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THE JERSEY CITY ENERGY CONSERVATION DEMONSTRATION PROGRAM

Final Report

By
Robert F. Newbold

August 1978

Work Performed Under Contract No. EY-76-C-02-2820

The Aerospace Corporation
Energy and Resources Division
El Segundo, California

U. S. DEPARTMENT OF ENERGY

Division of Buildings and Community Systems

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Prepared for
U.S. DEPARTMENT OF ENERGY
Office of Conservation and Solar Applications
Division of Buildings and Community Systems
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ABSTRACT

Under the sponsorship of the U.S. Department of Energy (formerly ERDA), The Aerospace Corporation, the City Government, and the Board of Education of Jersey City, New Jersey, have conducted a group of energy conservation experiments at Jersey City to explore a number of conservation techniques believed to offer quick payback and to be of wide applicability. Experiments include the updating and/or rehabilitation of the energy consuming features of old buildings and installation of devices designed to minimize energy losses caused by human error or laxity. Among the experiments conducted, some specific examples include the upgrading of the deteriorated and inefficient steam distribution system of the city hall (originally constructed in 1894); an extensive program of reducing infiltration in an old school building; use of several timing devices in connection with heating, ventilation, and lighting systems to encourage energy conservation practices; retrofit of school classrooms with high-pressure sodium lamps; and demonstration of practical and cost-effective ways of increasing the efficiency of conventional steam boilers.

The report describes the nature of the selected experiments; technical, human, and organizational factors which proved to be significant in performance and evaluation of the experiments; discussions of observations and lessons learned; and general recommendations for an extended program of energy conservation in local governments. It is emphasized that, in the retrofit of existing buildings, the unexpected is commonplace; and the habits and attitudes of building occupants are elements of the system which must always be taken into account.

This report shows the benefits of energy saving, cost-saving, and added comfort which may be attained by retrofitting old buildings for improved energy conservation, noting typical complications which arise in doing so. The effectiveness of the conservation methods has been presented in terms of costs relative to effective payback periods which were calculated from results of their application in Jersey City.

ACKNOWLEDGMENTS

It is impossible to acknowledge all of the contributions and the contributors to a program such as this one, which spans almost three years in time, includes the efforts of many organizations, and involves many changes in personnel. Limitations of available space alone make it impossible to recognize all of the many people who helped.

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Contractors and Consultants

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Ms. Mary Lou Black, Ms. Kay Miller, and Ms. Patricia Dunn for invaluable secretarial support and great patience in the preparation of this report. Mr. Cecil St. Aubin, of the Engineering Section, for engineering support.

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1.0 BACKGROUND AND OBJECTIVES

1.1 PROGRAM BACKGROUND

The Arab oil embargo of 1973 focused attention on the United States' growing imbalance between energy supply and demand, a matter of greater long term significance than the immediate problem precipitated by the Arabs. It was generally recognized that several steps would be necessary in order to define and implement a new national energy policy. The Energy Research and Development Administration (ERDA) was formed, and the need for energy conservation began to get widespread attention. ERDA perceived that local governments constituted a bloc of large users of energy which could provide visible examples of conservation practices. Furthermore, it appeared likely that local governments, which are perpetually pressed to provide more and more services within the constraint of very limited budgets, would respond to the opportunity for monetary savings afforded by energy conservation.

The Aerospace Corporation had been concerned for several years with the technical needs of communities and perceived that energy conservation offered an important possibility for economy in local governments with potential benefits to the nation as well. Aerospace solicited and obtained support from the National Science Foundation for planning a program to demonstrate energy conservation in public housing. This program was initiated by Aerospace with four local housing authorities under sponsorship of the U.S. Department of Housing and Urban Development.

In 1974, The National Science Foundation initiated a program, the Urban Technology System, to assist local governments in applying and utilizing available technology to meet municipal needs. In this program, "technology agents" were assigned to 27 local governments on an experimental three-year basis under the management of Public Technology, Inc. (PTI). One such technology agent was assigned to Jersey

City, N. J. In that assignment he recognized that technical efforts for energy conservation within Jersey City for city buildings, schools, and other municipal agencies had a potentially high payoff in dollars and in energy savings.

In a meeting between a representative of The Aerospace Corporation and the PTI Technology Agent of Jersey City, the need for energy conservation measures by local governments was discussed. The applicability of energy conservation measures to Jersey City and the opportunities for energy conservation there were observed. The Aerospace contract for the Jersey City Energy Conservation Demonstration Program came from this meeting and ensuing discussions.

1.2 OBJECTIVES

The fundamental objective of the Jersey City program was to demonstrate examples of energy conservation technology for public buildings which might be expected to have a short payback time and to have wide application for local governments. Specific demonstration projects selected for the program are described in Section 3.0 of the report. As will be seen, these projects have a strong technical emphasis.

As the program progressed, it involved a large number of agencies (as will be described in more detail later), each with its own established methods of operation. The problems which arose in trying to do new kinds of things rapidly within this complex of organizations proved to be managerially difficult and much more complicated than had been anticipated.

Moreover, human factors were found to have a pronounced effect on the progress and outcome of the demonstration experiments. Habit, emotional and psychological factors frequently had as significant an effect on energy consumption as did the technological fixes provided to achieve conservation.

Accordingly, two ancillary objectives were identified: (1) to observe and to report results with regard to the human behavior and institutional factors which have been found important in the performance of the energy conservation programs; and (2) to identify those portions of the program affected most heavily by these factors. A record of such sensitivities might help develop awareness from which pertinent human and institutional factors will be taken into account in planning and conducting future programs for energy conservation in local governments.

1.3 SCOPE

As indicated above, the original scope of the program was primarily technical, in that only technical means for conservation were considered and quantitative assessments of results were emphasized. It proved necessary to increase the emphasis on human behavior, on the institutional and bureaucratic factors that affect the program, and on qualitative and judgmental effects which proved to be significant.

The scope of the projects selected was limited to consideration of energy saving in public buildings. Local Jersey City government bodies which have buildings that are important energy users include the City administration, the Board of Education, the Medical Center, and local public housing. Of these, the City administration and the Board of Education were selected as participants in this program.

The nature of these demonstration experiments (with limited funds available for equipment) restricted some projects to examples of limited size rather than full-scale retrofits. For instance, the timed light controller (Section 3.2.2) was installed in one bay of the Central Garage, representing only a small part of the total Central Garage space in which benefits might accrue from application of this concept.

1.4 TECHNICAL PREPARATION FOR THE CONSERVATION DEMONSTRATION PROGRAM

A great deal of on-site work in Jersey City was required to accumulate the information and perspective necessary to identify potential energy conservation opportunities, to evaluate their potential, to select equipment and techniques which would best meet the need, and to obtain the advice and support of the people who subsequently participated in the conservation projects.

It was necessary to obtain, consolidate, and interpret energy consumption records, usually in the form of billings, for facilities and activities in the city administration, the school system, the city medical center, and public housing. Field work and detailed observation was required to identify wasteful practices, obsolete or worn-out equipment, and other conditions leading to energy waste.

Assimilation and interpretation of the accumulated data was necessary, using such devices as scatter-plots of seasonal energy consumption per unit of floor area for about forty school buildings. Energy-use time profiles were examined to determine use patterns and to evaluate peak-load charges. Calculations were made of potential savings and their relative cost-effectiveness. New devices and techniques were investigated for possible applicability.

Much of this work had been done by the Jersey City Technology Agent before the inception of the program, and it was supported and assisted by technical advisory groups of the Urban Technology System (UTS) sponsored by the National Science Foundation and operated by Public Technology, Incorporated. (For further information concerning participants in this program, see Section 2.1.)

2.0 PROGRAM ORGANIZATION

The Jersey City Energy Conservation Demonstration Program described in this report had a temporary project-type organization, composed of persons or elements of many participating organizations, usually participating part time.

2.1 PARTICIPATING ORGANIZATIONS

Organizations participating in the Demonstration Program are listed below with a brief statement of their roles.

2.1.1 Department of Energy

The U.S. Department of Energy (DOE), formerly The Energy Research and Development Administration (ERDA), was the contracting agency which funded and directed the Jersey City demonstration program.

2.1.2 Public Technology, Inc.

Public Technology Inc. (PTI), Washington D.C., provided technical and financial support for the local Technology Agent. The PTI information network (called the Urban Technology System, UTS),, consisting of 27 technology agents assigned to local governments throughout the United States, was a valuable resource for the project, both for obtaining information as to useful materials and techniques and for disseminating the ideas and practices for energy conservation which were identified and tested in the Demonstration Program The UTS was sponsored by the National Science Foundation.

2.1.3 City of Jersey City

The City of Jersey City, N. J., under an agreement with The Aerospace Corporation and the Jersey City Board of Education, as approved by DOE, provided test sites for some of the demonstration experiments. The City also provided: procurement services for all equipment and installation services purchased under the program; labor by city employees for some of the installations in city buildings; and some assistance in data gathering.

The City provided the services of the PTI Technology Agent assigned to Jersey City, as described in Section 2.1.4 below. The Agent served as the on-site planner, supervisor, quality control supervisor, data taker, reporter, and program coordinator, as well as the technical representative of Jersey City for the program.

2.1.4 The Jersey City Board of Education

The Jersey City Board of Education also participated in the program by providing demonstration test sites in school buildings, installation labor on special projects, and data collection assistance on some projects. (In Jersey City usage, the term "Board of Education" encompasses the entire administrative and management organization of the city school system, and not merely the governing body.)

2.1.5 The Aerospace Corporation

The Aerospace Corporation is a not-for-profit federal contract research center originally founded in 1960 to provide support and direction for U.S. Air Force missile and space programs. In working for the USAF, Aerospace has assembled a uniquely diversified technical staff and a technical management organization.

Since 1969 Aerospace has assumed progressively increasing responsibilities in such diverse fields as: analyses and program direction in energy systems; resources; transportation; the environment; law enforcement; and forestry.

Aerospace, as the DOE contractor for the Jersey City program, was responsible for planning, specifying equipment, supervising and/or verifying proper installation and operation of the equipment, gathering of project data, and reporting on results of the program. Aerospace, in performing these tasks, coordinated the activities of all agencies participating in the program; these agencies and their relationships in the program are shown in Section 2.2 In addition, Aerospace was made responsible for disbursing project funds for equipment or services to Jersey City on proof of an appropriate purchase commitment; see Section 2.2.1.

2.1.6 Architect-Engineer and Consultant

In support of its function, Aerospace retained the services of J.A.B. Associates, an engineering firm of Livingston, N. J. Invaluable support on site has been provided by this organization, and especially by its President, Mr. Robert Haiken, P.E. In addition, Mr. Walter McIlveen, of Walter McIlveen Associates, Avon, Connecticut assisted in planning the technical approach to serious problems which arose in modifying the existing non-standard city hall steam heating system (Section 3.1.2).

2.1.7 Other Organizations Concerned

Other organizations which have had a significant impact upon the direction and conduct of this program include:

The National Science Foundation (sponsor of the PTI program for technology agents)

The State of New Jersey Board of Education

The New Jersey Public Utility Commission

Numerous contractors, consultants and vendors

The roles of these organizations are described in Section 3.0 in connection with the individual projects with which they were concerned.

2.2 PROGRAM STRUCTURE

The Jersey City Energy Conservation Program had both formal and informal organizations. The formal organization included both the relationships defined by or derivative from the DOE contract to Aerospace and the statutory relationships which directly affected actions under the contract. The informal organization existed within the formal as a complex of personal, professional, and political ties which were neither explicitly defined nor directly under the control of the formal organization. The informal organization -- and particularly that part of it within Jersey City -- had very significant effects on the program; some of these effects are discussed elsewhere in this report.

2.2.1 Formal Organization

The formal structure of the Jersey City Energy Conservation Program is derived from and based upon the Aerospace contract with the DOE. Under this contract, Aerospace was responsible for: (1) reaching suitable working agreements with the City and the Board of Education of Jersey City, (2) for selecting and recommending the experiments to be employed, (3) the specific hardware to be used, and (4) the data-taking procedures to be used for project evaluation. DOE (ERDA) also made Aerospace responsible for the disbursement of project funds to reimburse Jersey City for purchases of goods and services.

A formal agreement between Aerospace, Jersey City and the Jersey City Board of Education was negotiated. (See Appendix A-1). The original purchasing and reimbursement procedures of this agreement were revised and approved later; these procedures are given as Appendix A-2. The fact that meticulous revision was necessary and the detailed nature of the necessary procedures are indicative of the complexity of institutional relationships and constraints of the program. These are typical of working relationships which may be required in dealing with local governments.

A unique aspect of the fiscal arrangement between Aerospace and the City of Jersey City arises from New Jersey state law. Jersey City cannot carry an unbalanced revenue statement beyond the end of the City fiscal year, which coincides with the end of the calendar year. Therefore, a special agreement, Section C of Appendix A-2, was necessary to facilitate reimbursement to Jersey City by Aerospace for project obligations in late December for compliance with the law.

Figure 1 shows the elements of the formal relationships which existed within the program and the parties involved. The key relationship of this program is the funded contract between The Aerospace Corporation and DOE. Supporting this are: formal agreements between Aerospace, the city, and the board of education; an Aerospace subcontract for local architectual and engineering support; Jersey City contracts with Public Technology, Inc. and with local contractors and vendors.

2.2.2 Internal Functional Organization

The complexity of the project organization, including contractual, official/legal and information channels is suggested by Figure 2, which shows the organizations participating in the demonstration project, the constraints upon policy, funds, and technical approval which exist among them, and the principal channels through which

RELATIONSHIP	SYMBOL
CONTRACT	C
AGREEMENT	A
STATUTORY	S

	AEROSPACE	CITY OF JERSEY CITY	JERSEY CITY BOARD OF ED	STATE OF NEW JERSEY	STATE BOARD OF EDUCATION	PUBLIC TECHNOLOGY, INC	A&E CONSULTANTS	CONTRACTORS/VENDORS
DEPARTMENT OF ENERGY	C							
AEROSPACE		A	A				C	
CITY OF JERSEY CITY				S		C		C
JERSEY CITY BOARD OF EDUCATION					S			

Figure 1. Organizational Relationships
Jersey City Energy Conservation Demonstration Program

technical information was transmitted in some formal sense. The constraints shown in this figure are formally imposed by law (as between the State and the City Boards of Education), by contract (as between DOE and The Aerospace Corporation), and by formal agreement (as between The Aerospace Corporation, the City of Jersey City, and the Board of Education).

