NO. 2/2B ELECTRONIC SWITCHING SYSTEM
TELEPHONE EQUIPMENT BUILDINGS
MECHANICAL SYSTEM DESIGN GUIDE

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Figures

1. INTRODUCTION

1.01 This section serves as a guide for designers of mechanical systems for No. 2/2B Electronic Switching System (ESS) telephone equipment buildings. It provides recommendations on many aspects of mechanical system design — particularly in recognized areas where better quality or lower construction costs can be readily achieved.

1.02 Whenever this section is reissued, the reason(s) for reissue will be listed in this paragraph.

1.03 Basically, this section focuses on items where a considerable latitude of choice exists for the designer and attempts to narrow the choice to designs appropriate for the subject buildings, thereby assuring full advantages of modern material, equipment, and methods.

1.04 Although many recommendations within this section may be considered controversial, they are based on long years of satisfactory Operating Telephone Company (OTC) experience. Each OTC is expected to develop its own individual design guide, incorporating American Telephone and Telegraph Company (AT&T) recommendations, resulting in a more complete guide.

1.05 Air-conditioning requirements for No. 2/2B ESS equipment have been reduced drastically over the past several years. The original heat-release values have been cut virtually in half. The Building Energy Management and Redesign Retrofit (BEMARR) program has provided actual power usage (and, consequently, heat release) data for this equipment. Actual data suggests that air-conditioning systems for many No. 2/2B ESS buildings have been seriously overdesigned. This fact, along with revised operating conditions, now mandates a revised standard for mechanical systems that serve No. 2/2B ESS buildings.

2. SYSTEM SIZING

EQUIPMENT HEAT DISSIPATION

2.01 Recent comparisons of theoretical No. 2/2B ESS equipment heat dissipation, versus actual power consumption data, have indicated the use of excessive values for equipment heat dissipation in sizing air-conditioning equipment. Further study indicated several sources of heat dissipation information.

2.02 Heat dissipation information is available in the Telephone Office Planning and Engineering System (TOPES). Information is available on a per-frame basis (theoretical maximum values) or on a system basis (planning values based on measurements made of working offices). (See Fig. 1.) Both types of information are contained in Floor Plan Data Sheets (FPDSs) 820-600-150-6, Sheets 1 and 2. (See Section 800-020-021.)

2.03 Sheet 1, a summary sheet, lists theoretically maximum heat dissipation values for each particular frame of No. 2/2B ESS switching equipment. These values assume complete, maximum, "wide-open throttle" use of the frame, a condition that seldom, if ever, is realized when the frame is part of a working switching system. The TOPES data unit has in its data base a data sheet for each frame that gives the same theoretical maximum values of heat dissipation. Summing these theoretical maximum values on a frame-by-frame basis yields excessive numbers for equipment heat dissipation and leads to serious overdesign of the air-conditioning system.

2.04 Sheet 2 gives curves that plot heat dissipation as a function of the office capacity. These curves were plotted from data gathered by measuring the heat dissipated at more than 50 offices. Algorithms for these curves are contained in TOPES under the "Local" module of the "Plan" unit. The planning engineer or the equipment engineer will be able to provide the number of line trunk networks for different phases of office growth. Sheet 2 is also reproduced in Section 760-100-055, Space Planning for Medium-Sized Switching Offices.

2.05 Use the system curves (Sheet 2) or algorithms (TOPES Plan, Local) to obtain planning values for heat dissipated by the ESS equipment.

Note: These values do not include toll equipment, power equipment, lighting, or any building loads. The frame-by-frame values (Sheet 1 of TOPES Data) should be used to develop the required pattern of air distribution on a pro rata basis with the relative heat dissipation density throughout the switchroom.

2.06 Heat-dissipation values for toll terminal and power equipment should be calculated separately from current FPDS information. Since it is often difficult to obtain accurate estimates for toll terminal equipment, there has been a tendency to overstate the requirements "to be on the safe side." If heat dissipation from toll terminal equipment exceeds about 50 percent of that for switching equipment, it is recommended that the building engineer obtain a detailed estimate from the transmission engineer to justify equipment requirements.

2.07 The building engineer should play an active role in deciding whether to air condition or merely ventilate the power equipment (rectifiers, batteries, inverters, etc). An engineering study should be made for each location. The heat dissipated by this equipment is often a significant portion of the total heat dissipation, and its exclusion can result in greatly reduced air-conditioning requirements.

2.08 Total equipment heat dissipation should be tabulated in several installments: initial installation, 5-year growth requirements, and ultimate building capacity. ***Do not include heat-release figures for any equipment that cannot be shown as required by the long-range office forecast.***

2.09 Use of BEMARR survey data from comparable existing offices, as a check against planning values, is highly recommended. This data gives the engineer an excellent "ballpark" range for the expected heat-release values. This simple check can result in initial investment savings and prevent many serious operational problems of oversized air-conditioning systems.

EXTERIOR BUILDING ENVELOPE LOAD

2.10 Inside design conditions should be as recommended in Section 760-550-208. Outside design conditions should be taken from the 5 percent and 97-1/2 percent American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE) tables for both attended and nonattended buildings. The Building Insulation (INSUL) program in TOPES (or a similar type program) should be used to determine the optimum U-factor for the building envelope components.

2.11 Do not use safety factors when calculating the environmental load. Any minor effect on the building temperature, caused by temperature above outside-design conditions, can be tolerated by the telephone equipment.

2.12 Reduce outside air to minimum levels. Current BEMARR and ASHRAE 90/75 recommendations are for 5 cubic feet per minute (CFM) of outside air per person. Infiltration will more than supply the 5 CFM per person recommendation. The constant introduction of outside air on a set percentage basis of the total air quantity is not recommended. All outside air dampers should fit tight to minimize infiltration.

2.13 However, many local building codes require 10 percent of the circulated air to be outdoor air for a typical office building. In most locations, telephone equipment buildings fall within the office-building category. This 10 percent figure was established many years ago and is based upon an occupancy level of one person per 75 square feet of building and 7.5 CFM outside air per person. Obviously, No. 2/2B ESS building occupancy rates are much lower and this high rate of ventilation, therefore, is not required. If a building code requirement prevails, the following recommendations from Section 760-550-208 are appropriate for No. 2/2B ESS building:

(a) Each OTC should appeal for an exemption from any local ventilation code that requires 10 percent outside air or substantially more than the minimum amount required for people or continuously operated exhaust fans. (The minimum is 5 CFM per person.)

