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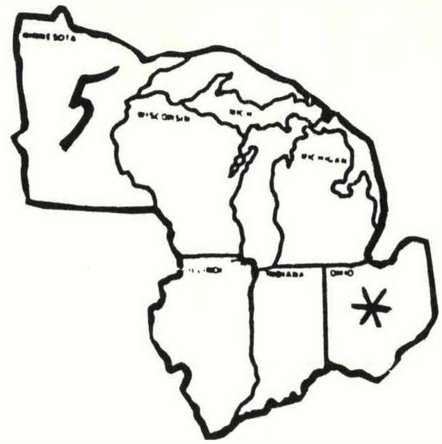


PUBLIC SCHOOLS

ENERGY CONSERVATION

MEASURES

Report Number 5

FAIRMOOR ELEMENTARY SCHOOL

Columbus, Ohio

JCOX ASSOCIATES



Prepared For The

FEDERAL ENERGY ADMINISTRATION

By

AMERICAN ASSOCIATION OF SCHOOL ADMINISTRATORS

Contract CR - 04 -60711 - 00

The views and conclusions contained in the document are those of the authors, and should not be interpreted necessarily representing the official policies of the U. S. Government.

January 24, 1977

# MANAGEMENT SUMMARY

## Fairmoor Elementary School

## Columbus, Ohio

A thorough and comprehensive engineering analysis of ten representative elementary schools across the nation was undertaken to identify cost-effective energy conserving opportunities. The reports of these studies are designed to provide school administrators, engineers, architects, and associated technical personnel with indicators of potential energy savers in similar buildings. The following information is a summary of one of these ten reports.

Fairmoor is representative of a late 40's multi-story building with a single story 50's addition located in a 3,000-6,000 degree day climate.

## BUILDING CHARACTERISTICS

<u>Size:</u>

42,765 sq.ft.
22 classrooms, library, multipurpose, cafeteria, serving kitchen and administration areas.

<u>Occupancy:</u>

475 students, K-6; 30 staff
School day: 8:45 a.m. to 3:15 p.m.
School year: Early Sept.-mid-June
After hrs: minimal

<u>Construction:</u>

Original structure (1949) 23,500 sq.ft., 3 story.
- Wall: 4" brick face on 8" concrete block. 28% glass N/S facing
- Roof: new (3 yr) 2.5" insulating board on steel deck

Addition (1955) 19,200 sq.ft. single story
- Wall: 4" brick face on 12" concrete block. 58% glass E/W facing
- Roof: built up on 2½" Tectum panels, no ceiling

<u>Heating, ventilating:</u>

Unit ventilators in all classrooms; original section--steam; addition--hot water
Heating: 2 gas fired boilers (converted from coal)

<u>Illumination:</u>

Fluorescent throughout school; approximately 1.86 watts/sq.ft.
Multipurpose room has (18) mercury vapor lamps and (4) 200 watt incandescent fixtures
Security lighting, 4 KW

Energy Consumption and Cost:

| Gas | | | | | Electricity | |
|---|---|---|---|---|---|---|
| Year | Therms | Th/sq.ft. | DD | Th/DD | KWR | KWR/sq.ft. |
| 1973-4 | 63,318 | 1.5 | 4,892 | 13.4 | 154,160 | 3.7 |
| 1974-5 | 72,024 | 1.7 | 5,284 | 13.6 | 148,440 | 3.5 |
| 1975-6 | 54,786 | 1.3 | -- | -- | 151,480 | 3.5 |
| Cost: | $0.165/Therm (11/76) | | | | --- | $0.05/KWR |

ENERGY CONSERVING RECOMMENDATION

The following recommendations are made for an existing building with the characteristics described above. They offer guidelines for analyzing buildings with similar characteristics; however, suggested energy conserving opportunities must be weighed in terms of the fuel used, its cost and associated savings as well as capital expenditure considerations. While it is not the primary intent of this report to address new construction concerns, the findings do have implications for such work.

Only ECOs that were found to be cost-effective are recommended. "Cost-effective" is defined as recovering the capital investment in 12 years or less from the anticipated energy saved. The following ECOs were recommended at Fairmoor:

- Improve boiler efficiency to 80% and shut down unit ventilators in unoccupied summer months
  --replace burners with new units
  --reduce size of flue
  --install new boiler controls to fire on demand

- Make night set back system operational
  --install time clock to shut unit ventilators, close dampers, stop exhaust fans

- Adjust unit ventilators to reduce outside air intake
  --air balance; upgrade controls

SUMMARY TABLE: Recommended Energy Conserving Measures at Fairmoor Elementary School, Columbus, Ohio

| ECOs | Estimated Cost | Recovery Rate |
|---|---|---|
| 1. Unit ventilator unoccupied shut down | $0.00 | immediate ($844 1st yr.) |
| 2. Improve boiler efficiency | 10,000 | 4 yrs. |
| 3. Night setback | 8,500 | under 3 yrs. |
| 4. Adjust unit ventilators to reduce outside air | 7,200 | under 4 yrs. |
| ALL RECOMMENDATIONS: | $25,700 | under 3 yrs. |

## OTHER CONSIDERATIONS

The above recommendations and calculations were based on $.165/Therm escalated at 10% per annum with 4% interest. As the cost of fuel exceeds this rate, other ECOs may become cost-effective and should be reviewed. Any reconsideration should not view adjusted energy and dollar savings in isolation; materials, labor, interest rates, etc. must also be assessed. The following ECOs may warrant review:

- double glazing all windows
- insulate addition roof
- add double doors
- reduce glass

Finally, it should be noted that in a free market availability is reflected in cost. However, natural gas has not had such a history. As long as fuel costs or supplies are in any way regulated, actual fuel availability should be part of retrofit considerations. The availability may transcend the cost-effective characteristics of a modification.

# PREFACE

The plight of the public schools in the face of rapidly depleting energy resources and escalating energy costs has been a matter of concern to the Federal Energy Administration (FEA) and other government agencies, as well as organizations such as the American Association of School Administrators (AASA). Reports have been published outlining the problems of energy usage in public schools, its impact on school budgets and possible ways to reduce energy consumption in existing buildings. More substantive information is needed to assist school administrators and federal energy/education decision makers in identifying specific cost-effective remedies to existing school buildings.

The schools of America consume eleven percent of the space heating/cooling energy. Over fifty percent of the schools now in use were built in the post World War II "baby boom" when first cost was far more important than energy efficient buildings. A recent FEA report revealed that energy costs to the schools increased 48.3% in a two year period (1972-73 to 1974-75). The continued escalation of energy costs coupled with energy inefficient buildings and exacerbated by general inflation has created a critical problem for the schools.

Since it has been estimated that nearly fifty percent of the space heating/cooling energy consumed by the schools is wasted, it is also a grave problem for our nation. The 1975 Congressional report on energy noted that the most economical, accessible way to "gain" fuel reserves is to reduce consumption.

School people want to reduce this waste and unnecessary expenditure. The development and dissemination of information which will enable school administrators to identify and analyze energy conserving opportunities in existing buildings is badly needed. It is critical that school people have access to the options available to meet identified energy needs, their respective costs, and the associated energy savings.

In order to provide such guidelines and to demonstrate the desirability of retrofitting existing school buildings, AASA initiated the project Saving Schoolhouse Energy. The emphasis in this study was placed on the cost effectiveness of capital modifications utilizing "off-the-shelf-hardware." The project was designed in five phases: (1) select ten elementary school buildings and analyze their energy conserving opportunities; (2) undertake needed architectural or engineering design work; (3) install or construct recommended modifications; (4) monitor and record post-modification energy use; and (5) disseminate the findings.

Phase 1, selection of the ten demonstration sites and an engineering analysis of energy conserving opportunities for each, was funded by the Federal Energy Administration.[1] This report for Fairmoor Elementary School in Columbus, Ohio, represents the culmination of Phase 1 for one of these sites and is one of ten (10) such reports. The map on page iv depicts its geographic and climate location. Other sites in the study were Harold C. Scott Elementary School, Warwick, Rhode Island; Central Elementary School, Glen Rock, New Jersey; Samuel Everitt Elementary School, Langhorne, Pennsylvania; Hindman Elementary School, Hindman, Kentucky; P. F. Brown Elementary School, Lubbock, Texas; Eastridge Elementary School, Lincoln, Nebraska; Garfield Elementary School, Sioux Falls, South Dakota; Plover Whiting Elementary School, Stevens Point, Wisconsin; Washington Elementary School, Kennewick, Washington.

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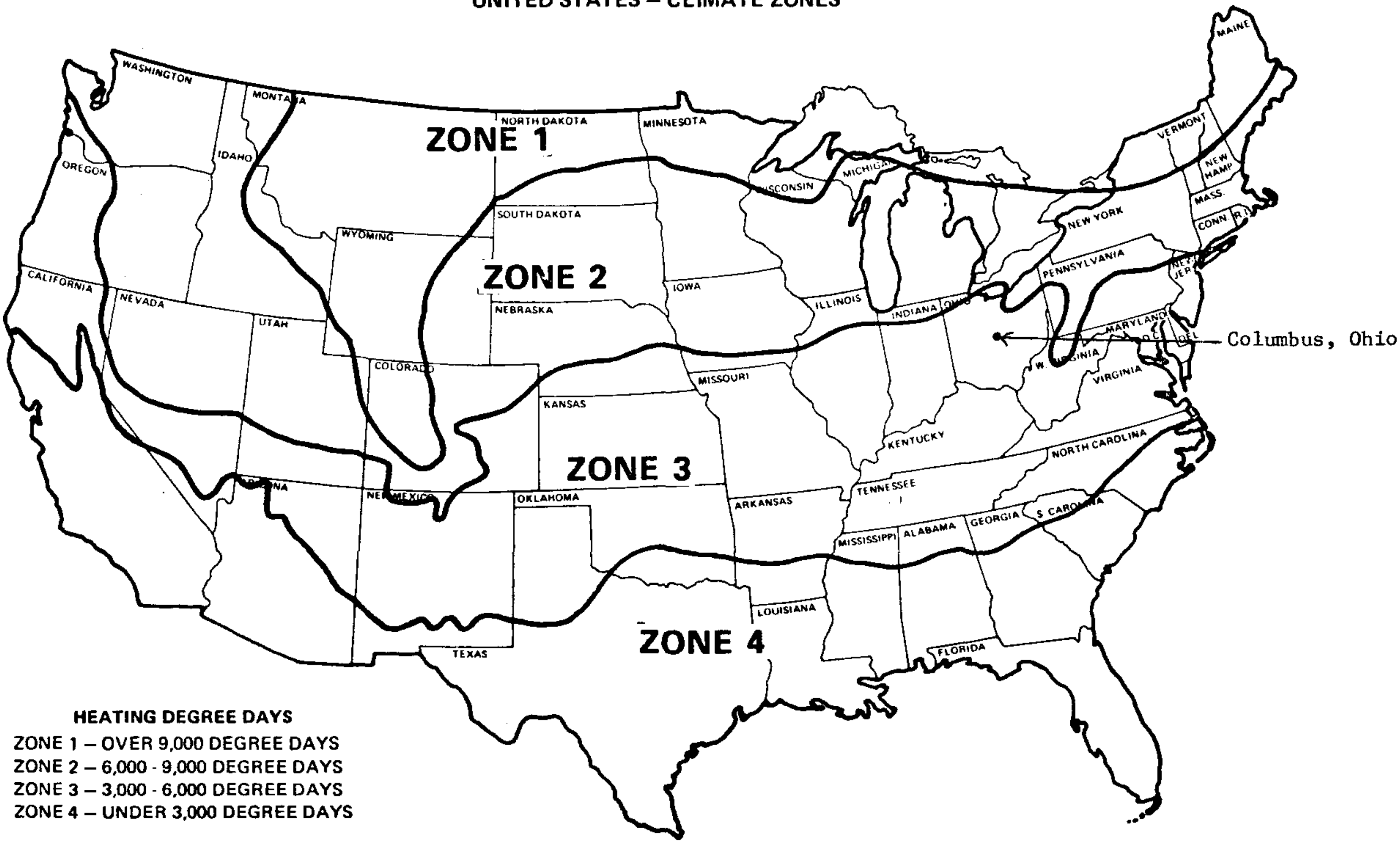
1. Federal Energy Administration Contract CR-04-60711-00, April 20, 1976.

## UNITED STATES – CLIMATE ZONES




**HEATING DEGREE DAYS**

ZONE 1 – OVER 9,000 DEGREE DAYS
ZONE 2 – 6,000 - 9,000 DEGREE DAYS
ZONE 3 – 3,000 - 6,000 DEGREE DAYS
ZONE 4 – UNDER 3,000 DEGREE DAYS

Under this first phase, ten elementary school buildings were selected, one from each federal region, with the exception of Region 9. Because the criteria established for selection could not be met by any of the applicants or any of the other Region 9 schools which AASA identified through a cooperative search with the respective state departments of education, this region was omitted and, instead, a second school was selected in Region 5 to represent the northern portion of that area. Criteria used for selection of the demonstration schools included: type of structure, predictably consistent usage patterns after modifications, building longevity, building size, student enrollment, available energy consumption data, and expected energy savings as predicted through the use of the Public School Energy Conservation Service (PSECS)[2] computer program. It is important to note that every effort was made to find typical schools, not "bad examples"; for experience has shown "energy and dollar saving retrofit opportunities exist at even the most well maintained facilities."[3]

After the sites were selected, a thorough and comprehensive investigation of energy conserving opportunities for each building ensued. In this study, the PSECS material, the TRACE[4] or Ross Meriwether[5] computer programs, as-built drawings, and on-site surveys were the basis for the engineering judgment as to feasible energy conserving measures to be recommended. Such recommendations considered: (a) changes in HVAC or lighting systems or equipment, including controls; (b) modification in operations; (c) structural

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2. PSECS was developed by the Educational Facilities Laboratories, Inc. under a Federal Energy Administration Contract.

3. Identifying Retrofit Projects for Federal Buildings, p. 2.

4. TRACE computer program 200 developed by Trane Company.

5. Meriwether ERE computer program.

changes; (d) estimated cost(s) of implementation; and (e) estimated energy savings that are expected to accrue. In addition to their engineering feasibility, the recommendations also considered the possibility of significant cost benefit, educational desirability, and environmental acceptability.

Phase 1 of the Saving Schoolhouse Energy project was completed under the auspices of AASA's Office of Governmental Relations. JCox Associates served as AASA's consulting engineer and coordinated the ten separate studies, in addition to conducting the investigation for one site.

A project of this magnitude requires the contributions and cooperation of many. The team assembled by AASA for Phase 1, PSECM # 5, Fairmoor Elementary School include the following firms and individuals:

Project Director: Shirley J. Hansen, AASA

Asst. Project Director: Charlotte Friedman, AASA

Coordinating Consultant: JCox Associates<br>Vienna, Virginia

James R. Cox, P.E.<br>Leland Eisenhower, P.E.

Engineer: JCox Associates<br>Vienna, Virginia

We would be remiss if we did not also acknowledge the fine cooperation and assistance we have received from Michael Pulscak and Faith Lambert of FEA and from Edward Stephan during his tenure at FEA.

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REPORT NUMBER 5

FAIRMOOR ELEMENTARY SCHOOL

## 1.0 INTRODUCTION

This study, prepared for the American Association of School Administrators, had as its objective the identifying and evaluation of energy conserving opportunities for the Fairmoor Elementary School. The analysis of this school is a part of the first phase of a five part program directed toward reducing energy consumption in existing public schools.

The AASA program will be conducted in the following five phases:

1. Evaluation and selection of ten school buildings for analysis of potential energy conserving modifications.
2. Preparation of architectural and engineering specifications and drawings for the recommended modifications.
3. Installation and construction of the modifications.
4. Monitoring and evaluation of energy use after modifications.
5. Dissemination of the information to school districts and others interested in energy conservation.

Fairmoor Elementary School is one of ten representative schools selected, one from each of the federal energy regions. This report summarizes the results of the field investigations, computer simulation and evaluations of the energy conserving opportunities available in this school.

## 2.0 METHODOLOGY

The emphasis in this study was on cost-effective capital investments for energy conservation. The recommended capital investments in this type of study should not be implemented without first having undertaken a comprehensive operational and maintenance program. This implies that sound energy management procedures is a continuing function and should include scheduling characteristics, periodic inspection and routine maintenance responsibilities. It further implies that the human element (faculty and students) is cooperative and appreciative of the intent of the function desired.

The objective of identifying and evaluating the cost effectiveness of various energy conserving opportunities for Fairmoor Elementary School was broken down into four phases.

1. Site Visitation and Data Collection
2. Computer Simulation
3. Identifying Energy Conserving Opportunities
4. Economic Analysis

The first phase involved visiting the school to obtain historical data (utility bills), architectural and engineering drawings, and field measurements of existing conditions. These measurements included such things as various motor consumptions, ventilation air quantities, light levels, boiler efficiencies, and operating and occupancy schedules.

The second phase of this analysis involved running a computer program to simulate the actual operating characteristics of the building. This computer simulation was performed with the Trane Company's TRACE program version 200 which was developed primarily for evaluating existing facilities.

The third phase involved analyzing the computer simulation and studying the existing conditions to determine the flow of energy in and out of the building and further identifying measures for reducing this flow of energy. These measures have been referred to as energy conservation opportunities (ECO).

After identifying the ECO's the fourth and final phase was to perform a cost analysis on each item. It was necessary to first determine the amount of energy saved and hence the dollar savings of each ECO, then a cost estimate for constructing this modification was made. The cost effectiveness of each ECO is then measured in terms of the payback period (cost effectiveness) of each item.

## 3.0 BUILDING DESCRIPTION

Fairmoor Elementary School is located in Federal Energy Administration Region No. 5 and is situated at 3281 Mayfair Park Place, Columbus, Ohio. The building has a total floor area of 42,765 sq. ft. and was constructed in two phases, the original building being built in 1949 and an addition, with a floor area approximately the same size as the original building, being built in 1955. This school presently has a total student enrollment of 475 pupils from kindergarten through 6th grade and there are 30 staff members.

## 3.1 ORIGINAL BUILDING

The original building (see floor plan Fig. 3-1) is a three-story building with a total floor area of 23,500 sq. ft. The second floor consists primarily of six classrooms and has a floor area of 8,200 sq. ft. The first floor, with a floor area of 8,950 sq. ft., includes the administration area, four classrooms and two additional classrooms having been converted into the school library. The basement floor, with a floor area of 6350 sq. ft., is comprised of the cafeteria, kitchen, boiler room and miscellaneous work rooms.

Fig. 3-2 shows the main entrance of North exposure and Fig. 3-3 show the rear or South exposure of the original building. The walls are constructed of four inches of face brick on eight inches of painted concrete block with no additional insulation or inside surface treatment. The overall "U" value for this type of wall construction is approximately 0.34 BTU/HR $FT^2 °F$ (Values taken from "ASHRAE GUIDE, HANDBOOK OF FUNDAMENTALS"). The windows in the North wall, see Fig. 3-2, comprise roughly twenty percent of the total wall area and are double hung, clear, plate glass with interior roller shades. Roller shades have been installed throughout the school to reduce the solar effect of the sun and also to help cut down heat loss and outside air infiltration. The "U" value for this glass is 1.13 BTU/HR $FT^2 °F$. The South facing wall as seen in Fig. 3-3 has the same wall construction as the North wall and the glazed area is approximately 23 percent of the total wall area. Note that the upper portion of the windows are glass block. The "U" value for these windows was determined by using a composite of the percentage (56%) of glass block and plate (44%). The composite "U" value used was 0.81 BTU/HR $FT^2 °F$.

A new roof was installed three years ago and consists of 2-1/2 inches of pressed fiber insulating board on a metal deck. The ceiling construction is plaster or acoustic tile attached to the underside of steel joists. The over "U" value for this composite is 0.11 BTU/HR $FT^2 °F$.