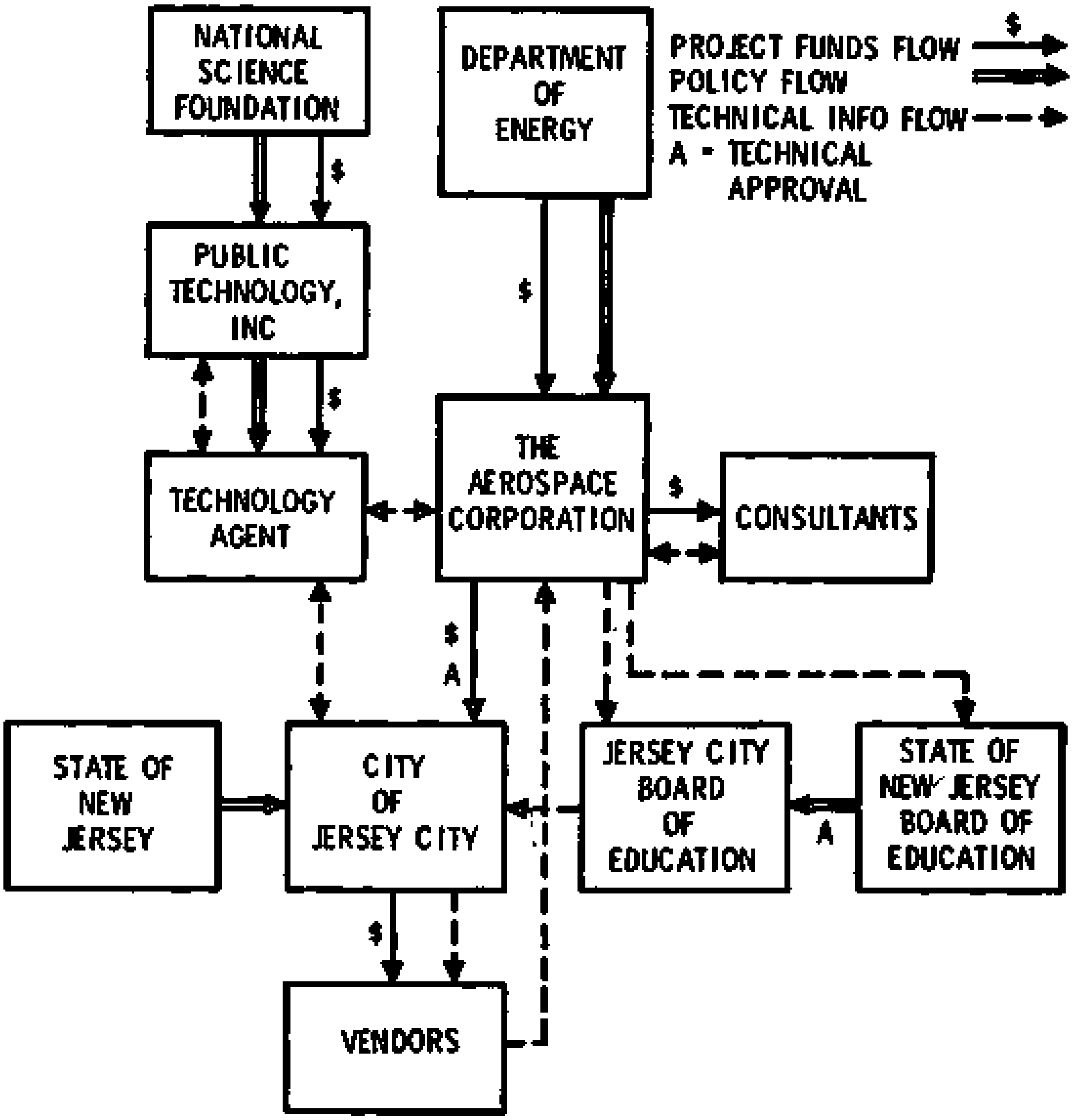


Figure 2. Functional Project Organization, Jersey City Energy Conservation Demonstration Program

No effort has been made to represent the loose, informal relationships of the program, which permitted the exchange of information between each and almost every other participant.

3.0 PROJECTS

All of the projects and project sites which were planned for this program are described in the following subsections, although some were changed during the program. For each there is a discussion of the initial rationale for selecting it, subsequent changes which proved necessary, new insights acquired, the energy savings attained, and how these savings were measured. Also described are those considerations which apply in interpreting the data or in applying techniques of the experiment elsewhere.

Projects have been evaluated in terms of energy saved (kWh, BTU, or gallons of oil), of dollars saved, and of simple payback time in years, defined as the ratio of project cost to the annual saving in dollars. Savings are computed on the basis of 140,000 BTU/gal for oil and at approximate mid-1978 costs of energy to large municipal users in Jersey City: 6.3¢ per kWh and 36¢ per gallon for #2 or #4 fuel oil.

3.1 CITY HALL PROJECTS

The City Hall of Jersey City (Figure 3) houses the City's administrative offices and serves the general public for licensing and permits. It houses the mayor's office and the City Council chambers. Features of the building are shown in Table 1. The architect's original concept of the exterior of City Hall is presented in Figure 4.

When this energy conservation demonstration program was being planned (in 1975) the city hall of Jersey City was notable as a heavy user of fuel oil. Over calendar year 1974, a relatively mild season of just over 4700 heating degree days, the city hall heating system used 66,100 gallons of No. 2 fuel oil. Adjusted to an average season of 5000 degree days, this is the equivalent of 69,700 gallons per average season, 0.85 gallons of oil or 119,000 BTU's of energy per square foot of its 82,000 square foot floor area. By comparison, some of the

Figure 3. City Hall: Jersey City, N.J.

Table 1

CITY HALL FEATURES
JERSEY CITY, NEW JERSEY
(Condition prior to this program)

Building Description:

Year of construction:	1894
Number of floors;	3 plus basement
Total area:	82,000 sq. ft.
Type of construction:	granite block and brick with interior courtyard
Windows:	About 330 wooden, double-hung, single-glazed sash, approximately 14,000 sq. ft.

Energy Systems:

Heating system: steam, two-zone

Boilers: 2 Mulhearn, fire tube forced draft, 22 psi; #2 oil

Burner; Iron Fireman, gun type, 10 gph

Domestic hot water: electric heater

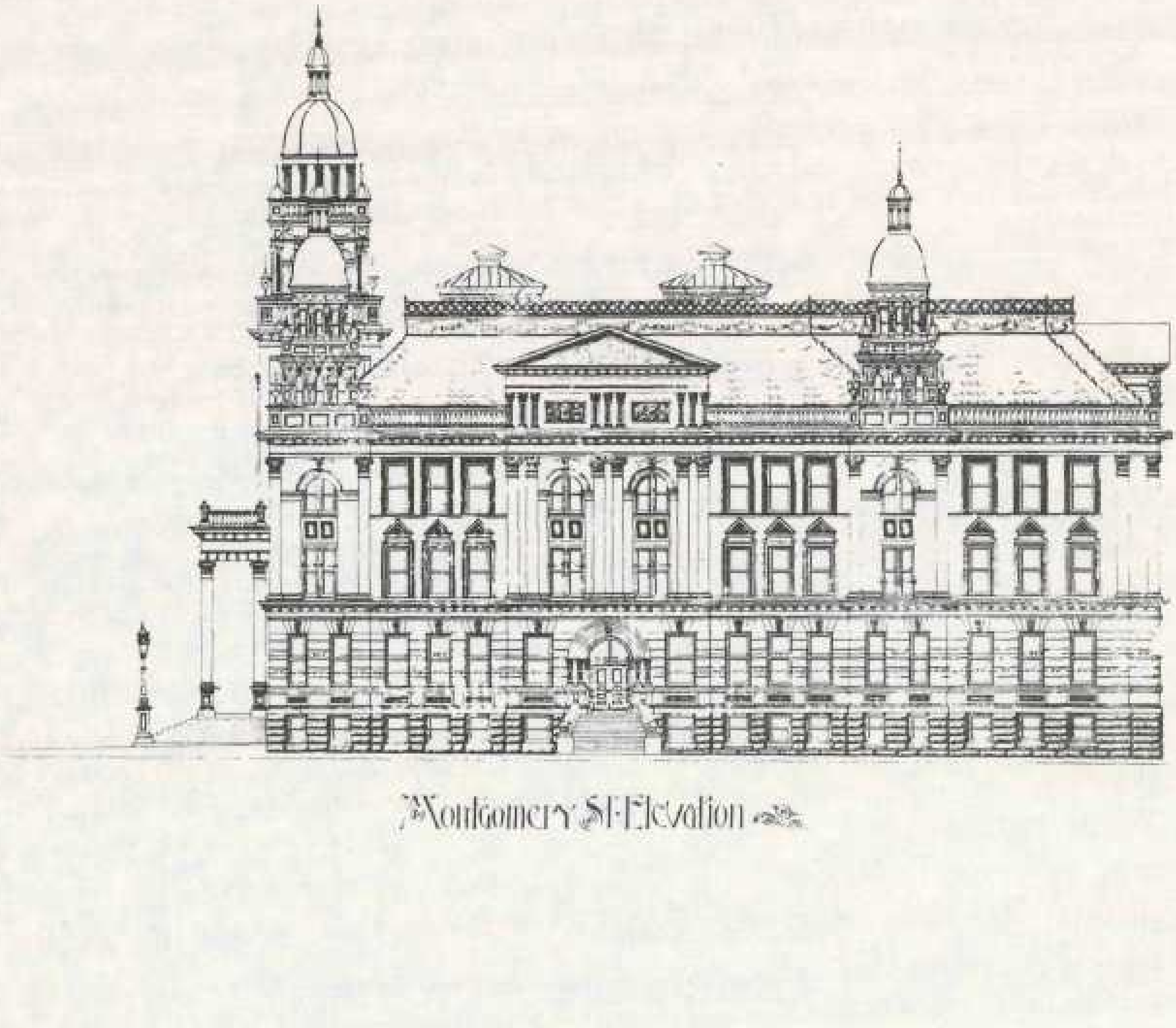
Ventilation System:

Exhaust system: open window

Air conditioning: window units

Electrical:

Lighting: fluorescent



Montgomery St. Elevation

Figure 4. City Hall, Jersey City, N.J.
Architect's Concept

newer school buildings in Jersey City were consuming energy at only slightly more than half this rate per unit floor area. The City Hall was clearly a promising locale for energy conservation efforts.

Prior to the inception of this ERDA/DOE conservation program, the City of Jersey City had started to deal with one major source of energy loss in City Hall: its windows. There were over 300 single-glazed double-hung frame windows totalling in area almost 14,000 square feet. These were the original equipment of the 1894 building. Besides the losses implicit in the use of single-glazing, the sashes of these windows were weathered and warped, so that infiltration losses were excessive.

The steam distribution system of the building and user practices for controlling room heat were judged to be other major sources of heat loss in City Hall. Room temperatures and the availability of heat were highly variable throughout the building. Some areas were under-heated, with corresponding discomfort for personnel. Many rooms were overheated. The unbalance was tentatively attributed to the unequal loading of the two steam mains serving the building. Temperature control of individual offices had originally been maintained by hand-controlled throttle valves at the individual radiators. However, many of these valves had eroded so badly that they could no longer be closed. Thus, occupants of overheated offices without operable radiator valves had no choice but to open windows for temperature control. The general use of this practice, however, tended to further deprive cold areas in the building of needed heat. In addition, there were no steam traps in the two-pipe system, so that live steam was free to flow through the radiators and to heat the condensate return system. This appeared to be a wasteful misapplication of heat.

Estimates of losses due to these several effects (and of the energy to be saved by their elimination) have been made. However, it should be noted that such estimates inevitably have large uncertainties, since there are several critical parameters, of which some are time-variant, interacting, and impractical to measure accurately when the building is in use.

Savings Attainable by Double Glazing

As previously noted, the approximately 330 windows of City Hall have an exposed area of about 13,800 square feet, of which about 5000 square feet open into the inner courtyard where wind speed has been assumed to be negligible. Using parameters from Reference 1, Chapters 20 and 21, it was determined that for the 8800 square feet of outside windows and an assumed 15 mph wind speed, double-glazing would provide a saving of

$$\frac{0.55 \text{ BTU}}{\text{hr} \times \text{ft}^2 \times {}^\circ\text{F}}.$$

Similarly, for the 5000 square feet of windows in the courtyard (assumed windless), the saving is

$$\frac{0.32 \text{ BTU}}{\text{hr} \times \text{ft}^2 \times {}^\circ\text{F}}.$$

In combination, using the average Jersey City season of 5000 degree days, replacement of all original single glass windows with double-glazing has been estimated to save 7.7×10^8 BTU per season. For 75 percent efficiency of the heating system and 1.4×10^5 BTU per gallon of No. 2 oil, a saving of 7300 gallons of oil per year was computed for double-glazing the windows of City Hall.

Savings Attainable by Reducing Infiltration

As noted above, the old weathered windows of City Hall, had developed large cracks and gaps, which were clearly the cause of serious infiltration losses. Reference 1, in Chapters 20 and 21, gives approximate relationships and parameters for determining infiltration losses. Important parameters affecting infiltration include the length and average size of leaking cracks (around and between the window sash in this case), the pressure differential between the inside and outside of the building, and the air temperature differential between inside and outside. However, these differentials are dynamic rather than static parameters, extremely difficult to determine accurately by measurement and impractical to calculate on the basis of static parameters, such as a fixed value for building leakage, or for leakage which is assumed constant for all wind directions. The internal building pressure will depend upon wind speed, direction, and the distribution of leakage effects around the building perimeter; it is not readily determinable, nor can it be expressed realistically as a single, static number characteristic of the building.

Sample calculations were made of the savings which could be effected by reducing the infiltration losses to levels expected of present-day heating and ventilating practices. These calculations were based upon parameters given in Reference 1, using the arbitrary assumption of internal building pressure 0.2 inches of water greater than outside pressure. The resultant estimated savings which might be expected from reduction of infiltration (based upon the arbitrarily selected 0.2 inches pressure differential) was 10,750 gallons of oil for an average season. These savings would vary in almost direct proportion to the actual average differential pressure.

Improved Efficiency of Steam Heating System

Installation of steam traps at individual radiators was recognized as a possible energy-saving measure, since, in the absence of such traps, heat was flowing directly through the radiators and into the condensate return system (as shown by the high temperature of condensate lines). However, the precise extent of such losses was not easy to determine because (1) the flow was not readily measurable, and (2) the proportion of the heat entering the condensate system which represented actual waste was not distinguishable from that portion which was merely misdirected heat.

Correction of system unbalance, which was attributed to deficiencies in the steam main configuration and to the deteriorated (open) radiator steam valves, appeared to be a promising measure for energy conservation. It was anticipated that such correction could eliminate overheating and therefore the necessity for opening windows to control the temperature of overheated offices.

The general and habitual use of open windows for temperature control in City Hall made measurement of heat losses due to system imbalance impractical. Moreover, uncertainties in the number and extent of open windows and in the internal building pressure made estimation of losses due to overheating impractical. Prediction of savings attainable by restoring the capability for temperature control in individual offices was accordingly not feasible.

In summary, the large uncertainties in City Hall heat losses attributable to leaking, single-glazed windows, the simultaneous unknown losses caused by deficiencies in the steam heating system, as well as interactions between these effects, made detailed predictions of savings which might result from any single conservation step impractical. Yet it appeared that important energy savings were possible and practical in City Hall in the areas considered.