(b) Investigate the possibility of classifying air-conditioning systems as process cooling systems since they are employed to provide the appropriate environment for equipment. Some local codes and ordinances do allow significant reductions in outdoor air requirements when the apparatus is not designated for personnel comfort only.

SIZING RECOMMENDATIONS

2.14 Install refrigeration capacity to take care of the initial load plus the 5-year growth forecast, but install duct work for the ultimate full-building load during the initial construction project. Dampers or blanking devices should be installed to shut off air from initially vacant areas. Additional refrigeration should be added ***when required*** on a measured load basis. One way this can be accomplished is as follows:

(a) Build the cooling coil as a face-split 3-section cooling coil with each section sized for 5 tons. Each coil would have its own high-quality residential 5-ton condensing unit giving a total capacity of 15 tons in three 5-ton stages. Stage 1 should be the lowest coil section, stage 2 in the center, and stage 3 on top. Initially, the top coil section would be blanked off with sheet metal and its corresponding condensing unit would not be installed.

Note: Sizing is based on measured experience which shows the initial refrigeration requirements of these offices to be approximately 6-8 tons with an ultimate load of approximately 15 tons.

(b) The main air-handling unit fan would be sized for the ultimate air delivery required but its speed should be reduced by changing sheaves to properly balance the initial system load.

(c) This arrangement provides advantages of distinct 5-ton steps of capacity reduction, partial duplication for unit failure protection, maintenance simplicity, and low first cost. When additional capacity is required, the third condensing unit can be added and the controls reconnected either using a 3-stage cooling thermostat, or combining the first two units into one stage of cooling.

2.15 Use engineering judgment in the equipment sizing process. If, eg, the initial equipment load plus the 5-year growth requirement indicates a load of 10-1/2 tons, a total of 10 tons may well be economical for the initial installation. Keep in mind that equipment heat-release rates historically have grown less than predicted.

2.16 Barring an unusual amount of toll terminal equipment or extreme outside design conditions, a 10- to 15-ton system will adequately serve the initial plus 5-year growth requirements of any No. 2/2B ESS office.

3. SYSTEM SELECTION

LIFE-CYCLE COSTING

3.01 Life-cycle costing is a process that takes first cost, operating costs, maintenance costs, and life expectancy into account for various alternative systems and compares the systems on a present-worth basis. When various systems are being considered to provide the equipment cooling function, evaluate the systems using a life-cycle cost analysis.

LOAD MATCHING

3.02 It is important to analyze alternative systems in the appropriate size range of the required cooling capacity. For example, a chilled water system can be engineered and installed to serve this application. However, in most locations, the chilled water system does not prove economical on a life-cycle cost basis until a cooling tower can be used in lieu of air-cooled condensers. This breakpoint normally occurs in the 80- through 100-ton range, which is far in excess of the air-conditioning load requirements for this application. Therefore, although a chilled water system could be used to cool a No. 2/2B ESS office, generally it would not be economical or practical.

3.03 It is also important to understand the load. The BEMARR studies reveal that No. 2/2B ESS telephone equipment power consumption is virtually constant day and night — unlike busy-hour figures from earlier vintage equipment. This constant load characteristic opposes the benefits obtained from a Variable-Air-Volume (VAV) system. Fan cycling is recommended and this will also severely restrict any VAV savings potential. While highly advantageous in other applications, VAV systems are not recommended for No. 2/2B ESS applications.

3.04 The ESS equipment produces a relatively uniform heat-dissipation load. Heat-dissipation densities of various areas within the switchroom stay relatively in the same proportions through the growth stages of the office. Experience shows that proper air balancing can adequately compensate for any "hot spot" locations.

Example: More air should be supplied to the processor area than to the mainframe area. Also, on a daily basis, heat dissipation for all areas within the switchroom varies in the same manner with respect to time. Peak heat dissipation of the processor will occur at the same time as peak heat dissipation of the remaining switching equipment. This process allows the equipment room to be treated as a single zone with air distribution designed on a pro rata basis. For these reasons, single-zone systems are recommended; conversely, multizone systems are not recommended.

SYSTEM DUPLICATION

3.05 The results of heat-stress tests made in working No. 2/2B ESS offices indicate that maximum temperature limits are in little danger of being met or exceeded. Equipment Cooling states that no emergency power will be required to power the air-handling or refrigeration units where the average equipment heat dissipation is less than 10 watts per square foot. No. 2/2B ESS equipment falls in this category.

3.06 Do not include the air-handling unit fan motor horsepower in sizing the standby generator. However, if there is extra generator capacity available ie, 60 kilowatt (KW) generator with a 50-KW load, it is recommended that the fan be placed on the generator.

Note: The latter described control sequence includes wide band temperature operation with fan cycling.

3.07 The previous recommendation that the total air capacity be handled by two separate fans, each sized for 50 percent of the total capacity, is hereby rescinded. Any common operational problem such as belts, pulleys, motors, or even fan shaft bearings can be corrected without causing the space ambient to exceed the short-term room maximum temperature of 120°F.

SYSTEM SELECTION RECOMMENDATIONS

3.08 The use of direct expansion, air-cooled, split system, package-type equipment is recommended. This type system consistently beats the alternatives in this size range using a life-cycle cost analysis. An acceptable alternative would be self-contained unit(s) — again, direct expansion, air-cooled type. This type of equipment is available from several major manufacturers in the required size range.

HEATING

3.09 The need for a heating plant should be carefully evaluated. A permanent heating plant should be provided only as required to maintain the minimum occupied temperature (65°F) on a design heating day (ASHRAE 97-1/2 percent) at the ultimate, full-building condition. Supplemental heating capacity required for the equipment installation period — or until the equipment heat release reaches ultimate capacity — should be in the form of wall-mounted electric unit heaters powered from spare circuit breakers in the main electrical panel. This arrangement allows for easy removal of the unit in the future.

Note: Remove these heaters when no longer required and reuse at another location. All temporary heaters should be controlled by a dual-set point thermostat with a 2-hour manual timer override switch to change from unoccupied to occupied settings.

