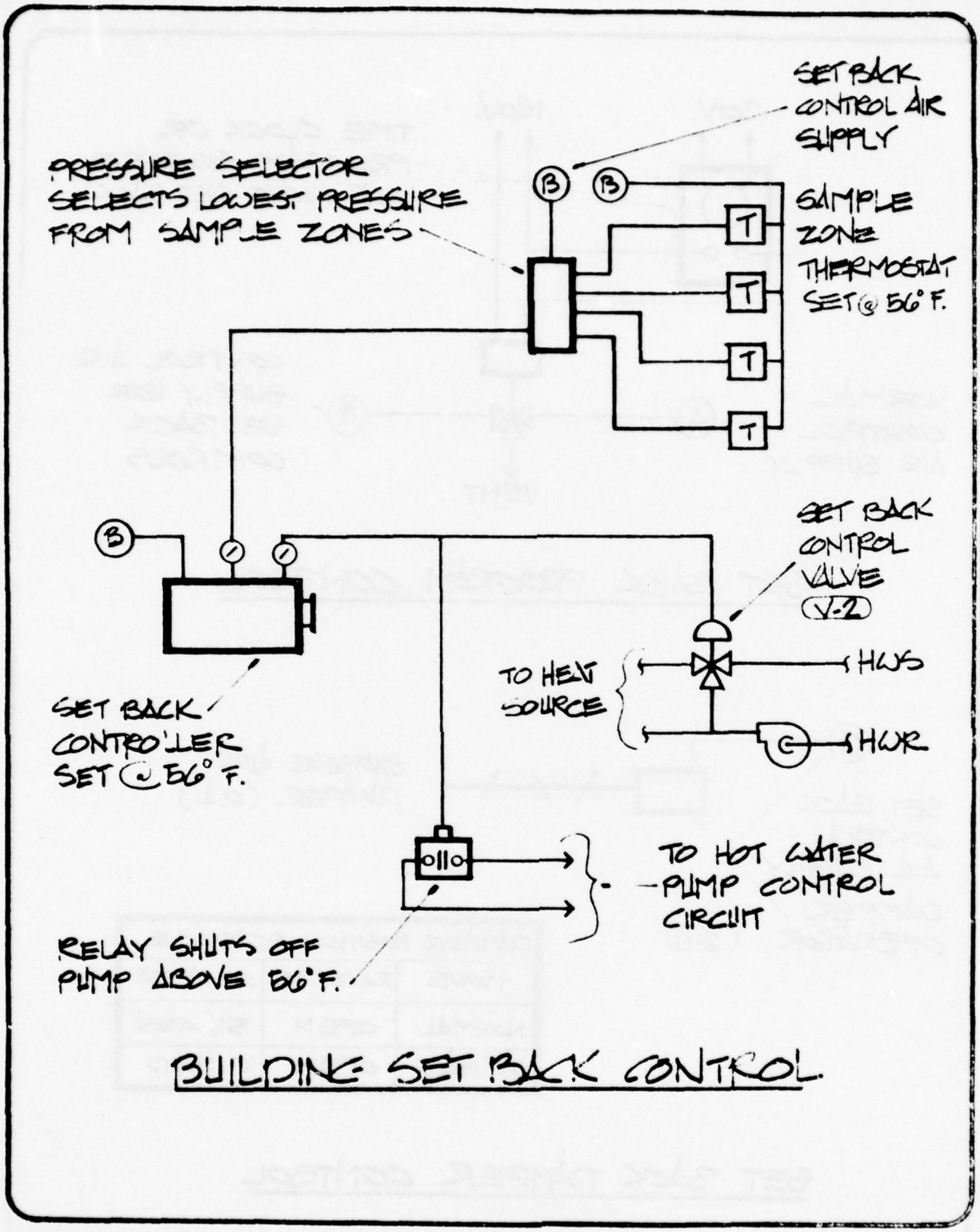
DAMPER POSITION SCHEDULE		
MODE	R.A. DAMPER	O.A. DAMPER
NORMAL	OPEN	15% OPEN
SET BACK	OPEN	CLOSED

SET BACK DAMPER CONTROL

GUIDE FOR NIGHT AND WEEKEND TEMPERATURE SET BACK

RETROFIT CONTROL DIAGRAM

SYSTEM 2



BUILDING SET BACK CONTROL

GUIDE FOR NIGHT AND WEEKEND TEMPERATURE SET BACK

RETROFIT CONTROL DIAGRAM

SYSTEM 2

SYSTEM TYPE	Steam Radiation
OUTSIDE AIR	None
FUEL	
HEATING	Natural Gas
AUXILIARY	Electric Blower
CENTRAL EQUIPMENT	
HEATING	Steam Boiler
COOLING	None
ENERGY DISTRIBUTION	Steam
PRIMARY AIR TREATMENT	
HEATING	Radiation, Convection, Fan Coil Units
COOLING	None
AIR DISTRIBUTION	Natural Convection/Forced Air
ZONE AIR TREATMENT	None
CONTROL SYSTEM	Manual; Pneumatic and Electric

SEQUENCE OF OPERATION

Normal Sequence

Heating is supplied by a gas fired steam boiler and conveyed through insulated piping to various direct radiation devices, including baseboard radiators, wall convectors and fan coil units. Temperature control for the radiation units is usually manual. Occupants throttle the manual valves to obtain the desired level of comfort; virtually little can be done with respect to automatically maintain a set point. Additionally at the end of the working day the valves are left in the open position. This results in an acceptable temperature upon returning for work the next day.

Temperature control for the fan coil units is automatic consisting of a thermostat and control valve. The space thermostat for fan coil units adjusts the position of the steam valves to maintain a set point of 68F.

Night/Weekend Set Back Sequence

The existing system is allowed to function normally with the following exceptions:

a. A time clock is installed which selectively and serially arranges two modes of operation, normal and night/weekend set back.

b. A control valve is installed adjacent to the existing boiler.

c. A space thermostat with a set point of 56F is installed in a representative space. In the case of pneumatic controls, more than one thermostat may be installed to modulate the above control valve. Consequently, the space having the greatest demand initiates the positioning of the control valves.

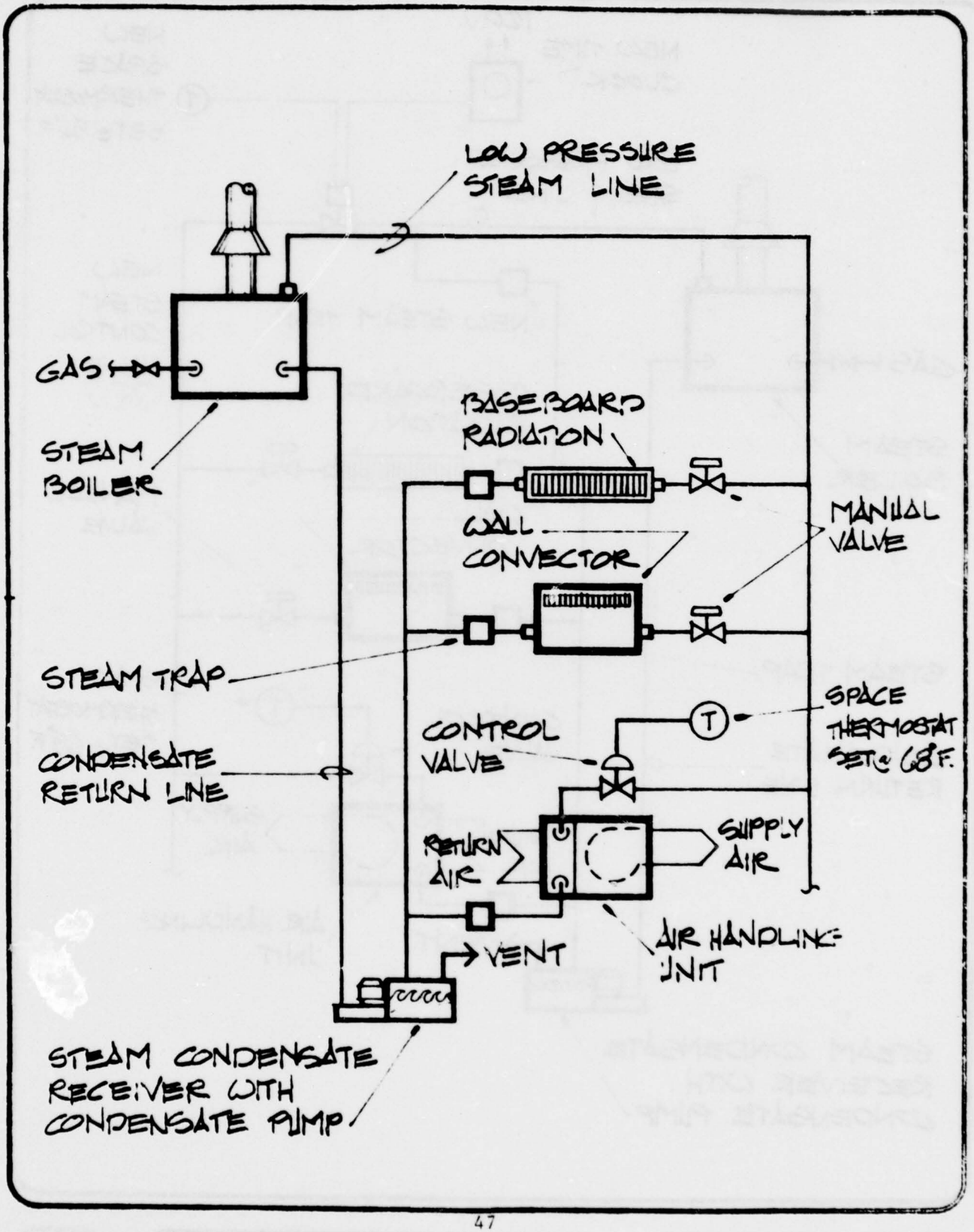
When the time clock initiates the night/weekend set back control, the new steam control valve closes off the supply of steam to all spaces. The entire building will be allowed to float in terms of temperature, between the 68F normal and the 56F set back temperatures. The automatic control valves in the existing fan coil systems will shift to a wide open position as the space temperature is decreased but no steam will be available for heating. The time clock will initiate the normal mode at the preset time and the building system will function at normal 68F.

Precautions

Steam and steam condensate piping do not respond well to rapid changes in temperature. It is necessary to evaluate each system in terms of the piping physical condition.

Old and/or corroded piping could very well fail under conditions of thermal shock, repeated contraction and expansion and water hammer resulting from condensate in the steam piping when starting cold.