When the DOE demonstration program for Jersey City was being planned, the city had already decided to replace the old double-hung, single-glazed windows of City Hall with modern units, as described in Section 3.1.1.

For this program, the remaining step of renovation and upgrading of the steam system was planned, as is described in Section 3.1.2.

3.1.1 Window Replacement - City Hall

Approximately 330 windows in City Hall, original equipment, were single-glazed, double-hung sash which had weathered and warped badly; accordingly, severe heat losses were occurring both as a result of losses through the single-thickness glass by conduction and convection and from infiltration around and between the window sashes.

As indicated in Section 3.1, the detailed calculation of infiltration losses from static data to a useful degree of accuracy was not practical. However, rough estimates previously described suggested that use of double-glazed windows in City Hall would save about 7300 gallons of fuel oil in an average heating season of 5000 degree days, while potential savings of 10,750 gallons of oil per season were predicted from reduction in infiltration losses.

Prior to the inception of the DOE program, Jersey City had arranged for the replacement of 329 originally-installed double-hung, single-glazed windows and their frames with double-glazed units which are extremely well fitted and weatherstripped. The primary purpose of this replacement was renovation, since the old window sashes were badly weathered, cracked, and unsightly. Energy conservation, while promoted by the tight fit and the double glazing of the new windows, was a secondary concern. Furthermore, if energy saving had been the only purpose, much less costly ways of reducing losses from the windows of City Hall were available.

The Swedish-made double-glazed window type selected has a wooden sash, with exterior aluminum cladding; controllable slatted blinds are installed in the approximately one-inch space between the two glass panes. The frames are anodized aluminum. The single movable sash is pivoted on a vertical axis for opening and for cleaning the exterior. One fixed pane within the frame and below the movable section is removable for mounting a window air conditioner. The vendor from whom these windows were obtained is no longer in business in the United States.

The 329 new windows installed in City Hall varied from 3 ft x 5 ft to 5 ft x 10 ft in size, and they cost approximately $200,000. Additional costs, including the modification of drop ceilings to accommodate the pivoting sash, brought the total cost to about $236,000. Installation was effectively completed in December 1975.

The new double-glazed windows appear to have been as effective an energy-conserving measure as anticipated. In the 1974-75 season, before installation of the windows, City Hall consumed 73,600 gallons of No. 2 oil in a season of 4715 degree days, or a seasonal consumption rate of 15.6 gallons per degree day. After installation of the double-glazed windows, the seasonal consumption rate was reduced to 10.5 gallons per degree day as indicated in Table 2. This represents a saving of 5.1 gallons per degree day or about 25,500 gallons of oil per average (5000 degree days) year. At a current price of approximately 36¢ per gallon, the dollar saving attributable to these windows is about $9180 per average year.

This saving is somewhat greater than the arbitrarily derived estimated savings for these windows of 7300 gallons of oil for reduced conduction and convection losses and 10,750 gallons for reduced infiltration. The total of 18,050 gallons calculated saving per average year, would correspond to a cost reduction of about $6500. The difference suggests that the actual average pressure differential (inside versus outside) may have been greater than the estimated figure of 0.2 inches of water, or that the cracks of the old windows were larger than was assumed.

Table 2

JERSEY CITY CITY HALL
OIL CONSUMPTION VS DEGREE-DAYS

Before and After
Steam System Modification

	A Oil Usage in Month gals.	B Degree-Days in Month (Heating)	C Oil Usage Per Deg-Day (A div.by B)
Before Steam System Mod:			
January 1976	11,595	1172	9.9
February 1976	6,915	727	9.5
March 1976	7,084	651	10.9
April 1976	4,851	348	13.9
Totals	30,445	2898	
Average for period	7,611	725	10.5
After Steam System Mod:			
January 1978	10,085	1157	8.7
December 1977	9,574	967	9.9
November 1977	6.449	543	11.9
October 1977	4,764	318	15.0
Totals	30,872	2985	
Average for period	7,718	746	10.3

As noted earlier, the primary purpose of installing these windows was rehabilitation and modernization. Consequently, energy saving and direct considerations of cost-effectiveness were secondary concerns. Very significant savings, such as those achieved by the new windows in City Hall, could be achieved less expensively in analogous situations where energy savings and cost are the first considerations. For example, the approximately $10,000 annual savings demonstrated might have been attained by use of storm windows, weather-stripping, and calking. Simple payback in five years could have been achieved with an installation cost of about $50,000, or about $150 per window. This appears to be a realistic target cost for storm windows and sealing.

3.1.2 City Hall Steam Heating System--Refurbishment and Modernization

The steam heating system of the city hall was identified as having a potential for energy savings. Since the heating was very uneven, overheating was commonplace in many parts of the building. Worn-out manual radiator steam valves were common, so that the only available means of controlling room temperatures was by opening windows.

3.1.2.1 Energy Conservation Opportunity

Original Condition

The City Hall of Jersey City is a three-story-plus-basement structure (with a partial fourth story) of granite and brick, built in the typical grandiose style of American architecture in the late Victorian period. The building was originally equipped for steam heating, with two coal-fired Mulhearn cast iron boilers, and a two-pipe orifice-metered steam distribution system with manual throttle valves on individual radiators. Drawings and specifications for the system are not available.

Age and changing circumstances had modified the city hall heating system. Atomizing oil burners had replaced hand firing of coal. An improved facility for feed water control, including a storage tank and feed water pumps, had replaced the original mechanical condensate valve. The radiator steam orifices, used to balance flow to individual radiators, had eroded away and had never been replaced. Radiator vent valves had been poorly maintained and replaced sporadically with inappropriate or low-quality units. There were no steam traps on the radiators; it is not clear whether they had been removed or if they had never existed.

The two steam distribution zones in City Hall, established by the routing of eight-inch steam mains in the basement, shown in Figure 5, were dissimilar and badly balanced. One of these zones covered about two-thirds of the southern and northern exposures and all of the eastern. These zones were fed at about 6 psig by a pressure reducer from two boilers which provided steam through a common manifold at about 18 psig. This system, lacking balancing controls, had reportedly provided very uneven and unsatisfactory heating for the workers in City Hall for many years. This uneven heating had been accentuated by a relatively recent partitioning of the building spaces in which radiators were sometimes not divided proportionally with space.

Recommended Project

It was initially estimated that a significant energy saving, with improved employee comfort and efficiency, could be achieved by modifying the existing system. The initially proposed modifications would have changed the principal steam mains to provide three approximately equally-loaded zones rather than the existing two zones, added new manual throttle valves to all office radiators, and installed new thermostatic steam traps in all office radiators.

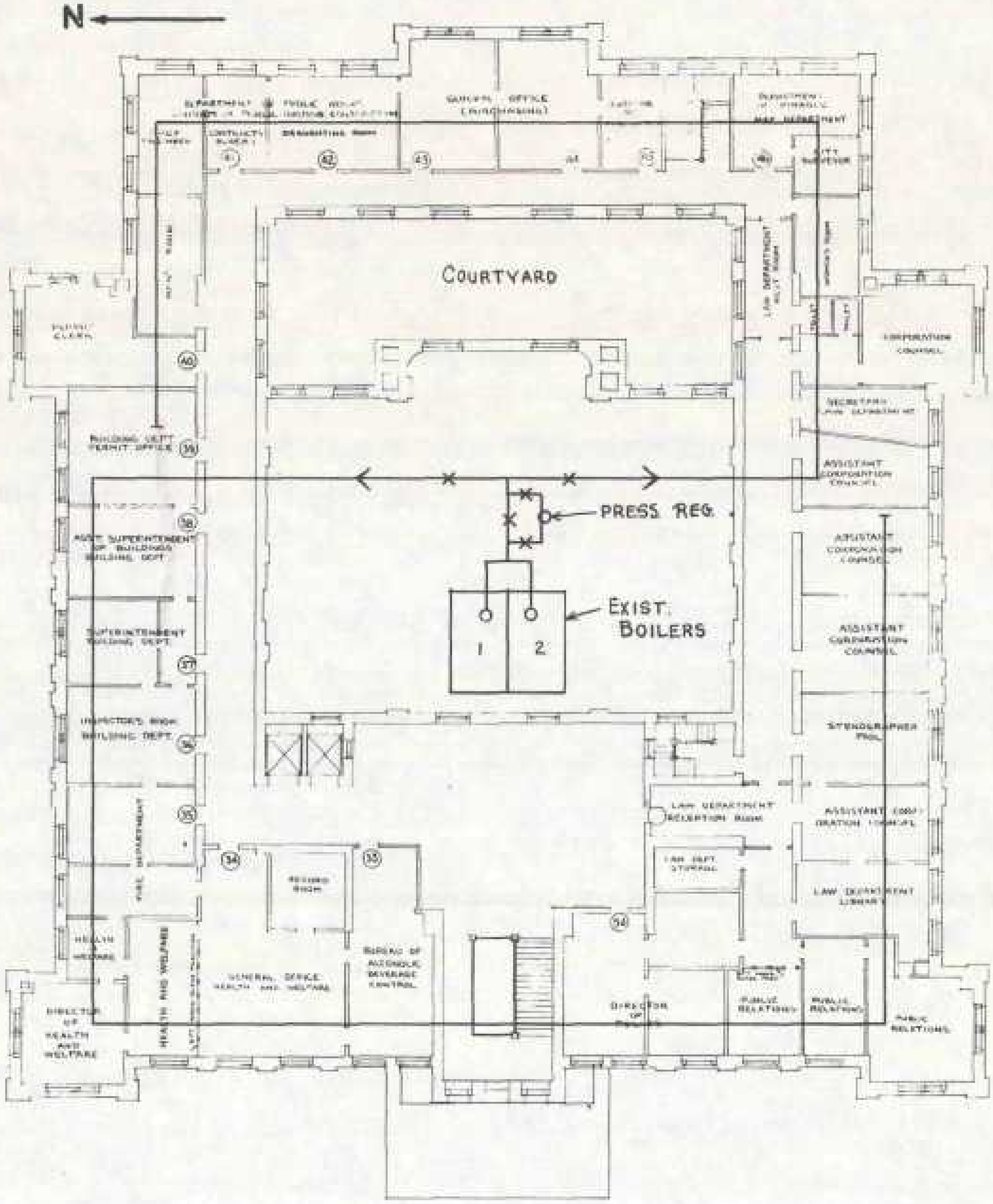


Figure 5. City Hall Basement Floor Plan
Showing Steam Distribution System

3.1.2.2 Project Implementation

Project Initiation

Specifications were prepared, bids were solicited, and in accordance with Jersey City procedures, a contract was let for the installation of self-contained thermostatically controlled steam valves and thermostatically controlled steam traps on approximately 150 radiators in City Hall. The work was initiated in October 1976 and completed in November 1976. Figure 7 shows the valve elements and a steam trap installed in an exposed radiator. Figure 8 shows elements of the control valve mounted on a more typical cabinet-enclosed radiator.

3.1.2.3 Narrative and Key Events

A contract to A&A Oil Burner Service of Clifton, N.J., for the installation of thermostatic control valves and steam traps at approximately 150 office radiators in City Hall, was approved by the City Council on August 23, 1976. The contract amount was $22,580. The work was substantially completed by late October.

As cold weather came in late October, building heat was required. It became evident immediately that a new and major heating system problem had developed. There was extensive hammering in the steam pipes, overheating in many rooms and "leaks"--mainly from the spraying of condensate water from defective radiator vent valves which had not been checked or replaced. There were many complaints.

The causes of these difficulties were at first not clear, and there was concern that the hammering in old pipes might break them. It was decided to return the system to (approximately) its original configuration by removing the thermostatic elements of the new steam traps so that condensate could flow freely. This was perceived as a way of avoiding catastrophic pipe damage while the causes of trouble were being sought.

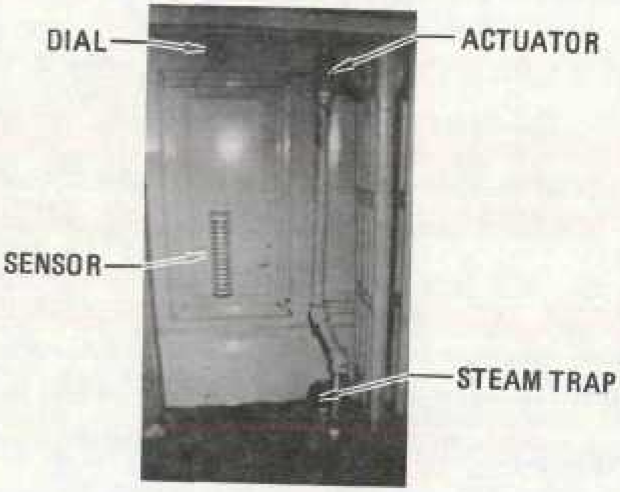


Figure 7. City Hall, Exposed View of Thermostatic

Control Valve and Steam Trap Installation

Figure 8. City Hall

Cabinet-mounted Radiator with Thermostatic Control Valve Installed

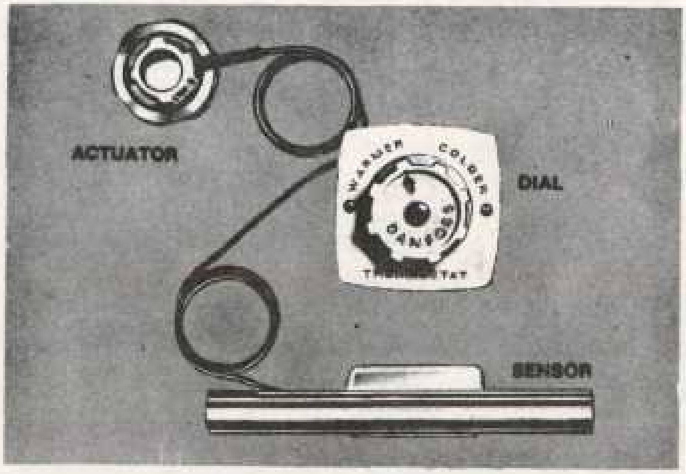
Changes in Plan

Cost studies indicated that rerouting large steam mains and the accompanying condensate return lines through the heavy load-bearing masonry partitions of the city hall basement, as originally proposed, would be costly and difficult. Consequently, a revised approach to the problem was adopted. A modified plan was developed to install new steam traps and individual thermostatically controlled valves at each of the approximately 150 room radiators, and to retain the original two-zone steam main configuration. The thermostatically controlled valves were designed to prevent overheating of the individual rooms and provide adequate steam to rooms previously underheated. This installation had the merit of being very simply done. Figures 6a and 6b show the elements of the Danfoss Type RA thermostatic control valves used.