4. CONTROLS

ECONOMIZER CYCLE

4.01 The use of outside air, dry bulb, economizer cycle cooling is recommended for its energy-saving performance. The additional savings potential from an enthalpy system should be carefully weighed against the calibration problems and increased maintenance requirements of that system and each case evaluated on its own merit. (Refer to Section 760-550-210* for a comparative analysis of various types of economy cooling cycles.)

Note: Use of an economizer cycle allows the mechanical refrigeration equipment to be locked out below 55°F; therefore, there is no need to specify low ambient temperature protection for the refrigeration system.

*Check Divisional Index 760 for availability.

CONTROL OPERATION

A. General

4.02 Refer to Fig. 2. Provide a complete system of pneumatic, electronic, or electric automatic controls to effect the Heating, Ventilating, Air-Conditioning (HVAC) operation as hereinafter described.

4.03 Provide a 7-day time clock to index the heating control for occupied and unoccupied conditions. T_{H1} shall control during occupied hours; T_{H2} shall control during unoccupied hours. Provide a 2-hour manual timer override switch to change from unoccupied to occupied settings.

4.04 Provide a freeze stat in the mixed air to stop the fan when mixed air temperature falls below 40°F. Follow this procedure only when water is used in the system, ie, hot water, steam, or a water spray humidifier.

B. Alarm Conditions

4.05 The following building alarm conditions will open monitored alarm circuits that are transmitted to a constantly attended location, such as the Switching Control Center (SCC) and the Building Operations Control Center (BOCC):

(a) ***Low Space Temperature at 50°F–A_{TL}:*** Locate this alarm sensing point adjacent to heating thermostats T_{H1} and T_{H2}.

(b) ***High Space Temperature at 85°F–A_{TH}:*** Locate this alarm sensing point adjacent to mechanical cooling thermostat T_C.

(c) ***High Space Relative Humidity at 60 Percent RH–A_{HH}:*** Locate this sensing point adjacent to humidistat H_H.

(d) ***Low Space Relative Humidity at 20 Percent RH–A_{HL}:*** Locate this sensing point adjacent to humidistat H_L.

(e) ***Fire Detection:*** Fire detection controls, as described in Section 760-640-100, shall stop the fan system when their set points are exceeded. The fan shall also stop when the early warning fire detection system, covering the building area served by the fan system, is activated.

C. Interlocks

4.06 Observe the following interlock conditions:

(a) Mechanical refrigeration and mechanical heating shall not be allowed to operate simultaneously.

(b) Humidifier, mechanical heating, and mechanical refrigeration shall be inoperative when the supply air fan motor is not running.

(c) All exhaust fans shall be interlocked with supply air fan. This does not include the toilet room exhaust fan which should be interlocked with the toilet room lighting fixture.

(d) Humidifier and mechanical refrigeration shall not be allowed to operate simultaneously. (This item would not apply to arid areas such as the southwest.)

D. Cooling

4.07 The following cooling conditions apply when outside air temperature is below the set point of thermostat T_O. For many areas of the country, the changeover temperature can be set at 65°F or even higher.

(a) On a rise in space temperature, above the set point of T_V, the supply air fan shall start; mixed air thermostat T_M with an averaging sensing element set at 55°F (adjustable) located in the mixed air will modulate the outside, relief, and return air dampers to maintain its setting. On a drop in space temperature, below the set point of T_V, the supply air fan shall stop and the dampers shall return to their normal positions.

(b) On a continued rise in space temperature, above the first and second stage set points of thermostat T_C, the refrigerant solenoid valves shall operate in sequence.

(1) When the first solenoid valve opens, a low-pressure switch shall start the condenser fans which shall allow the compressor to start through an interlock in the fan starter.

(2) The second stage of the thermostat shall open the second solenoid valve.

(c) On a rise in space, relative humidity above the set point of space humidistat H_H, the outside and relief air dampers shall close, the return air damper shall open, and the supply air fan shall stop. A rise in space temperature, above the first stage point of thermostat T_C, will start the supply air fan and energize the refrigeration machine as described above. The refrigeration machine shall operate to maintain the set points of thermostat T_C. On a drop in space, relative humidity below the set point of space humidistat H_H, the refrigeration machine and the fan shall cycle off together and the system shall be indexed to its normal position.

(d) On a drop in space, relative humidity, below the set point of space humidistat H_L, the supply air fan shall start and space humidistat H_L shall control a 2-position water valve to the humidifier. When the space relative humidity rises above the set point of H_L, the supply air fan and the humidifier shall cycle off together.

4.08 The following cooling conditions apply when outside air temperature is above the set point of thermostat T_o:

(a) All dampers shall be in their normal positions.

(b) On a rise in space temperature, above the first stage set point of thermostat T_C, the supply air fan shall start and T_C shall control the refrigerant solenoid valves in sequence. When the first solenoid valve opens, a low-pressure switch shall start the condenser fans which shall allow the compressor to start through an interlock in the fan starter. The second stage of the thermostat shall open the second solenoid valve. Humidity addition and 100 percent outside air cycles shall be inoperative.

(c) On a drop in space temperature, the reverse action shall occur.

E. Heating

4.09 For the heating plant which is integral with the air-handling unit, the following sequence should be followed:

- On a drop in space temperature, below the set point of thermostat T_{H1} or T_{H2}, as determined by the 7-day time clock, the supply fan shall start and the heating plant shall be energized to maintain the thermostat set point. When the thermostat is satisfied, the heating plant and fan cycle off together.

4.10 Space-mounted heaters shall be controlled by dual-set point thermostats which are indexed by the 7-day time clock.

F. Humidification

4.11 On a drop in space, relative humidity, below the set point of humidistat H_L, the supply fan shall start and the space humidistat H_L shall control a 2-position water valve to the humidifier. When the space relative humidity rises above the set point of H_L, the supply air fan and the humidifier shall cycle off together.

G. Inspection and Acceptance

4.12 At the time of final inspection, the contractor should be required to sequence the HVAC equipment to prove the control operation. The set point of instruments will need to be adjusted to do this, eg, raising the heating thermostat set point to prove the operation of the heater. Building operations personnel should be present to witness the inspection, resetting, and locking of all control instruments.

5. AIR FILTRATION

COST STUDY

5.01 The air filtration system in the No. 2/2B ESS office offers the designer a significant variation in filtration effectiveness and cost. Although building operations personnel can reduce their labor costs if a filter is specified which, because of its higher dust-holding capacity can be changed less frequently, the building engineer should determine whether the reduced maintenance expense can justify the higher initial cost.