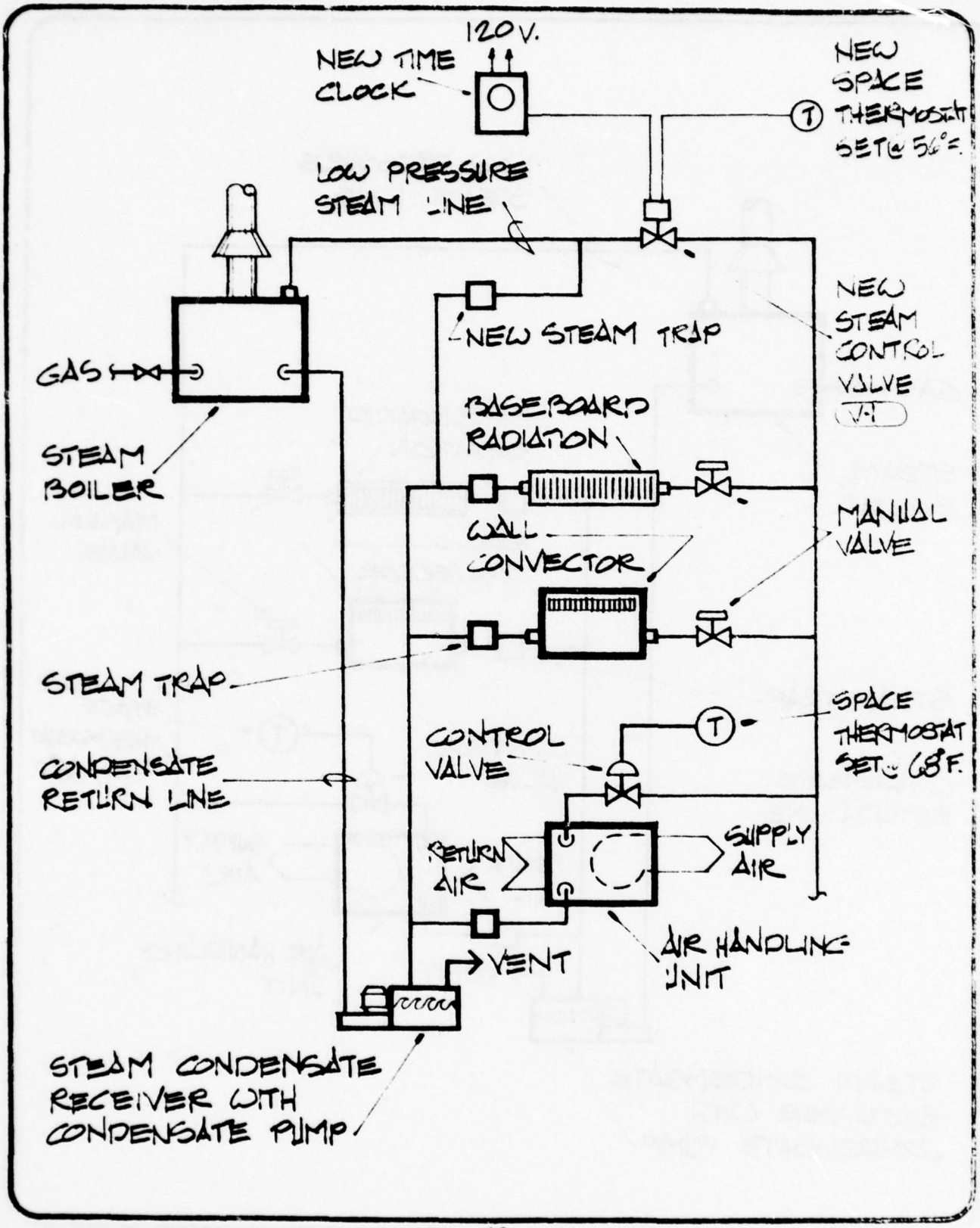
Trap sizes and trap types may require attention; possible removal and replacement with new traps may be necessary. The main control valve which opens the steam supply must do so very slowly; a valve with a time-cycle of at least four minutes from CLOSE to OPEN is suggested.



GUIDE FOR NIGHT AND WEEKEND TEMPERATURE SET BACK

EXISTING FLOW DIAGRAM

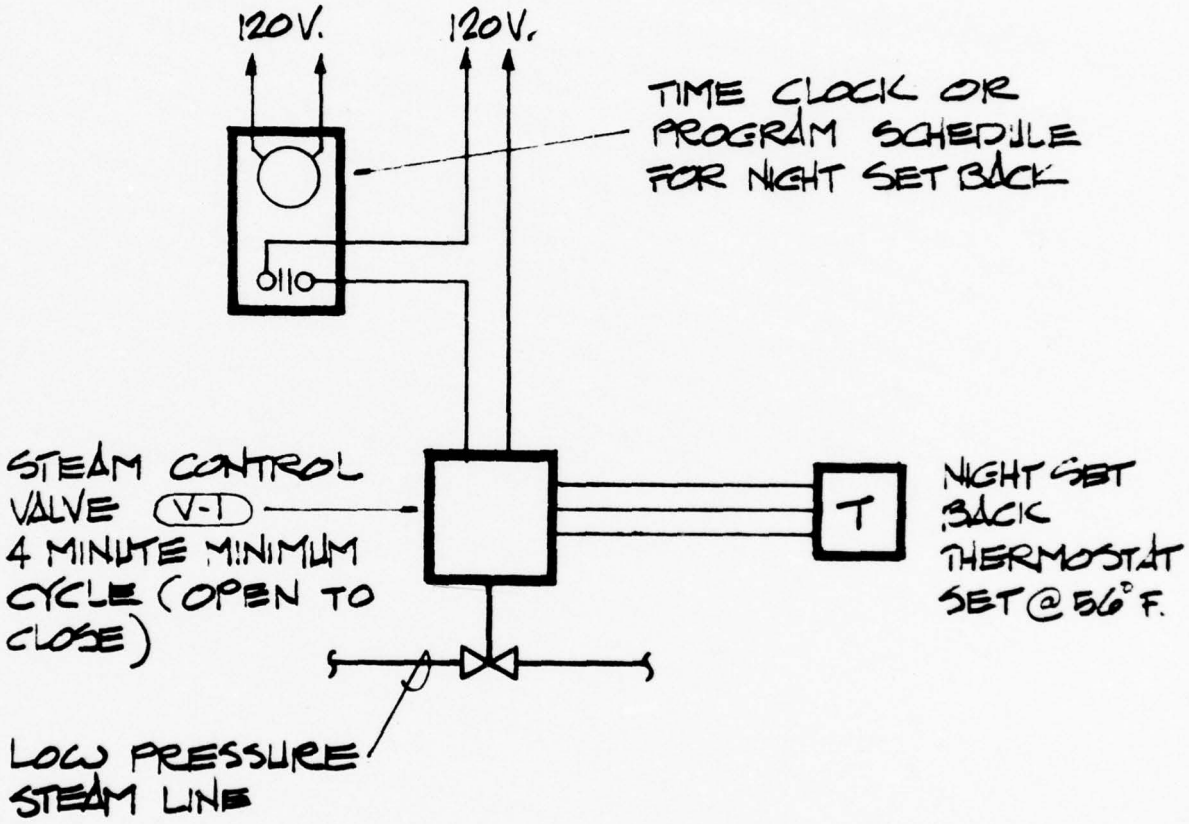
SYSTEM 3



GUIDE FOR NIGHT AND WEEKEND TEMPERATURE SET BACK

RETROFIT FLOW DIAGRAM

SYSTEM 3



GUIDE FOR NIGHT AND WEEKEND TEMPERATURE SET BACK

RETROFIT CONTROL DIAGRAM

SYSTEM 3

SYSTEM TYPE	Hot Water Radiation
OUTSIDE AIR	None
FUEL	
HEATING	Natural Gas
AUXILIARY	Electric Blower
CENTRAL EQUIPMENT	
HEATING	Hot Water Boiler
COOLING	None
ENERGY DISTRIBUTION	Hot Water
PRIMARY AIR TREATMENT	
HEATING	Radiation, Convection, Fan Coil Units
COOLING	None
AIR DISTRIBUTION	Natural Convection/Forced Air
ZONE AIR TREATMENT	None
CONTROL SYSTEM	Manual, Pneumatic or Electric

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SEQUENCE OF OPERATIONS

Normal Sequence

Hot water is supplied by a gas fired water boiler and pumped through insulated piping to various direct radiation devices, including baseboard radiation, wall convectors and fan coil units. Temperature control for radiation units is usually manual; temperature control for fan coil units is automatic consisting of a thermostat and control valve.

Occupants throttle manual valves at the radiation units to obtain the desired level of comfort; virtually little can be done with respect to automatically maintain a set point. Additionally, at the end of the working day the valves are left in the open position. This results in an acceptable temperature upon returning to work the next day.

The space thermostats for the fan coil units adjust the position of their control valve to maintain a set point of 68F.

Night/Weekend Set Back Sequence

The existing system is allowed to function exactly as before with the following exceptions:

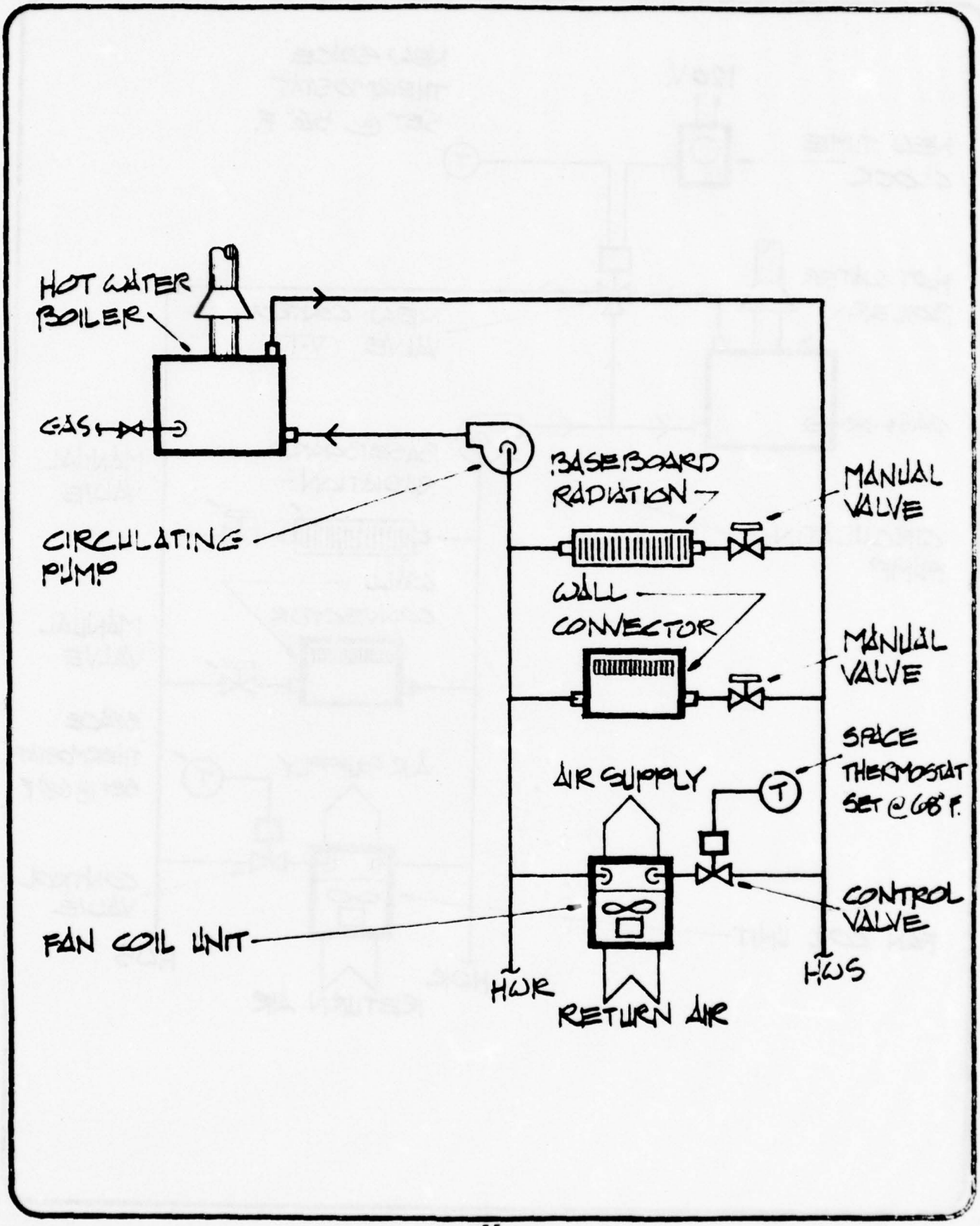
a. A time clock is installed which selectively and serially aranges two modes of operation; normal, 68F and night/weekend set back, 56F.

b. A control valve is installed adjacent to the existing water boiler.

c. A space thermostat is installed in a select space with a set point of 56F. In the case of pneumatic controls, more than one thermostat can be installed to position the control valve. That is, the space having the greatest demand initiates the positioning of the control valves. The retrofit control illustrated for System 4 shows a single electric thermostat. Refer to System 2 retrofit control for multiple pneumatic thermostatic control.