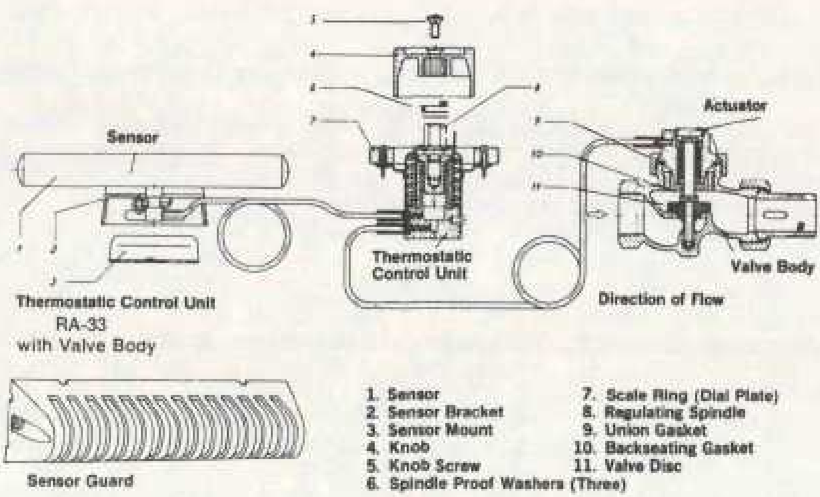
Savings comparable to those attainable by the original plan were expected from the much simpler approach using thermostatically controlled radiator valves because it appeared that: (1) overheating of many regions in the building could be prevented by use of the thermostats, and (2) heat losses resulting from the flow of steam through the radiators and into the condensate lines could be eliminated by use of radiator steam traps, which would pass condensate out of the radiator but retain (trap) steam. Some proportion of the project costs could properly be allocated to system renovation and modernization, rather than to energy conservation alone.

Data Requirements

Evaluation of energy savings was planned on the basis of comparisons of oil consumption (adjusted for heating degree-days) before and after the change.



a - Pictorial View



b - Cutaway View

Figure 6. Danfoss Type RA-33 Thermostatic Control Valve

A request for emergency assistance was made to the Jersey City Facilities Maintenance Division. After less than half of the elements had been removed, City Maintenance people were arbitrarily withdrawn from the job on the basis of a jurisdictional concern over the issue of City versus contractor responsibility. Meanwhile, the hammering of pipes, the sputtering of radiator valves, and the threat of serious damage and possible flooding were substantially unabated.

On the request of project people, the contractor finally completed removal of the trap elements (at no cost), although he had no contractual obligation to do so. As hoped, the most extreme system problem, the water hammering, was alleviated.

Consultations were held to identify the cause of the problems observed. These included the Jersey City Technology Agent, the engineer who had been retained for the job, a special consultant on older steam systems, the installation contractor, and a representative of The Aerospace Corporation. It was found that an heretofore unnoted feature of the original City Hall steam system was causing the problem.

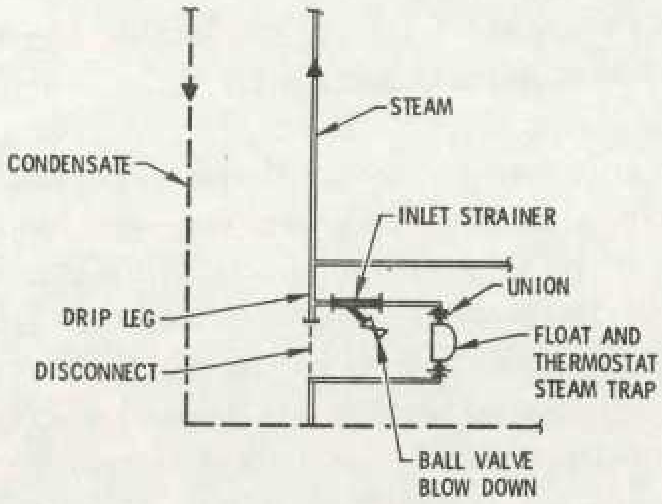
Reexamination of the steam system revealed a feature (apparently typical of steam systems of the 1890's period) which explained the difficulties observed after installation of radiator steam traps and control valves. Individual radiator steam traps were apparently not commonly used in the year 1894 when City Hall was built. Each vertical array of radiators on the several floors was fed by a single steam riser and drained by an adjacent condensate return line; these were connected to steam and condensate mains in the basement. A direct bypass of 1/2-inch or 3/4-inch pipe was found at the base of each such riser pair, evidently installed to eliminate condensate accumulation in the steam main.

When these bypasses were discovered, it was immediately evident that they were the heart of the problem. Increased backpressure due to the radiator valves and traps had forced steam to flow through the bypass lines into the condensate risers. There the resulting high steam temperature on the back side of the radiator traps sometimes held the thermostatic radiator traps closed, causing radiators to fill with hot water. Spewing water from radiator air valves resulted. Hammering resulted from the interaction of steam and condensate flows throughout the system. In fact, at least two cases of broken steam pipes were found. Instances of room overheating were found, caused by the uncontrolled heating by radiators full of very hot water. In addition, low places were found in the mains where provision for "dripping" with additional traps was needed, and almost every radiator air vent valve was found to be deteriorated beyond acceptable limits.

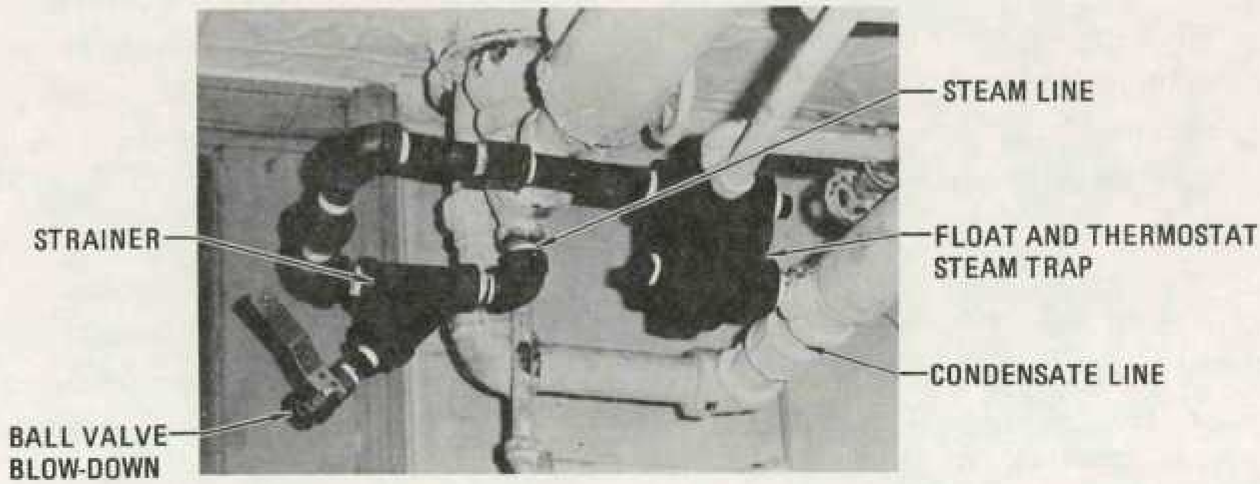
When the entire problem was understood, specifications were prepared quickly for additional work to resolve the problems: elimination of the direct steam bypasses; their replacement with over 50 float-and-thermostatic steam traps in the mains system, each with strainer and blow-out valve for cleaning; installation of new high-quality air vent valves in every radiator; and replacement of the radiator trap elements previously removed. A typical installation is diagrammed in Figure 9a and illustrated in Figure 9b.

Since winter had come, it was important that this work be done at once and with minimum disruption of work routines at City Hall. Fortunately, the City Attorney concluded that the work was within scope of the previous contract for traps and valves so that it was not necessary to obtain new bids. The original contractor provided a satisfactory price (about $10,000), so it was convenient and appropriate to award the additional work to him.

There might have been a severe problem of getting funds for the unplanned additional work, except that deletion of another planned



a - Diagram



b - Photograph

Figure 9. City Hall Steam Riser Trap and Strainer Installation

project of the program (which had proved infeasible) freed money in the project equipment fund provided by DOE. DOE project people supported the reallocation of funds to meet the emergency.

All preliminary actions necessary to implement the city hall contract extension were completed with dispatch. An enabling resolution was placed before the City Council on December 21, 1976. Some members of the Council opposed the contract extensions, apparently because they blamed the contractor (incorrectly) for the difficulties with the city hall heating system. In the resulting vote, the resolution was rejected. A similar resolution was tabled at the next meeting of the Council on December 28. It was finally passed on January 4, almost surely as a result of effective lobbying by the city Business Administrator.

The contract went into effect promptly, and the new work was initiated at once. It was not completed in time to permit an evaluation of energy savings in the winter of 1976-77, although it was possible to verify that the actions taken had improved personnel comfort and the control of temperature within City Hall and that the system revision had effectively eliminated problems in the system.

Early in the winter of 1977-78, a very unspecific list of steam system difficulties ("doesn't work", "leaks", etc.) was accumulated by the custodian of City Hall. Aerospace pressed for resolution of these complaints, both in the interest of the City and as pertinent input information for this report. In January a meeting was held in which the Jersey City Engineering Department assumed responsibility for disposition of these problems. Most appeared to be trivial matters of adjustment. The contractor disclaimed responsibility, and the conventional requirement for a one-year guarantee had inadvertently been omitted from his contract with Jersey City. Accordingly, responsibility for corrective action fell upon the City. As of mid-July 1978 these matters had not been corrected.

3.1.2.4 Results

Data Obtained

Evaluation of energy savings was to be based upon a degree-day adjusted comparison of fuel oil consumption before and after the steam system modifications.

Degree-day data were obtained from the U.S. Department of Commerce National Oceanic and Atmospheric Administration (NOAA) Environmental Data Service. Daily oil consumption records have been maintained by Mr. Thomas Finnegan, City Hall Stationary Engineer, since 1975. These data were made available by him.

Local Climatological Data sheets are not published separately for Jersey City by the NOAA. However, Jersey City degree-day data are published in the monthly NOAA Climatological Data pamphlets for New Jersey (Ref 2). In a few instances where minor differences would not be important, Newark degree-day data were used, which are avilable in greater detail (Ref 3).

Evaluation of Data

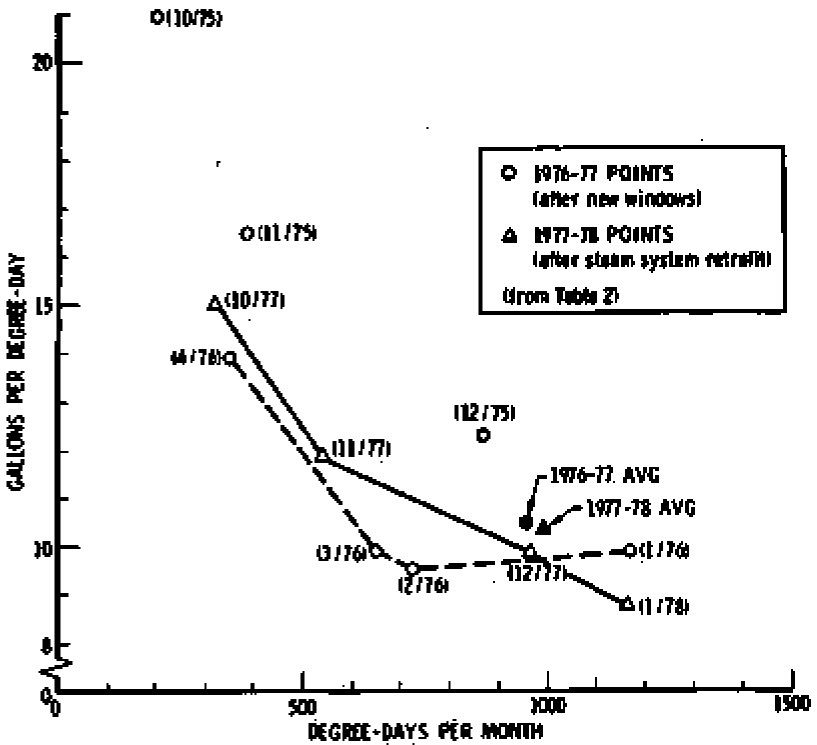
In evaluating effects of the steam system rehabilitation on energy consumption for space heating, it was necessary to account for effects of the double-glazed windows installed in late 1975. The time period of January 1976-April 1976, inclusive, appeared to be a suitably long interval after the windows were installed; it was taken as representative of building performance with the double-glazed windows and before the steam system modifications. The period of October 1977 - January 1978, inclusive, was selected as a suitable time for measuring building performance with the new windows and steam system modifications. As indicated by the data of Table 2, the numbers of degree-days per month have similar distributions in these two periods.

Data from the winter of 1976-1977 were not useful for evaluating steam system modifications because significant system changes were being made throughout the heating season.

A convenient figure of merit is the number of gallons of oil consumed per degree-day. As Table 2 shows, in the period of January 1976-April 1976--with the new windows, but before steam system changes--the average oil consumption was 10.5 gals per degree day. In the period of October 1977-January 1978, after steam system changes, oil consumption was 10.3 gallons per degree-day. Plots of these data are given as Figures 10a and 10b. It is clear that the average energy usage, both seasonally and monthly, is not much different between the two time periods examined: before the steam system modifications (1/76-4/76 incl.), and after the modifications (10/77-1/78 incl.)

As a partial explanation of the small change in oil consumption following the heating system modifications, it has been observed that many windows are open in City Hall on cold days. This is a familiar phenomenon, also observed in Public School No. 40 (Section 3.6.3): the practice of modulating room heat by adjusting open windows rather than by use of the thermostatic controls such as those recently installed in the city hall. Though it cannot be proven conclusively, it appears that the very general use of open windows (instead of thermostats) for temperature control explains the apparent lack of benefit from the new steam traps and thermostatic valves. The practice is extremely wasteful.

Figure 10b shows that, in periods both before and after installation of the experimental equipment in City Hall, the oil consumption per degree-day varied inversely with the severity of cold as measured by the number of degree-days per month. The reasons for this phenomenon are not absolutely certain, but it is probably a result of modulating room heat by opening windows. In mild weather, open windows a.



b.