5.02 Section 760-230-110 contains complete information on the various types and efficiencies of filters and should be used as a reference.

RECOMMENDATIONS

5.03 Use one thickness of the KS-7406 filter (or equivalent) unless local atmospheric conditions can justify the use of a more efficient system.

6. DUCT DESIGN

6.01 Duct design standards for earlier vintage equipment buildings were greatly influenced by the tight clearances between the telephone equipment cabling and support and the room ceiling structure. This space, often less than 12 inches high, led to the use of large aspect ratio duct and to the development of space conserving joint details.

6.02 New Equipment Building System (NEBS) standards allow more space for building systems which allow the use of more conventional, less costly design.

GAUGES, DETAILS, REINFORCEMENTS

6.03 All ducts should be galvanized steel sheet metal. The standards to be followed in specifying sheet metal duct work are found in *Low Pressure Duct Construction Standards* by SMACNA. Aspect ratios should be in the range of 1.0 to 1.5 to minimize the amount of sheet metal fabricated.

INSULATION

6.04 Duct insulation is not required where duct work is exposed within the conditioned space. All supply ducts not in the conditioned space should be insulated to a minimum resistance value of R-5 with fiberglass duct insulation or equivalent. All insulation should be applied to the exterior surface of the sheet metal duct and should have an exterior vapor barrier.

SIZING

6.05 Size duct work based on the equal friction method. The friction factor should be between 0.05- and 0.1-inch water per 100 equivalent feet of duct. In all cases, the total system static pressure should not exceed 1-1/2 inches of water (including duct, diffusers, dirty filters, wet coils, etc).

7. HEATING, VENTILATING, AIR-CONDITIONING (HVAC) LOAD CALCULATIONS

7.01 The outside design conditions are as follows:

Summer	88°F db,	70°wb (5% column)
Winter	5°F db	(97.5% column)

7.02 The inside design conditions are as follows:

Cooling:	80°F, 50% RH
Heating:	65°F, 20% RH

7.03 The telephone equipment heat release numbers are as follows:

	INITIAL	5 YEAR	ULTIMATE
Number of Equipped Lines & Trunks	11,000	14,500	20,000
Switching Equipment (Watts)	7,258	8,525	10,426
Power Equipment (Watts)	2,818	3,646	4,474
Toll Equipment (Watts)	0	4,160	14,230
Total (Watts	10,076	16,331	29,130
Total (BTU/Hr)	34,400	55,700	99,300

A. Building "U" Factors

7.04 The INSUL program in TOPES can be used to determine the optimum overall building U-factor. Figures 4, 5, and 6 show the energy curves for the three growth stages of the office. Based on these charts, an overall building U-factor of 0.10 was selected. This is obtained by a wall U-factor of 0.06 and a roof U-factor of 0.13.

B. Outside Air

7.05 Assume an infiltration rate of 1/4 air change per hour which more than satisfies the BEMARR recommended 5 CFM/person. No additional outside air load will be used in the design.

7.06 Safety factor is 0 percent.

7.07 The cooling load recap is as follows:

Building Envelope	
Wall Load (Total)	2,600 BTUH
Roof Load	12,500
Door Load	200
Outside Air (Infiltration)	1,700
People	600
Motor Heat (7 1/2 Hp)	19,100
Misc Lights (1 KW)	3,400
Total Sensible Load	40,100 BTUH
Total Latent Load	1,900
Total Environmental Load	42,000 BTUH

	INITIAL	5 YEAR	ULTIMATE
Telephone Heat Release	34,400 BTUH	55,700 BTUH	99,300 BTUH
Environmental Load	42,000	42,000	42,000
Total Building Load	76,400 BTUH	97,700 BTUH	141,300 BTUH
Sensible Heat Factor	98%	98%	99%

7.08 The heating load recap is as follows:

Wall Load	11,400 BTUH
Roof Load	30,000
Door Load	1,800
Outside Air (Infiltration)	13,000
Perimeter Floor Loss	2,400
Total Heat Loss	58,600 BTUH

C. Equipment Selection

7.09 The refrigeration plant should be selected to serve the 97,700 BTUH load and be expandable to a capacity of 141,300 BTUH. The previously described system of 3-5 ton units (with the top coil initially blanked off) is appropriate for this load. In roughly 5 years, if the anticipated telephone equipment heat release materializes, the initial installation will be handling its maximum sensible heat capacity. At that time, the third condensing unit should be added as mentioned earlier.

7.10 The air handling unit and duct work should be capable of handling the ultimate load or, assuming a 20° ΔT, about 6400 CFM. However, the fan should initially be slowed down to supply only about 4500 CFM.

7.11 The air supply pattern should be sized in relation to the relative "per frame" heat release values. See Fig. 7 for frame-by-frame heat release and Fig. 3 for a single line duct layout.

7.12 Since the ultimate equipment heat gain exceeds the building heat loss, no permanent heating plant should be provided. A temporary system of electric unit heaters should be provided to supply a maximum of 17-1/2 KW. This will be enough heat to keep the empty building at 65°F on a design heating day.