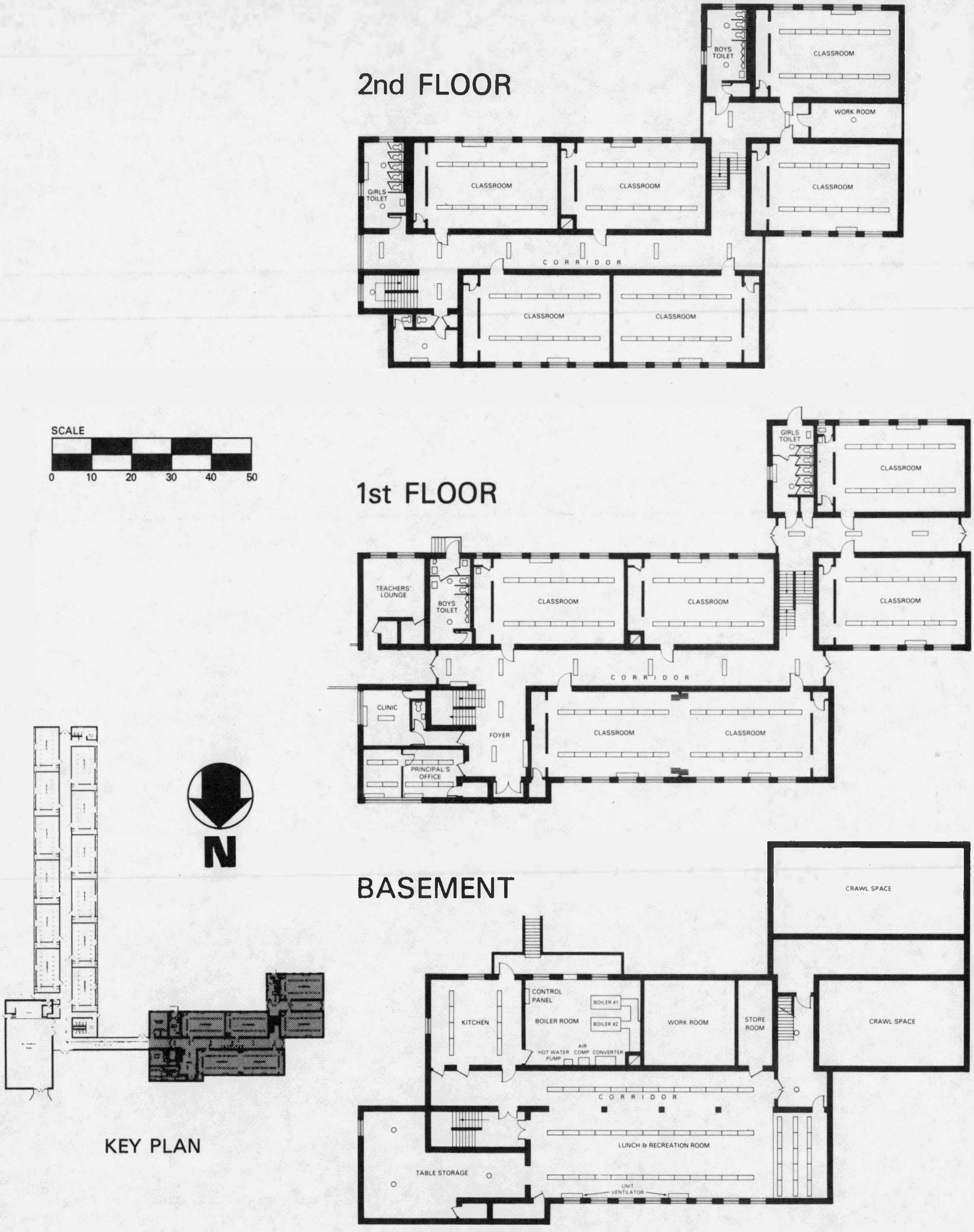



FIG. 3-1: ORIGINAL BUILDING

FIG.3-2 NORTH FACE
ORIGINAL BUILDING

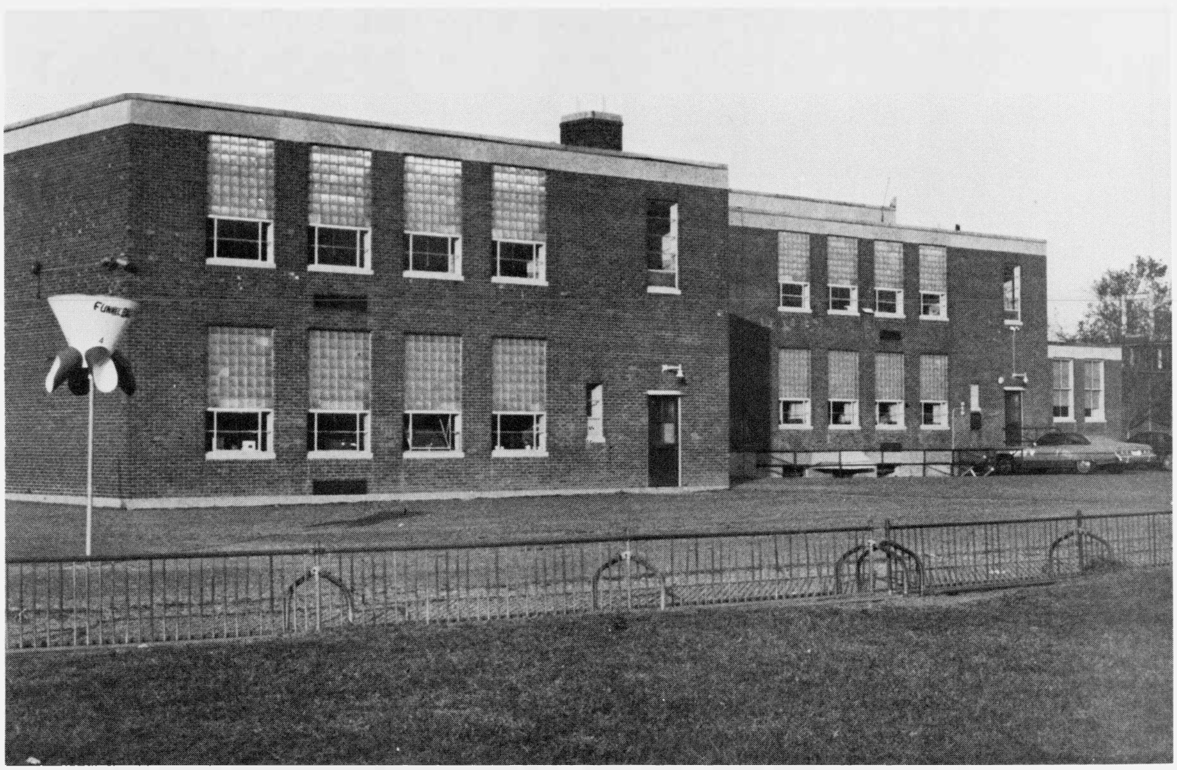


FIG.3-3 SOUTH FACE
ORIGINAL BUILDING

## 3.2 ADDITION

The addition (See Floor Plan Fig. 3-4) is a single story building with a total floor area of 19,200 sq. ft. This floor area is broken down into twelve classrooms and a multipurpose room. Fig. 3-5 shows the West face of the addition and Fig. 3-6 shows the East exposure with the multipurpose room located at the extreme right in the picture.

The walls are constructed of four inches of face brick on four inches of painted concrete block, with no insulation or inside wall treatment. The roof over the addition consists of built up roofing on 2-1/2 inches of Tectum panels with no ceilings. The roof is supported by solid steel I beams which extend out through the exterior walls and support a corrugated plastic sun screen. (See Fig. 3-7) The treatment of these exposed beams was examined and it was decided to treat them as part of the wall acting as fins radiating heat to the surrounding atmosphere. It should be noted that the sun screens will reduce the solar effect and provide greater comfort during the warm Spring and Fall months but actually have a negative effect during the cold Winter months. The overall "U" value for the walls was adjusted to 0.70 BTU/HR FT$^2$°F to compensate for the exposed beams, and a corresponding "U" for the roof of 0.22 BTU/HR FT$^2$°F. For the computer simulation it is necessary to adjust "U" values to a single term. Therefore the treatment of the wall is a composite. The amount of glazing is approximately 58 percent of the total wall area. The windows are clear plate glass with the top and bottom portions being operable sash. Roller shades have been installed throughout the addition. The "U" value for the glass is 1.13 BTU/HR FT$^2$°F.

The multipurpose room wall construction is four inches of face brick on twelve inches of concrete block with no inside treatment and a "U" value of 0.31 BTU/HR FT$^2$°F. Glass is located near the top of the East and West walls and comprises roughly fourteen percent of the total wall area. The "U" value for this glass is 1.13 BTU/HR FT$^2$°F. The floor area for the multipurpose room is approximately 3,300 sq. ft. and the roof is similar to that of the classrooms with a "U" value of 0.22 BTU/HR FT$^2$°F.

The original building is connected to the addition via a glass wall corridor shown in Fig. 3-8.