When the time clock initiates the night/weekend set back control, the new control valve closes off the supply of hot water to all spaces. The entire building is allowed to float, in terms of temperature, between the 68F normal condition and night/weekend set back temperature of 56F. Upon reaching 56F, the new space thermostats will modulate the control valve to a position which maintains a 56F space temperature. The automatic control valves in the existing system will shift to a wide open position as the space temperature is decreased thereby giving up their function of control to the night/weekend set back thermostats. Upon reaching the end of the

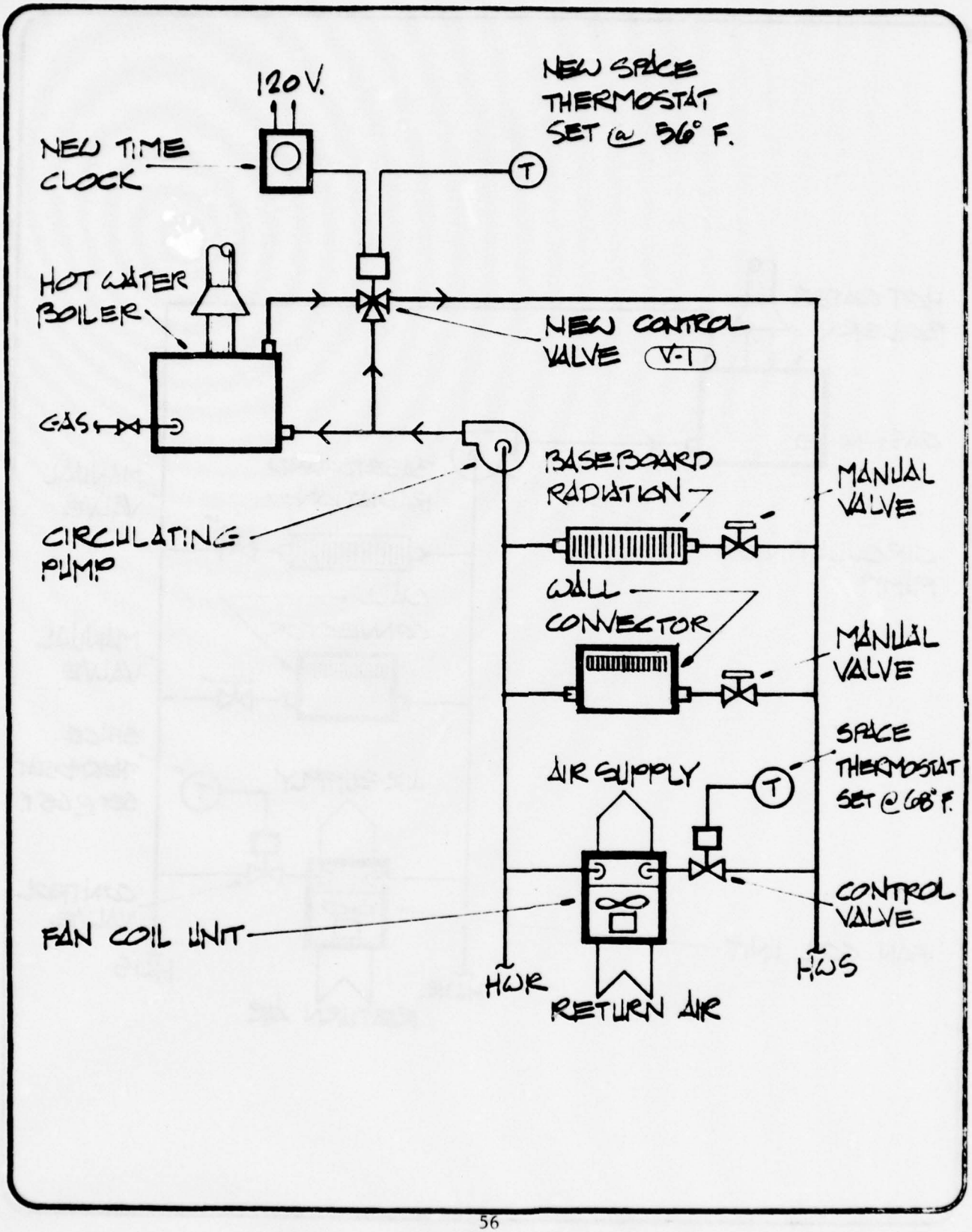
night/weekend set back mode the time clock will initiate the normal mode and the building system will function as normal at 68F.



GUIDE FOR NIGHT AND WEEKEND TEMPERATURE SET BACK

EXISTING FLOW DIAGRAM

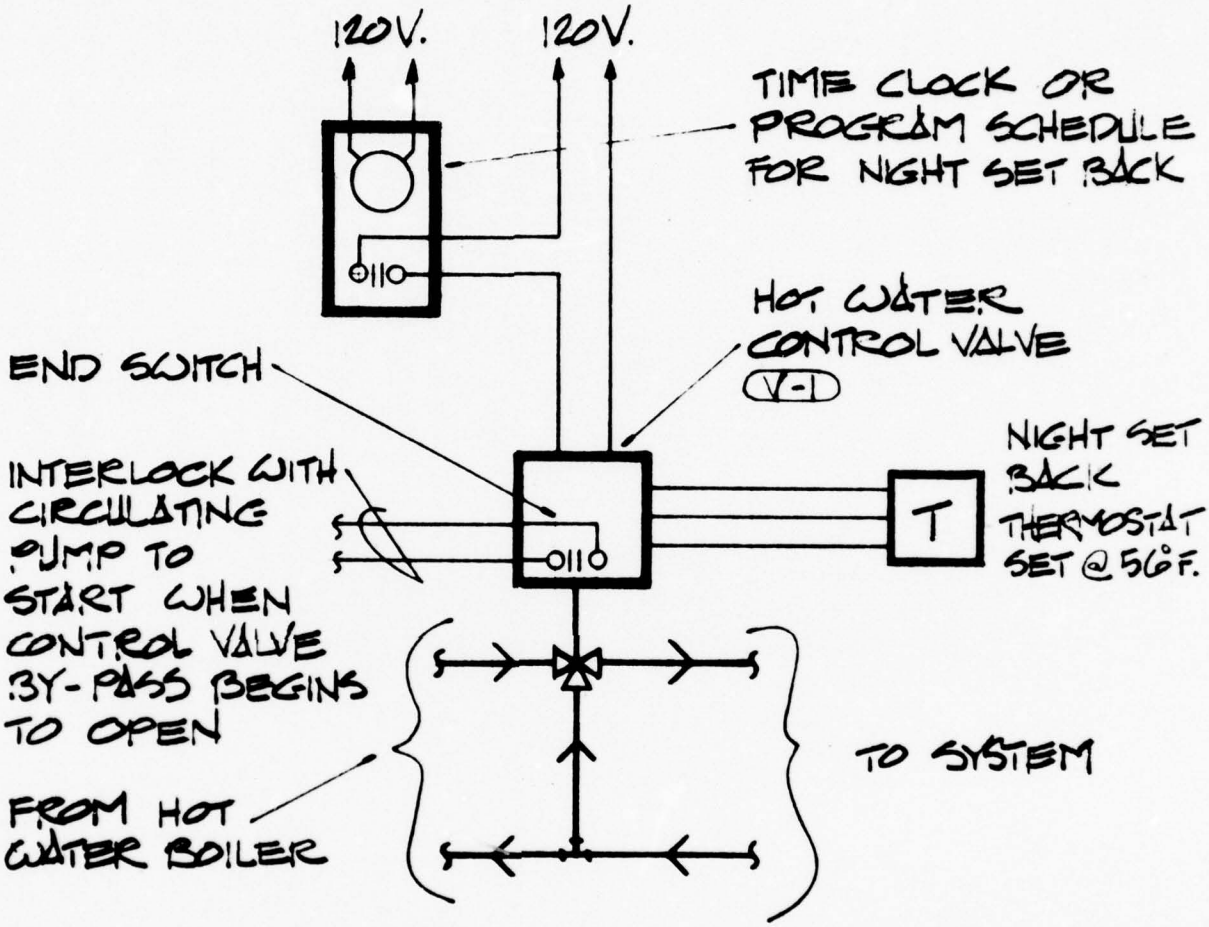
SYSTEM 4



GUIDE FOR NIGHT AND WEEKEND TEMPERATURE SET BACK

RETROFIT FLOW DIAGRAM

SYSTEM 4



GUIDE FOR NIGHT AND WEEKEND TEMPERATURE SET BACK

RETROFIT CONTROL DIAGRAM

SYSTEM 4

SYSTEM TYPE	Central Air Handling-Mixing
OUTSIDE AIR	Varies; With or Without Economizer
FUEL	
HEATING/COOLING	Gas/Electric
AUXILIARY	Electric Blower
CENTRAL EQUIPMENT	
HEATING	Hot Water Boiler
COOLING	Electric Driven Chiller
ENERGY DISTRIBUTION	Hot Water/Chilled Water
PRIMARY AIR TREATMENT	
HEATING	Hot Plenum
COOLING	Cold Plenum
AIR DISTRIBUTION	Ductwork and Air Diffusers
ZONE AIR TREATMENT	Mixing Dampers
CONTROL SYSTEM	Pneumatic or Electric

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SEQUENCE OF OPERATION

Normal Sequence

Heating and cooling is possible at the same time with this system. Hot water is generated in a gas fired water boiler and pumped through insulated piping to a heating coil located at a central air handling unit. The temperature of the air leaving the heating coil is more or less at a fixed temperature between 90F and 110F depending on the outdoor air temperature.

Similarly, chilled water or direct expansion refrigeration cools the air passing through the cooling coil to a temperature of approximately 55F. The hot and cold ducts at this point are referred to as hot and cold plenums respectively. The hot and cold air is then conducted through insulated ductwork to mixing dampers where hot and cold air mixed through modulating dampers to obtain the temperature of the thermostat set point, usually 73F. A common thermostat with a narrow throttling range maintains the space temperature by mixing hot and cold air. Examples of mixing systems are multizone and double duct systems. These terms are very familiar to HVAC industry and warrant no further discussion.