D. Humidification

7.13 The mixed air condition will be approximately as follows on a design heating day:

$$\frac{(6200)(65)+(200)(5)}{6400} = 63°F$$

$$\frac{(6200)(18)+(200)(0)}{6400} = 17 \text{ gr/lb}$$

7.14 A water spray humidifier should be sized as follows:

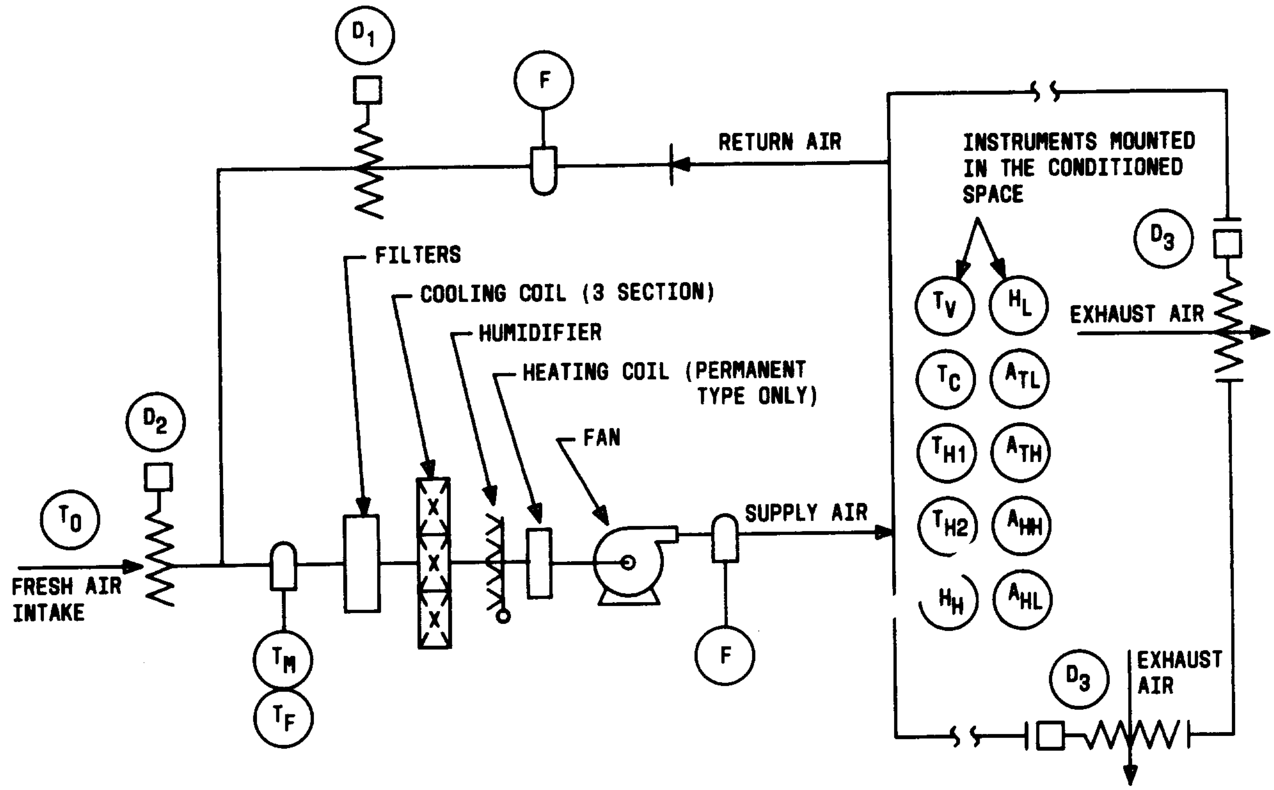
$$\frac{6400 \text{ CFM}}{1 \text{ grain/pound} \times 13.33 \text{ CF/ pound}} = 480 \text{ gr/min}$$

$$\frac{480 \times 60}{7000} = 4 \text{ pounds water/hour}$$

GUIDE		1981	1986	2001
INPUT DATA	ULTIMATE WORKING LINES	24000.	24000.	24000.
	WORKING LINES	11000.	14500.	20000.
	LINE FILL FACTOR	95.	95.	95.
	LINE CONC RATIO	4:1	4:1	4:1
	LINES E/W LRE	0.	0.	0.
SPACE REQUIREMENTS (SQ FT)	NETWORK (FERREED)	1160.	1570.	2080.
	NETWORK (REMREED)	800.	1090.	1420.
	MDF (HIGH DENSITY BLOCK)	616.	616.	616.
	MDF (STANDARD BLOCKS)	896.	896.	896.
	PROCESSOR AREA (ESS2PROC)	600.	0.	0.
	PROCESSOR AREA (ESS2BPRO)	400.	400.	400.
OVERALL LIST 1 CURRENT DRAINS (AMPS)	24VOLT MIN (ESS2PROC)	120.	0.	0.
	24VOLT MAX (ESS2PROC)	180.	0.	0.
	-24VOLT MIN (ESS2PROC)	100.	0.	0.
	-48VOLT MAX (ESS2PROC)	160.	0.	0.
	24VOLT AVG (ESS2PROC)	128.	154.	193.
	-48VOLT AVG (ESS2BPRO)	125.	145.	175.
OVERALL HEAT DISSIPATION	WATTS MIN (ESS2PROC)	7675.	0.	0.
	BTU/HP	26203.	0.	0.
	REFRIGERATION (TONS)	2.18	0.00	0.00
	WATTS MAX (ESS2PROC)	11995.	0.	0.
	BTU/HR	40952.	0.	0.
	REFRIGERATION (TONS)	3.41	0.00	0.00
	WATTS AVG (ESS2BPPO)	7258.	8525.	10426.
	BTU/HR	24777.	29104.	35593.
	REFRIGERATION (TONS)	2.06	2.43	2.97

Fig. 1—ESS 2/2B Planning Data Summary

HVAC CONTROL SCHEMATIC



- D_1 — RETURN AIR DAMPER - NORMALLY OPEN
- D_2 — OUTSIDE AIR DAMPER - NORMALLY CLOSED
- D_3 — RELIEF AIR DAMPER - NORMALLY CLOSED
- T_0 — OUTSIDE AIR CHANGEOVER - ADJUSTABLE SETTING BY LOCATION
- T_V — NATURAL COOLING (100% OA) - SET @ 78°F
- T_C — MECHANICAL COOLING - STAGE 1 - SET @ 80°F; MECHANICAL COOLING - STAGE 2 - SET @ 80°F
- T_{H1} — MECHANICAL HEATING - OCCUPIED - SET @ 65°F
- T_{H2} — MECHANICAL HEATING - UNOCCUPIED - SET @ 55°F
- H_H — HIGH HUMIDISTAT - SET @ 55% RH
- H_L — LOW HUMIDISTAT - SET @ 25% RH
- T_M — MIXED AIR, SET @ 55F
- T_F — FREEZE 'STAT - SET @ 40°F
- F — FIRE DETECTION
- A_{TL} — ALARM - LOW TEMPERATURE @ 50°F
- A_{TH} — ALARM - HIGH TEMPERATURE @ 85°F
- A_{HH} — ALARM - HIGH HUMIDITY @ 60% RH
- A_{HL} — ALARM - LOW HUMIDITY @ 20% RH