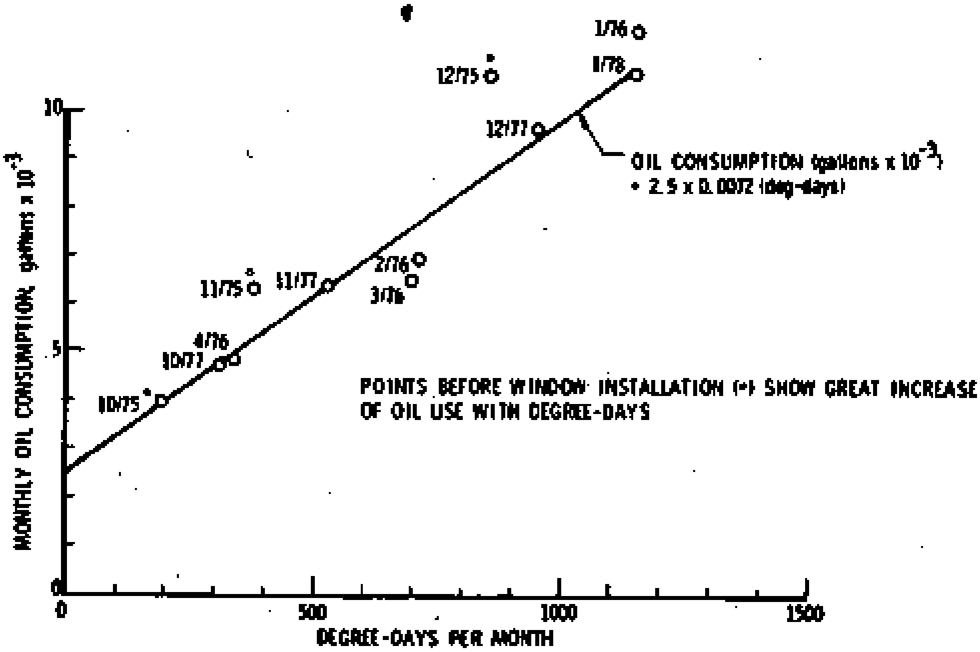


Figure 10. Jersey City City Hall
Monthly Fuel Oil Consumption vs. Degree Days

are a convenient and habitual means of controlling temperature. In colder weather, the drafts which result from open windows are unpleasant and tend to discourage temperature control by open windows. The data in Figures 10a and 10b seem to confirm these hypotheses.

The boiler room personnel of City Hall state that they are required by law to provide heat when the outside temperature falls to $55^{\circ}F$ or below, and the boiler is at present controlled to a set steam pressure, with no means of controlling the amount of heat delivered. Accordingly, if the boiler is operating at all, heat consumption is unconstrained. There is no built-in means of preventing deliberate overheating in individual offices or the waste of heat by opening windows while thermostats are demanding heat.

3.1.2.5 Conclusions and Recommendations

The difference between the oil consumption rates before and after changes were made in the steam system is not statistically significant. Contrary to expectations, based upon general experience in the industry, our data do not show benefit from this project. The most likely reason for this unexpected result is the persistent tenant practice of controlling room temperature by opening windows, rather than by use of the new thermostatic valves. This is attested by visual inspection of the building exterior at any time in cold weather. It is believed that functioning steam traps and thermostatic valves will be beneficial in installations, such as that in City Hall, when the upgraded system is operated as intended.

Several changes could be implemented in order to discourage waste and achieve economy in energy usage of the City Hall heating system. A continuing program of training, reminders, and ultimate disciplinary action for persistent window-openers is recommended. This is easily established, since open windows are readily visible from outside the building. Technological fixes could also be implemented, but many of these would be more costly and less desirable than administrative methods. For example, controls for the boiler system could be added which limited the heat available to a user to the estimated actual need, based upon a reasonable criterion such as outside air temperature or chill factor. One implementation of such a scheme would convert the steam system by addition of a vacuum pump, so that system pressures lower than atmospheric could be maintained and controlled. By reference to suitable outside temperatures, absolute steam pressure would be controlled to make available only that limited amount of heat needed to maintain comfortable room temperatures with the windows closed. Simple electrical switches have also been considered which would sense the opening of windows and cut off steam flow to adjacent radiators accordingly.

3.1.2.6 Observations and Lessons Learned

In the retrofit of old structures or systems, drawings frequently do not exist (as in the case of the city hall steam heating system). Where they do exist, they are commonly incomplete or not up-to-date. Since many now obsolete practices of long-past times may not be known by engineers of the current generation, it is important to avoid making invalid assumptions about the design or condition of an old system. A detailed survey and analysis should be made of its design and the physical condition. The actual functioning of every such system should be determined before modernization or major rework is undertaken.

Anomalous conditions may be expected in the major rework of old buildings. In City Hall, one radiator was standing on rotten floor joists, supported mainly by piping. When the pipe connections were loosened, it nearly fell through the floor to the room below. Very corrosive coal furnace ashes were used as acoustic insulation between floors in the building. This had led to severe external corrosion of steam pipes imbedded in the ashes. The problem of frozen pipe threads inevitably arose. Problems of contractor access to especially sensitive building areas were also experienced; e.g., the mayor's office, the council chambers, and the credit union office. Contractor work hours presented a problem in that: work on the steam system was not possible with steam pressure up; steam pressure (for heat) was essential during most of the normal winter workday; and after-hours contractor work engendered inconvenience and resentment on the part of those city employees who are concerned about admission and building security.

Serious deficiencies in cooperation and responsiveness, especially by city personnel, arose during the program, to the point where cooperation and the needs of the city and the project were adversely affected:

- City departments in Jersey City were found to be rather specialized, so that joint actions or the explicit undertaking of non-routine work by one division at the request of another could not be expected to take place smoothly.

- Strong resentment of the contractor was quite evident among some City employees. It is possible that this resentment came, in part, from the fact that the contractor was not a union organization, whereas City employees were unionized.

- The City Council was apparently well aware of employee attitudes and of hallway rumors in City Hall, including attitudes towards the contractor; the council evidently attempted to be responsive to them.

A stationary boiler of 15 psig or over is rated by the Underwriters as a "high-pressure" boiler, and such high-pressure boilers require around-the-clock attendance. It is likely that a saving in both insurance and manning costs might be effected by operating the city hall boiler at the service pressure (6 psig) and feeding the mains directly (without the regulator) at less than 15 psig pressure. However, it has not been established that the city hall boiler would meet system heat requirements operating directly at pressures of 6 psig or less.

3.2 PUBLIC WORKS SHOPS PROJECTS

The Public Works Central Garage facility is the major repair and storage complex for all the divisions within the Department of Public Works. The complex consists of two buildings: Central Garage No. 1, the repair facility and administrative offices, and Central Garage No. 2, the vehicle storage facility. The conservation demonstrations were conducted in Central Garage No. 1, also called the Centralized Maintenance Facility, which is depicted in Figure 11 and described in Table 3.

Activities performed in this facility include: welding, carpentry, radio repair, signal repair, traffic vehicle repair, tire repair, paint spraying, machining, steam cleaning, plumbing repair, and sign making. It serves as a mustering and storage area for the divisions of forestry, streets and sewers, sanitation, traffic, water, and facility maintenance.

Central Garage No. 1 also houses the city's computer center and serves as a supply center for the Department of Public Works. The second floor houses the Department's administrative offices and the Engineering Division.

Three energy conservation procedures were adopted for Central Garage No. 1. These were (1) automatic timed closure of garage doors, (2) time control of overhead lights, and (3) timing of the duration of space heating in selected work bays. The rationale for these projects and the results of their implementation are discussed below.

3.2.1 Timed Closure of Garage Doors

3.2.1.1 Energy Conservation Opportunity

The Central Garage No. 1 has 32 large operator-actuated (motor-driven) vehicle doors in the shop and assembly areas, in addition to four at the facility loading docks. Its interior space is heated with

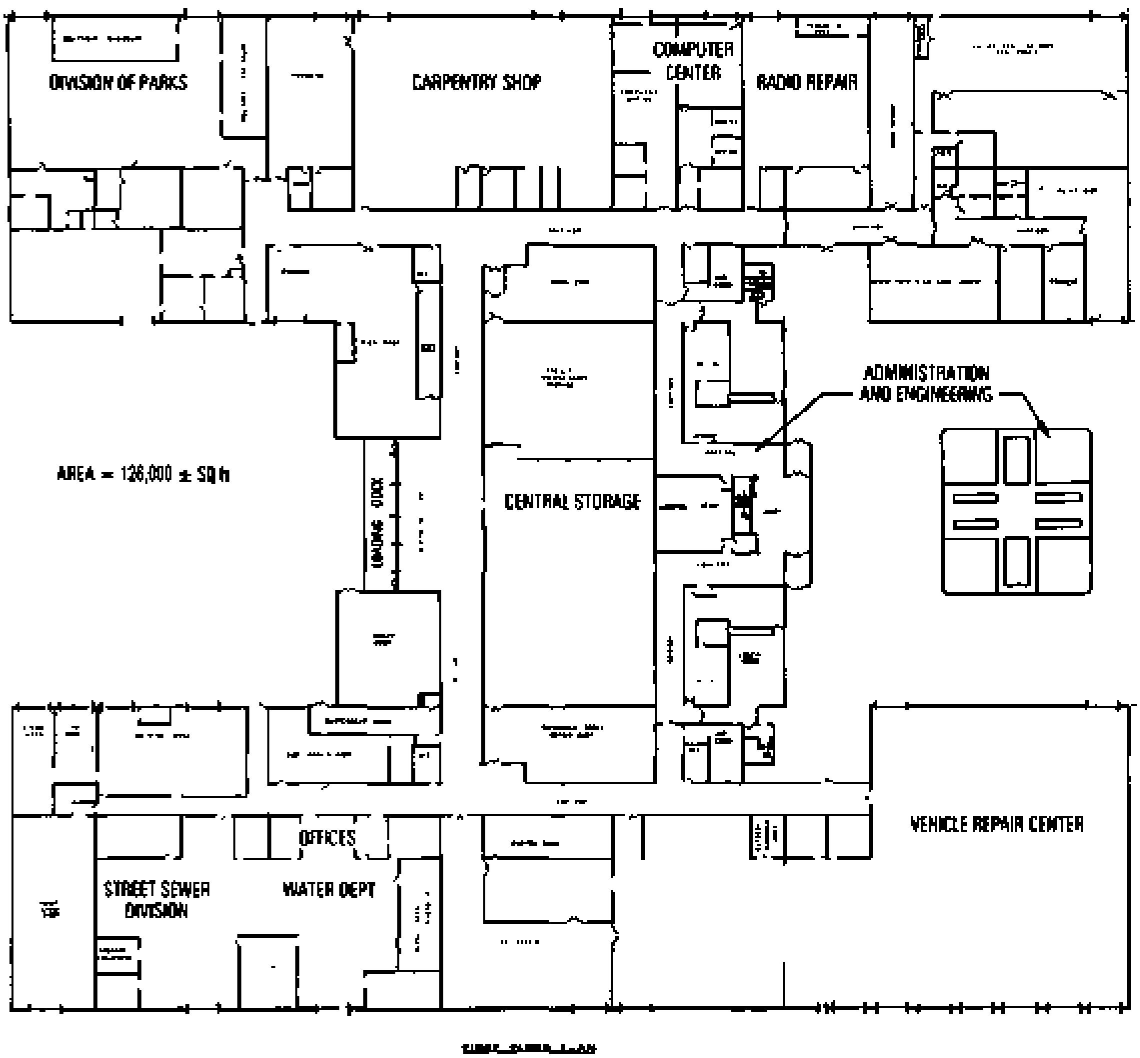


Figure 11. Public Works Shops Central Garage No. 1

Floor Plan

Table 3

PUBLIC WORKS SHOPS
CENTRAL GARAGE NO. ONE DESCRIPTION

STRUCTURE

Year of Construction:	1965
Floor Area:	first floor - 119,300 sq. ft. second floor - 6,700 sq. ft.
Type of Construction:	steel, concrete floor; brick and block walls
Windows and Exterior Doors:	the shop windows are typical clear glass four ft. in height, located on the upper wall and continuous around the entire perimeter of the building. There are thirty-one power-operated high bay overhead vehicle doors around the building, in addition to four at the loading dock.

HEATING SYSTEM

Distribution:	hot water, with down-blow unit circulators in the shop area and constant volume terminal reheat in administrative area
Boilers:	two, Pacific National fire tube, hot water, forced draft
Type:	Pacific National - fire tube, hot water, forced draft
Burner:	gun type, atomizing
Domestic Hot Water:	generated by a Patterson-Kelly gas-fired unit

VENTILATION SYSTEM

Type:	shop area: open door administrative office: central fan
Exhaust System:	shop area: area fan administrative office: central fan, 300 CFM
Air Conditioning:	administrative offices only: constant volume, reheat

LIGHTING	fluorescent, mercury vapor, and incandescent as appropriate.

ELECTRICAL SYSTEM

Lighting:	fluorescent, mercury vapor, incandescent

large thermostatically controlled down-blow hot water circulators as shown in Figure 12. Interior partitions between bays along the east and west sides of the building do not extend to the ceiling, so that heat losses in one part of the building tend to cool off large regions of the building.

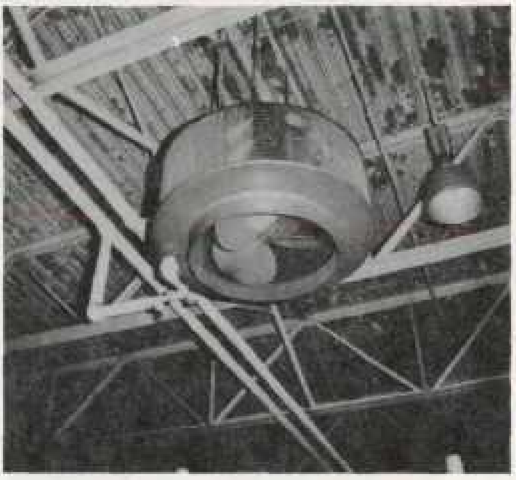


Figure 12. Public Works Shops
Central Garage No. 1
Typical Blow-down Hot Water Circulator

The pattern of operation in various shops is for the crews to muster at Central Garage No. 1, to prepare for the day's work, and then to leave during the early morning for work around the city; the crews (and vehicles) return in the middle and late afternoon to work in the shop and to prepare for the next day. The garage doors are controlled from inside the building. The relative locations of the vehicle doors, personnel doors and the location of vehicle door controls on the inside building wall made it inconvenient for departing work crews to close the vehicle doors after they had exited. It was much more convenient to simply drive away and leave the vehicle doors open and very often, even on winter days, they were left open after the trucks departed. Administrative controls were not applied effectively in preventing this practice.

Recommended Project

It was recommended that the motor-driven vehicle door operator be equipped with a time-delayed closing feature so that it would close automatically at a preselected (and adjustable) time after opening. A 1-1/2 minute maximum interval was recommended, and the times were initially to be set on the maximum. For safety, convenience, flexibility, and maximum conservation of heat energy, the following additional features were specified:

- Bright red lights, inside and outside the building, flashing when the door is in motion;

- A pressure-actuated safety-edge strip along the bottom of the door to instantly reverse the descending door if it should hit an obstruction;

- An interlock relay to hold the heater-circulator blower "off" while the adjacent vehicle door is open;

- A spring-loaded takeup reel for the flexible electrical cord connection to the safety edge switch;

- A limit switch at the lower extreme of door motion to disable the safety-edge reversal feature when the door seats at the end of downward motion;

- A key-operated switch to change the mechanism from timed automatic closing to manually-directed closing.

- A placard explaining door opener/closer operation to be placed at each control switch

Predicted Savings

It was believed that up to 20% of the fuel used for space heating of the Public Works Shops might be saved by use of the timed automatic closer with a feature which turns off the heat circulator blower when the door is open. This would be a saving of about 18,000 gallons of No. 4 fuel oil in a normal (5000 degree-day) year, based upon average oil deliveries in the 1974-75 and 1975-76 seasons of 18.4 gallons per degree-day.