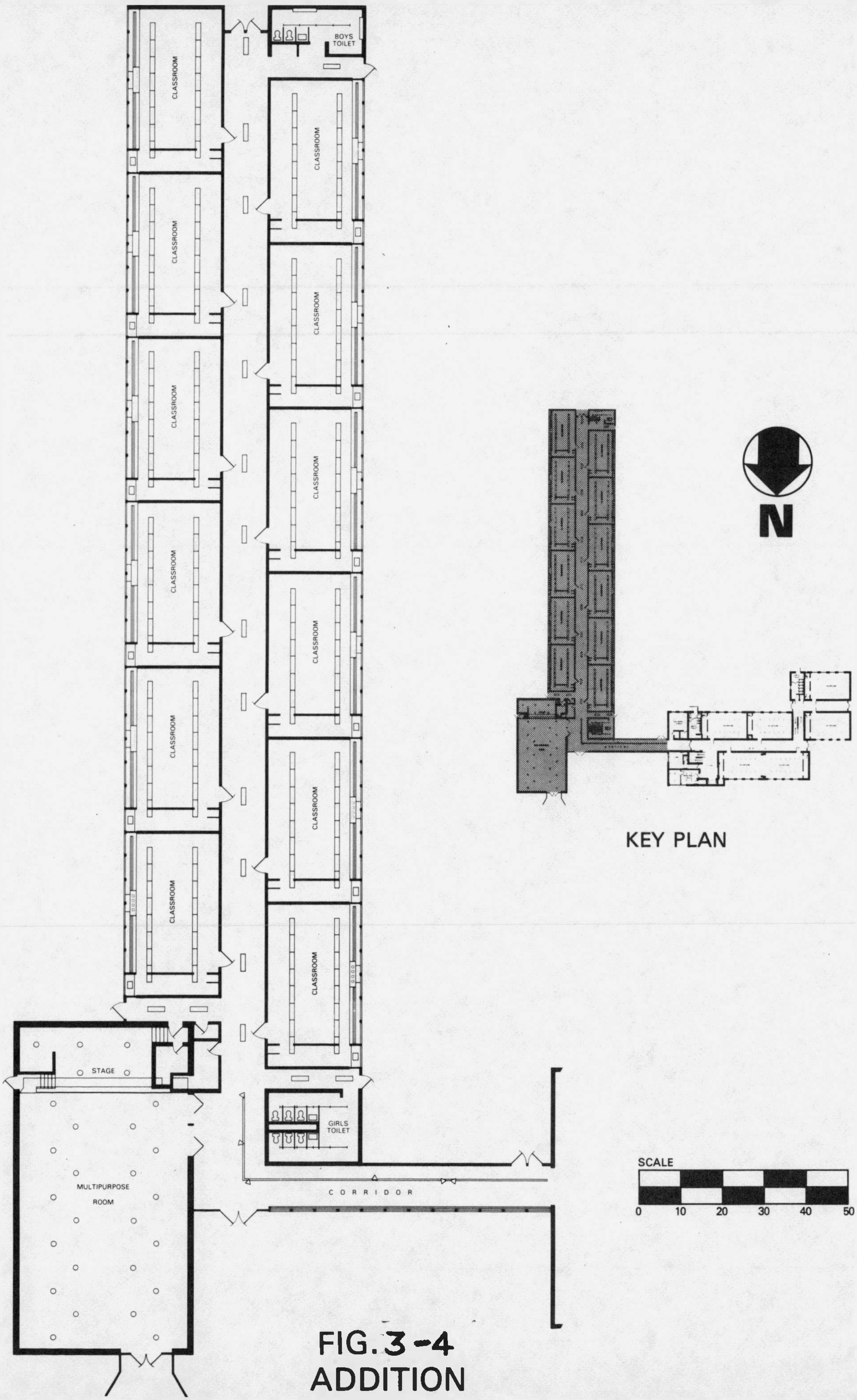



FIG. 3-4
ADDITION

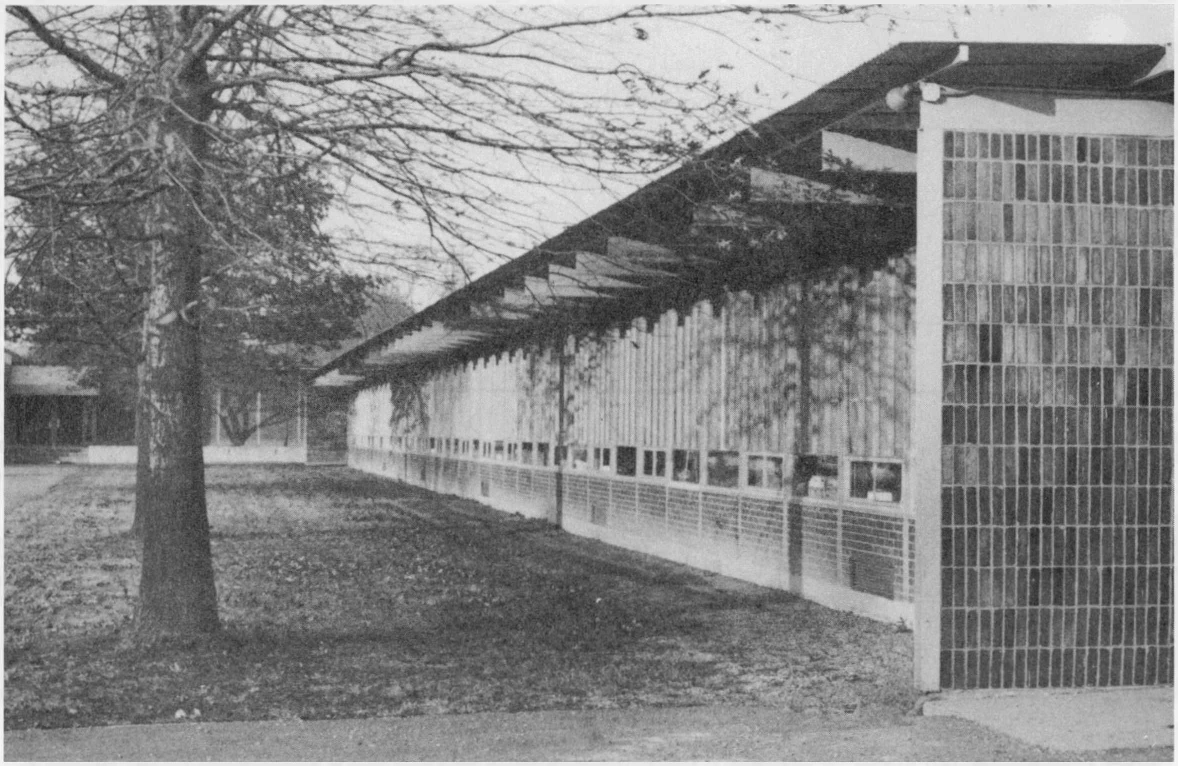


FIG.3-5 WEST FACE
ADDITION

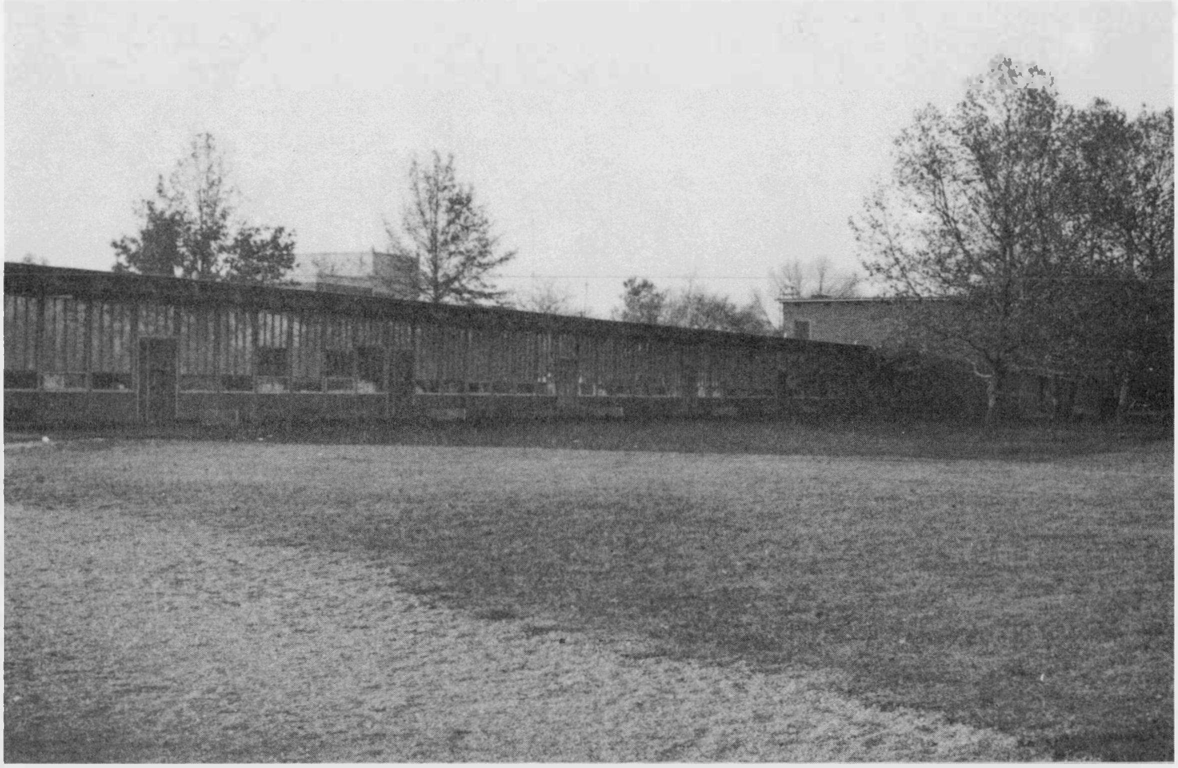


FIG.3-6 EAST FACE
ADDITION

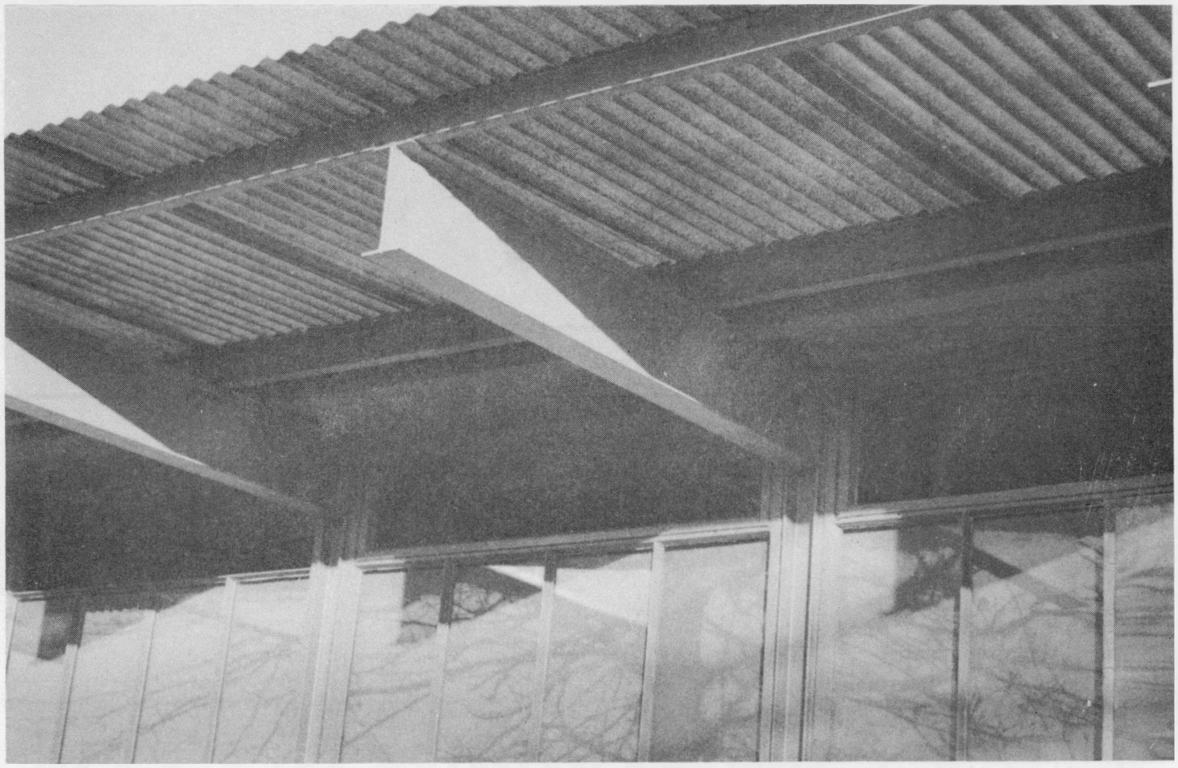


FIG. 3-7 ROOF OVERHANG
ADDITION

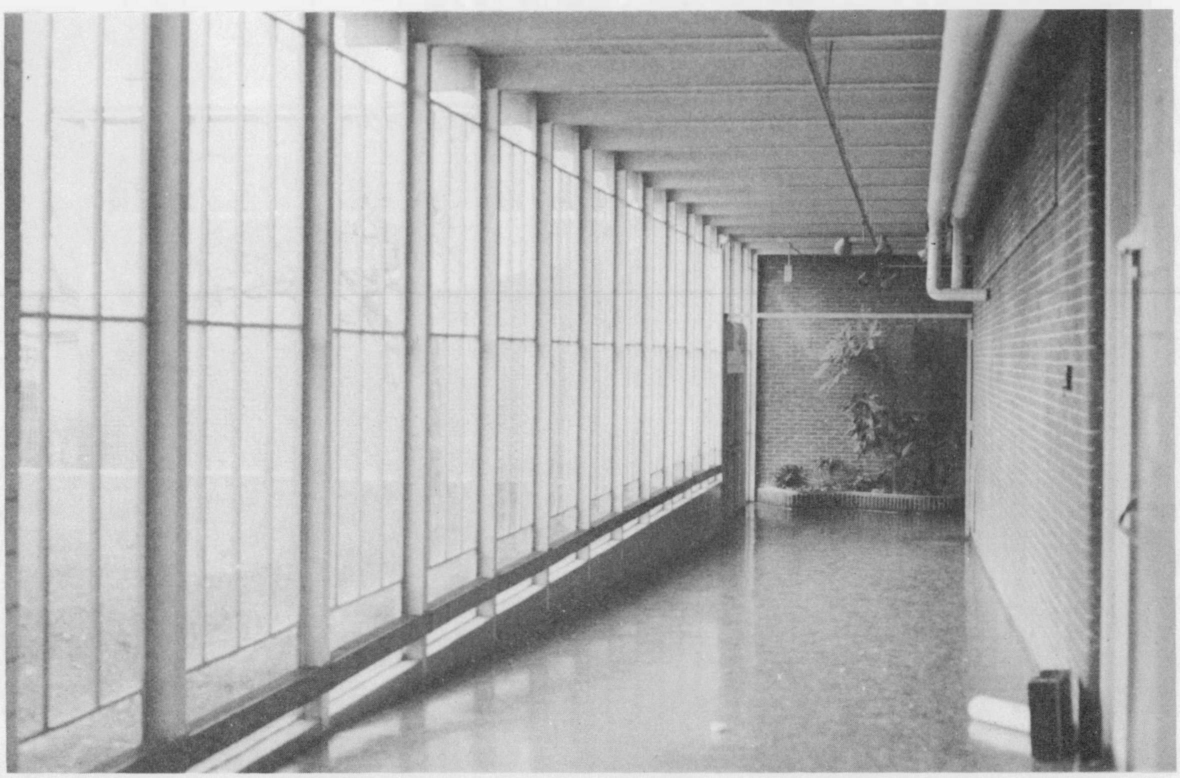


FIG. 3-8
CONNECTING CORRIDOR

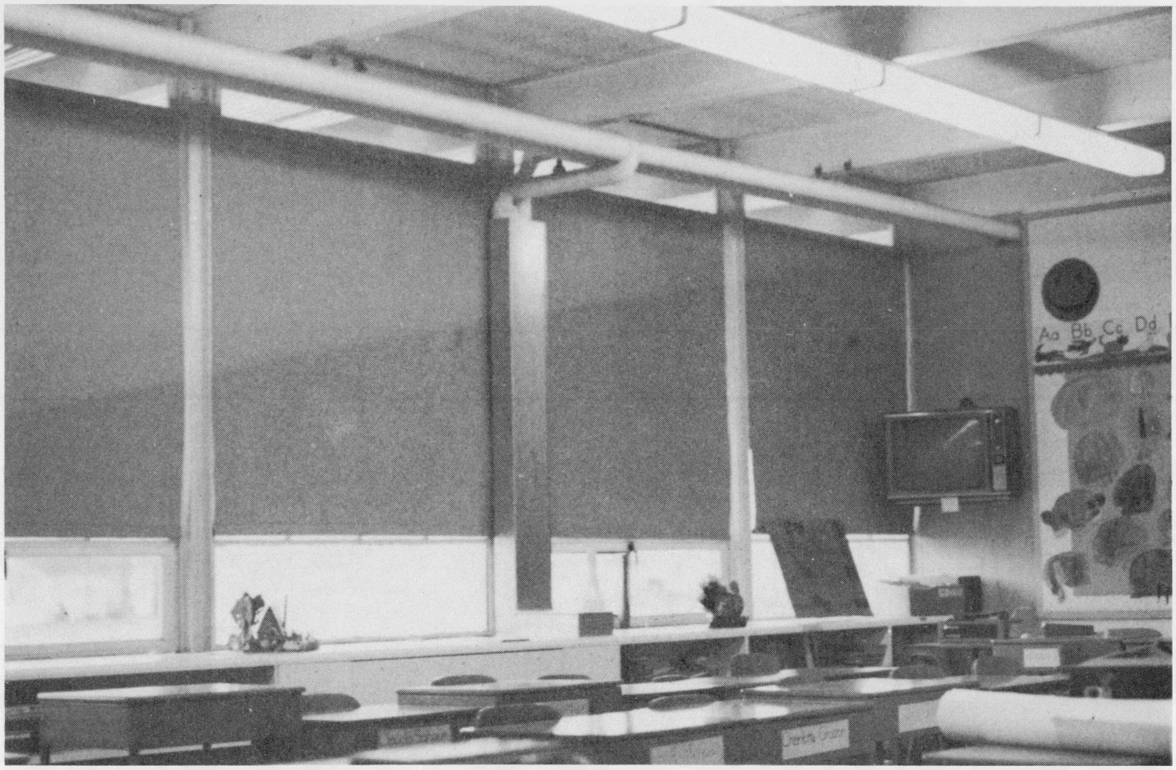



FIG. 3-9 TYPICAL CLASSROOM
ADDITION

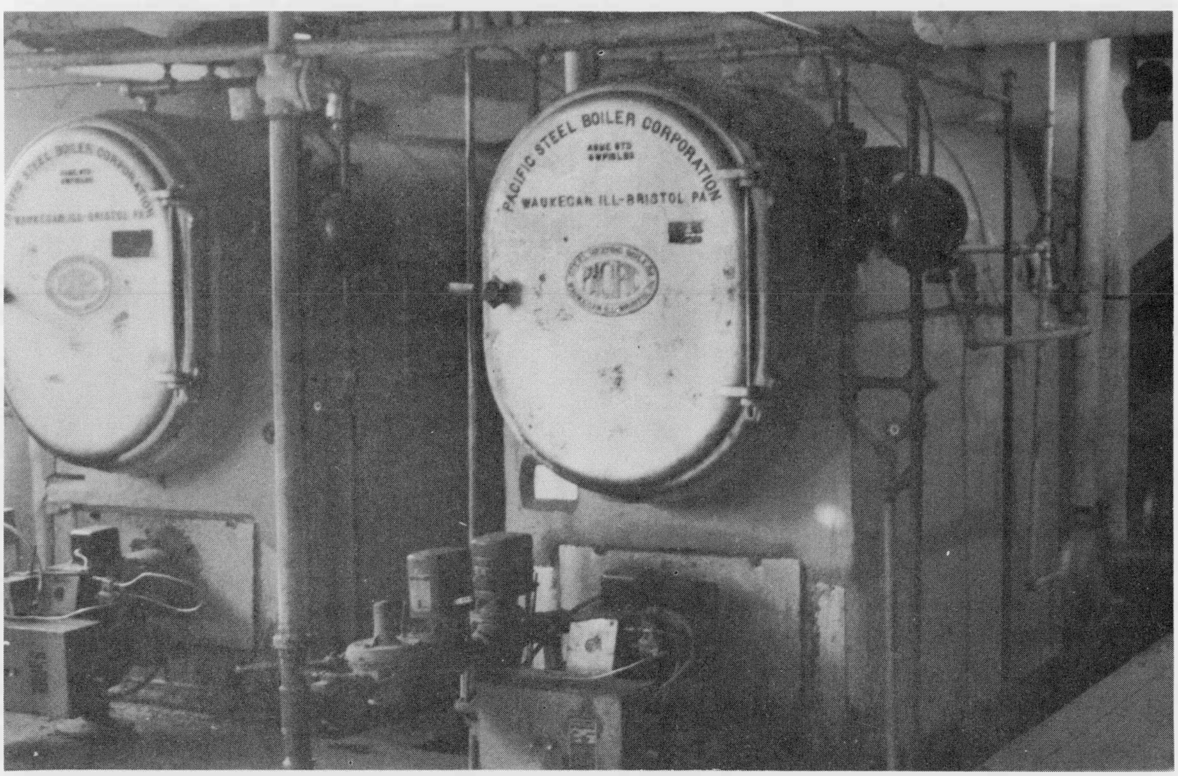



FIG.3 10
BOILER ROOM

## 3.3 OCCUPANCY SCHEDULES

As previously mentioned the student enrollment for this school is 475 pupils and 30 staff members. The absenteeism rate is very low and estimated at four percent for the computer simulation. It is noted that heat is given off by human beings and for this simulation was taken at 245 BTU/HR sensible and 155 BTU/HR latent.

The school year begins in early September and runs thru mid-June. Students begin classes at 8:45 in the morning and leave at 3:15 in the afternoon with a lunch break and a recess period in the morning and the afternoon.

The evening activities are confined to the multi-purpose room and average two hours a night, five nights a week.

## 3.4 HEATING AND VENTILATING SYSTEM

The heating and ventilating system in the original building consists of steam unit ventilators and hot water unit ventilators in the addition (a typical classroom is shown in Fig. 3-9). These units are fed from two identical gas fired (converted from coal fired), three pass fire tube low pressure steam boilers (see Fig.3-10). Each unit is a forced draft, steel boiler with a heating surface of 350 sq. ft. and a steam output of 1790 pounds per hour. The addition which is served with hot water unit ventilators is fed from the same boilers serving the original building. A steam to water convertor in the existing boiler room provides heating water for the addition. Primary pumps are located in the boiler room of the original building. The schematic of this heating plant is shown in Fig. 3-11 and the following is a general description of the operation of that plant.

Low pressure steam (5 psig) is generated in the two boilers and distributed to the original building via the steam supply piping and returned in the condensate return piping by gravity to the vacuum pump located in the boiler room. The addition which uses hot water for heating is fed from the convertor. Steam from the boilers is used to heat the water in the convertor and the water is distributed to the addition via an exposed piping system running overhead at exterior wall through the classrooms. Steam condensate from the convertor and the original building system returns to the receiver and is then pumped back to the boiler for conversion back to steam. The toilet rooms are exhausted by fans located on the roof.

It is felt at this point that a description of a typical unit ventilator cycle might be helpful. (Refer to Fig. 3-12) During the night or unoccupied portion of the cycle 3-12a the outside air damper remains closed and the steam or hot water control valve is wide open under control of room thermostat and the unit fan is cycled

HEATING PLANT SCHEMATIC

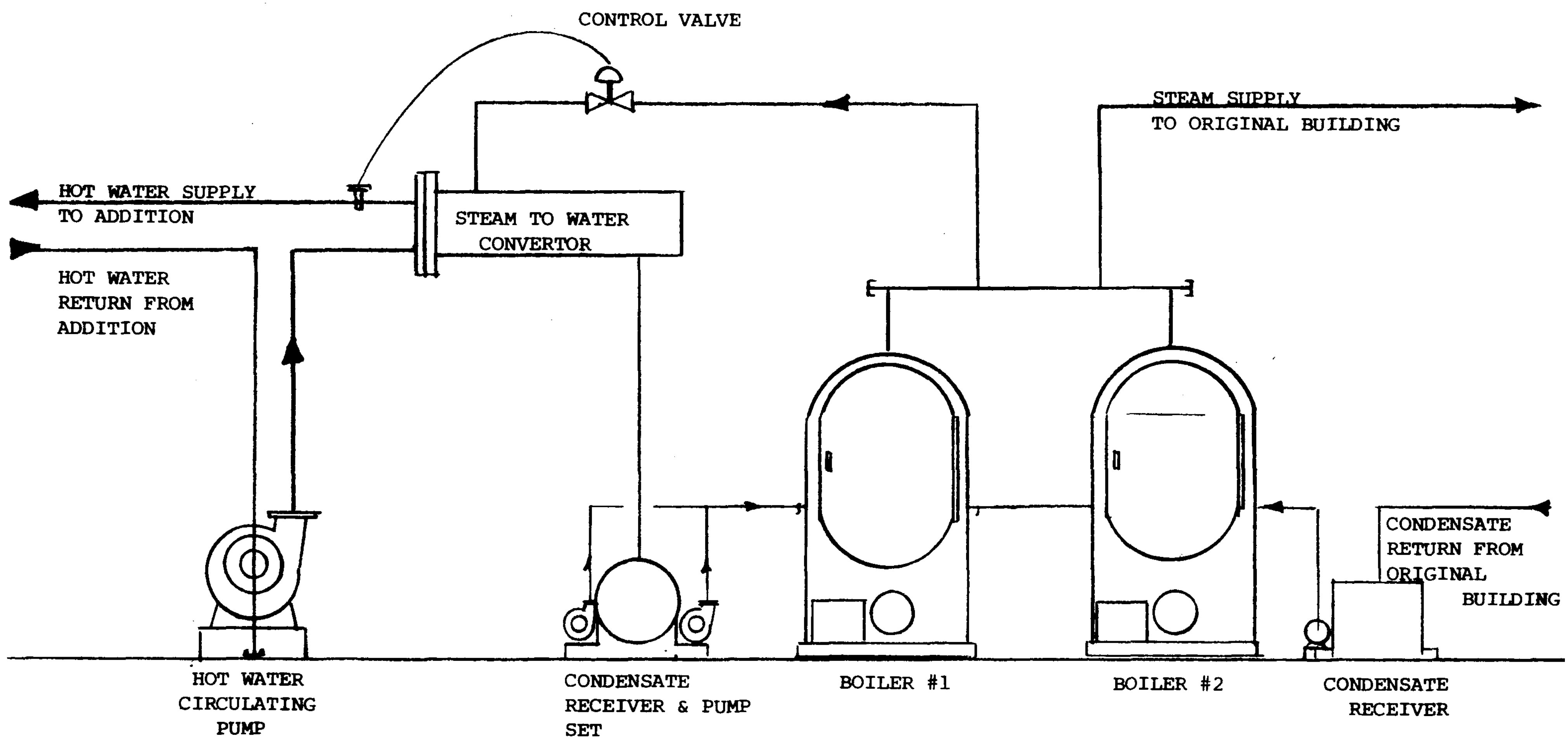
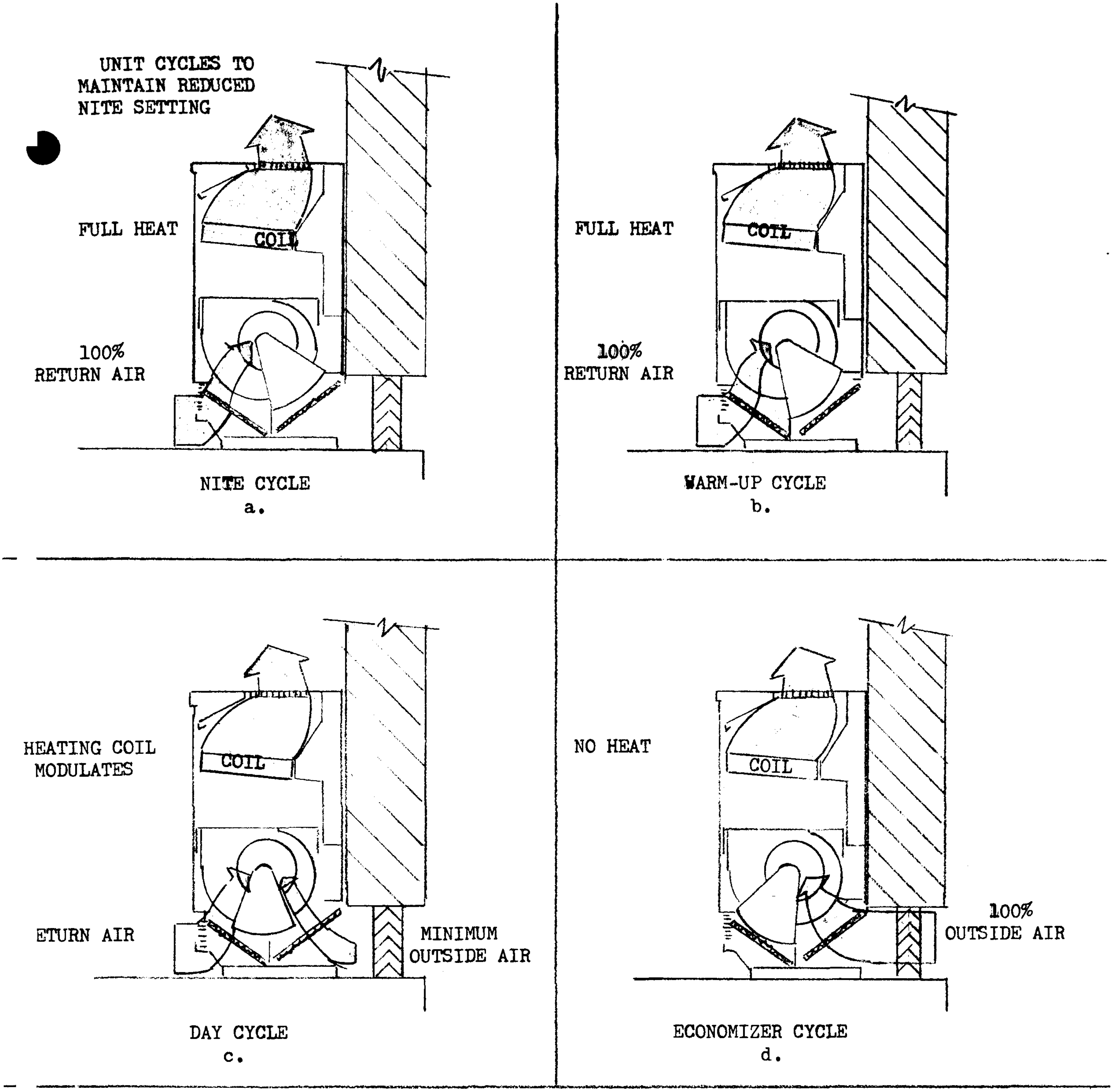



FIG 3-11




<u>UNIT VENTILATOR</u>

<u>CONTROL CYCLE</u>

FIG 3-12

on and off to maintain a reduced night setting. Prior to room occupancy the unit goes to the warm-up cycle (3-12b), the outside damper remains closed and 100 percent of the air is recirculated and controls function to provide a rapid rise in temperature to return the room temperature to the day or occupied setting. After the day setting is reached the outside air damper opens to a fixed minimum setting to allow ventilation air into the classroom and the valve is then modulated to maintain the desired thermostat setting (3-12c). If the space temperature should rise above the setting of the thermostat then the outside damper modulates open (up to 100%) and the return air damper modulates closed thereby using outside air for cooling and ventilation (3-12d). The heating coil valve is closed during this mode in order that the controls are not fighting each other. The reverse sequence occurs in the drop of room temperature below the room thermostat setting.