A single air handling system can have any number of zones

with thermostats depending on the physical size of the system. It is neither practical nor desirable to include the existing zone thermostats in the night set back scheme; see precautions.

Night/Weekend Set Back Sequence

The existing system requires minor changes in and about the central equipment. These changes include:

a. A time clock to initiate the normal mode 73F and to initiate the night set back mode 56F.

b. Sample thermostats which can be placed strategically in various areas of the building; or optionally, a single thermostat placed in the return air duct at the air handling unit.

Upon initiating the normal mode 73F, the system operates as described before maintaining space temperature by mixing hot and cold air. When the time clock initiates the night set back control it deactivates the chilled water pumps or refrigeration equipment and deactivates the hot water pump. The boiler, or heat source, is left intact to function on its own controls.

The space temperature will continue to float between the 73F set point under normal operation and 56F set point under the night set back mode; it is anticipated that the morning

starting temperature within the normal mode may be as low as 68F even with the set point of the zone set at 73F.

The mixing dampers which are controlled by the existing zone thermostats will open to the hot plenum and recirculated air will be distributed throughout the building. At the same time the pump deactivation occurs, it is mandatory that the outside air damper moves to a fully closed position. More often than not the minimum position of 15 percent outside air results in considerably more outside air.

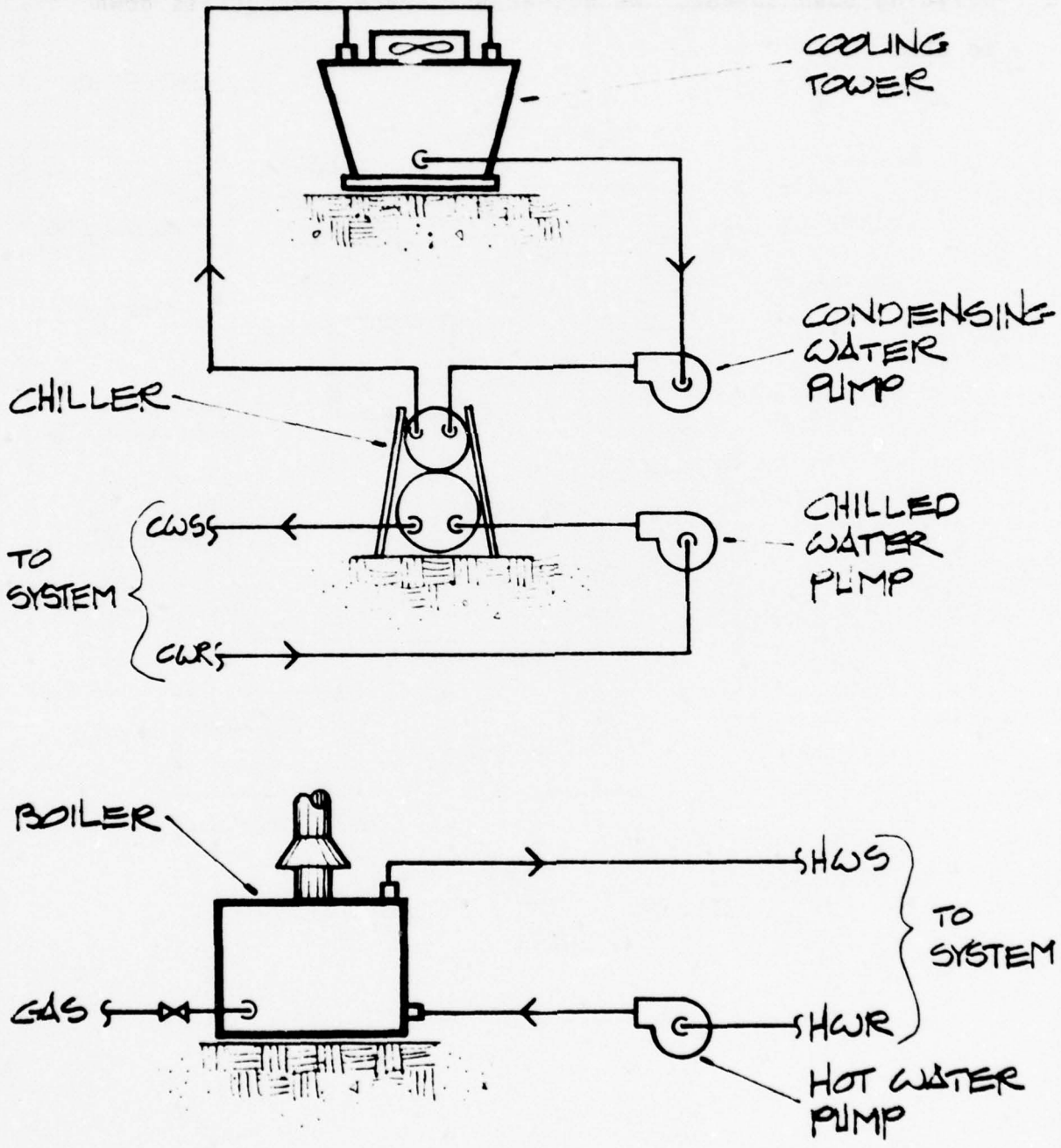
Recirculation of building air will continue until a zone, or in the case of a single return air thermostat, reaches its set point 56F. The hot water pump will be energized providing hot water for the hot plenum, the space will increase in temperature until the night set back set point is satisfied.

Precaution

A differential of at least 1.5 degree is preferred on the night set back thermostat such that the pump is energized at 56F and de-energized at 57.5F. This will prevent rapid cycling of the hot water pump.

Lowering of the space thermostat from 73F to 68F, as in other

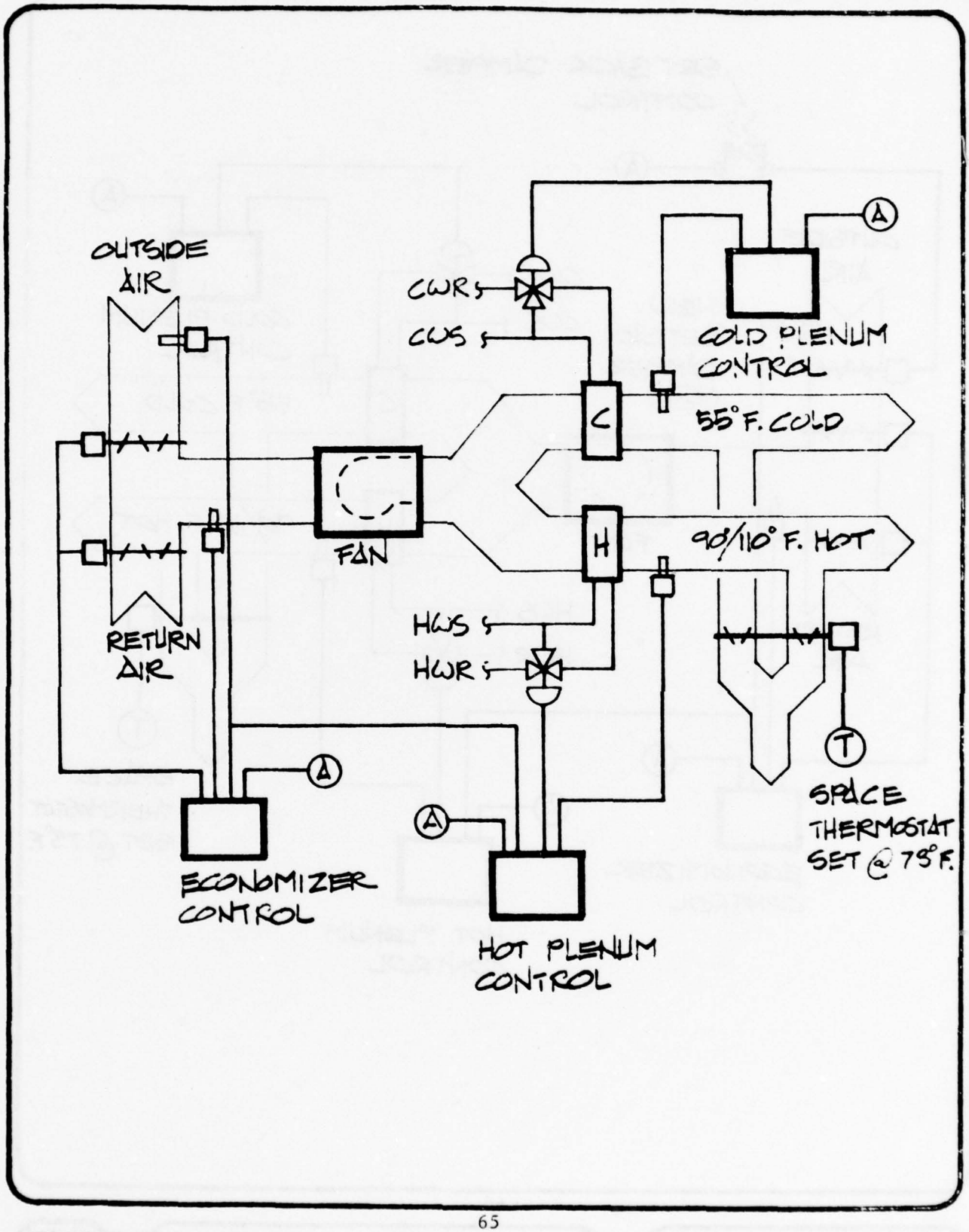
systems, will result in energy consumption for cooling the building down to 68F. Do not adjust space thermostats down to 68F!