Data Requirements

Evaluation of this project was to be based on before-and-after seasonal oil consumption data, adjusted for degree-days and for savings attributed to the timed door closure experiment equipment (Section 3.2 3).

3.2.1.2 Narrative and Key Events

During project planning, the design and functioning of the timed automatic garage door closer were described to supervisors in the Public Works Shops, and general approval of the plan was obtained. Required features of the system were defined as listed in Section above.

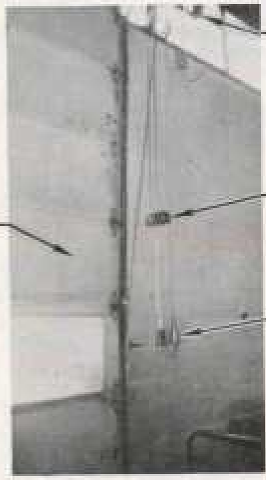
The Public Works Shops' motor-driven vehicular door operator/actuators, installed as original building equipment, were made by the Overhead Door Company. It was determined that a division of this company made auxiliary equipment which could provide the automatic closure and the safety features required, and it was clearly expedient to use equipment of their design to ensure compatibility. However, the local Overhead Door distributor did not handle this auxiliary equipment, was not familiar with its design and application, and could not provide design, circuit, or ordering information.

Technical data for the several possibly applicable electronic timer assemblies were obtained, a tentative selection was made, and comments were solicited from the Overhead Door engineering staff. Their response indicated the possibility that a communications problem existed. Accordingly, an Aerospace design engineer was sent to the Overhead Door plant in Dallas, Texas to work with the company's engineering staff in deriving a circuit and parts list which would fulfill the requirements.

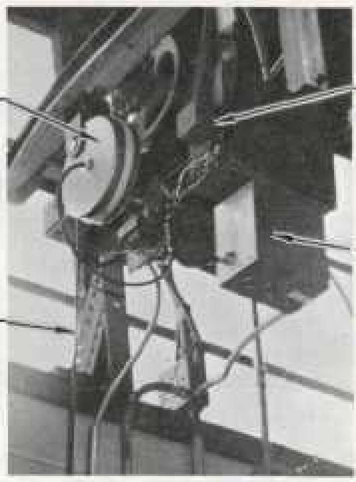
Drawings were prepared (see Appendix B-1), and materials were ordered. The Aerospace design engineer traveled to Jersey City in January 1978 and worked with Jersey City's Facility Maintenance Division electricians to verify and demonstrate the system design by installing and operating one complete system. An example of the installation is shown in Figures 13a and 13b.

Installation by Jersey City electricians continued slowly until about 14 sets had been installed. Then it was decided that the Jersey City people would not have the time to complete this work, so a contractor was hired to install five more, leaving several uncompleted installations. Seven other doors and the loading dock doors were not included in the plans for timer installation because they were infrequently used.

Placards as shown in Figure 14 were prepared by Aerospace and attached near the control box for each door having the timed closure feature.



a - General View



b - Detailed View of Actuator

Figure 13. Public Works Shops Central Garage No. 1
Timed Door Closer Installation

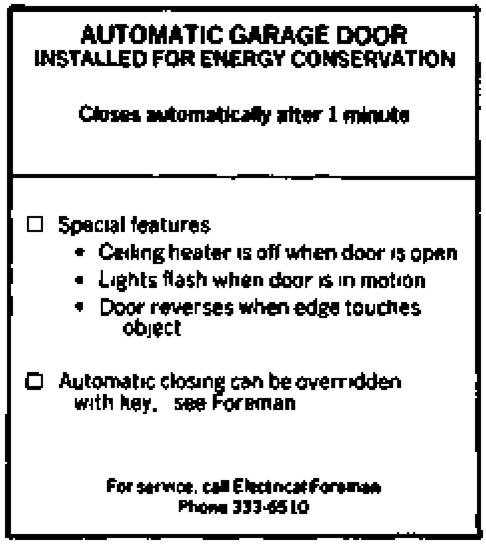


Figure 14. Public Works Shops, Central Garage No. 1 -- Timed Door Closer Installation Placard

The initial block of contractor installations was let under an abbreviated City procurement procedure, applicable for contracts under $2500, which permits soliciting bids by telephone. Jersey City officials ultimately decided to contract for the installation of the last group of timer systems, but this put the job over the $2500 limit, so that bids and City Council approval of the additional contract were required. Whether from the added complexity so induced, or inertia, or lack of funds, the contract was never let and the last group of six timers was never installed.

Meanwhile, an entirely new city administration was elected in Jersey City, and there was a substantial break in the continuity of the conservation programs. Several Public Works supervisors, familiar with the timed closer concept, were replaced. The Jersey City contract with the PTI Technology Agent, who had been leading these projects locally, came to an end, and he resigned in the summer of 1977.

Resistance by Public Works people to the use of the timed closing feature became evident, particularly in activities where frequent door operation is required, or where several vehicles must pass through a door at about the same time. In one instance, there was damage to a door and vehicle when a large articulated fire truck couldn't be maneuvered through a maintenance facility door in the one and one-half minutes allowed by the timer in the "automatic" mode.

Although all timer installations were ultimately reported to work properly, during installation some electronic modules were found to work incorrectly. These were returned to the manufacturer, who tested them and found them functional. After discussion, Overhead Door ran factory tests of the particular control circuit used in Jersey City. They report finding relay chatter which is not explainable or expected from inspection of the circuit used. They have recommended changes in the circuit hookup used, but Jersey City prefers not to undertake rewiring, since the systems equipped with timers now appear to work properly, and the timer system is not being used (as discussed below).

In an October 1977 meeting, the new Jersey City Business Administrator assigned local responsibility for program work and for communications with Aerospace on the part of Jersey City to the new Director of Facility Maintenance, Mr. Jack James, who works under the Superintendent of Public Works. Mr. James and his people have been exceptionally cooperative in supporting the project.

However, the following circumstances required action from higher levels within the administration: need for completion of the timed door closer installation; and need for policy as to its use, both for short-term experimental purposes in the gathering of project data and for long-term operations. Several letters were sent and telephone calls were made by Aerospace to request such action. Responses by city officials were not timely. The installation was not completed, and no realistic trial of the timed door closers as energy-saving devices was made during the program.

However, in visits to the Public Works Shops in the winter of 1977-78, Aerospace personnel noted that the Central Garage No. 1 vehicle doors were consistently closed, even though the timed closers were not actuated and in use; this had not been the case in preceding winters. Upon questioning, it was indicated that there has been an increased emphasis upon conservation in Public Works by the new administration.

3.2.1.3 Results

<u>Data Obtained</u>

No data were obtained which can be ascribed directly to the effects of the timed garage door closers, since the systems were not fully installed or consistently used. As discussed below, however, the idea of the automatic timed door closer as an energy conservation measure has the merits originally ascribed to it for this project, when suitably applied and properly used.

<u>Discussion</u>

The rate of fuel oil consumption in the Public Works complex was much lower for the 1977-78 heating season than for previous seasons: 11.3 gallons per degree-day rather than 18 to 19, as in the past four seasons. This improvement may be ascribed to greater general concern for energy conservation and to a tightening of administrative control. It may also in some measure be due to the feature of the door timer installation which cuts off heat when the adjacent vehicle door is open, whether or not the timer feature of that door is turned on. This cutoff feature has the dual effects of (1) saving energy directly, and (2) encouraging personnel to close doors by the chilling effects of an open door with an inoperative heater.

3.2.1.4 Observations and Lessons Learned

Considering this project, one must speculate as to the relative merit of administrative controls for energy conservation versus use of technical measures which compensate for lack of such administrative controls. In this case, technical measures were attempted to compensate for the lack of adequate administrative controls. However, after major changes in personnel and in policy emphasis, resistance to the technical measures developed. Administrative pressures might have been applied to compel use of the technical solution. Instead, the Superintendent of Public Works opted to press strongly for operational rather than technical controls for conservation. As indicated above, this was an effective alternate choice for promoting local conservation. It was, however, a decision which effectively eliminated any possibility of getting the direct experimental results needed for this program.

The automatic vehicle door closing feature -- especially with the heater cutoff feature -- can be very useful in situations such as those which stimulated application of the concept for Jersey City. These are generally conditions under which open doors are energy-wasteful; where the closing of the doors presents an annoying inconvenience; and where administration does not provide adequate incentive for making the closing of doors habitual.

It is possible that the space heater interlock feature--which shuts off the down-blow heater fan when an adjacent vehicle door is open--may have had significant influence in discouraging employees from leaving the doors open. This cutoff is wired to operate in both the manual and the automatic modes of vehicular door control; it may in itself constitute a very useful means of encouraging energy conservation.

The utility of the timed door closer cannot be assessed definitively from this experience. As with most conservation measures, and as attempted here, its use should be undertaken only with the support of the prospective user. Applications should be evaluated in terms of the kind and frequency of traffic, locations of door controls and personnel doorways, and possible alternatives. For some kinds of traffic, radio control, exterior manual controls, or other relatively simple devices might be preferable. In many cases, the motivation of employees to exert a slight extra effort and close doors manually will obviate need for elaborate technical solutions. Moreover, experience in this program leads us to recommend that a retrofit, such as use of the door closing timer, involving moderately complicated changes and proprietary devices, should only be attempted if competent dealer installation advice and service are locally available.

3.2.2 Time-Limited Area Lighting

3.2.2.1 Energy Conservation Opportunity Description

Original Condition

The ground floor of Central Garage No. 1 consists, in part, of a series of large open bays having access to the outdoors via large vehicle doors which permit the entry of work vehicles, (see Figure 11). Lighting is provided by overhead 300-Watt mercury vapor lamps in individual fixtures; one such fixture is visible in Figure 12. Figure 15 shows the lighting arrangement within two bays which are part of the area assigned to Public Works. Light banks are individually controlled at a common switch panel located near the northwest corner of the area. These bays are used as storage areas for vehicles, large parts, equipment, and for crew assembly areas prior to work in the field. No detailed work requiring high light levels is performed here.

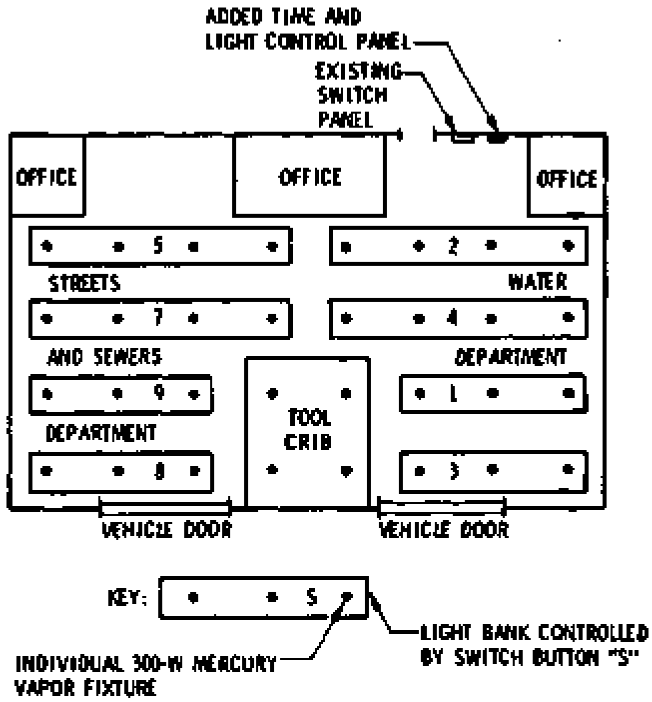


Figure 15. Public Works Shops, Central Garage No. 1
Typical Overhead Lighting Configuration, Showing
Identity of Timer-Controlled Banks

The typical use pattern of the Public Works Shops is that crews arrive in the morning, load their vehicles, and obtain work assignments for the day. Crews then leave the building and return in mid- or late afternoon to work in the shops and/or prepare for the following day. During their absence there is little or no activity requiring the lights in the bays to be on, especially since light is available from other sources, including a partial glass wall on one side of the building. Prior to the introduction of conservation practices, the level of illumination with all lights on was much higher than that needed for the kinds of work ordinarily performed in the Public Works area, yet it was common practice to leave the overhead mercury vapor lights on continuously 24 hours per day.

For an existing lighting installation, energy conservation may be considered in two dimensions: (1) intensity, determined by the number and rating of lamps, and (2) duration, or on-time. Over-illumination was a commonplace feature of buildings designed in the 1960's when the Central Garage was built. When electric energy was less expensive, architects tended to specify high illumination levels as a matter of course, based on the most demanding possible use anticipated. Where banks of multiple lights are used, it is often possible, as in this instance, to reduce illumination either by reducing lamp wattage or by removal of lamps.

Before the inception of this demonstration program, the light intensity in the storage bays of that portion of the Central Garage occupied by the Streets and Sewers and the Water Departments of Jersey City had been reduced to a reasonable minimum by removal of all but one of the lamps in each of eight individually switched banks shown in Figure 15. (In those areas of the garage where higher light levels were needed, flourescent lights in the office area and mercury vapor lamps over the tool crib area were not removed. Thus, "delamping" provided energy savings by the reduction of light intensity, with savings of from two-thirds to three-fourths of the previous energy consumption in the affected lamp banks and with no impairment of safety or function in the present usage of this area.)

Recommended Project

There remained an opportunity for worthwhile savings by restricting the on-time of the remaining lights from the customary 24 hours per day, seven days a week, to the actual time of need. An especially designed controller made by Touch-Plate Electro-Systems, Inc., was selected for the demonstration of timed lighting control in the Central Garage. This controller would utilize individual, inexpensive, pulse-actuated, magnetically-latched relays (of a proprietary design by Touch-Plate) wired in series with the existing switch for each of the eight light banks to be controlled.

The recommended Touch-Plate controller provided a bank of numbered control buttons and a conventional tab-set time-control clock, all in a single, standard NEMA steel enclosure. In opertion, each individual light bank could be turned on and off by depressing its individual control button. However, if a single light bank was not individually turned off, all lights could be turned off by either simultaneously depression of the "off" panel button or by the time clock at preset times. Economy was to be achieved by turning lights off periodically at times selected to minimize inconvenience and to prevent long periods of unneeded on-time. In operation, plans called for setting the time clock to provide automatic turnoff at selected times throughout the workday and at frequent (say, hourly) intervals after normal work hours. If automatic turnoff occurred when people needed the lights, depression of the Touch-Plate control button for the needed bank(s) would restore light after a short lamp warm-up time.

Rationale

The problem addressed in this experiment was fundamentally a lack of discipline in the control of lights. This was primarily an administrative problem, but an administrative solution might have required both prolonged surveillance and disciplinary action, if habits of waste were solidly ingrained. Such a solution was not being provided in the Jersey City Central Garage. An experiment involving automated light deactivation with manual reset capability, thus seemed appropriate for the Jersey City Public Works Department. The experiment offered an opportunity to explore both the energy savings and the social and institutional problems of timer-controlled illumination.