Fig. 2— HVAC Control Schematic

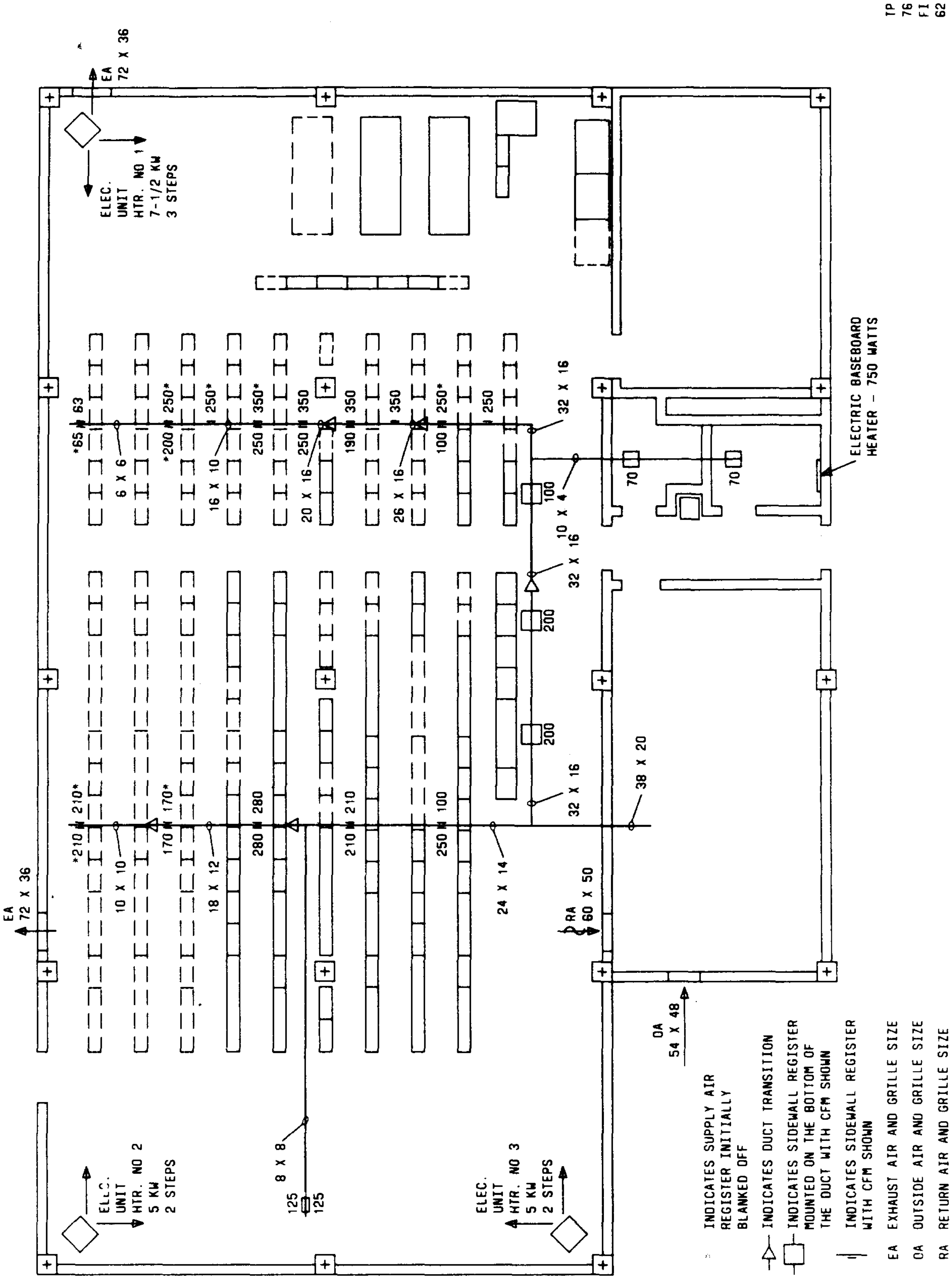


Fig. 3—Air Distribution Layout

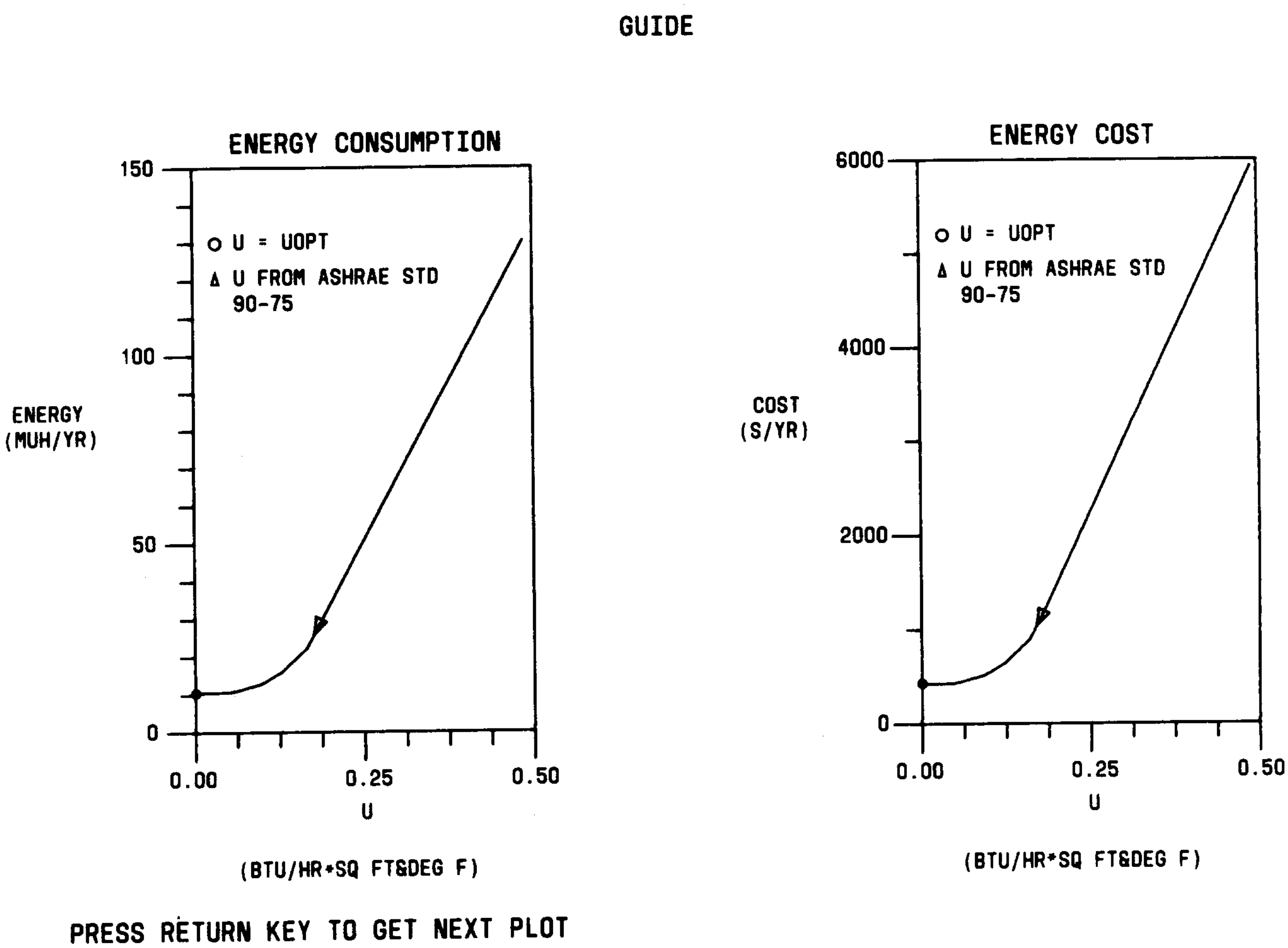