GUIDE FOR NIGHT AND WEEKEND TEMPERATURE SET BACK

EXISTING FLOW DIAGRAM

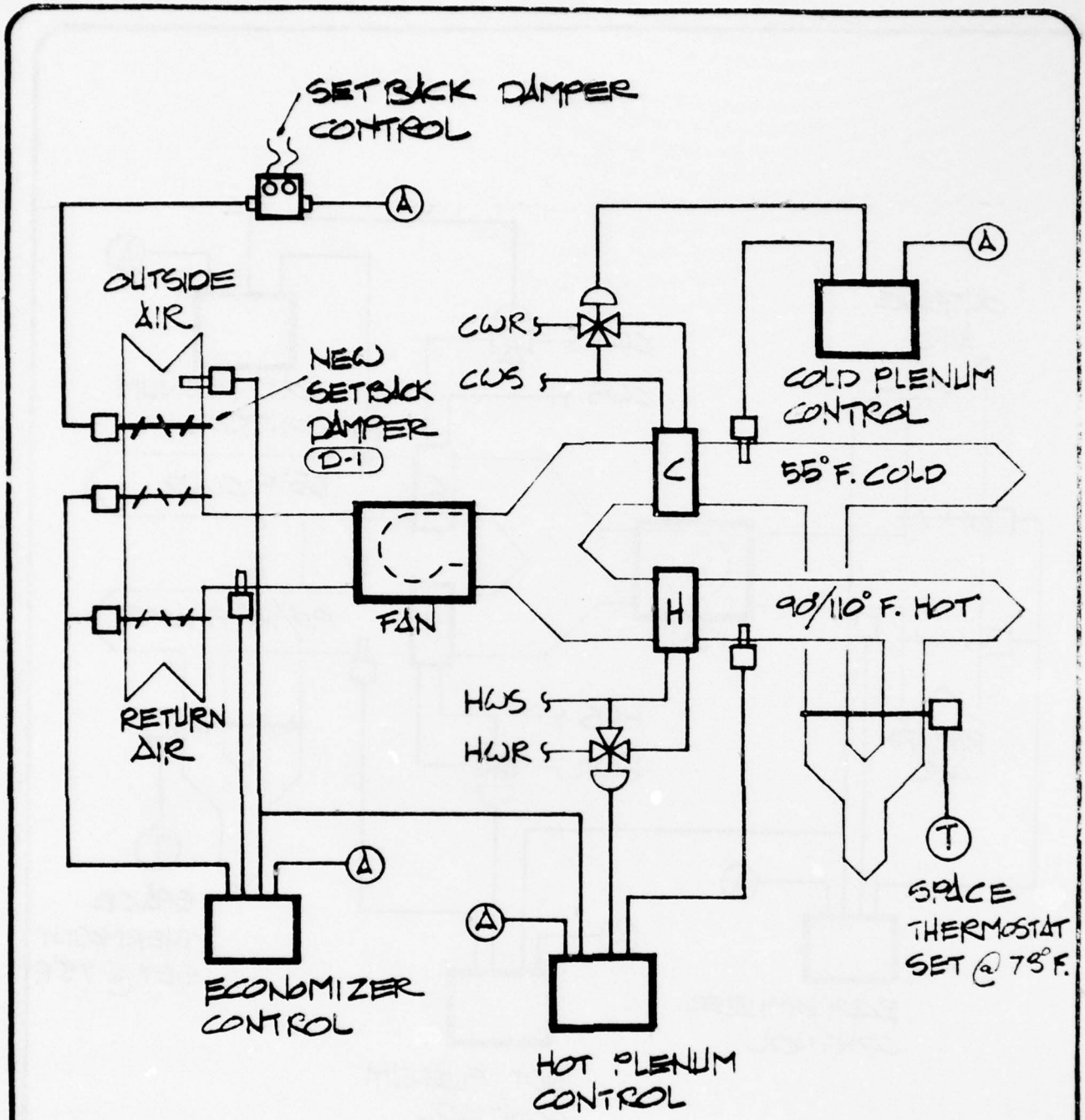
SYSTEM 5



GUIDE FOR NIGHT AND WEEKEND TEMPERATURE SET BACK

EXISTING FLOW DIAGRAM

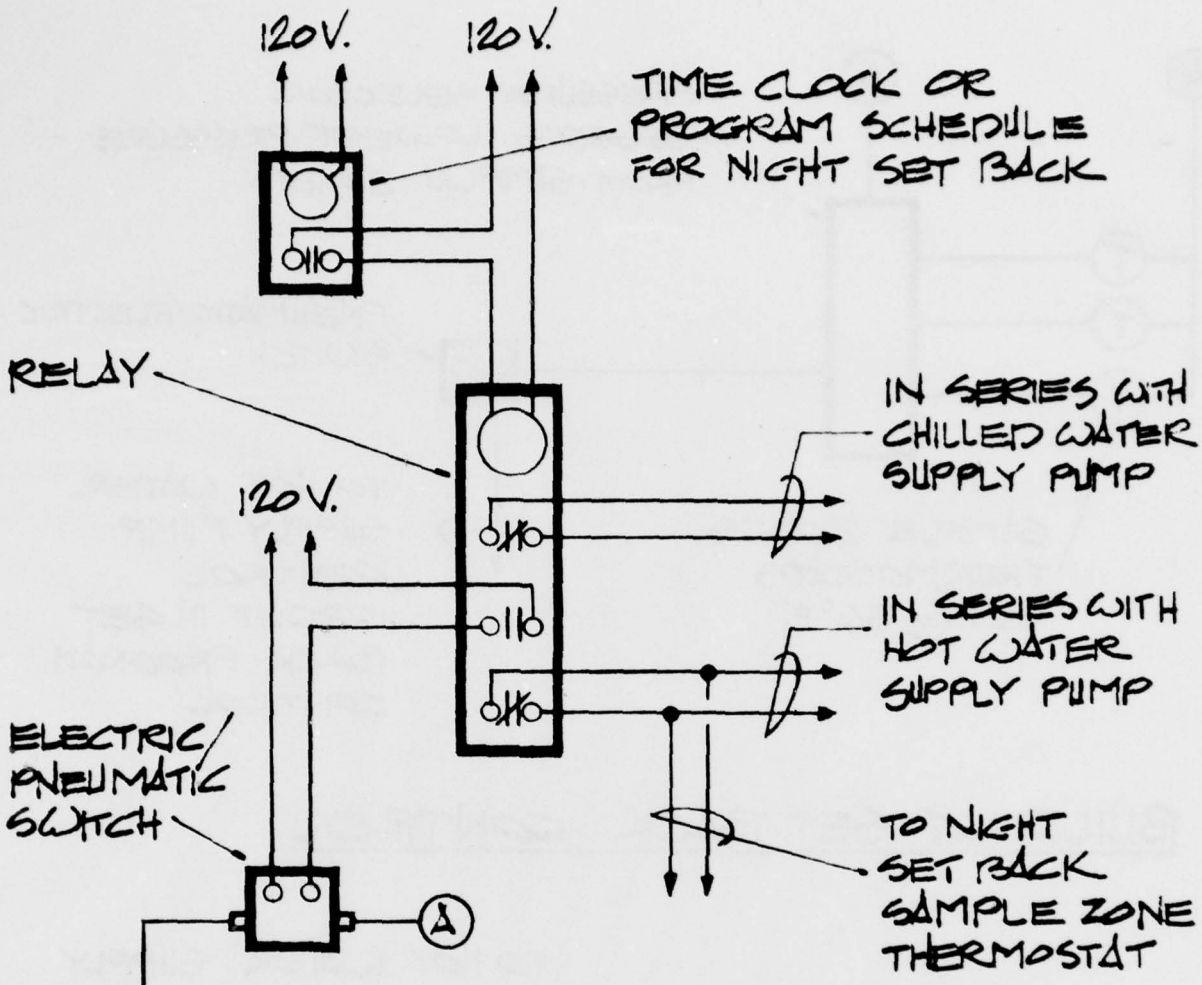
SYSTEM 5



GUIDE FOR NIGHT AND WEEKEND TEMPERATURE SET BACK

RETROFIT FLOW DIAGRAM

SYSTEM 5



SET BACK PROGRAM CONTROL

NEW NIGHT SET BACK OUTSIDE AIR DAMPER (D-1)

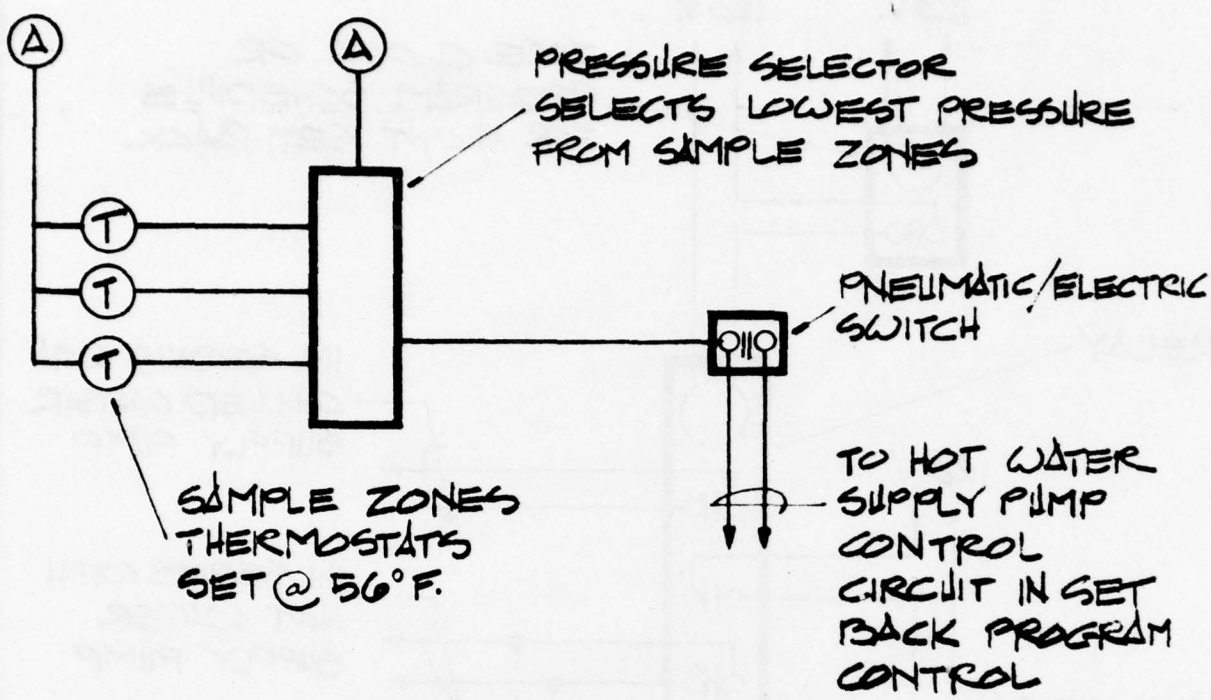
DAMPER POSITION	
NORMAL	OPEN
SET BACK	CLOSED

SET BACK DAMPER CONTROL

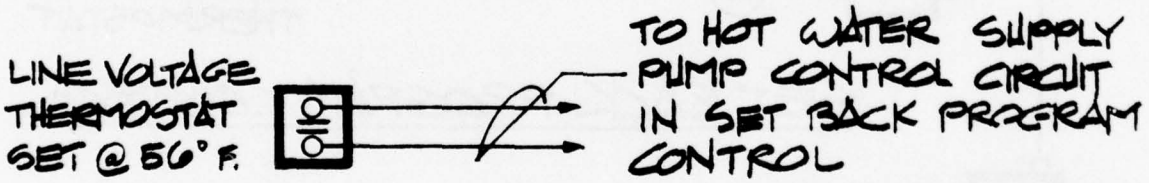
GUIDE FOR NIGHT AND WEEKEND TEMPERATURE SET BACK

RETROFIT CONTROL DIAGRAM

SYSTEM 5



BUILDING SET BACK CONTROL



ALTERNATE BUILDING SET BACK CONTROL FOR ONE SAMPLE ZONE

GUIDE FOR NIGHT AND WEEKEND TEMPERATURE SET BACK

RETROFIT CONTROL DIAGRAM

SYSTEM 5

SYSTEM TYPE	Central Air Handling - Reheat
OUTSIDE AIR	Varies; With or Without Economizer
FUEL	
HEATING/COOLING	Natural Gas/Electric
AUXILIARY	Electric Pumps, Cooling Tower, Fans
CENTRAL EQUIPMENT	
HEATING	Hot Water Boiler
COOLING	Electric Driven Chiller, Cooling Tower, Pumps
ENERGY DISTRIBUTION	Hot and Chilled Water
PRIMARY AIR TREATMENT	
HEATING	With or Without Preheat Coil
COOLING	Cold Plenum
AIR DISTRIBUTION	Ductwork and Air Diffusers
ZONE AIR TREATMENT	Hot Water Reheat Coils
CONTROL SYSTEM	Pneumatic or Electric

SEQUENCE OF OPERATION

Normal Sequence

Heating and cooling is possible at the same time with this system. Hot water and chilled water are produced at a central location and are distributed to preheat coils and cooling coils located within an air handling unit; additionally, hot water is distributed to reheat coils which adjust the space temperature through a valve and thermostatic control sub-system, set point 73F. There exists as many reheat coils as are required for any particular facility; number and arrangements are infinite.