Predicted Costs and Saving

The pre-experiment cost of lighting in the Public Works Department was approximated based on the following data.

- Each light with its associated ballast required about 330 W.

- Pre-experiment light usage was 24 hours per day, seven days a week

- The marginal electric power rate was 63 mills/kWh.

The nominal annual energy cost for 28 overhead lights in the Public Works Department, burning continuously, would be $5100. After reducing the total number of lamps to eight by delamping, the annual cost would be $1460.

The cost savings expected from use of timed lighting is proportional to the average fraction of time that the lights remain off. If this fraction is designated by F_o. the nominal annual dollar savings for the full complementwould be given by

$$\text{Annual Savings} = \$5100 \; F_o$$

Assuming an 8 hour daily work period, a 1-hour lunch period, and 1/2-hour at the beginning and end of the shift for preparatory work by supervisors, the maximum expected daily (weekday) illumination period would be no greater than 10 hours. Correcting this for the fraction (5/7) of working days per week gives as a lower bound for F_o:

$$F_{o_{min}} = 1 - \frac{50}{168} = 0.7$$

Accordingly, if the use of timers can limit the period of workday illumination to 10 hours and entirely eliminate lights on Saturdays and Sundays, the resulting cost saving would be

Annual Saving = 0.70 x \$5100 = \$3570/year

Even larger savings would be potentially achievable if the timers were selected which could be programmed to turn lights off during the middle of the day when work crews were absent; the selected Touch-Plate equipment has this capability.

The estimated cost for purchase and installation of timing and control equipment for this experiment was \$1000. This figure is exclusive of the costs of instrumentation (elapsed time meters) required for evaluation of the experiment.

Data Requirements

Evaluation of the time-limited area lighting experiment required three categories of data:

- A measure of the average weekly on-time of lights in the experimental area before connection of the on-time limiting circuit.

- A measure of the average weekly on-time of lights in the experimental area after connection of the on-time limiting circuit. These data were desired for 1 year or more in order to assess seasonal changes in work patterns and possible resulting changes in illumination requirements.

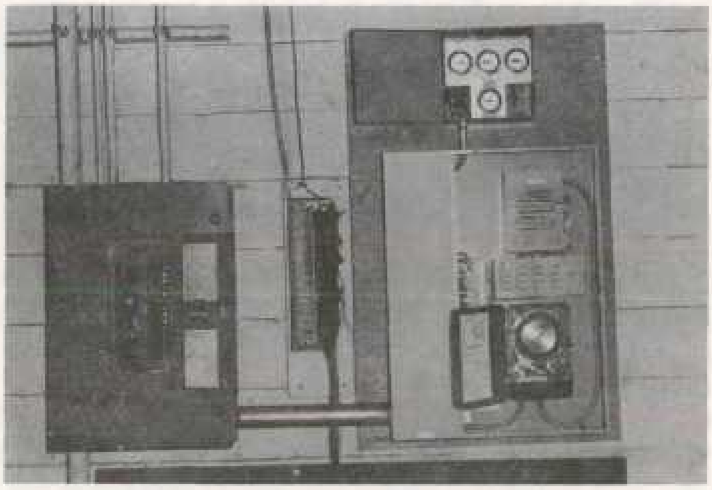
- Information (comments and suggestions) from users indicating satisfaction or dissatisfaction with the experimental system and its goals. This information was needed to evaluate institutional considerations which might be important in assessing future applications of time-limited lighting.

3.2.2.2 Project Implementation

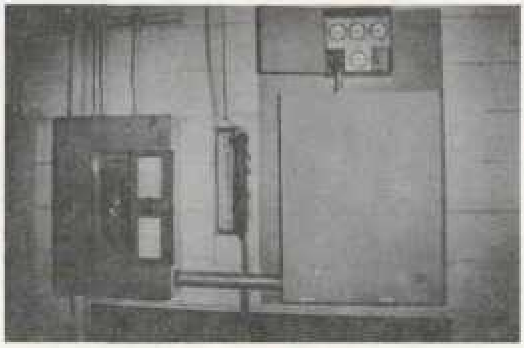
The functional configuration (described in Section 3.2.2.1) selected provided: (1) simultaneous automatic turn-off of all controlled circuits at selectable times (as determined by the stop settings on the timeclock dial), (2) manual turn-off and turn-on of individual controlled circuits by successive depressions of a control button unique to that circuit; (3) simultaneously turn-off of all controlled circuits from a master control button; and (4) a remote-located master button for turn-off at the interior bay exit door.

Aerospace prepared drawings of the impulse-control relay system with functional specifications. Key sections of these drawings are presented as Appendix B-2. The entire control assembly, including the time clock, was procured from Touch-Plate as a unit at a net price of $630.25; installation labor and materials are estimated to have cost $200, for a total installed cost of the system of about $850. The purchased unit included provision for controlling twelve circuits, of which only eight were used.

Figure 16a shows the controller cabinet partly opened. The large electrical panel at the extreme left is the original lighting switch panel. It was retained in its initial functional form in order to maintain circuit breaker protection. At the lower right is the Touch-Plate control panel, partially opened for display. The assembly of four elapsed-time meters is located at the top of the figure. The small assembly in the center is an existing telephone system terminal strip. The 110V circuitry of the Touch-Plate panel, including impulse control relays and terminal strips, are concealed under the vertical panel on the left edge of the Touch-Plate cabinet. The controlling time clock, with cover open, is at the right. The array of light control buttons is in the center, and the solid-state electronic control assembly is at the upper right.



a - Timed Lights Control Panel Installation (Open)



b - Timed Lights Control Panel (Closed)

Figure 16. Public Works Shops -- Central Garage No. 1

Figure 16b shows the control assembly with cover panels in place, and Figure 16c is a detailed view of the control button array. Figure 16d shows a ceiling of Central Garage No. 1 with a typical array of mercury vapor lamp fixtures.

Appendix B-3 shows the placard which was attached to the light control panel, correlating control button numbers with light bank location and listing the programmed turn-off times. Turn-off times shown in Appendix B-3 are those initially selected. These turn-off times, and the rationale for them, are:

10:00 AM	After normal departure of work crews to the field
12:30 AM	After any all-morning work in the shop
3:00 PM	Following afternoon departure of crews
5:00 PM	After end of workday
9:00 PM	Following any evening activity in the area
12:00 PM	After late night work

Later, on the basis of experience and local preference, these times were slightly modified. Automatic hourly turnoff was provided after working hours.

3.2.2.3 Results

Data Obtained

On December 6, 1976, installation of the timed light control panel with the four elapsed time meters was completed.

c - Timed Lights Control Button Array

d - Typical Mercury Vapor Lamp Fixture Array

Figure 16. Public Works Shops -- Central Garage No. 1
(continued)

Initially, the timed interrupt feature was bypassed so that the use pattern for the lights was unchanged, but the elapsed time meters (ETM's) were connected. One ETM was wired directly to the building mains so that the duration of any building power outage could be known.The other three ETM's were connected to the power circuits of three of the eight mercury-vapor banks committed to timed control. For 53 days these elapsed time meters recorded the on-time of the mercury vapor lights in the banks to which they were connected without timer control. It had been believed that all lights were being left on most of the time--a premise which the data supported. On January 28, each of the four ETM's showed 1270 hours of on-time for its circuit. This indicated that:

- There had been no significant power outages in the interval;

- The lights had been on 24 hours per day and 7 days a week during the interval.

On January 28, 1977, the timed cut-off feature was activated and the controller time clock was set. Banks 3, 4, and 8 of Figure 15 were monitored by ETM's as before. Results are presented in Table 4.

Evaluation of Data

In summary, from the timer system actuation on January 28, 1977 to April 19, 1978 the three light banks with elapsed time meters were on for an average of 334 hours total time, out of 10,683 hours during which the building was powered. Thus, average actual on-time is 3.1% of the elapsed powered time, whereas, as the early measurements showed, the lights were being left on continuously before actuation of the timed controller. On-time with the controller in operation averages about 5 hours per week per bank, or about one hour per workday. This is clearly a true measure of the need for lighting in the particular Central Garage bay housing this experiment. Considering the functions performed

Table 4: CENTRAL GARAGE NO. 1 TIMED LIGHTS
Elapsed Time Meter Readings

- Cumulative On Time
- Change (Δ) in On-Time
- Δ as a Percentage of Total Elapsed Time

Meter No. / Reading Date	1			3			4			8			Total Elapsed Time (Hr)
	Cum Hr	Cum Δ Hr	Cum Δ %	Cum Hr	Cum Δ Hr	Cum Δ %	Cum Hr	Cum Δ Hr	Cum Δ %	Cum Hr	Cum Δ Hr	Cum Δ %	
12/6/76 (1300 hr)	0			0			0			0			
12/13/76 (1200 hr)	167	167	100	167	167	100	167	167	100	167	167	100	167
1/28/77 (1300 hr)	1270	1270	100	1270	1270	100	1270	1270	100	1270	1270	100	1270
1/28/77 TIMER ACTIVATED*													Note 5:
2/3/77 (1200 hr)	1413	143	100	1277	7	4.9	1275	5	3.5	1274	4	2.8	1415 / 143
2/14/77 (1500 hr)	1680	410	100	1288	12	4.4	1288	18	4.4	1288	18	4.4	1682 / 410
3/31/77 (1500 hr)	2743	1473	98.7	1332	62	4.2	1306	36	2.4	1300	30	2.0	2762 / 1490
8/23/77 (1430 hr)	6222	4952	99.6	1341	71	1.4	1326	56	1.1	1314	44	0.9	6242 / 4970
4/19/78	11953	10683	99.8	1399	129	1.2	2000	730	6.8	1413	143	1.3	11,978 / 10,706

Average of 3 banks, 1/28/77 to 4/19/78: 334 hr on, or 3.1% of elapsed time.

Notes:
1) Meter No. 1 reads total elapsed time building was powered from 12/6/76.
2) Meters No. 3, 4 and 8 show cumulative on-time of corresponding circuits since 12/6/76.
3) See Figure 15 for location of numbered banks.
4) Tool crib mercury vapor lamps and fluorescent office area lights are always on.
5) Elapsed time since 12/6/76 over elapsed time since 1/28/77.

*Δ's below measured from 1/28/77

in this bay (Streets and Sewers and Water Department, shown in the lower left of Figure 11), this low usage of the overhead lights is reasonable. The open floor area is seldom occupied before 8:00 AM or after 4:30 PM. During the workday period, the usual activity is crew assembly and loading of trucks in the morning, unloading in late afternoon. The floor is not commonly occupied through the middle of the day or by people involved in detailed work requiring high illumination levels. Finally, the ambient light level, with contributions from the outside wall windows, from continuously-on mercury lamps over the tool crib (Figure 15) and from continuously-on flourescent lights in the office area, was adequate for most needs.

Savings may be computed from several viewpoints. If there had been no delamping program, then, as discussed in Section A above, Fo = 1.0 - .031 or .969, and the savings would be \$5100 x Fo, or \$4940 per year.

In the delamping program, all but one 300W bulb (330W power consumption with ballast) was removed in each bank of lights so there were actually 8 lights in use rather than 28. Thus, (assuming the three metered banks are typical) the actual savings after the delamping was 8/28 of the savings indicated above, or \$1412 per year. For the approximately \$1000 initial cost, the payback time, even with delamping, is less than 9 months.

Conclusions

It is concluded that, for applications in which lights tend to be left on unnecessarily, the use of automatic turnoff at selected times can be a very cost-effective means of saving energy. Clearly, the same scheme can be applied to other energy-consuming facilities also.

Delamping and use of timer cut-off are not mutually exclusive. For this project, both techniques were very cost-effective, singly and together.

3.2.2.4 Observations

The timed light controllers are a substitute for human concern, awareness and motivation, and for the administrative methods which induce these attitudes. Thus, while the controller provided a convenient way of saving energy, in principle it was not essential to such savings. Nevertheless, the low cost of the equipment and excellent conservation results confirm that the timed controller is a useful tool for conservation. The controller concept is likely to be especially useful in lighted areas where responsibility for lighting control discipline is divided, or where people are unpredictably in-and-out, or where administration is weak.

Sufficient continuous lighting for safety should be assured at all times. In Central Garage No. 1 this was provided by windows, by tool crib lights, and by fluorescent lights in the office area.

The Touch-Plate timed controller was readily wired into the power circuit next to the existing switch panel so that no extensive wiring or conduit runs were needed.

Use of the system did not appear to impose any problems nor cause objections by workers in the areas.

The timed cutoff arrangement is somewhat inconvenient when used with mercury vapor or other hot cathode gas discharge tubes because of the long restart time, typically, 1 to 3 minutes.

The turn-off schedule on the placard (Appendix B-3) was selected initially on the basis of known work hours and habits. Minor changes were later made at the suggestions of users. Yet, in the late spring of 1978, a check of the controlling time clock indicated that it had not been reset at the end of daylight saving time the preceding fall. The implied indifference to turnoff times is probably a result of the infrequent need for lights.

The Touch-Plate control system used as the Central Garage No. 1 timed light control could be improved for any future applications in three aspects:

- Identifying numerals on the control buttons should be embossed in the surface of the buttons. It was noted in early 1978 that they were painted on the surface and had been nearly worn away under finger pressure.

- The array of control buttons (Figure 16b) could be larger, more distinctive in appearance, and generally more eye-catching. Perhaps a large, tersely worded identification sign and bright local lighting would help in this.

- Provision of advance warning of impending turnoff so that it can be overridden without restart delays, preferably from the actual work station. This would necessitate a significant change in the circuits, but it could be done readily.

There was early discussion within the project as to the specific control function desired. The Touch-Plate system selected simultaneously turns off all circuits at one or more specific times set on a standard time clock--typically, through the day at times selected to follow normal crew assembly operations and every hour through the evening and night. An alternate scheme, which could be readily implemented and might have distinct advantages, would provide a selected on-time period for each bank of lights, after being actuated by the control button. This would avoid unanticipated work interruptions and would provide possible time overlap of lighting in adjacent areas. It would be analagous to the timed heat arrangement described below.

3.2.3 Timer-Controlled Heat in Work Bays

3.2.3.1 Description of Energy Conservation Opportunity

Original Condition

The assembly and work bays of the Central Garage No. 1 are heated with thermostatically-controlled overhead down-blow hot water heat exchangers. Use of heat in the shops has been much in the pattern described for light in Section 3.2.2: it has been commonly left "on" continuously, subject only to control of wall thermostats, and these were commonly set for above-normal room temperatures.