Fig. 4—Energy Curve for Growth Stage 1

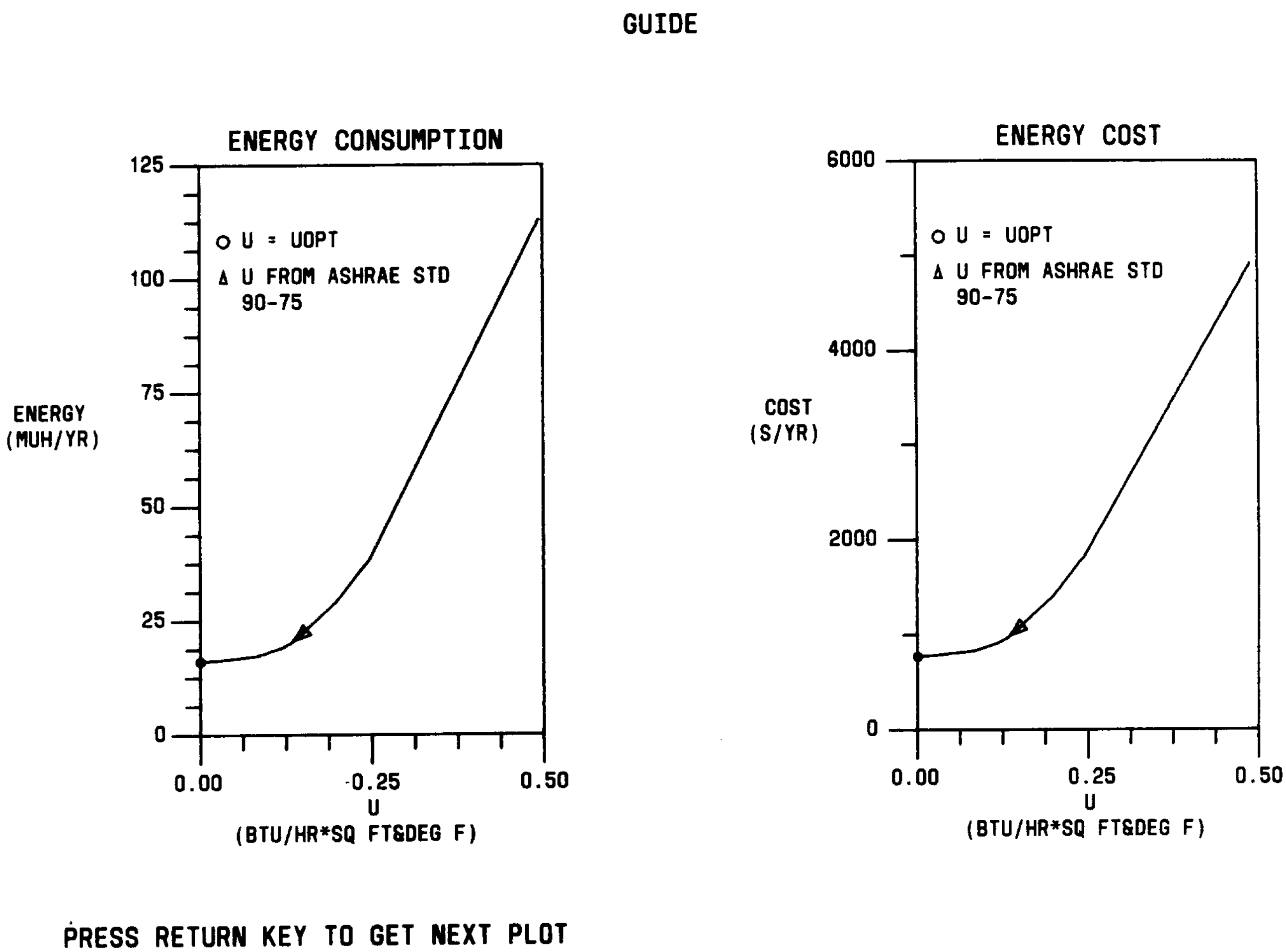
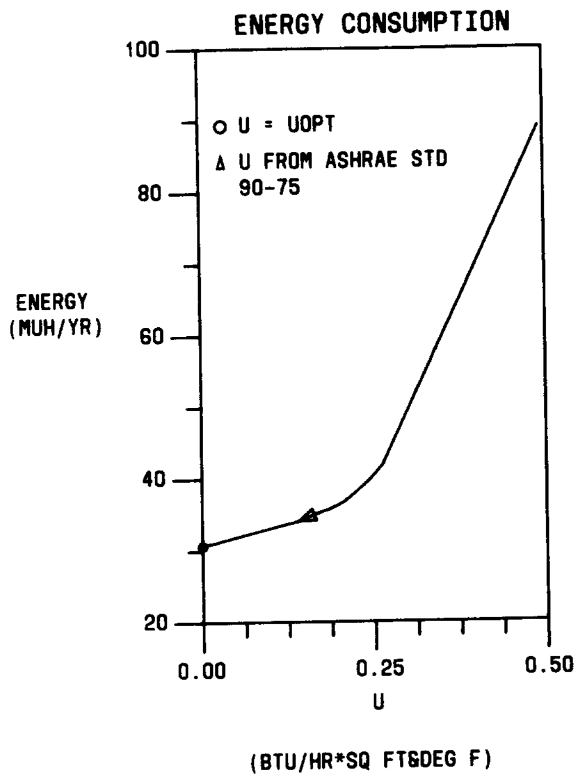
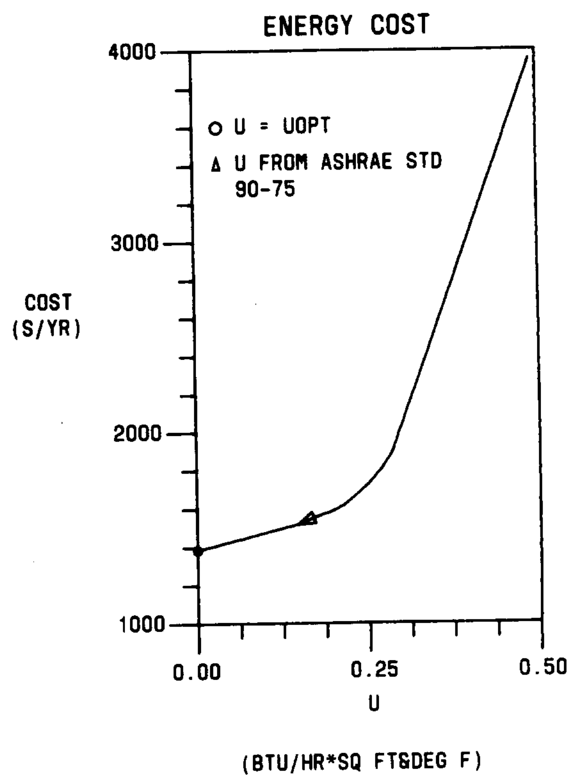