Any one of the central air handling units can be arranged with outdoor air, return air mixing dampers, commonly known as an economizer system which allows for a certain amount of "free" cooling during certain weather conditions. Each of the above items must be included in the night set back control retrofit.

Night/Weekend Set Back Sequence

The existing system requires minor changes in and about the central equipment. These changes include:

a. A time clock to initiate the normal mode of 73F and to initiate the night set back mode of 56F.

b. Sample thermostats placed strategically in various areas of the building or optionally in a single return air duct of the central air handling unit.

c. Pneumatic-electric switches and electric solenoid air valves.

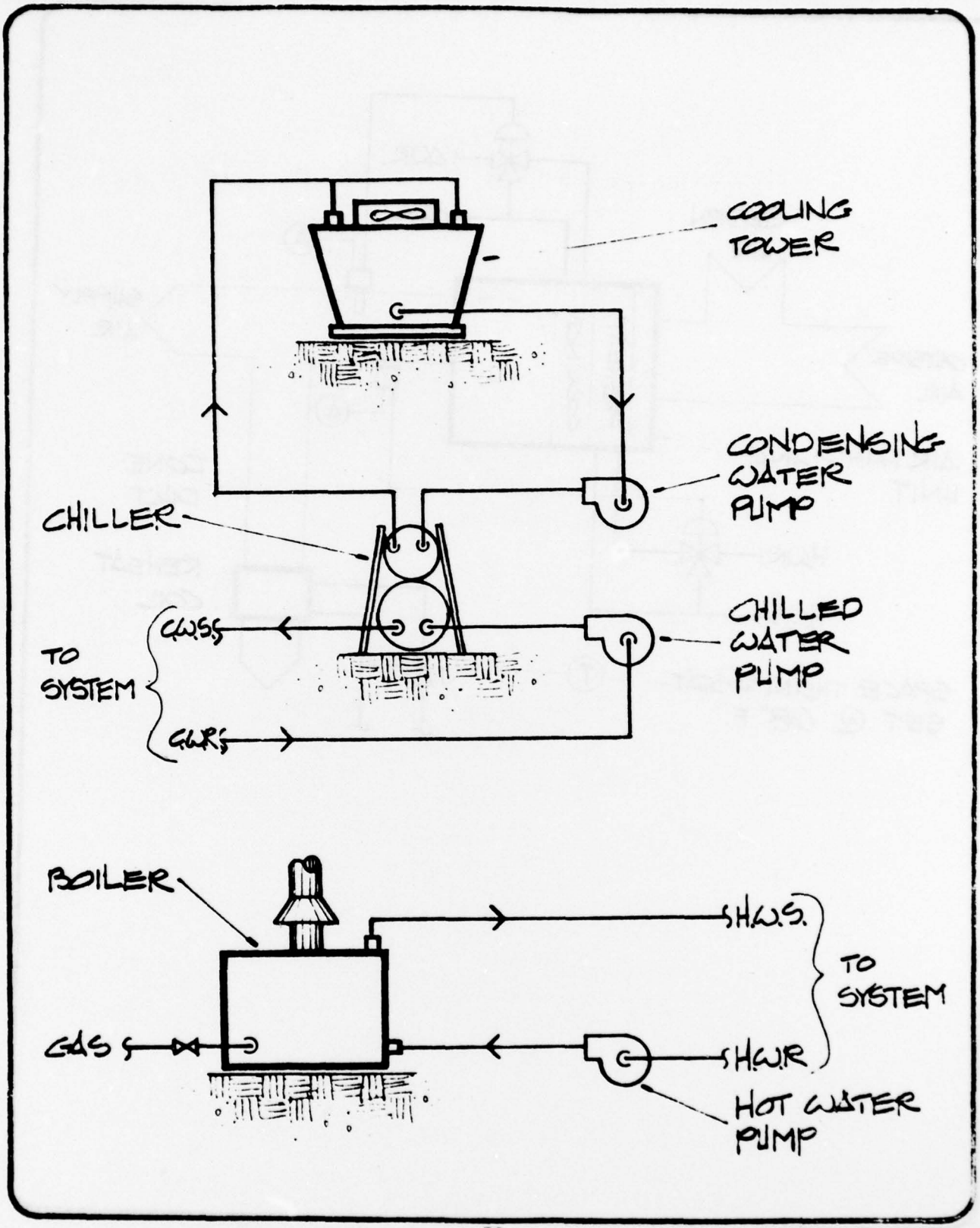
Upon initiating the normal mode, the system operates as before described, maintaining space temperature by regulating the position of the reheat coil control valve. Upon initiating the night set back control, the time clock, through a suitable relay, deactivates the chilled water pumps or refrigeration equipment, and deactivates the hot water pump. The space temperature will continue to float between the 73F setpoint under normal operation and the 56F setpoint under the night/weekend set back mode; it is anticipated that during the early morning hours, the space temperature within the normal mode may be as low as 68F, even with the set point of the zone set at 73F.

The control valves on the reheat coils which supply heat to the various zones will automatically open as the space temperature floats downward toward the night/weekend set

back set point of 56F. However, since the hot water pump is de-energized and the new hot water mixing valve is open to bypass, no heating energy is expended to the facility. When the temperature of the space reaches 56F, the night set back thermostat energizes the hot water pump and begins to close the by-pass of the new control valve. As the by-pass is closed, hot water is circulated through each reheat coil thus providing limited heating to the set point of 56F.

Precautions

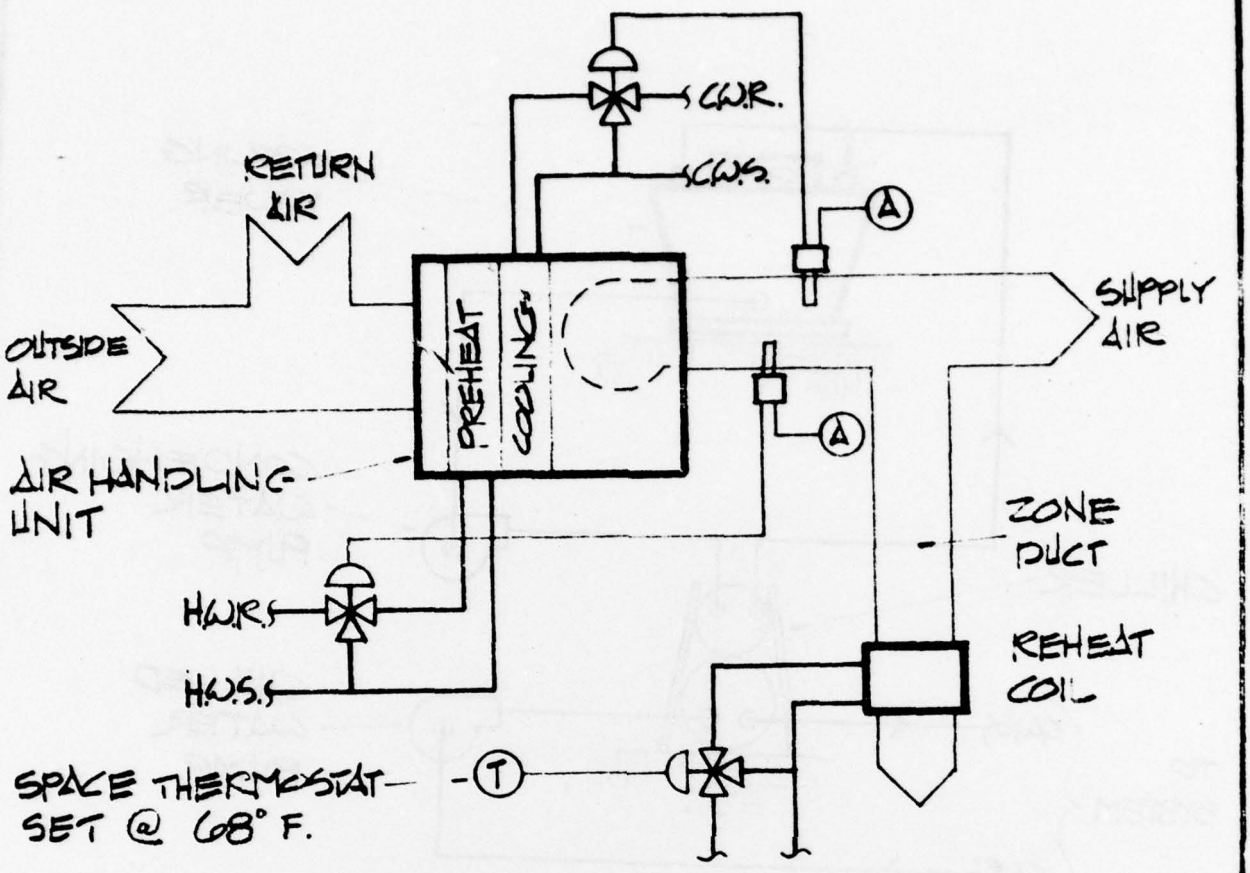
The space thermostat must not be adjusted from 73F to 68F. Lowering of the space thermostats will result in energy consumption for cooling the building down to 68F. Do not adjust space thermostats to 68F!