The multipurpose room is heated and ventilated with an air handling unit located in a room adjacent to that space. This unit als has the ventilation cycle with a capability of 100% outside air. The administration area, corridor, and other miscellaneous spaces are heated with either fin tube radiation or convectors with manual control valves.

The night set back-reduced operation control is inoperative resulting in all classrooms remaining on Day cycle 24 hours a day, year round. There are no zone controls for the building zones (original, addition, multipurpose). The boilers and heating water pump are manually controlled.

## 3.5 ELECTRICAL SYSTEM

Classroom lighting throughout the school is with fluorescent fixtures. A typical classroom in the addition has two rows of four foot long, two tube fixtures, eight in each row for a total of sixteen fixtures or approximately 1.86 watts per sq. ft., a lighting level of approximately 45 F.C.. The classrooms in the original building have two rows of seven fixtures for a total of fourteen fixtures. The multi-purpose room has eighteen mercury vapor lamps plus four 200 watt incandescent fixtures. In addition the building has approximately 4 KW of outside security lighting.

## 3.6 DOMESTIC HOT WATER

Domestic hot water is supplied to the toilets and miscellaneous sinks and lavatories throughout the building by three 30 gallon residential gas fired storage water heaters. Because all of the lunches are catered and the kitchen is only used sparingly and just for warming the lunches, there is only a minimal hot water load on the building. The water temperatures are maintained at 140° year round.

## 4.0 DATA COLLECTION AND SIMULATION

Prior to conducting an investigation to determine energy conservation opportunities, it was necessary to conduct an in-depth survey to determine the present operating characteristics of this school. By submitting building description parameters such as areas, exposures and "U" values, along with internal loads and their operating characteristics to computer simulation, it is possible to model the existing building and its energy consumption. This model is then compared to the actual utility bills to validate the input data. It is then possible to determine the benefits obtained from the ECO's and assume that they will closely approximate the actual savings obtained from the building modification.

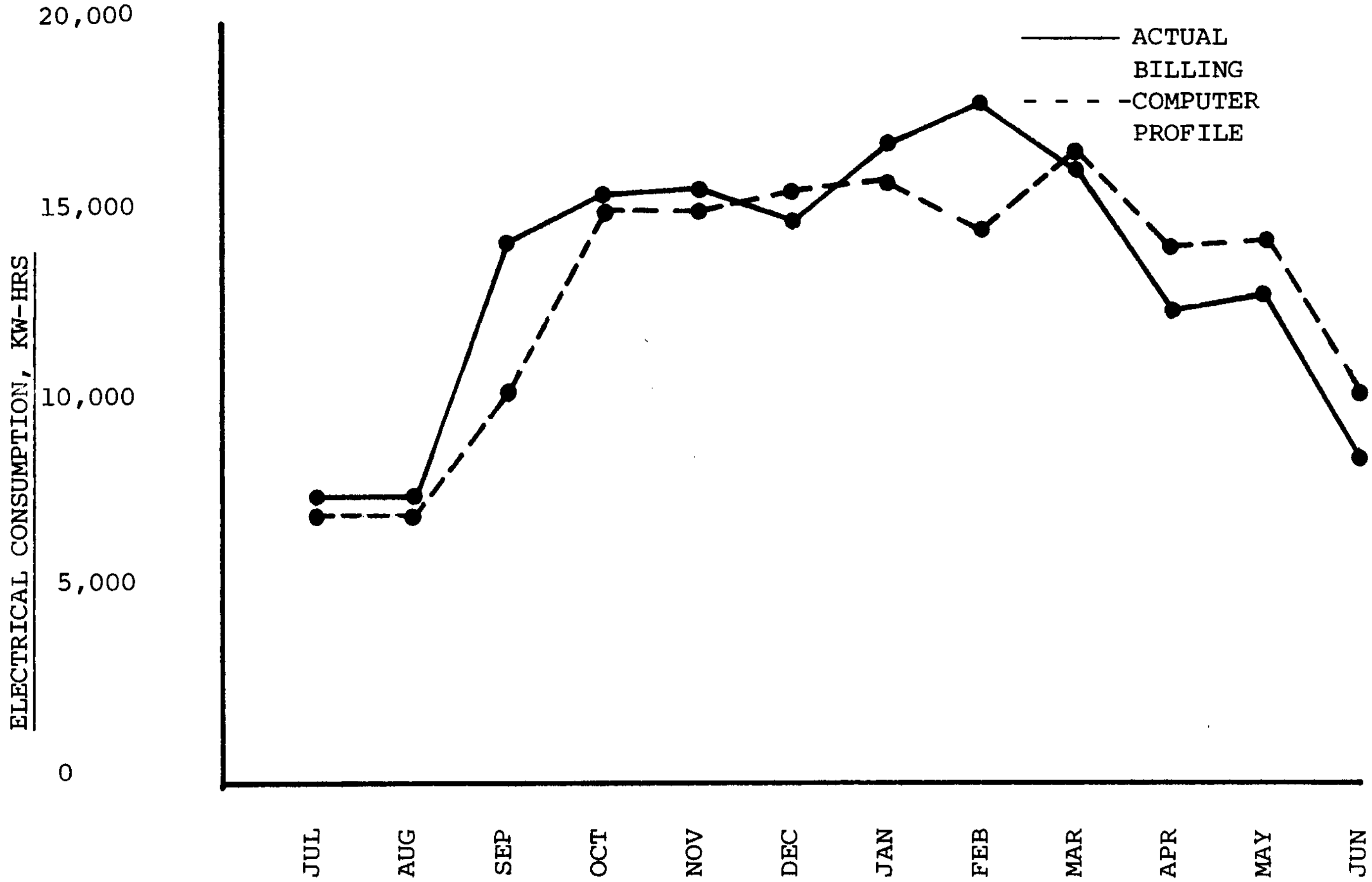
## 4.1 ACTUAL ENERGY CONSUMPTION

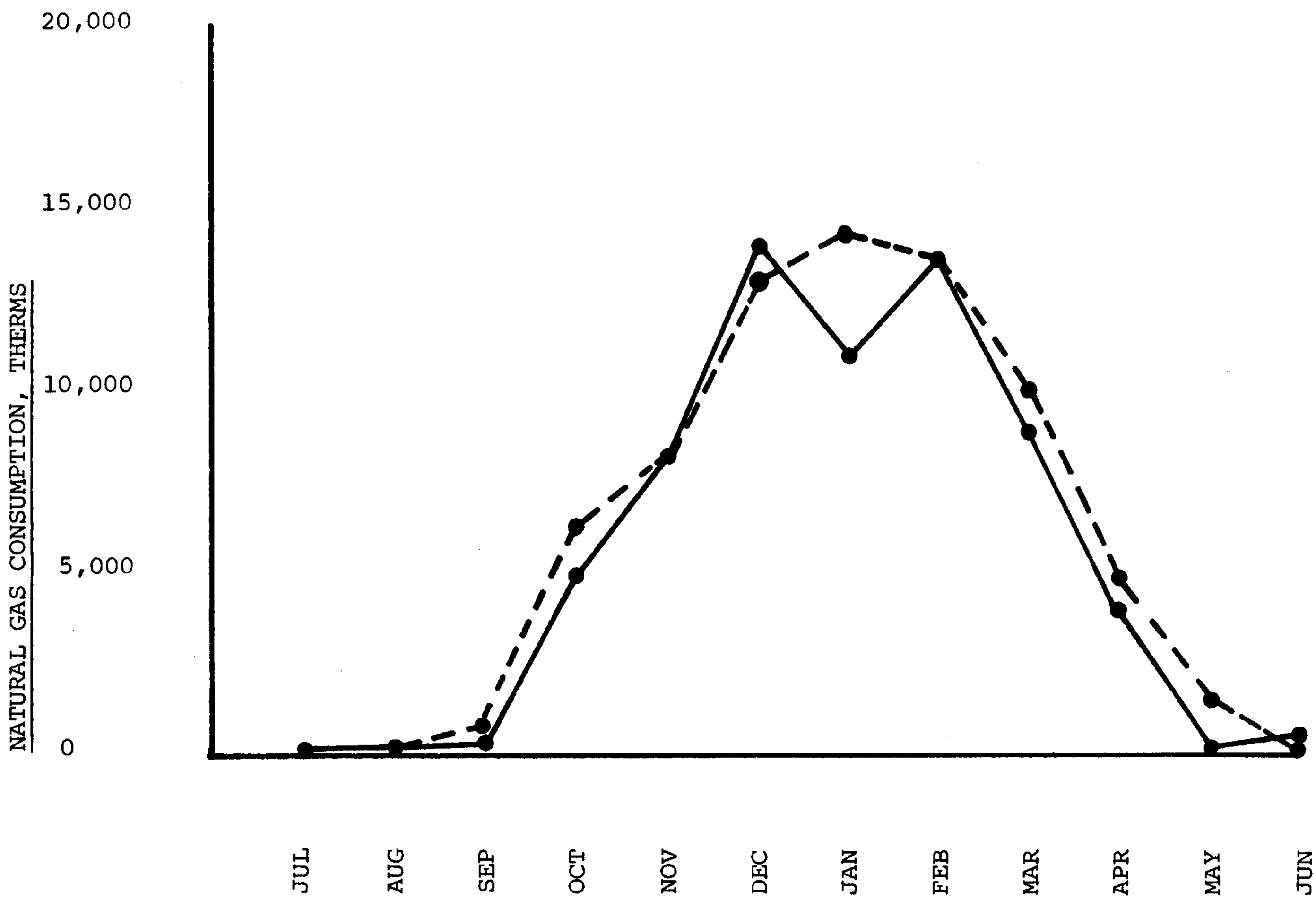
The utility bills for the last three years were obtained from the school board, and the gas and electric consumption were plotted against the computer profile, and are as shown in figures 4 - 1 thru 4 - 3.

Examining the plot of gas consumption versus time it can be seen that a minimal amount of gas is consumed, approximately 50 therms, during each of the summer months. This consumption then starts to increase as the heating season approaches in September to October, and peaking from December to February, approximately 15,000 therms, and then falling off again in April to May. If the consumption is totaled for those years the following table will show how the consumption varied with the number of degree days.

FUEL ENERGY

| Year | Therms - Gas | Therms/sq. ft. | Degree Days | Therms/DD |
|---|---|---|---|---|
| 1973-74 | 65,318 | 1.5 | 4,892 | 13.4 |
| 1974-75 | 72,024 | 1.7 | 5,284 | 13.6 |
| 1975-76 | 54,786 | 1.3 | - | - |
| TRACE | 72,743 | 1.7 | 5,467 | 13.3 |




ENERGY CONSUMPTION SCHOOL YEAR 1973-1974

FIG 4-1

SCHOOL YEAR: 1973 - 1974

Examining the plots of the electrical consumption it can be seen that the electricity is being used at a rate of approximately 7,000 KW-hours per month during the summer months. This consumption increases to roughly 12,000 to 14,000 KW-hours during the school year with some higher peaks being experienced during the peak of the heating season when the heating plant auxiliaries are being used most.

ELECTRIC ENERGY

| YEAR | KWH CONSUMPTION | KWH/SQ.FT. |
|---|---|---|
| 1973-74 | 159,160 | 3.7 |
| 1974-75 | 148,440 | 3.5 |
| 1975-76 | 151,480 | 3.5 |

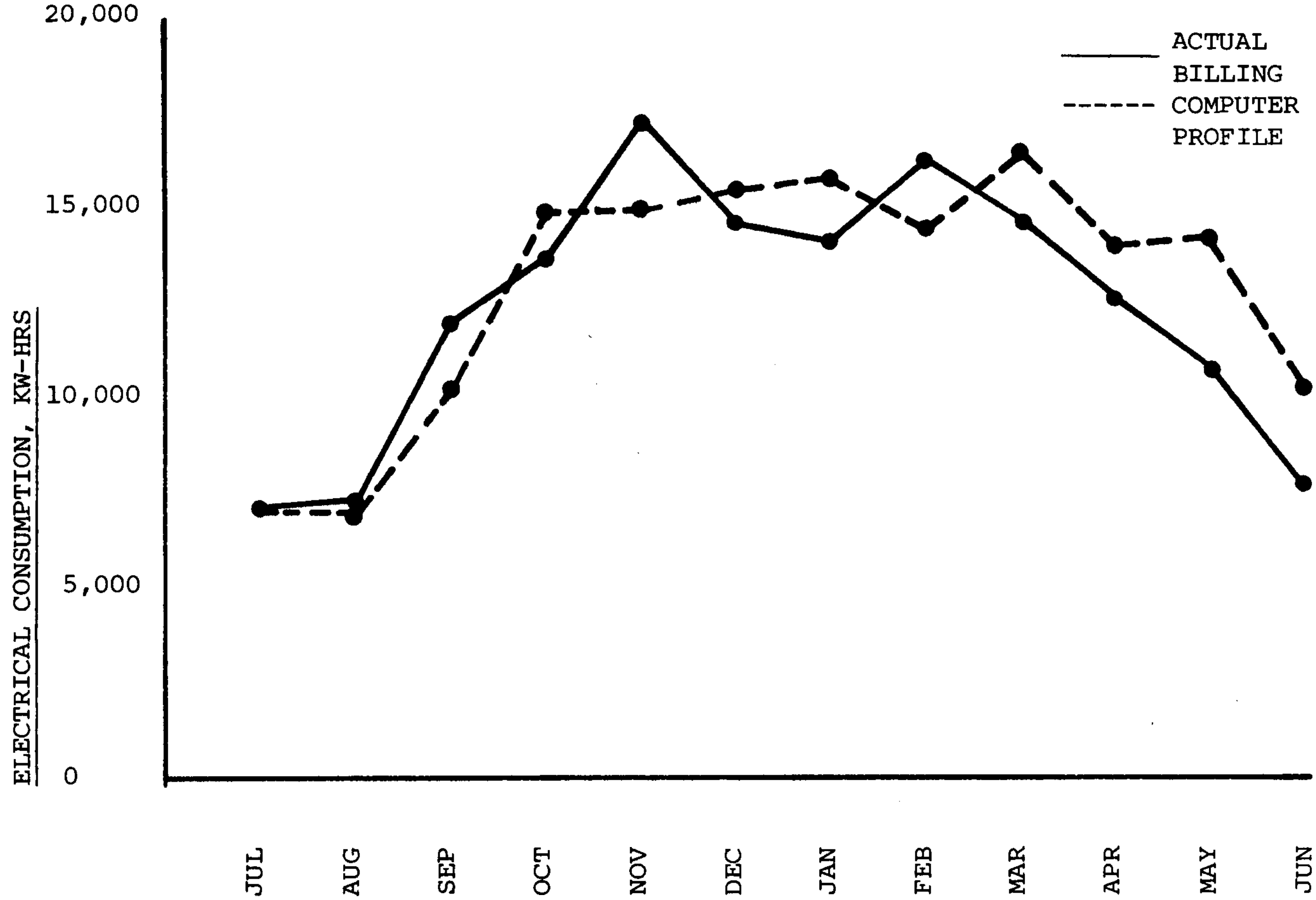
## 4.2 COMPUTER SIMULATION

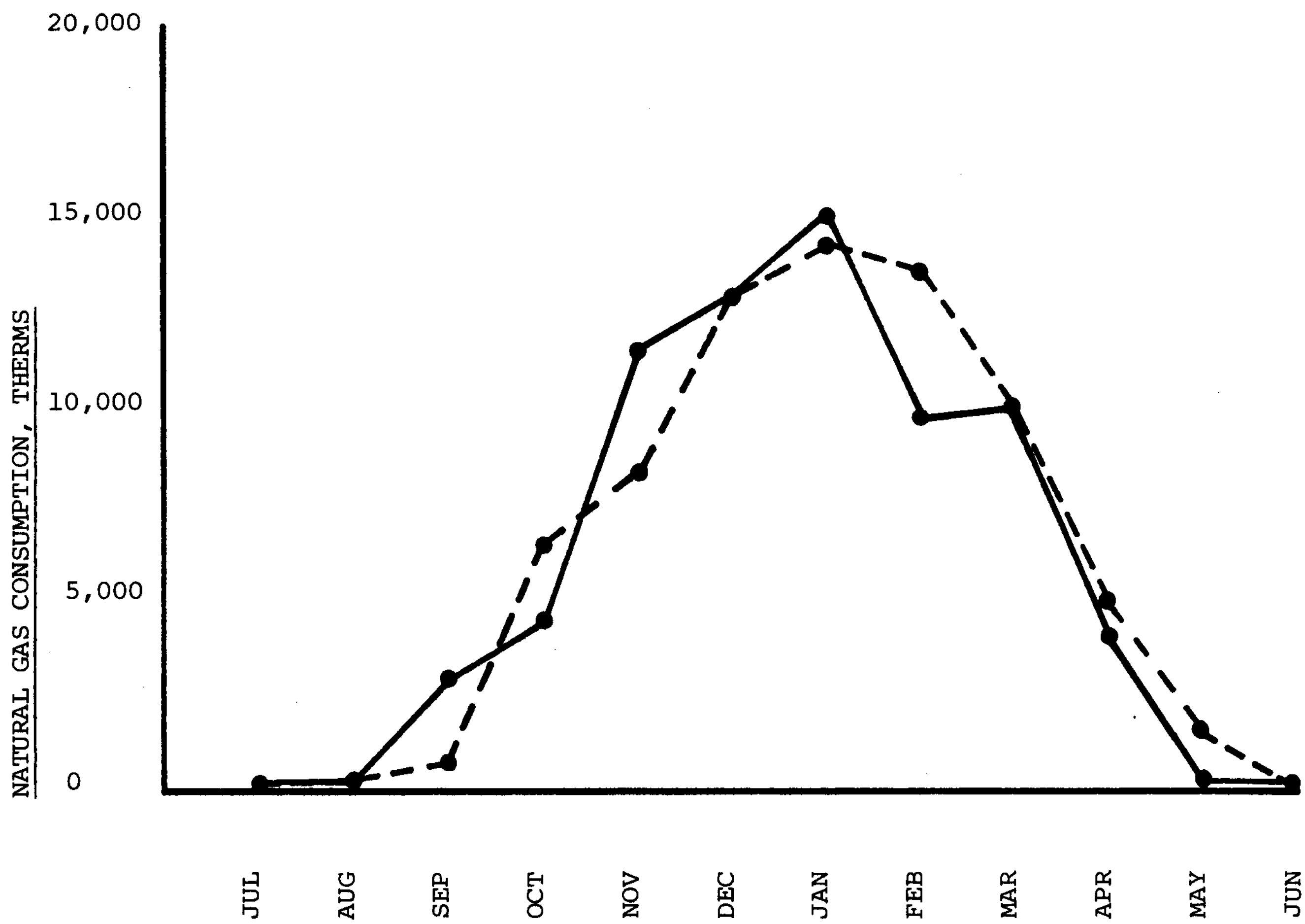
The next sequence in the analysis was to simulate the actual consumption curves with the TRACE computer program. It is felt that by simulating actual conditions the various components of this building could be examined in detail to determine the effect that each component of the building has on the total energy usage of the school. The weather data used was for the year 1964, being the most accurate information for this locality available to the TRACE program.