Fig. 5—Energy Curve for Growth Stage 2

GUIDE





PRESS RETURN KEY TO GET NEXT PLOT

Fig. 6—Energy Curve for Growth Stage 3

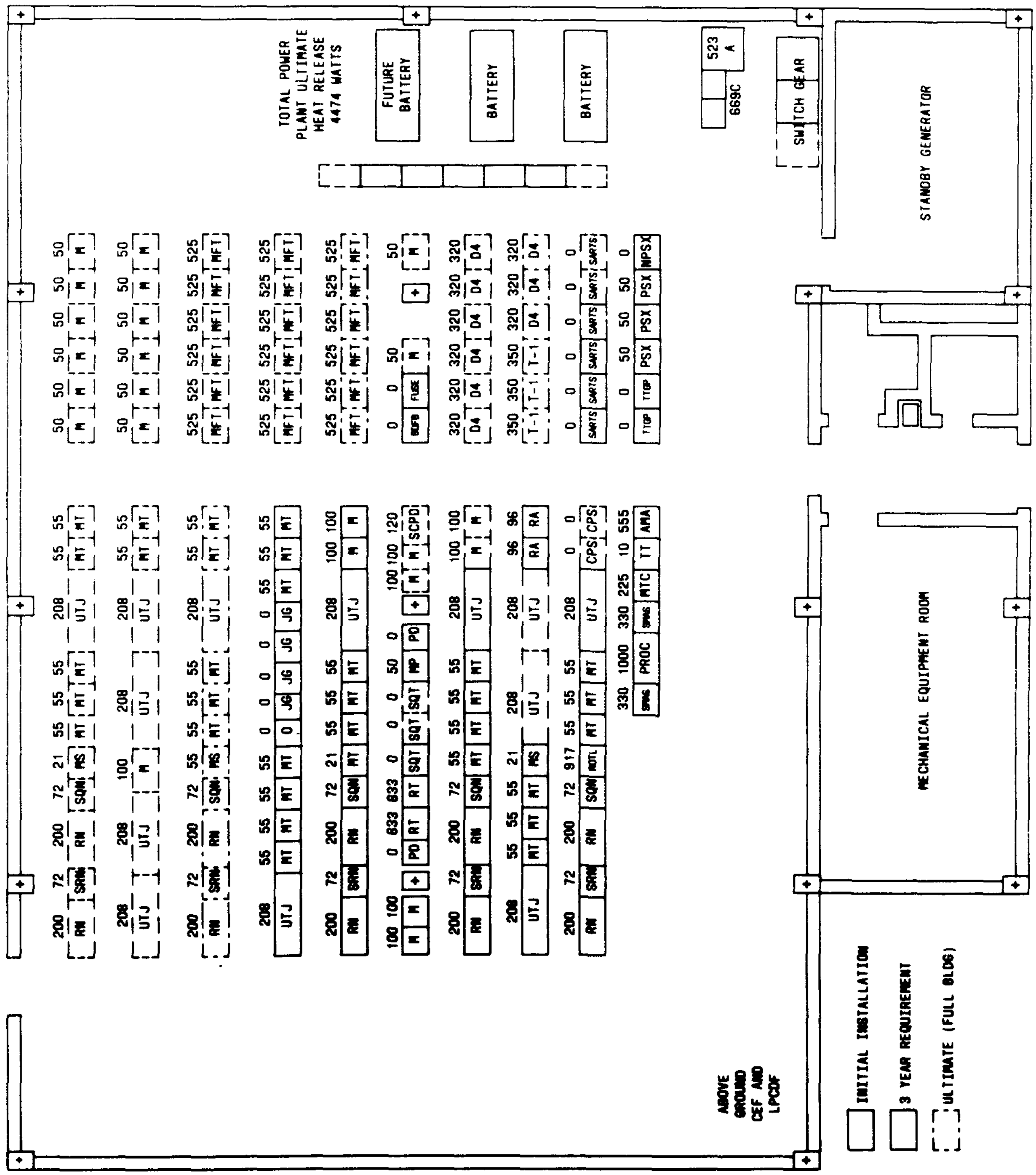


Fig. 7 — Frame-By-Frame Heat Release