GUIDE FOR NIGHT AND WEEKEND TEMPERATURE SET BACK

EXISTING FLOW DIAGRAM

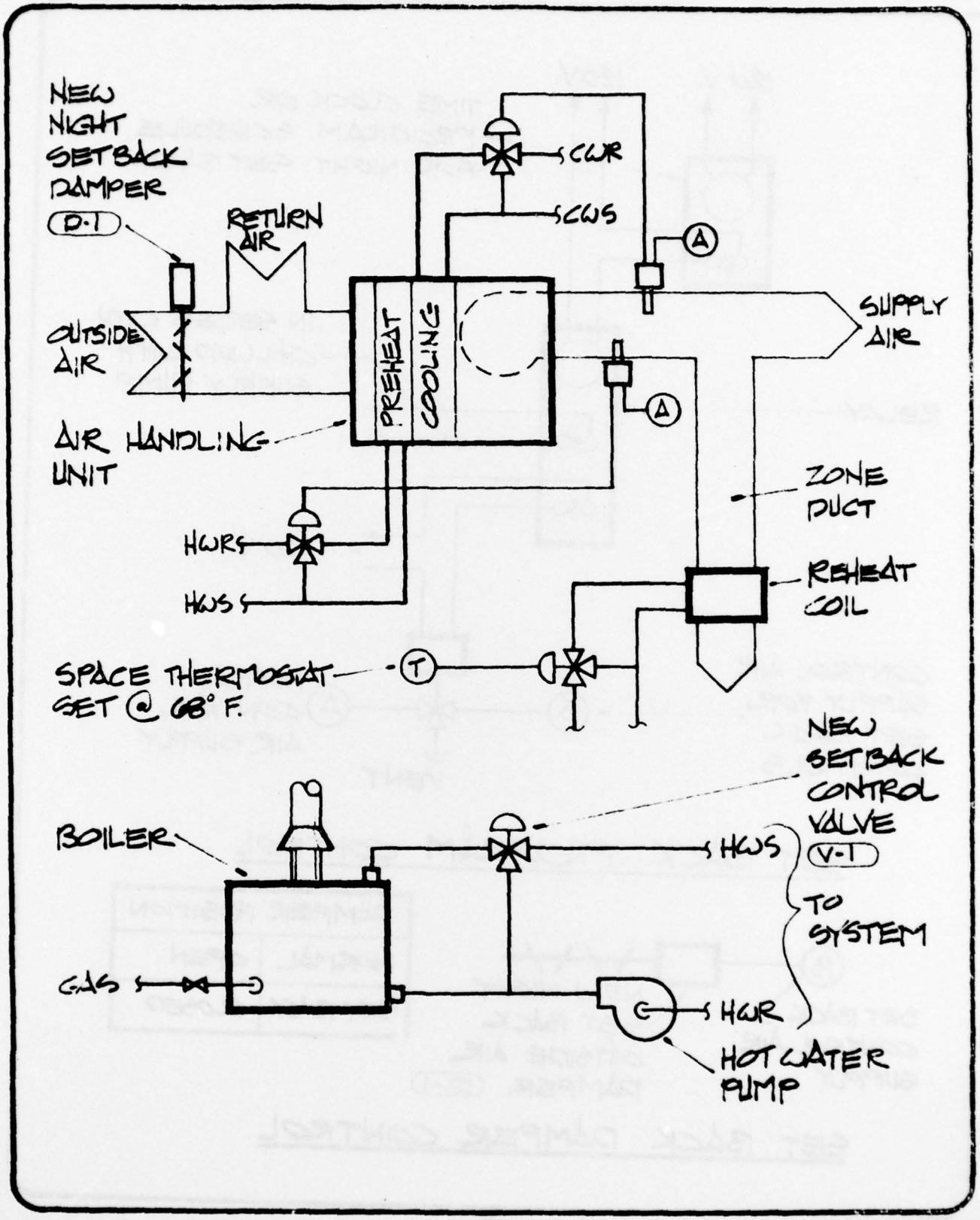
SYSTEM 6



GUIDE FOR NIGHT AND WEEKEND TEMPERATURE SET BACK

EXISTING FLOW DIAGRAM

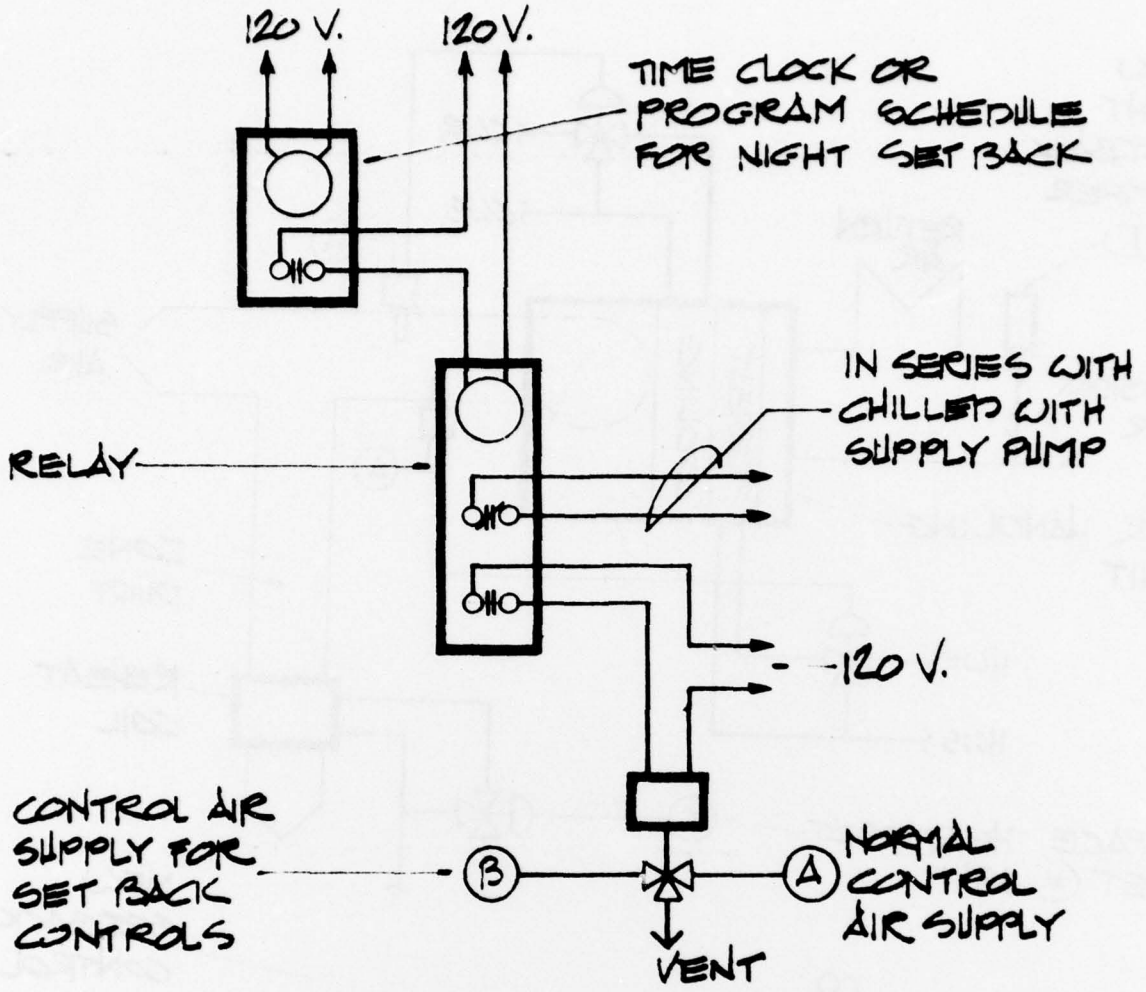
SYSTEM 6



GUIDE FOR NIGHT AND WEEKEND TEMPERATURE SET BACK

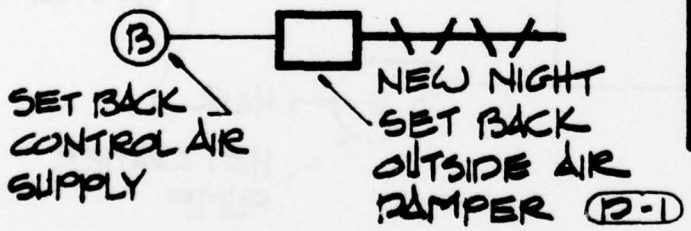
RETROFIT FLOW DIAGRAM

SYSTEM 6



SET BACK PROGRAM CONTROL

DAMPER POSITION	
NORMAL	OPEN
SET BACK	CLOSED

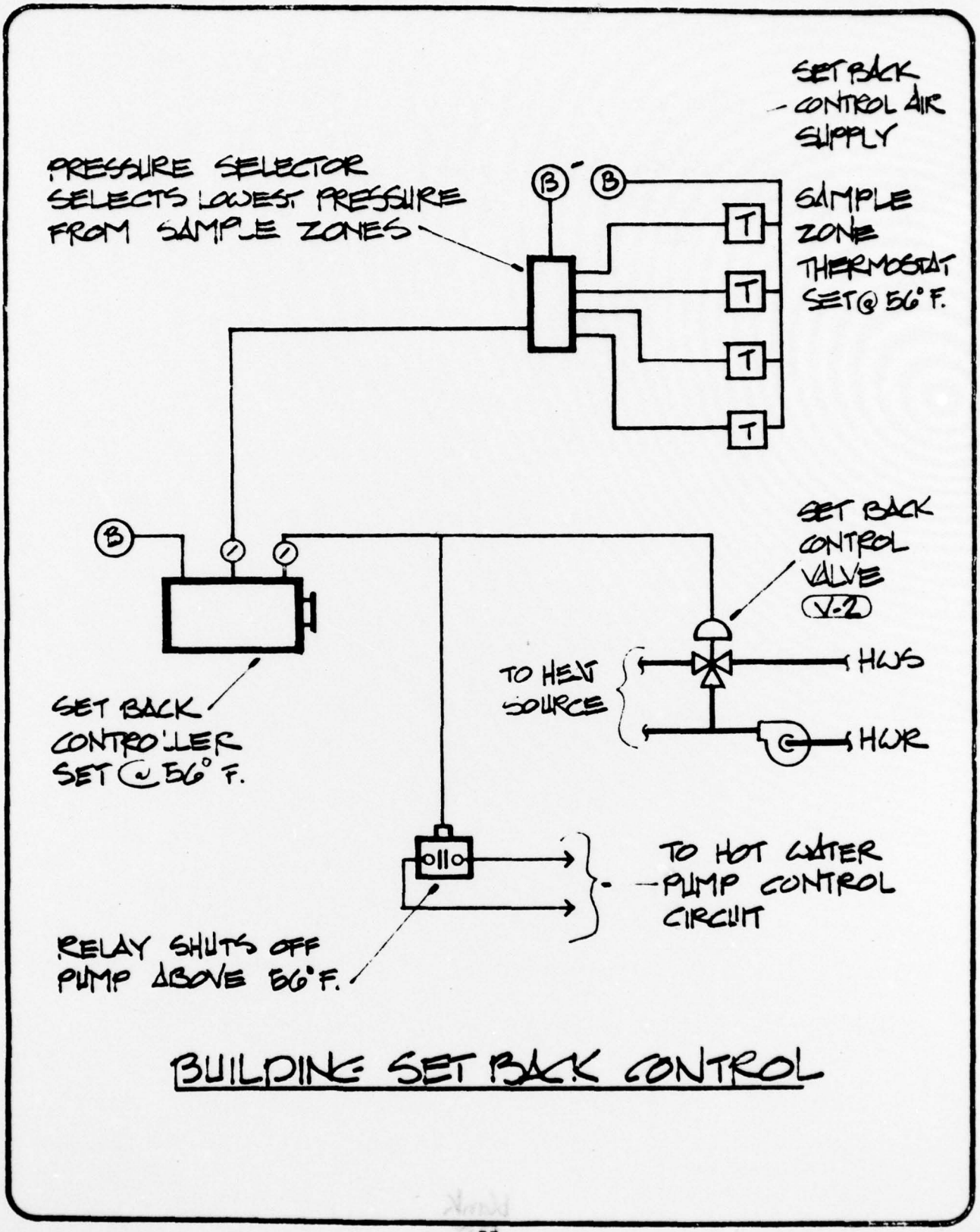


SET BACK DAMPER CONTROL

GUIDE FOR NIGHT AND WEEKEND TEMPERATURE SET BACK

RETROFIT CONTROL DIAGRAM

SYSTEM 6



BUILDING SET BACK CONTROL

GUIDE FOR NIGHT AND WEEKEND TEMPERATURE SET BACK

RETROFIT CONTROL DIAGRAM

SYSTEM 6

SYSTEM TYPE	Packaged Heating and Cooling
OUTSIDE AIR	Varies, With or Without Economizer
FUEL	
HEATING/COOLING	Natural Gas/Electric
AUXILIARY	Electric
CENTRAL EQUIPMENT	
HEATING	None
COOLING	None
ENERGY DISTRIBUTION	Air
PRIMARY AIR TREATMENT	
HEATING	Heating Section
COOLING	Cooling Section
AIR DISTRIBUTION	Fan, Ductwork and Air Diffusers
ZONE AIR TREATMENT	None
CONTROL SYSTEM	Electric

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SEQUENCE OF OPERATION

Normal Sequence

This type of heating, ventilating and air condition equipment includes many variations:

a. Single packaged roof-mounted with or without Economizer.

b. Split-package consisting of an indoor unit and an outdoor unit connected with refrigerant piping and electrical wiring that may or may not be equipped with an Economizer system.