### 4.2.1

The input requirements for the computer program required that field measurements be taken. The first area examined was the quantity of outside air being introduced into the building for ventilation. An examination of the classroom unit ventilators revealed that the operation of the units varied from room to room. It should be pointed out that the automatic temperature controls are over twenty years old and some degradation is to be expected. The outside air dampers were found to be fully closed in some cases and wide open in others. The modulating control valves regulating the quantity of either steam or hot water entering the heating coils were malfunctioning in a number of the units. There were situations where the outside air dampers were wide open while the heating coils were delivering full heat. In one instance the control valve was delivering full heat to the classroom and the window was opened to maintain temperature. The above discussion has been presented to illustrate difficulties in trying to determine the exact quantities of outside air being introduced into the building. Air flow readings were taken and averaging these results the following tabulation is a presentation of the approximate quantities of air being introduced.

| | |
|---|---|
| Addition (12 classrooms @ 250 CFM/Unit) | - 3000 CFM |
| Original Bldg. (12 Classrooms @ 440 CFM/Unit) | - 5280 CFM |
| Door Infiltration | - 250 CFM |
| Multi-Purpose Room Unit | - 1200 CFM |
| TOTAL | 9730 CFM |

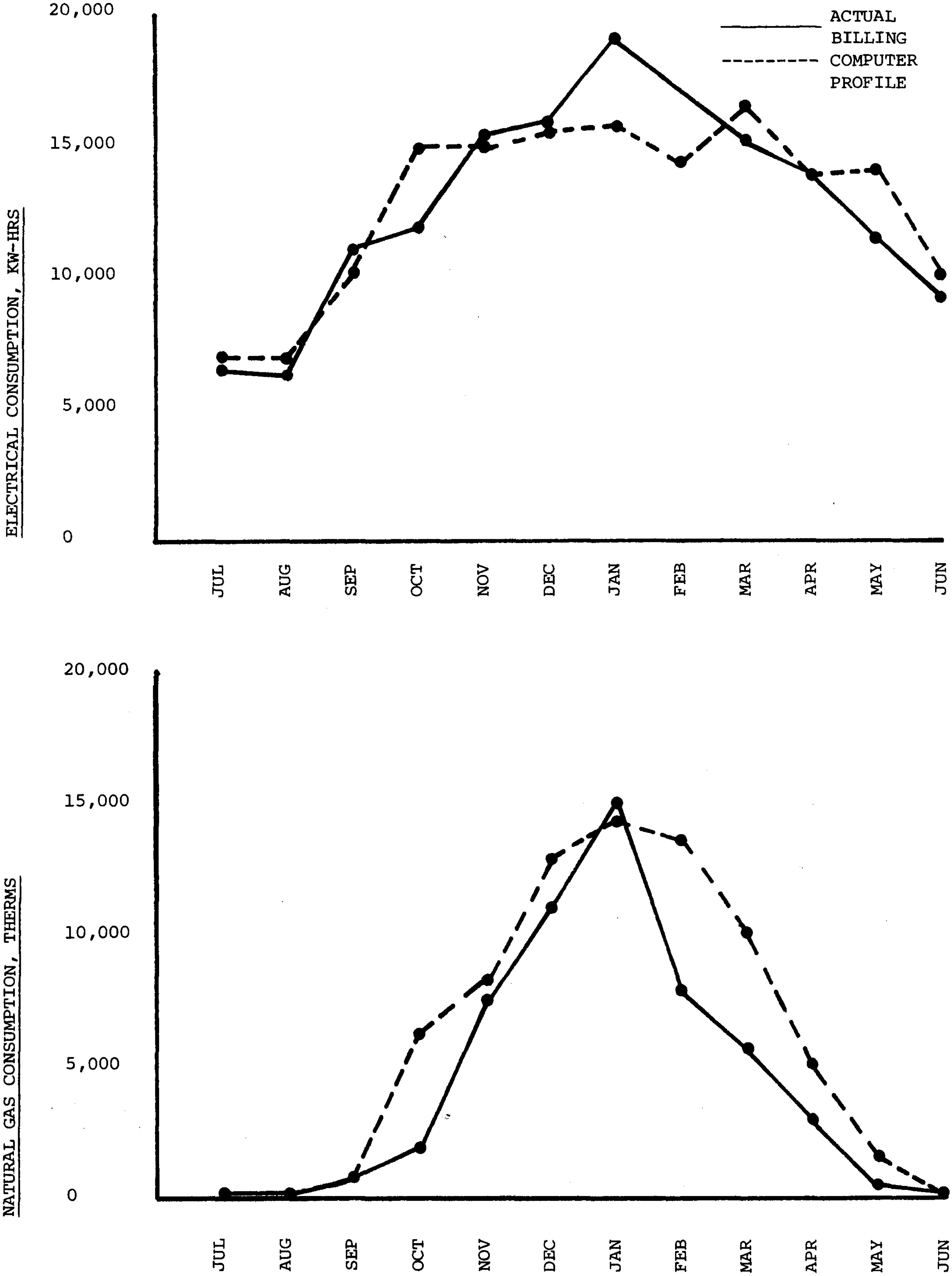



ENERGY CONSUMPTION SCHOOL YEAR 1974 - 1975

FIG. 4 - 2

SCHOOL YEAR: 1974 - 1975




ENERGY CONSUMPTION SCHOOL YEAR 1975 - 1976

FIG 4 - 3
SCHOOL YEAR: 1975-1976

4.2.2

The next area of examination was the boiler room itself. Flue gas analysis was performed on the two boilers and it was determined that they were operating at about 65% efficiency. This low combustion efficiency can be attributed to several factors. The boilers were originally coal fired and natural draft and subsequently converted to force draft gas fired. The stack is considerably oversized and very high creating a natural draft effect in excess of what the fan is delivering. This results in too much excess air and hence excessive heat loss out of the stack. In addition the lead boiler is being fired 100% continuously, regardless of the load on the building. The second boiler is fired intermittently when the load requires it.

The steam to water convertor serving the addition has a reset system installed but was not functioning. The intent of this system is to reduce the temperature of the heating water as the outside temperature increases and the converse as the outside temperature approaches design (4°F.); the water temperature should increase to approximately 200°F. As previously stated this system was not operating and the supply water temperature remained constant at the temperature required to heat the addition at design ambient temperature. When the outside temperature reaches approximately 55°F. and above, the boiler plant is shut down.

4.2.3

A night setback system has been installed to reduce the temperature throughout the building during the unoccupied hours of the day. This system was also found to be working improperly and all of the unit ventilators would run continuously and were maintaining the temperature of the day settings.

4.2.4

The doors which open for entrance and exit at recess contributed large quantities of infiltrated outside air.

4.3 ENERGY BREAKDOWN

An analysis of the computer model revealed the following breakdown of the annual heating and electrical energy required for this school.

| | | |
|---|---|---|
| HEAT ENERGY | | |
| Wall Transmission | - | 22.8% |
| Glass Transmission | - | 27.1% |
| Roof Transmission | - | 16.5% |
| Outside Air | - | 33.6% |
| ELECTRICAL ENERGY | | |
| Lighting | - | 36.0% |
| Base (Security Light & Exhaust Fans) | - | 16.5% |
| Unit Ventilators | - | 37.9% |
| Circulating Pump | - | 5.1% |
| Boiler | - | 4.5% |

## 5.0 DESCRIPTION OF ENERGY CONSERVING OPPORTUNITIES

The computer simulation, shown in Fig. 4-1 thru 4-3, was felt to closely approximate the actual energy consumption for the years that data has been collected. From this base building profile the various components of the building, contributing to energy usage, were determined. From this computer analyzation and from the on-site inspection, the following areas were identified for further study to determine their effectiveness as energy conserving opportunities.

### 5.1 MECHANICAL

#### 5.1.1

The boiler combustion efficiency, approximately 65 percent, is considered to be very low compared to a new installation which assumes boiler efficiencies in the order of 80 percent. It is felt that by replacing the burners with new units, modifying the boiler flue to reduce the extremely high quantity of excess air, and installing new boiler controls to fire the boiler on demand and not manually, the boilers can be brought back up to approximately 80 percent efficiency.

#### 5.1.2

In addition to upgrading the boilers, the reset system on the hot water convertor should be placed back into operation. This reset system should operate to provide 200°F. hot water when the outside temperature is 0°F. and then modulate or reset down to provide 70°F. hot water when the outside temperature is 70°F.

#### 5.1.3

The night setback system has been identified as another area for saving energy. There are many variations and methods of reducing the energy consumption during unoccupied hours of operation for a building, and the following is what has been considered for this particular facility. Time clocks should be installed to shut the unit ventilators down during the unoccupied hours and cycle the units on and off to maintain a reduced temperature setting. Simultaneous with this shut down the outside air dampers should go full closed and remain closed, and exhaust fans stopped, thereby eliminating outside air from entering the building during the entire unoccupied period, except by infiltration or leakage. A warm-up cycle should also be included that would keep the outside air dampers closed until the space is brought up to the daytime or occupied temperature. Because of limitations in the computer program the temperature could not be reduced, therefore the simulation for night setback only includes stopping the units and reducing the quantity of outside air. The occupied cycle was scheduled from 8:00 am to 5:00 pm Monday through Friday.

Evening activities are confined to the multi-purpose room, therefore when a night setback system is incorporated the unit serving this area should be separate so that it can be brought up to an occupied schedule without affecting the remaining portion of the building.

5.1.4

The quantity of outside air being introduced into the building was selected as another area of examination. The total quantity of air presently being introduced was previously shown as 9730 CFM. The minimum quantity required by the Ohio Building Code is 5 CFM/person. Therefore based on thirty pupils per classroom and 5 CFM/pupil the minimum required per classroom would be 150 CFM.

| | | |
|---|---|---|
| 24 Classroom @ 150 CFM/Cl.Rm | = | 3600 CFM |
| Multi-purpose Room 60 pupils x 5 CFM/Pupil | = | 300 CFM |
| Infiltration | = | 250 CFM |
| TOTAL | | 4150 CFM |

Therefore the present quantity can be reduced 60 percent and satisfy the State Code. In order to accomplish this reduction the unit ventilator controls must be upgraded and an air balance performed on each unit and the dampers set to introduce the required quantity of ventilation air.

5.1.5

Weatherstripping of doors and windows was not examined for this building because it is felt that when the controls are performing satisfactorily the building will be under positive pressure and exfiltration rather than infiltration will occur. Some leakage during the unoccupied cycle will occur, but it would not be cost effective to weatherstrip for this time.

## 5.2 ELECTRICAL

Examination of the electrical energy breakdown, see Fig. 5-1, indicates that considerable energy is being used during the summer months just to run the unit ventilator fan motors (approximately 5000 KWH/MO.). These fans are not required during the unoccupied months; therefore, the simplest ECO, requiring no capital expenditure, would be to shut the unit ventilators down during the summer vacation period. The areas shown in Fig. 5-1 under their respective portions of the total curve represent the total energy being consumed annually by that component.

In addition to shutting the units off during the summer these motors will also be cycled on and off during night setback and this energy savings is reflected under the night setback alternative described under paragraph 5.1 above.

The base electric usage is comprised of outside security lighting and toilet exhaust fans. It is felt that the security lighting cannot be changed significantly but that the exhaust fans could be shut down and this is accomplished under the set back alternative.

The classroom lighting level is presently at a minimum and should not be decreased. They are now switching all lights off when a room is left unoccupied and it has been observed that this program is followed very faithfully. Therefore it is felt that little or no savings can be achieved from any lighting modification.

The remainder of the electrical load is comprised primarily of auxiliaries required to run the heating plant, such as pumps, fans and controls. If the boiler efficiencies are improved then some additional savings will be achieved from less use of auxiliaries with the more efficient operation.

## 5.3 BUILDING

### 5.3.1

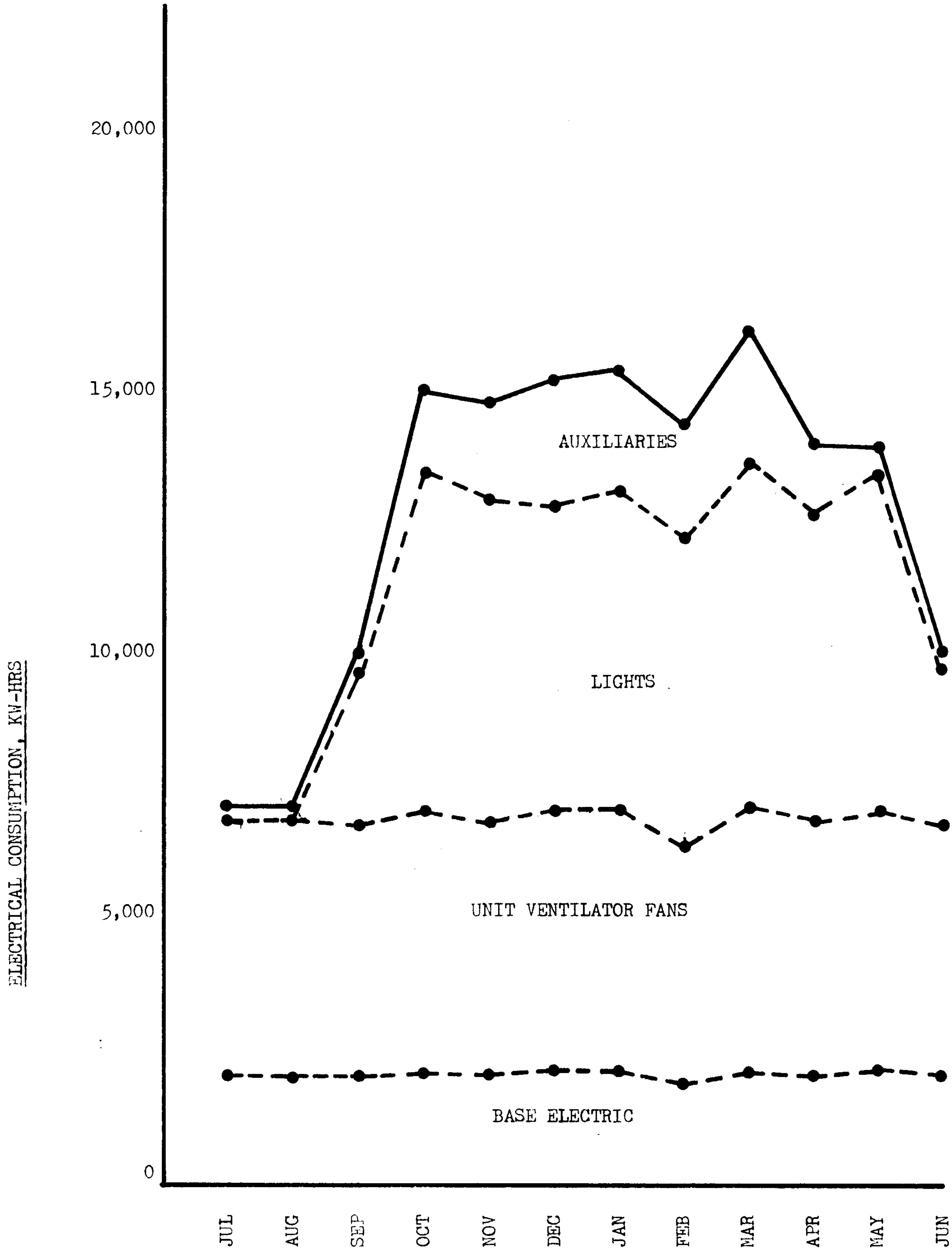
The roof in the original building has been recently replaced and new insulation added with a resultant composite with a good "U" value. Therefore no modification was considered. In the addition however the roof value, including the exposed structural beams, is very poor. Therefore, a simulation was run to examine the effect of installing a new ceiling with insulation on top of the ceiling. The insulation has a value of R-10 and would be installed below the exposed beams reducing the heat loss, in addition to the loss through the Tectum roof deck.

### 5.3.2

Whenever the corridor doors are opened, in particular in the building addition, the corridors become like wind tunnels. It is relatively difficult to determine the exact amount of heat loss due to this infiltration, but an approximation was made, and this alternative examined the effect of reducing this quantity of infiltration. The modification would entail installing double doors at either end of the corridor in the addition. An alternative method might be to install a brick screen just outside of the doors to form a wind break.

### 5.3.3

The next ECO considered, involving a building modification, was to evaluate the cost effectiveness of reducing the amount of window area. Because of the extremely high percentage of glass per total wall area in the addition this was the area analyzed. The quantity of glass was reduced by 50 percent by covering the area to be reduced with a 1/8" masonite panel on the outside and the inside, and 1/2" of fiber batt insulation in between.




BREAKDOWN OF ELECTRICAL ENERGY CONSUMPTION

FIG 5-1

5.3.4

The final ECO of investigation was the evaluation of the cost effectiveness of double glazing all windows throughout the school. This can be accomplished by replacing the windows with a thermopane glass or as an alternative to add another pane such as a storm window.

Fig. 5-2 is an approximate consumption breakdown of the heat loss, plotted in therms, from the building by the roof, wall, glass, and outside air.

## 5.4 MISCELLANEOUS

5.4.1

There are other energy conservation opportunities that were not evaluated because the payback periods did not appear attractive or because of the physiological effects. For example, a reduction in the lighting intensity was considered but the present level of 45 foot-candles is considered to be a minimum for good classroom illumination level.

5.4.2

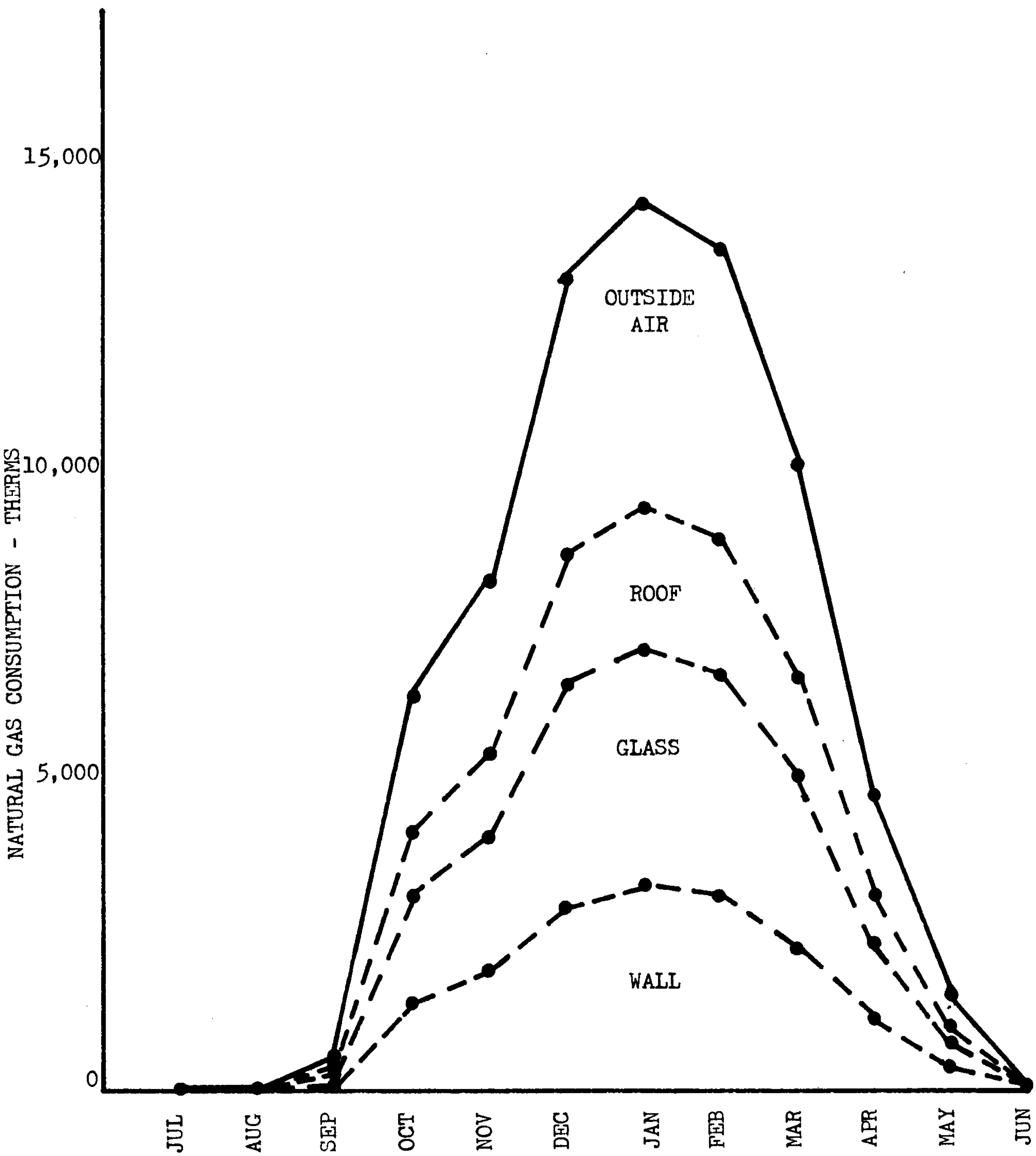
As previously mentioned, weatherstripping was examined but it is felt that when the building is brought under positive pressure that infiltration will be at a minimum and the resultant energy savings would not have very attractive payback. In addition, sealing the existing windows to reduce infiltration will restrict the use of the operable windows for natural warm weather ventilation.

5.4.3

Reducing the thermostat settings is a very viable energy conserving opportunity. This can be accomplished with no capital expenditure. Therefore, this should be performed by the operating personnel to the extent permissible for student comfort allowable by applicable codes and for this reason, was not considered in this study.

5.4.4

Another energy conservation opportunity worthy of further examination and study is the requirements for outside or ventilation air, but is beyond the scope of this study. Considerable amounts of energy are continually being consumed for the heating and cooling of outside air (when school is air conditioned) during the occupied hours. For instance, purging the school, say for one hour during the unoccupied portion of the day, might satisfy the fresh air requirements for good physiological comfort. Reducing the amount of outside air per occupant might also be considered but this would be in violation of the present codes. The interpretation of minimum ventilation codes prevents consideration of this concept in this study. If and when this code interpretation is relaxed then further study of this concept would be in order.




BREAKDOWN OF GAS CONSUMPTION

FIG 5-2

## 6.0 ECONOMIC EVALUATION

The first run of the computer program was to establish the calibration curve or in other words to establish a profile that approximates the actual energy usage as the building presently exists. From this point the ECO's, that were identified in the previous paragraph, were input to the program as alternatives and an economic analysis performed on each alternative. The objective of this economic analysis being to determine the cost effectiveness, or payback period, to recover the initial investment with operating energy savings. The method used in this study for determining the payback on investment is based on the series of Cumulative Cash Flow Figures. From this series of yearly cumulative totals, the year in which the cumulative case flow equals or exceeds the first cost difference is located. The year in which this occurs is the payback period for the investment.

The cash flow effect for this particular building is defined by the following equation:

Cash Flow Effect = Utility Cost + Interest Cost + Principal Cost.

## 6.1 CALIBRATION RUN

The first computer run establishes the calibration curve. Referring to Fig. 6-1 it can be seen that the electrical consumption of 155,886 KW-HRS closely approximates the average consumption for the three years that records have been kept. The gas consumption of 72,743 Therms closely approximates the actual consumption based on the number of degree days or as the difference between 65°F. and the mean outdoor temperature. The degree days provide an indication of the severity of the weather for a given year. The total combined gas and electricity utility costs were then computed at $0.05 per KW-HR and $0.165 per Therm, which is the cost of energy as of November 1976.

## 6.2 ALTERNATIVE #1

The first alternative was run with an improved boiler efficiency of 80 percent and the unit ventilators shut down during the summer months. The shutting down of the unit ventilators would be an operation item requiring no capital expenditure and resulting in an approximate annual savings of $844. Improving the boiler efficiency resulted in a net savings of $2,320 for a combined total electric and gas savings of $3,164 per year. The estimated cost to upgrade the boilers is $10,000.

The dollar values reflecting the energy costs and savings shown in Fig. 6-1 are based on present day utility rates. It is recognized that these utility rates will escalate in the future. After some discussion it was concluded that a representative value of utility escalation would be in the order of 10 percent per year with no cut off. Hence, this value has been used in the economic evaluation of all the ECO's in this study. In addition monies required to perform the capital modifications would have to be obtained by selling bonds and therefore this was input at borrowing money at four percent for twenty years. In determining the payback period the cumulative cash flow effect was used. This method takes into account the utility rates escalating at 10 percent and money being borrowed at 4 percent. The time required to recoup the $10,000 needed to modify the boilers is something in excess of three years and is therefore rounded off to four years.

A graphic comparison of the energy profiles between the existing conditions and Alternative #1 is shown in Fig. 6-2.

## 6.3 ALTERNATIVE #2

This alternative looked at including a night setback system throughout the school. As previously stated this night setback system closed outside air dampers and cycled the unit ventilators and did not reduce the temperature, because of limitations in the program. If this alternative is adopted, reduced unoccupied temperatures should be incorporated and savings in addition to those shown will be gained. Another item that could not be simulated but should be included, would be to reset the time required for morning warm-up. In other words the warmer the outdoor temperature the less time required to bring a building back up to temperature. Most present day systems are set to start-up very early in the morning at a time required to satisfy a design day condition. This time is therefore required only a few days out of the year.

It is noted at this point that all the alternatives #2 thru #7 were run in conjunction with Alternative #1, that is with the increased boiler efficiency. The rationale behind this is that if boiler efficiency is improved, as we recommend that it is, then the savings in gas energy will be somewhat less for the remaining modifications than if it were operating with a less efficient boiler plant. Hence it is felt that this would be a more realistic way of looking at the actual energy savings.

The actual annual energy savings gained by increasing boiler efficiency and including this night setback would be approximately $7,089 but the effect of the night setback alone would be $3,926. The cost to accomplish this modification is estimated at $8,500 and would take less than three years to pay back this investment based on the cumulative cash flow.

A graphic comparison of the energy profiles between the existing conditions and Alternative #2 is shown in Fig. 6-3.

## 6.4 ALTERNATIVE #3

Alternative number three looked at installing a new ceiling in the building addition and adding new insulation above this ceiling. In order to accomplish this the fluorescent light fixtures would have to be extended down below the new ceiling. It is noted that lowering the lights will increase the footcandle level in classrooms. The net effect of this new ceiling insulation would be to decrease the "U" value through the roof and decrease the effect that the exposed beams have on the heat loss.

The annual energy savings for this modification by itself has been calculated at $449. The capital cost of modification was estimated to be $9,000 with a resultant payback of less than 19 years.

A graphic comparison of the energy profiles between the existing conditions and Alternative #3 is shown in Fig. 6-4.

## 6.5 ALTERNATIVE #4

This modification encompasses the effect of adding double doors to the corridor in the addition. The effect on saving energy is relatively difficult to calculate but is reflected here as a reduction in the infiltration rate, with a resultant savings in gas consumption.

The cost of modification has been estimated at $2,400 and will take something in the order of 19 years to recoup this investment.

A graphic comparison of the energy profiles between the existing conditions and Alternative #4 is shown in Fig. 6-5.

## 6.6 ALTERNATIVE #5

Alternative #5 looked at adjusting all of the unit ventilators throughout the school such that they are only introducing the quantity of outside air that is required by code. It is pointed out that in order to accomplish this that a cost was figured to upgrade the unit controls in addition to the air balance. This cost of controls upgrade is also a part of the capital modification cost used in alternative #3. Therefore, if both alternatives are accepted, then the combined costs should be somewhat less than total of both individually.

The resultant energy savings by reducing the outside air will be approximately $2,242. The cost of modification is $7,200 with a resultant payback of less than four years.

A graphic comparison of the energy profiles between the existing conditions and Alternative #5 is shown in Fig. 6-6.

## 6.7 ALTERNATIVE #6

This run looked at reducing the quantity of glass in the addition by fifty percent. It was felt that because of the extremely large percentage of glass per total wall area in the addition that if a reasonable payback could not be achieved here then it could not be achieved for the remainder of the school.

The cost to make this modification was estimated at $6,128 with a resultant savings in energy costs of $154 per year. The payback based on the cumulative cash flow effect would then be approximately twenty-seven years.

A graphic comparison of the energy profiles between the existing conditions and Alternative #6 is shown in Fig. 6-7.

## 6.8 ALTERNATIVE #7

The final energy conserving opportunity that was examined was to double glaze all of the existing glass areas in both the addition and the original building. The estimated cost of capitalization is $28,461 with an energy savings of $1,578 per year and a resultant payback of less than seventeen years.

A graphic comparison of the energy profiles between the existing conditions and Alternative #7 is shown in Fig. 6-8.

## 6.9 COMPUTER PRINTOUT

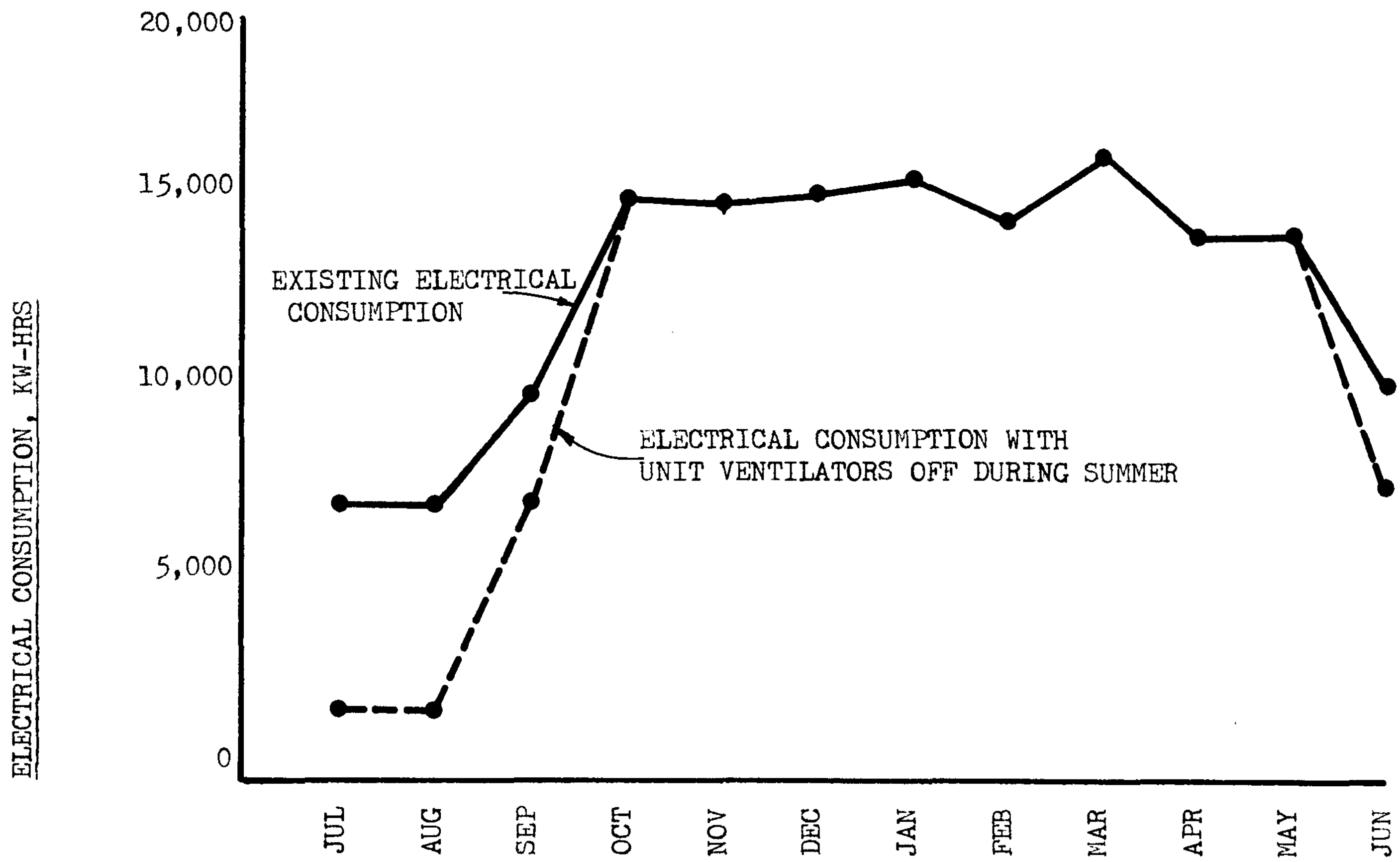
The computer program printouts reflecting energy usage and the resultant savings from the foregoing alternatives are available for examination from either AASA or JCox Associates. The addresses and phone numbers of the above are listed on Page VI of the Management Summary.

| ALTERNATIVE NUMBER | DESCRIPTION | ANNUAL ELECTRICAL CONSUMPTION KW-HRS/$ | ANNUAL ELECTRICAL SAVINGS KW-HRS/$ | ANNUAL GAS CONSUMPTION THERMS/$ | ANNUAL GAS SAVINGS THERMS/$ | TOTAL ANNUAL UTILITY COST $ | TOTAL ENERGY SAVINGS FIRST YEAR | ESTIMATED CAPITAL COST OF MODIFICATION | PAYBACK YEARS |
|---|---|---|---|---|---|---|---|---|---|
| ACTUAL BILLING | SCHOOL YEAR 73-74 | 159,160 / 7,958 | - | 65,318 / 10,778 | - | 18,736 | - | - | - |
| ACTUAL BILLING | SCHOOL YEAR 74-75 | 148,440 / 7,422 | - | 72,024 / 11,884 | - | 19,306 | - | - | - |
| ACTUAL BILLING | SCHOOL YEAR 75-76 | 151,480 / 7,574 | - | 54,786 / 9,040 | - | 16,614 | - | - | - |
| CALI-BRATION | PRESENT OPERATION SIMULATION | 155,886 / 7,794 | - | 72,743 / 12,002 | - | 19,797 | - | - | - |
| #1 | 80% BOILER EFFICIENCY AND UV'S OFF DURING SUMMER | 139,008 / 6,950 | 16,878 / 844 | 58,683 / 9,683 | 14,060 / 2320 | 16,633 | 3164 | 10,000 | 4 |
| #2 | NIGHT SET BACK | 108,892 / 5,445 | 30,116 / 1,506 | 44,018 / 7,263 | 14,665 / 2420 | 12,708 | 3926 | 8,500 | 3 |
| #3 | ADDITION ROOF INSULATION IN ADDITION | 138,362 / 6,918 | 646 / 32 | 56,156 / 9,266 | 2,527 / 417 | 16,184 | 449 | 9,000 | 19 |
| #4 | ADD DOUBLE DOORS | 139,008 / 6,950 | 0 / 0 | 57,994 / 9,569 | 689 / 114 | 16,520 | 114 | 2,400 | 19 |
| #5 | OUTSIDE AIR REDUCTION | 139,008 / 6,950 | 0 / 0 | 45,096 / 7,441 | 13,587 / 2242 | 14,391 | 2242 | 7,200 | 4 |
| #6 | GLASS REDUCTION 50% IN ADDITION | 138,672 / 6,934 | 336 / 17 | 57,853 / 9,546 | 830 / 137 | 16,479 | 154 | 6,128 | 27 |
| #7 | DOUBLE GLAZE ALL WINDOWS | 137,094 / 6,855 | 1914 / 96 | 49,700 / 8,201 | 8,983 / 1482 | 15,055 | 1578 | 28,461 | 17 |

NOTES:

1. Electrical costs @ $0.05/KW-HR
2. Gas costs @ $0.165/THERM
3. Energy costs and savings shown are for the first year.
4. Payback period based on cumulative cash flow escalating utility costs @ 10% and financing money @ 4% for twenty years.
5. Energy savings are not additive. The individual alternatives encompass portions of other alternatives and therefore should be considered independently. Alternative #1 has been incorporated in calculations of savings for Alternatives #2 - 7.