Each of the above basic arrangements can evolve into several different configurations. However, for the purpose of this guide, they are functionally the same. The interior components of the packaged heating, ventilating and air conditioning system consists of:

a. A gas-fired forced air furnace with gas pressure regulator; automatic control valve; automatic pilot; high-limit thermostat; and a zone thermostat.

b. An electric motor-driven refrigeration compressor; air or water-cooled condensing unit and an evaporator section with refrigeration regulating valve; solenoid valve; and related refrigeration appurtenances.

c. All of the above items are fitted into one or two metal cabinets which, when arranged with ductwork, supply heated or cooled air for the facility.

The control of heating or cooling is accomplished through a dual space thermostat usually fitted with a switch subbase for mode selection. The subbase usually has a FAN ON/FAN AUTO switch and an HEAT-OFF-COOL switch. Systems with an automatic heating and cooling switch-over are equipped with a SYSTEM ON-AUTO switch. In any case, the system is initially turned ON or OFF at the thermostat location, after which the space demand initiates the mode; heating at 68F and cooling at 78F.

Night/Weekend Set Back Sequence

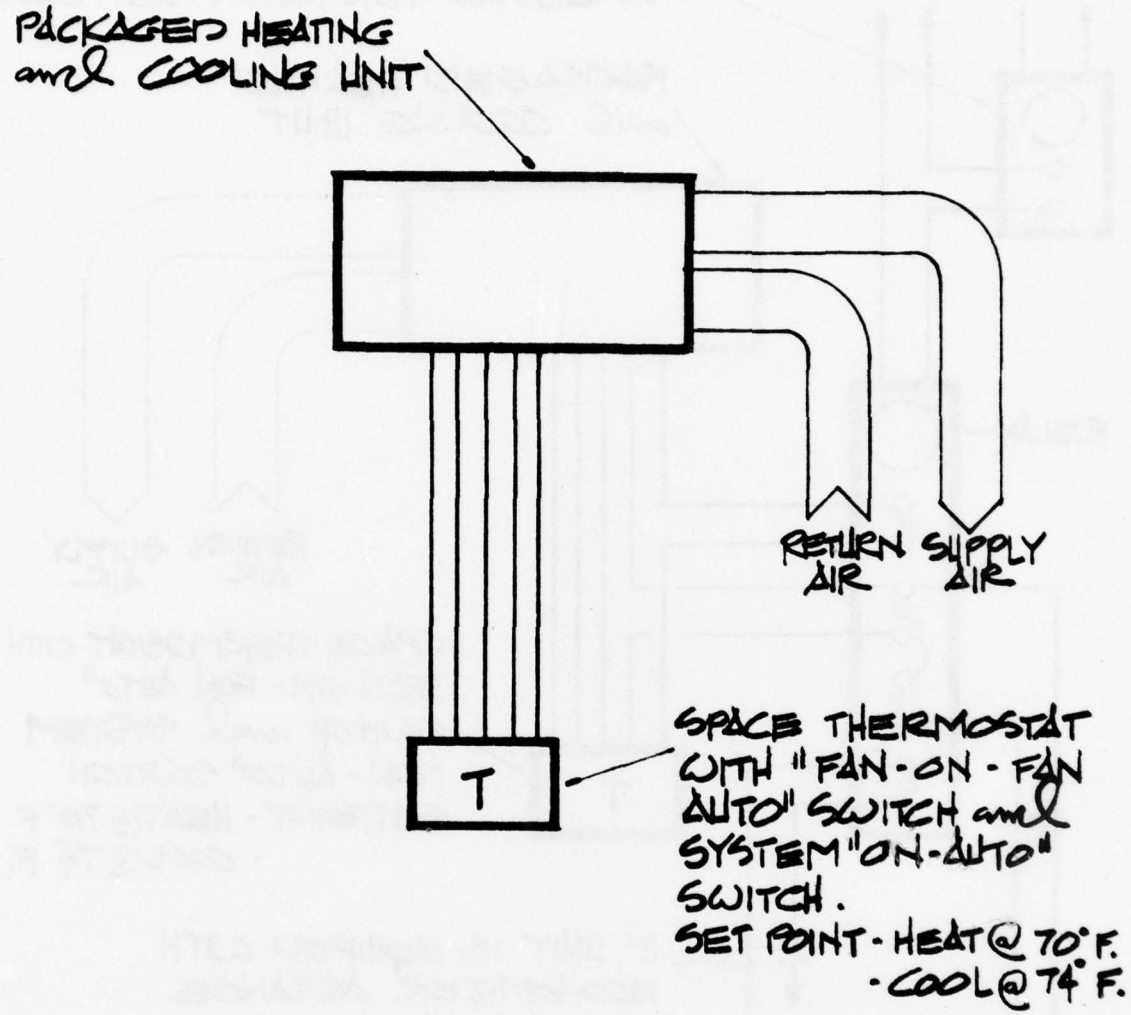
A time clock is used in conjunction with a multi-contact relay to accomplish the following:

a. De-energize the cooling mode regardless of existing thermostat setting.
b. De-energize the heating mode regardless of the existing thermostat setting.
c. Initiate a new thermostat circuit; a duct thermostat set in the return air duct and adjusted to a set point of 56F.

All of the above components can be conveniently placed adjacent to the HVAC equipment. It is imperative to review the manufacturer's wiring diagrams to ascertain the correct

terminal connections. The control diagrams shown herein are general only, but are sufficiently complete and correct to use as a guide.

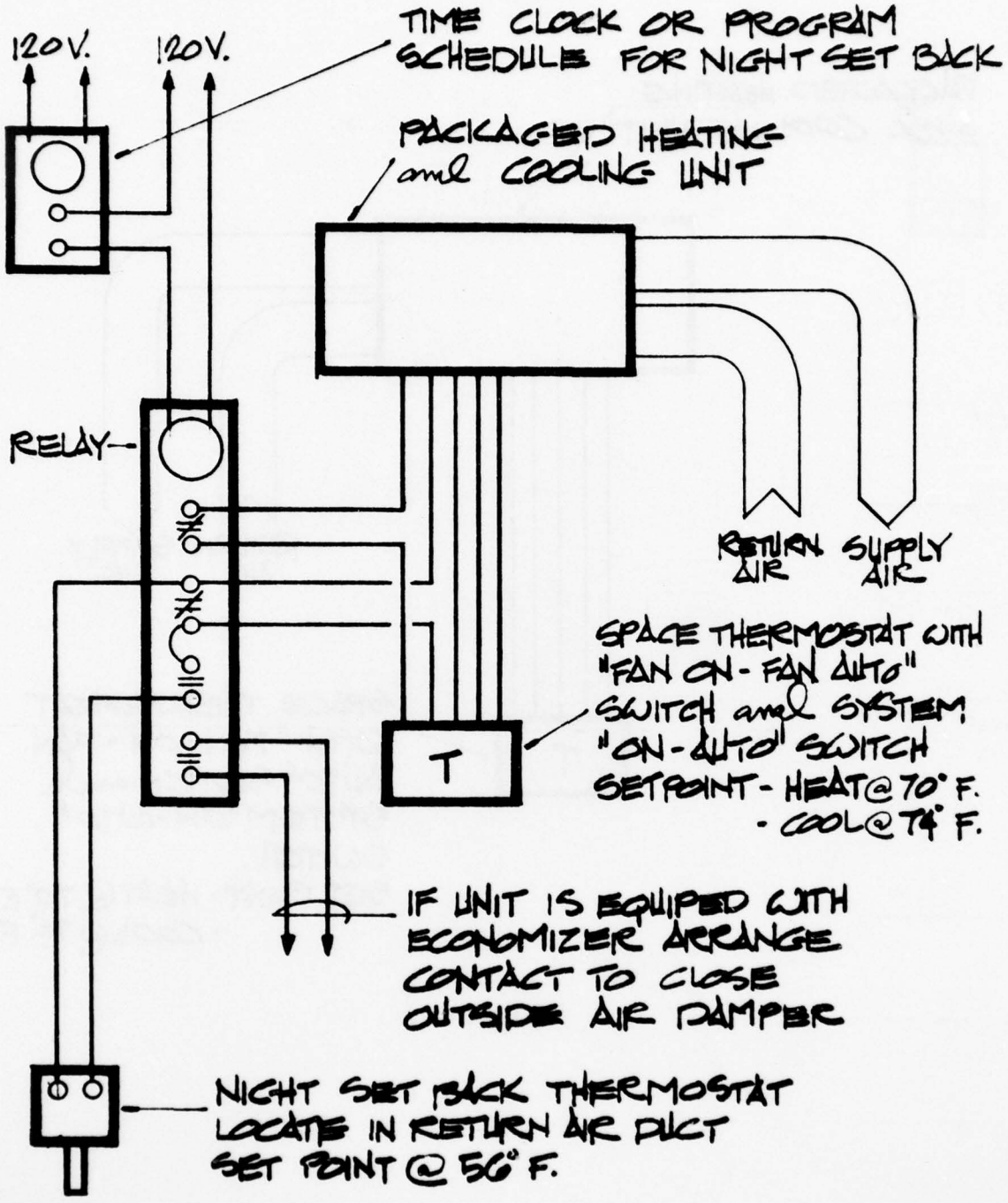
When the time clock initiates the normal mode, the system performs as described before. Upon initiating the night set back mode, the relay de-energizes the existing heating and cooling thermostat and switches to react with a new heating-only thermostat located in the return air duct. This thermostat is of the insertion bulb type with external adjustment.



GUIDE FOR NIGHT AND WEEKEND TEMPERATURE SET BACK

EXISTING CONTROL DIAGRAM

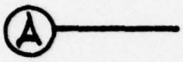
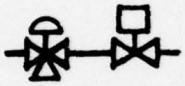
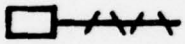
SYSTEM 7



GUIDE FOR NIGHT AND WEEKEND TEMPERATURE SET BACK

RETROFIT CONTROL DIAGRAM

SYSTEM 7

SYMBOL	ABBREVIATION	DESCRIPTION
	T.C.	Time Clock
	STAT	Space Thermostat
	A	Control Air Supply
	B	Night Set Back Control Air Supply
	V-	Control Valve
	D-	Control Damper
		Temperature Sensor
	HWS	Hot Water Supply
	HWR	Hot Water Return
	CWS	Chilled Water Supply
	CWR	Chilled Water Return

GUIDE FOR NIGHT AND WEEKEND TEMPERATURE SET BACK

LEGEND

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