FIG. 6 - 1



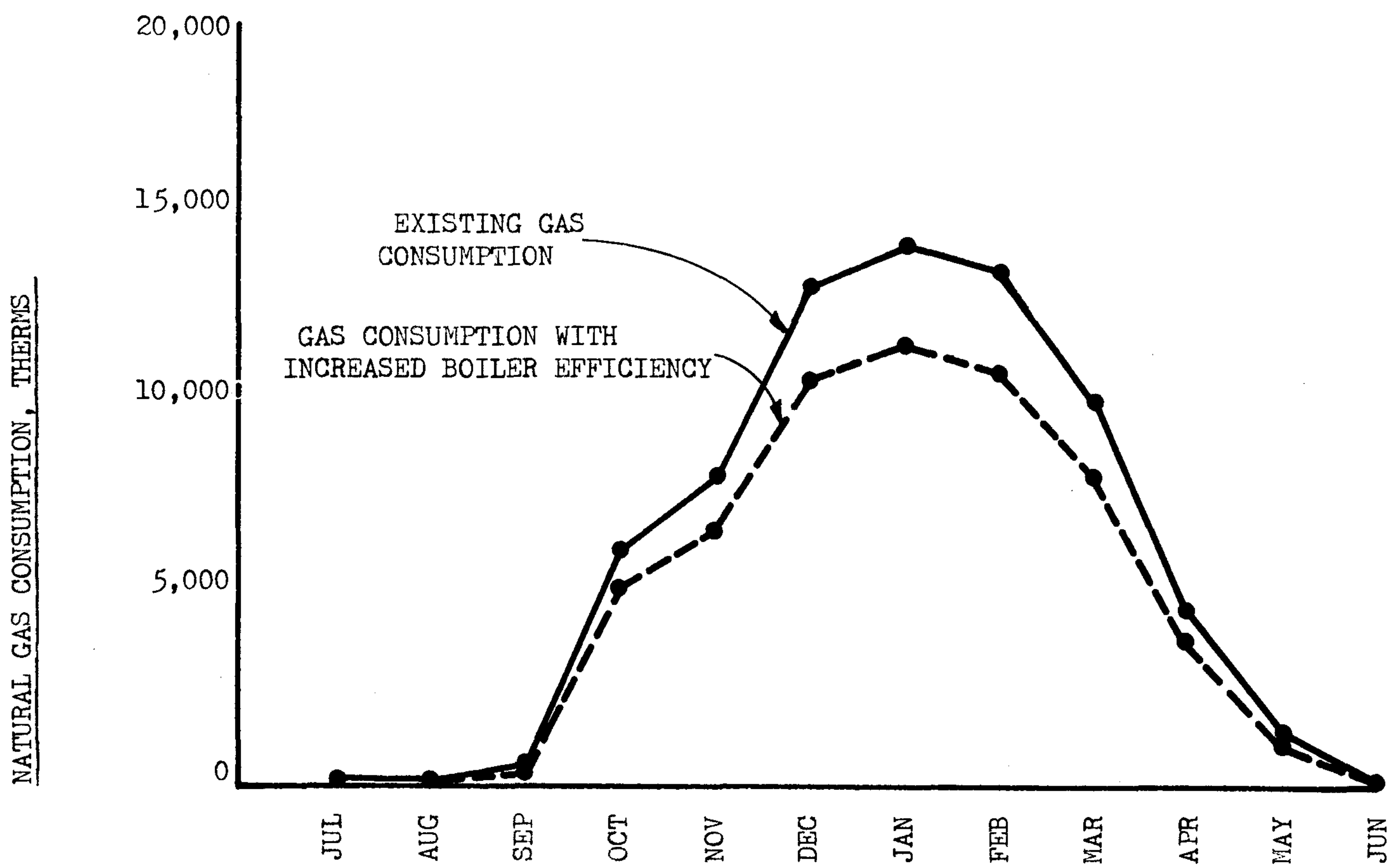




FIG 6-2
Alternative No. 1

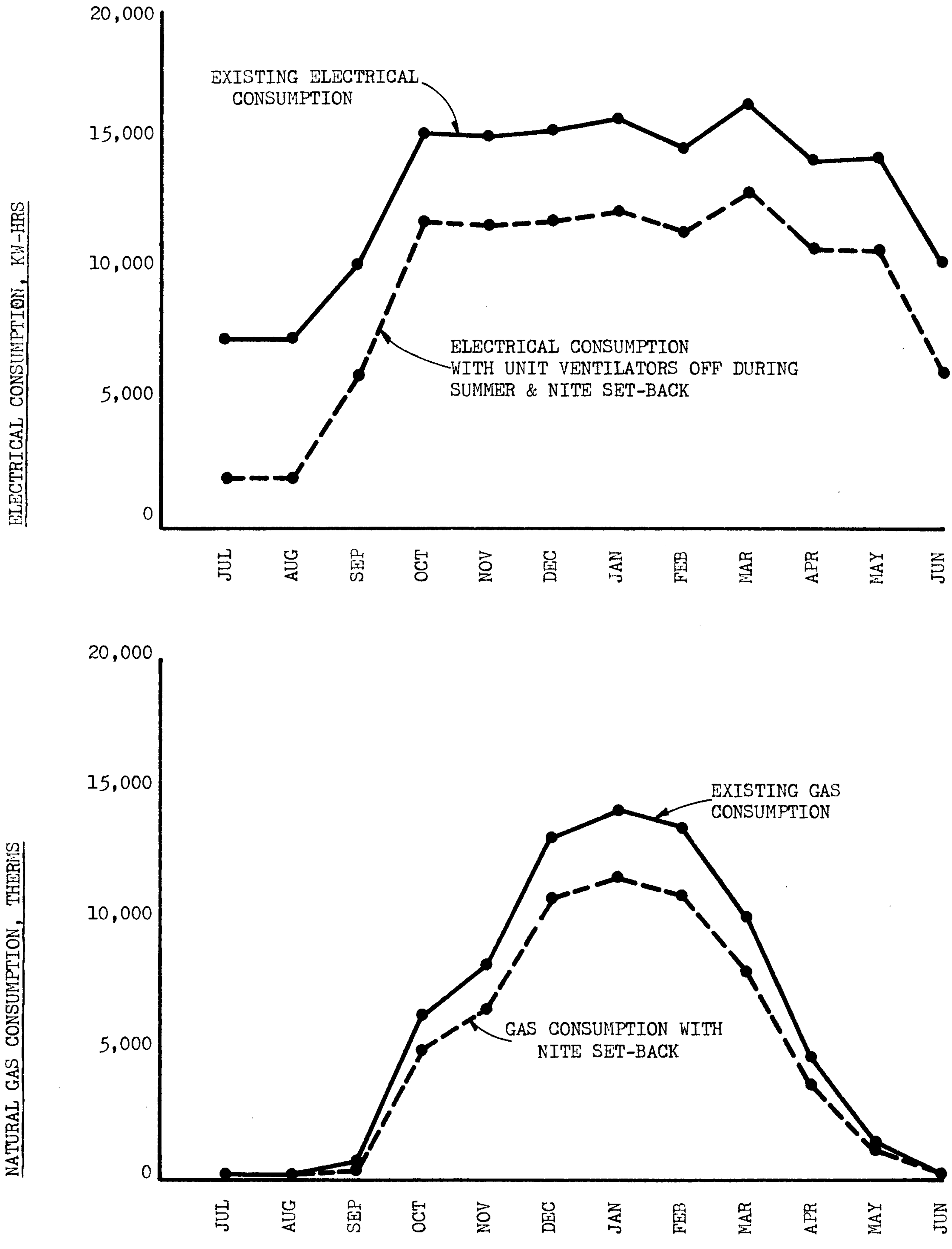



FIG 6 - 3

ALTERNATIVE # 2

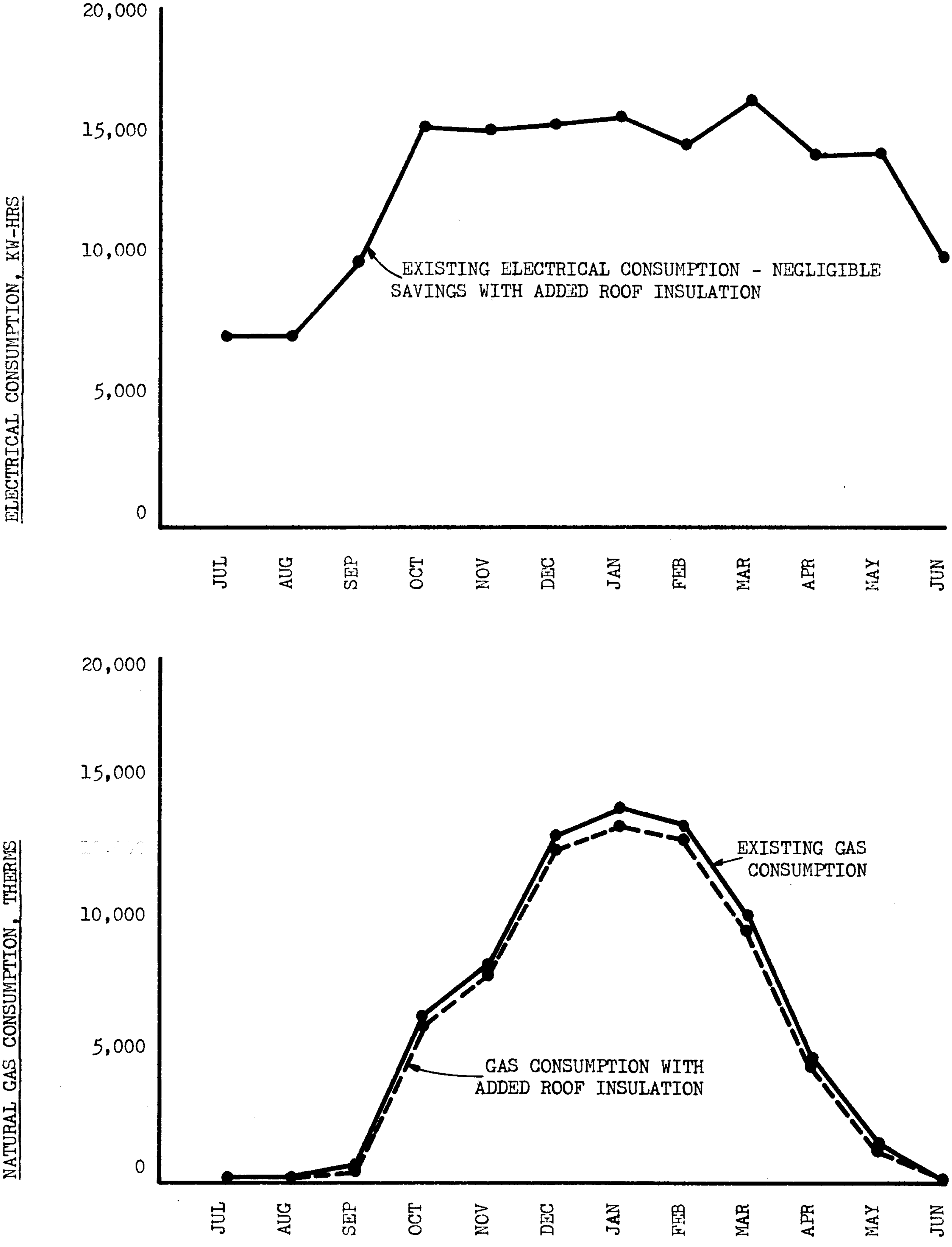
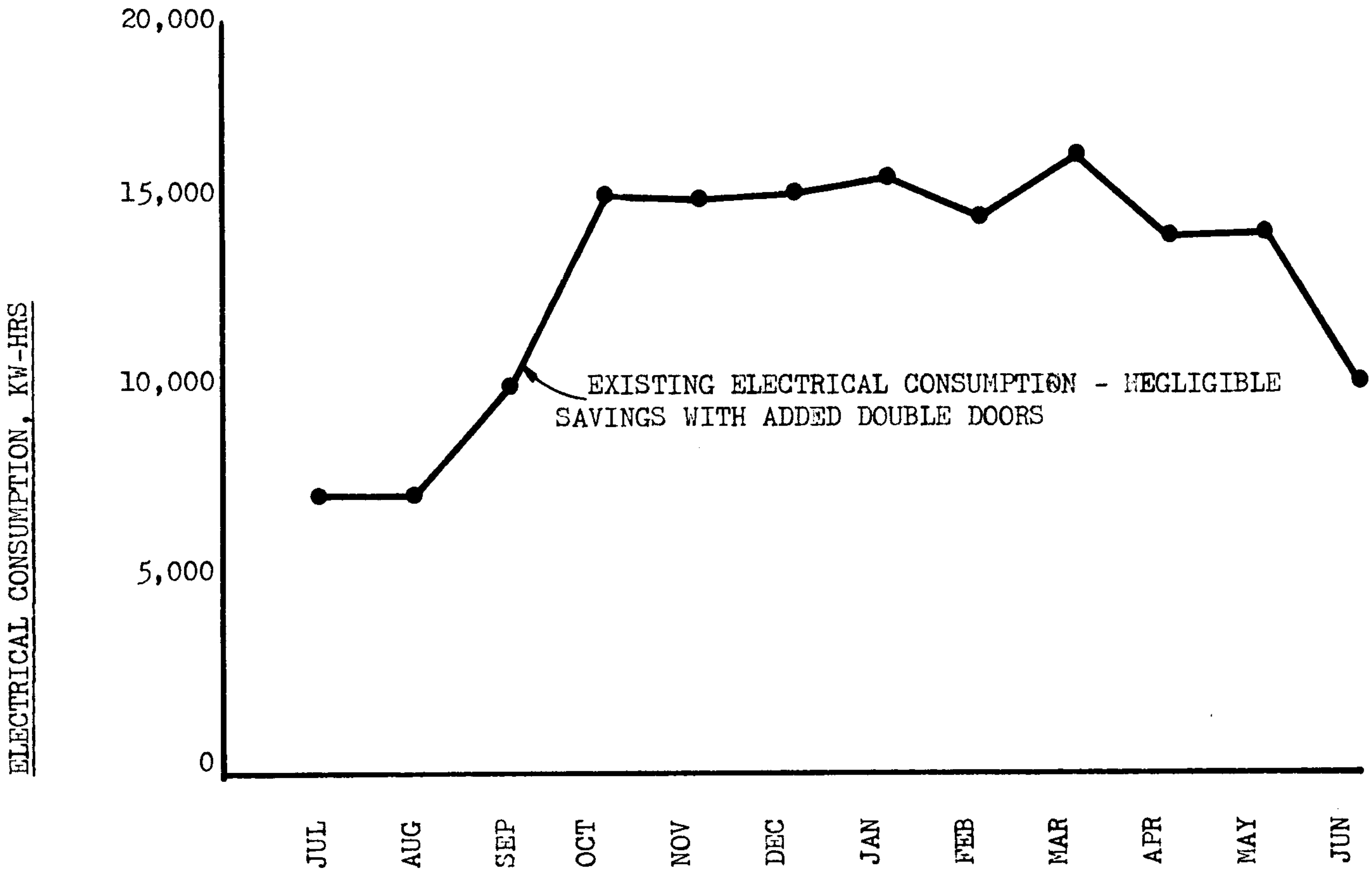



FIG 6-4

ALTERNATIVE # 3



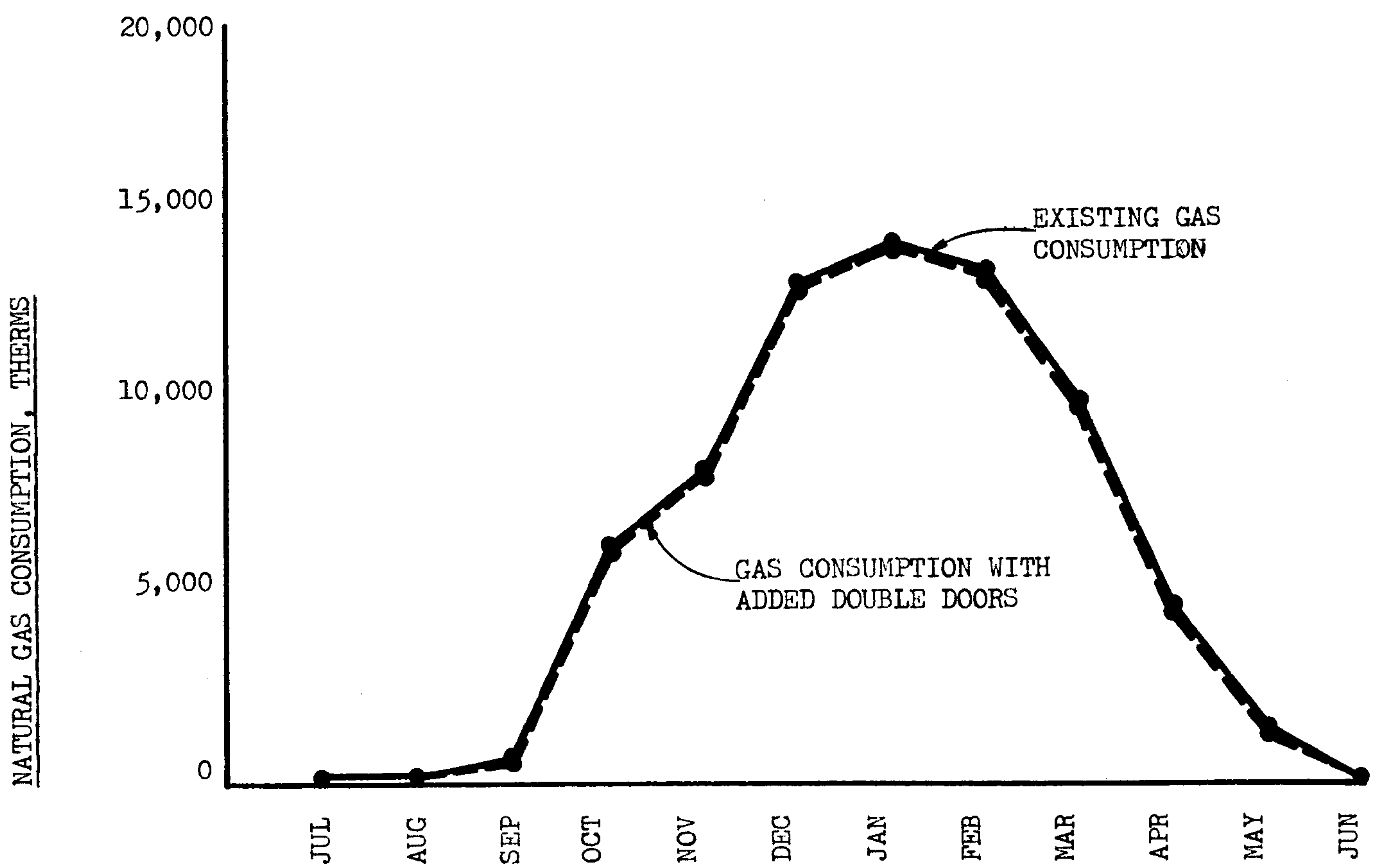
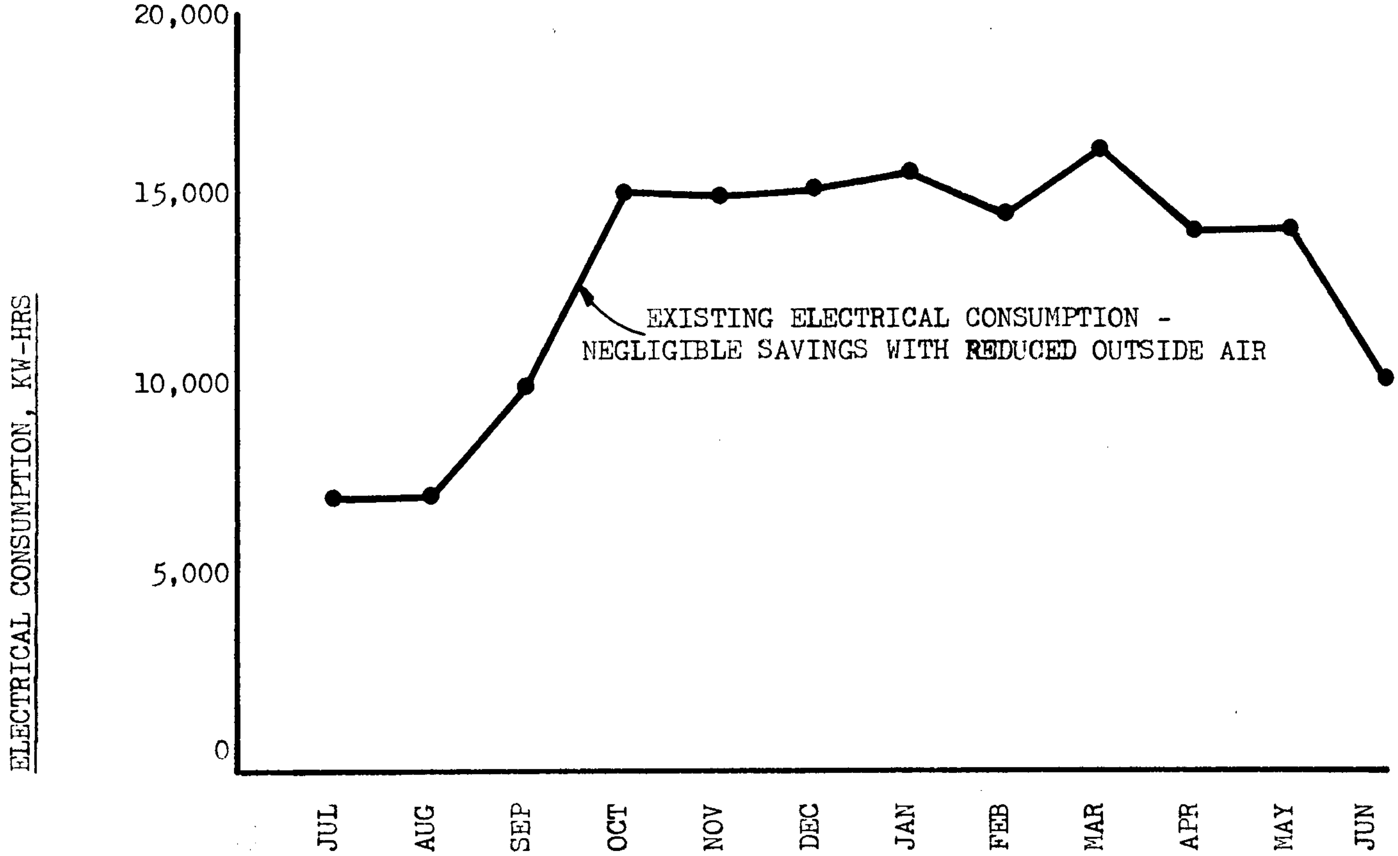




FIG 6-5

ALTERNATIVE #4



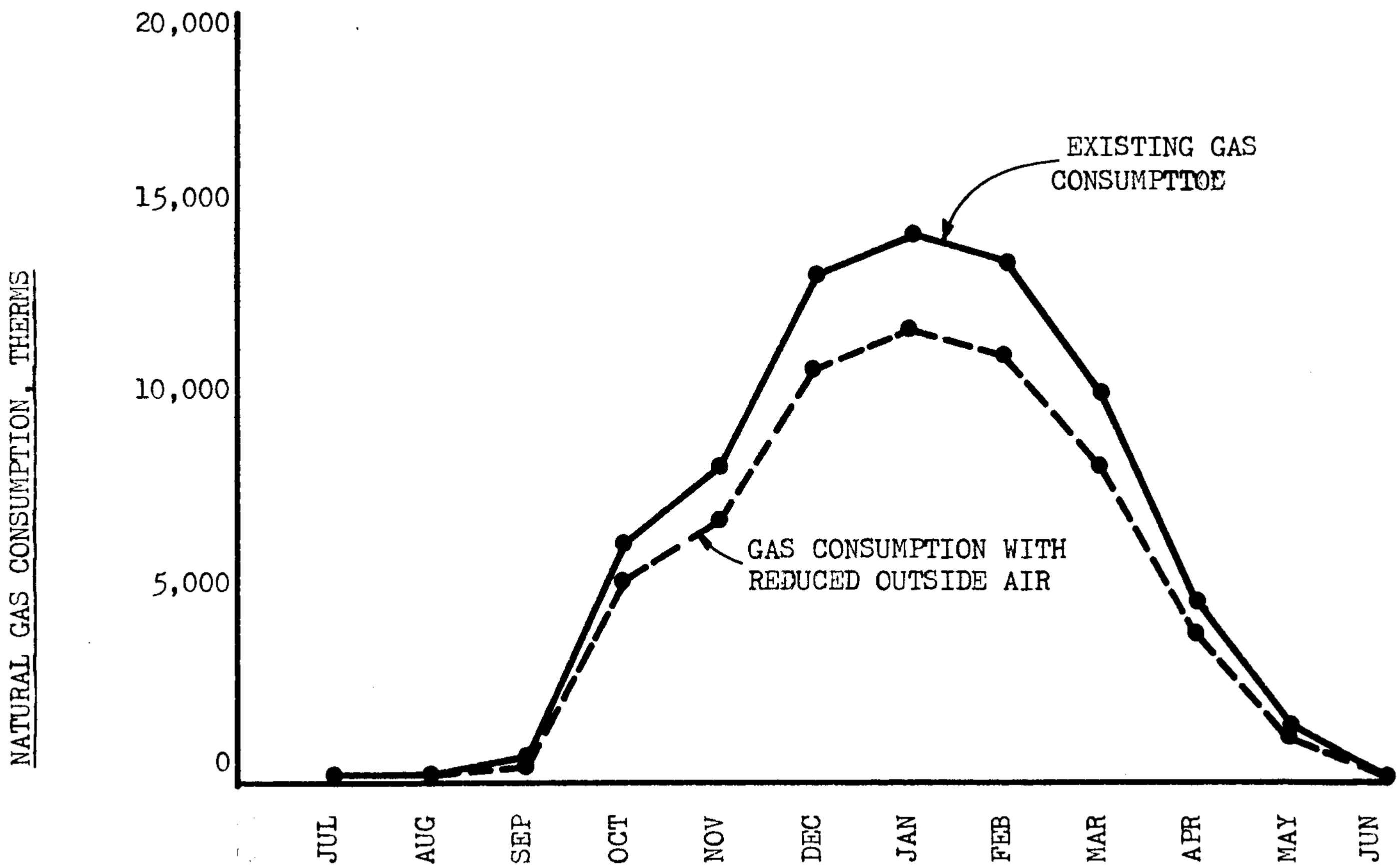
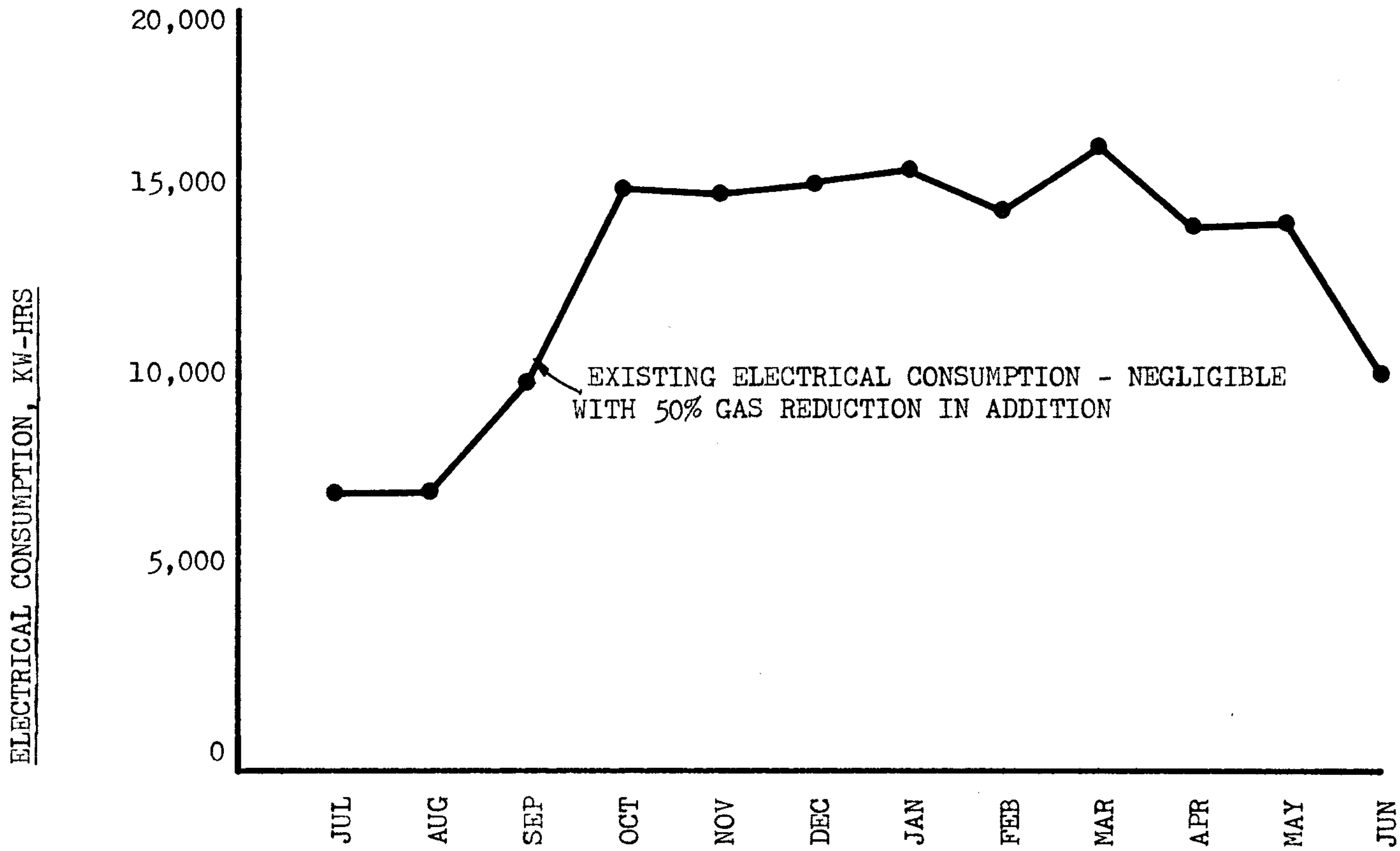




FIG 6-6

ALTERNATIVE #5



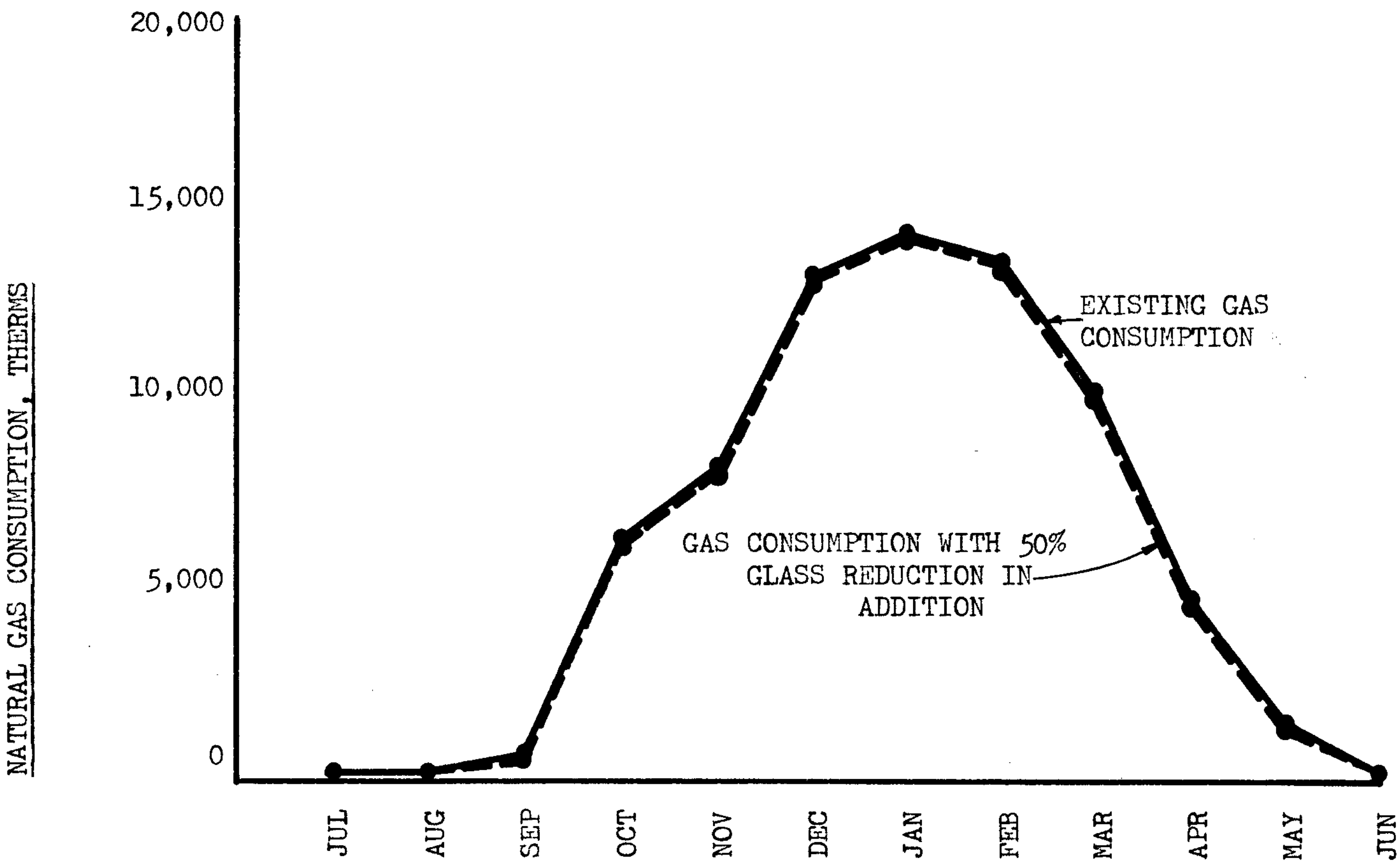




FIG 6 - 7

ALTERNATIVE #6

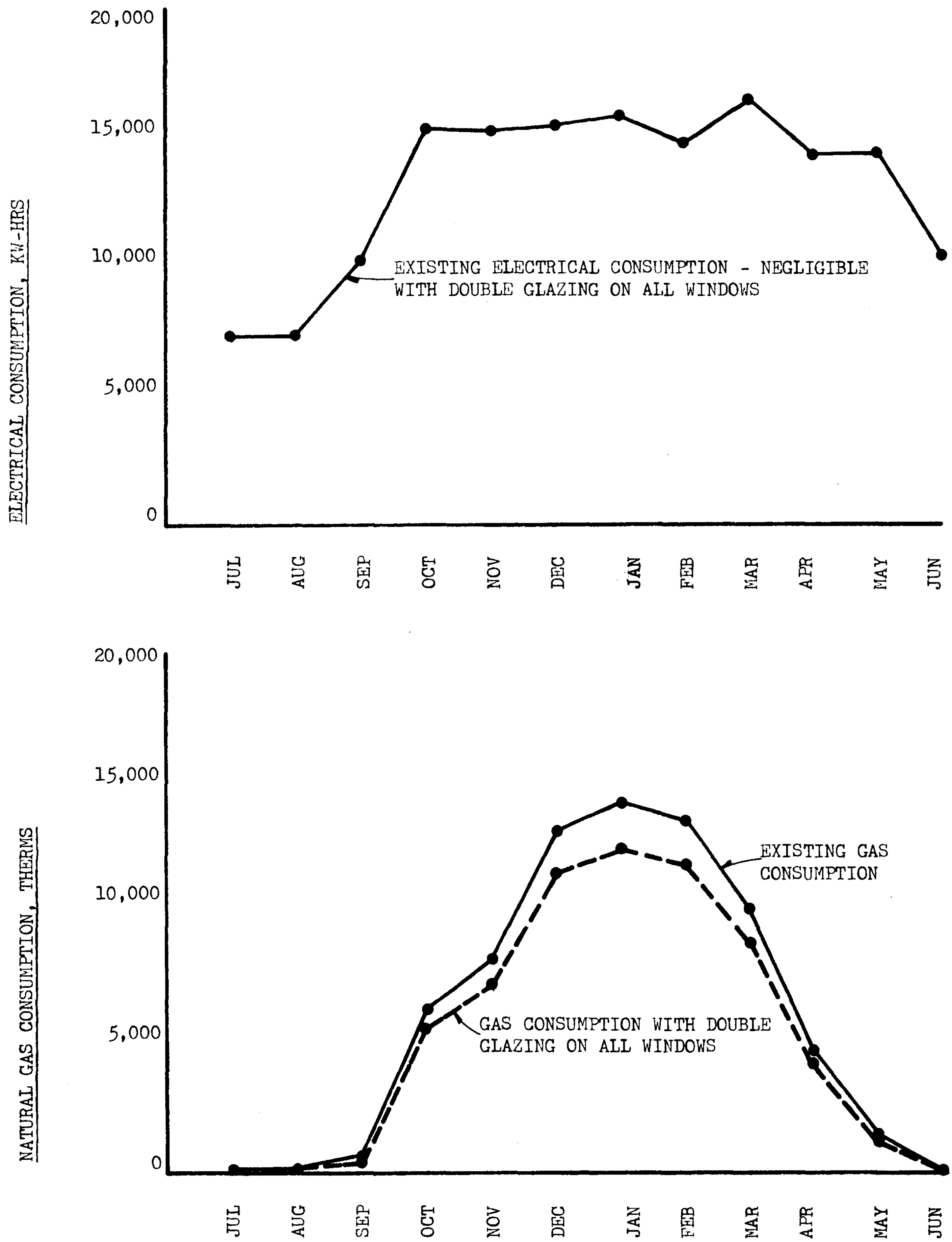



FIG. 6-8

ALTERNATIVE #7

## 7.0 RECOMMENDATIONS

The following energy conserving measures are recommended for implementation in the Fairmoor Elementary School in Columbus, Ohio.

1. De-energize all fans and electrical consuming devices when not required, in particular the classroom units during the unoccupied summer vacation months. (Alternative #1)

2. Modify the existing boiler plant to increase the boiler combustion efficiency. (Alternative #1)

3. Upgrade all of the classroom unit ventilators throughout the school and replace unit controls where required. (Alt. #1)

4. Install a night setback system to reduce unoccupied temperatures, stagger start-up times, cycle heating units as required, and close outside air dampers to reduce the amount of ventilation air being introduced. (Alternative #2)

5. Adjust outside air dampers to reduce the quantity of air being introduced in the building, during the occupied periods, to meet present day codes. (Alternative #5)

The total estimated cost to accomplish all of the above recommendations is approximately $25,000 and at present rates this could realize a payback period of less than three years.

The above recommendations and calculations were based on $0.165/Therm escalated at 10% per annum with 4% interest. As the cost of fuel exceeds this rate, other ECOs may become cost-effective and should be reviewed. Any reconsideration should not view adjusted energy and dollar savings in isolation; materials, labor, interest rates, etc. must also be assessed. The following ECOs may warrant review:

- double glaze all windows
- insulate addition roof
- add double doors
- reduce glass

## 8.0 CONCLUSIONS

The analysis of the Fairmoor Elementary School indicates that energy can be conserved with relatively minor changes to the existing building. The cost of making these modifications can be recouped with the savings in reduced utility bills realizing very attractive payback periods. If all of the areas analyzed as recommended in this study were incorporated as modifications to the school then it is estimated that over fifty percent of the present energy being used could be conserved.

The areas that yielded the lowest payback periods were in improving what might be classed as operating inefficiencies. The areas that did not prove as attractive were where capital modifications were required, such as replacing glass areas with insulated panels. It is felt that the relatively high cost of replacement or modification requires many years of energy savings to realize the initial investment, whereas if this were new construction the cost difference between the two alternatives would not be that great and it would pay for itself in a relatively short period of time.

The cost estimates for material, labor, and energy are derived from the best information available that in a free market, availability is reflected in cost. An exception is natural gas, which has not had such a history. As long as fuel costs or supplies are in any way regulated, actual fuel, or material availability should be part of retrofit consideration. The availability characteristics may transcend the cost-effect characteristics of a modification.

## SUMMARY OF CONCLUSIONS

**SCHOOL:** Fairmoor Elementary School

**LOCATION:** Columbus, Ohio

**POPULATION:** Students: 475
Staff: 30

**USE:** Day: K-6
Night: Multi-purpose Room 5 nights per week

**PHYSICAL DATA:**

| | Original Building | Addition | Total School |
|---|---|---|---|
| Built: | 1949 | 1955 | |
| Floor Area: | 23,500 sq.ft. | 19,200 sq.ft. | 42,700 sq.ft |
| Classrooms: | 12 | 12 | 24 |
| Walls: | 4"FB + 8"CB | 4"FB + 4"CB | |
| Windows: | 23% | 58% | |
| Roof: | BUR + 2-1/2" Ins. Board + Acoustical Tile Ceiling | 2-1/2" Tectum Exposed | |
| Heating System: | Steam Unit Ventilators | Hot Water Unit Ventilators | |
| Lighting: | Fluorescent | Fluorescent | |

**ENERGY CONSERVING OPPORTUNITIES:**

| Item | Initial Capital Cost | Annual Savings | Payback Years |
|---|---|---|---|
| Increase Boiler Efficiency | $10,000 | $3,164 | 4 |
| Night Setback | $ 8,500 | $3,926 | 3 |
| Roof Insulation | $ 9,000 | $ 449 | 19 |
| Double Doors | $ 2,400 | $ 114 | 19 |
| Reduce Outside Air | $ 7,200 | $2,242 | 4 |
| Reduce Glass 50% | $ 6,128 | $ 154 | 27 |
| Double Glaze | $28,461 | $1,578 | 17 |