Recommended Project

Restriction of heating of shop areas to times when the shop areas are occupied was recommended as a demonstration project. This was to be done by the use of knob-actuated clockwork timer switches. These were to be wired electrically in series with the wall thermostats in the shop areas of the Divisions of Parks, Streets and Sewers, the Water Department and the Carpentry Shop. The timer switches, when manually actuated, would hold the wall thermostat circuit closed to deliver heat only for the duration of a hand-set time interval. A maximum interval of 2 hours was originally planned, but 12-hours was later selected as providing more flexibility for workers. The thermostat timer function was superimposed on the control of heat by the vehicle door system (Section 3.2.1). The overhead heater fan only operates when: the vehicle doors are closed; the thermostat timer has been actuated; and the thermostat is demanding heat.

In planning this installation, concern was expressed that restriction of heat might cause freezing of water pipes in cold weather. It was concluded that spillover heat from bays with unrestrained heat would prevent such freezing.

3.2.3.2 Results

The timers were installed as planned (see Figure 17 and the circuit given in Appendix B-1). Full 12-hour timed intervals were provided so that employees in the area could select a heating period which would avoid the inconvenience of interrupting work to reset the switch. However, elapsed time meters which had been purchased for obtaining timer usage data were somehow lost, and replacements were never obtained. No usage time data were obtained, and no quantification of the energy saved by the timer, is feasible. However, the original rationale for use of timer switches in thermostat circuits to minimize unnecessary use of space heat is valid, and this simple technique should be used in cases of: intermittent use of a space; or intermittent reduced temperature requirements (as in sleeping space); and in many of those situations for which time-clock controls are commonly recommended.

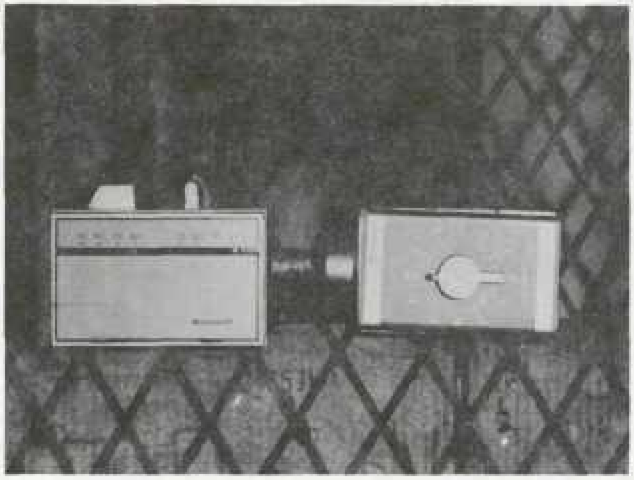


Figure 17. Public Works Shops, Central Garage No. 1, Timed Heat Controller Installation

3.2.3.3 Observations, Lessons Learned

Selection of the timer switch for timed thermostat installations should be made for the timed interval needed; mechanical stops on the knob can be used to restrict the maximum available interval if necessary. If the thermostat circuits are of the pilot-flame powered "millivolt" type, care should be taken to be sure that thermostat and timer switch contacts are precious metal or otherwise suitable for the low-voltage circuit.

The timed thermostat arrangement appears to have advantages over the now-conventional clock-operated night setback system in that it does not require resetting in the event of power failure or seasonal time changes, and it operates to save energy at all times when there is no demand, rather than at nighttime only The 12-hour timer configuration selected for this experiment can be readily modified (by installation of a shaft stop) to provide any selected lesser maximum on-time.

If it is important to maintain some low minimum temperature to prevent freezeup of water pipes or for other reasons, a modified configuration is feasible which uses a two-level thermostat. For this application, as for that installed in the shops, temperature control is maintained by the high temperature thermostatic element--which may be adjustable--as long as the timer is in operation. When the set timed interval ends, control reverts to a second, fixed low-temperature unit. Its set temperature must normally be above $32^{\circ}F$ to protect pipes from freezing damage; it may be higher if personnel comfort or safety is of concern in off hours. Figure 18 shows a circuit diagram of this two-level arrangement; the choice of specific components is a matter of detailed needs and component availability. The two-level timer switch configuration is basically an alternative to the more conventional clock-operated setback system. It has advantages in not being confined to a particular repetitive switching program and in not requiring readjustment after power outages.

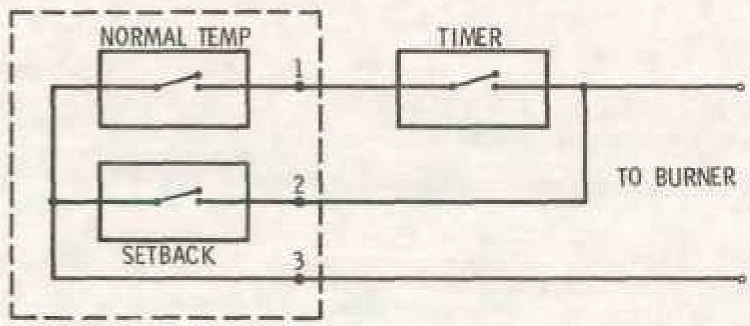


Figure 18. Two-level Thermostat and Timer Schematic

3.3 PUBLIC SCHOOL NUMBER 6 PROJECTS

Public School No. 6 is a typical urban brick school building constructed in the 1920's for elementary education. An exterior view is shown in Figure 19, and some characteristics of the building are given in Table 5. Two conservation experiments, described below, were conducted in the school. In one, an attempt was made to reduce excessive heat losses caused by the long-term effects of inadequate building maintenance. In the second, an investigation of the acceptability of efficient lighting sources was conducted.

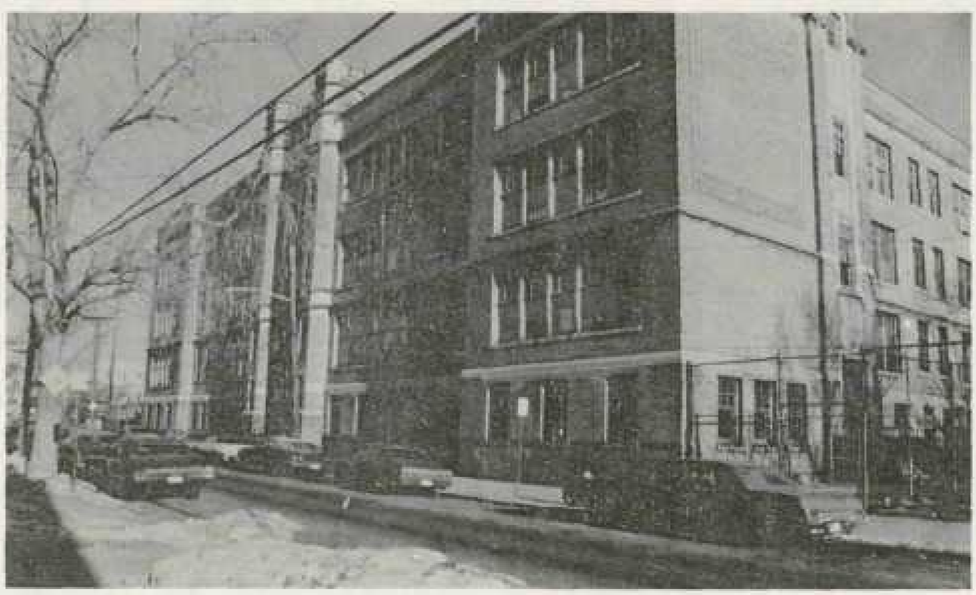


Figure 19. Public School No. 6 - Exterior View

3.3.1 Sealing of the Building Shell and Window Area Reduction

3.3.1.1 Energy Conservation Opportunity

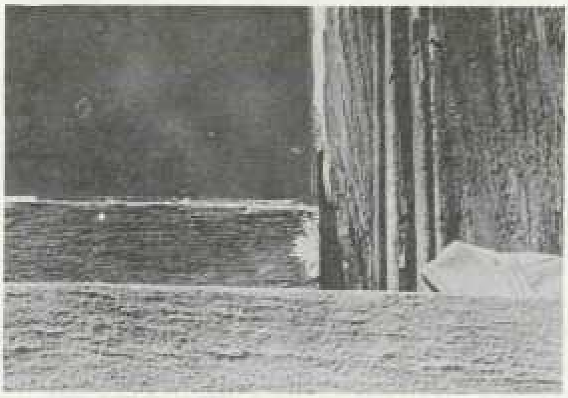
Original Condition

Each classroom in Public School No. 6 had five 4-by-8-foot double-hung, single-glazed windows, which exceeded the present state requirement that there be two operable classroom windows. Building maintenance had been neglected for many years, so that the exterior surfaces of frames and sashes had more bare wood than painted surface exposed. The bare wood was rotted, shrunken, deeply cracked, and warped; see Figures 20a, 20b, and 20c. Windows did not close properly, and there were large cracks around them. As a result, this building had substantial heat losses due to leakage, infiltration and convection at the windows.

Recommended Project

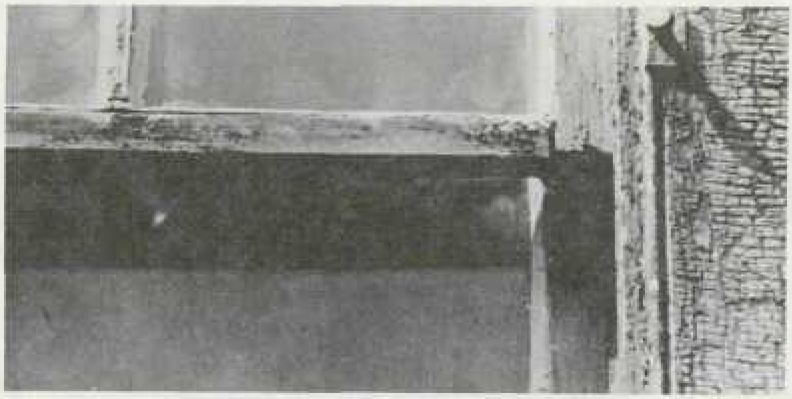
In order to eliminate air leakage around cracked and deformed window frames and sashes and to reduce heat losses through the single glass, it was recommended that three of the five windows in each classroom be fitted on the inside with an insulating semi-permanently mounted panel of translucent plastic, mounted in a wooden frame. The panel, in effect, forms a double-glazed window, permanently closed and sealed. LEXAN (polycarbonate) plastic was selected for its resistance to physical damage from vandalism.

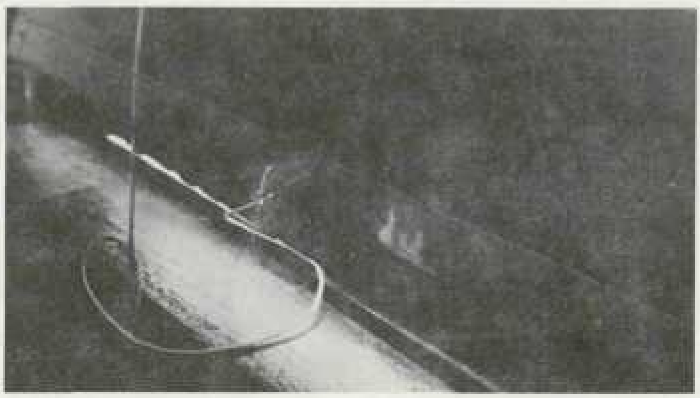
The remaining two classroom windows, which must be operable in order to meet State safety requirements, were to be weather stripped to reduce leakage and infiltration. Those windows not in classrooms were to be caulked or weather stripped as appropriate to eliminate the gaps and openings which caused excessive infiltration. Seldom-opened windows were to be weather stripped with felt edging.



a.

b.





c.

Figure 20. Public School No. 6

a. Typical Weathered, Cracked and Rotten Frame and Sash
b. Typical Weathered, Cracked and Rotten Frame and Sash
c. Large Crack Under Marred Classroom Sash

Table 5

PUBLIC SCHOOL NO. 6
BUILDING DESCRIPTION

General Description:

Size: 124,000 sq. ft.
2,079,000 cu ft.

Construction: brick, wood floors, 3 stories plus basement

Date of Construction: 1922

Number of Classrooms: 43

Windows: wood, double hung

Heating System:

Steam, 2 Boilers

Boiler: Pacific, fire tube Scotch Marine, natural draft 8,930 lbs. per hour

Burner: York, rotary cup 45 gallons per hour, #4 fuel

Domestic hot water: heat exchanger from steam

Ventilation:

Type: open window, central exhaust fan

Air Conditioning: none

Classroom Lighting: incandescent, replaced with high pressure sodium

Rationale

This approach to energy conservation in Public School No. 6 was not ideal; it circumvented rather than addressed the serious problem of deteriorated exterior woodwork. Moreover, the wooden molding frames which retained the sheet plastic window panels were not aesthetically very attractive.

The conservation approach was, however, consistent with the objectives and the emphasis of this program: to demonstrate low cost, practical ways of saving energy which had relatively rapid payback, short response times, and required minimal changes to existing conditions. In any case, program funds were far short of those which would be required for full rehabilitation of the exterior woodwork of Public School No. 6. Results of this project were expected to be indicative of the energy savings which could be obtained from a major rehabilitation effort using double-glazed or storm windows.

Predicted Costs and Savings

In planning the program, a preliminary estimate of the costs for labor and materials was $7500. Annual savings of $9000, or over 120 gallons of fuel oil per day, were predicted on the basis of standard calculations for infiltration and window losses. These estimates suggested a probable payback period of less than 1 year.

Data Requirements

The project was to be evaluated on the basis of a comparison of the total oil consumption by Public School No. 6 for heating seasons before and after the sealing and window area reduction. Project costs considered in evaluating results included both material costs and costs of installation work done by Jersey City Board of Education personnel.

3.3.1.2 Project Implementation

Actions for sealing the building shell of Public School No. 6 centered on the classroom windows. For a typical array of five 4-ft wide x 8-ft tall double-hung windows, several modifications were made to reduce losses of heat to the outside. Details of these changes are shown in Appendix B-4. Materials and parts requirements and installation details are also given in the Appendix. Weather stripping details are shown in Figure 21.

Three of the five windows in each classroom -- the outermost two and that in the center -- were permanently fastened in the closed position. These three windows were calked and closed over with plastic sheeting as shown in Figure 22, and in the construction drawing, Appendix B-4. An approximately 4-ft x 8-ft frame of 2 x 4 inch fir lumber was installed to fit inside the sash of each window. A textured-surface translucent sheet of .080 in. Lexan plastic was fastened over this 2 x 4 frame and retained by wooden moulding screwed to the 2 x 4 frame through the Lexan.

Textured, translucent plastic was selected to minimize the visibility of scratches and of grime expected to collect in the enclosed dead-air space. This material was also somewhat less expensive than clear Lexan. These modifications effectively sealed the three permanently closed windows, reduced infiltration losses at these windows to zero (for all practical purposes) and substantially reduced conduction and convection losses by use of the additional Lexan barrier -- in effect, double-glazing.

The remaining two windows of each classroom were modified as shown in Detail 1 of Appendix B-4, in accordance with State requirements (Ref. 5, Para. 1213) for openable classroom windows in each. The upper sash was permanently fastened in a closed position, and the lower sash was fully weather stripped with durable stripping which was expected to be capable of withstanding many operations.

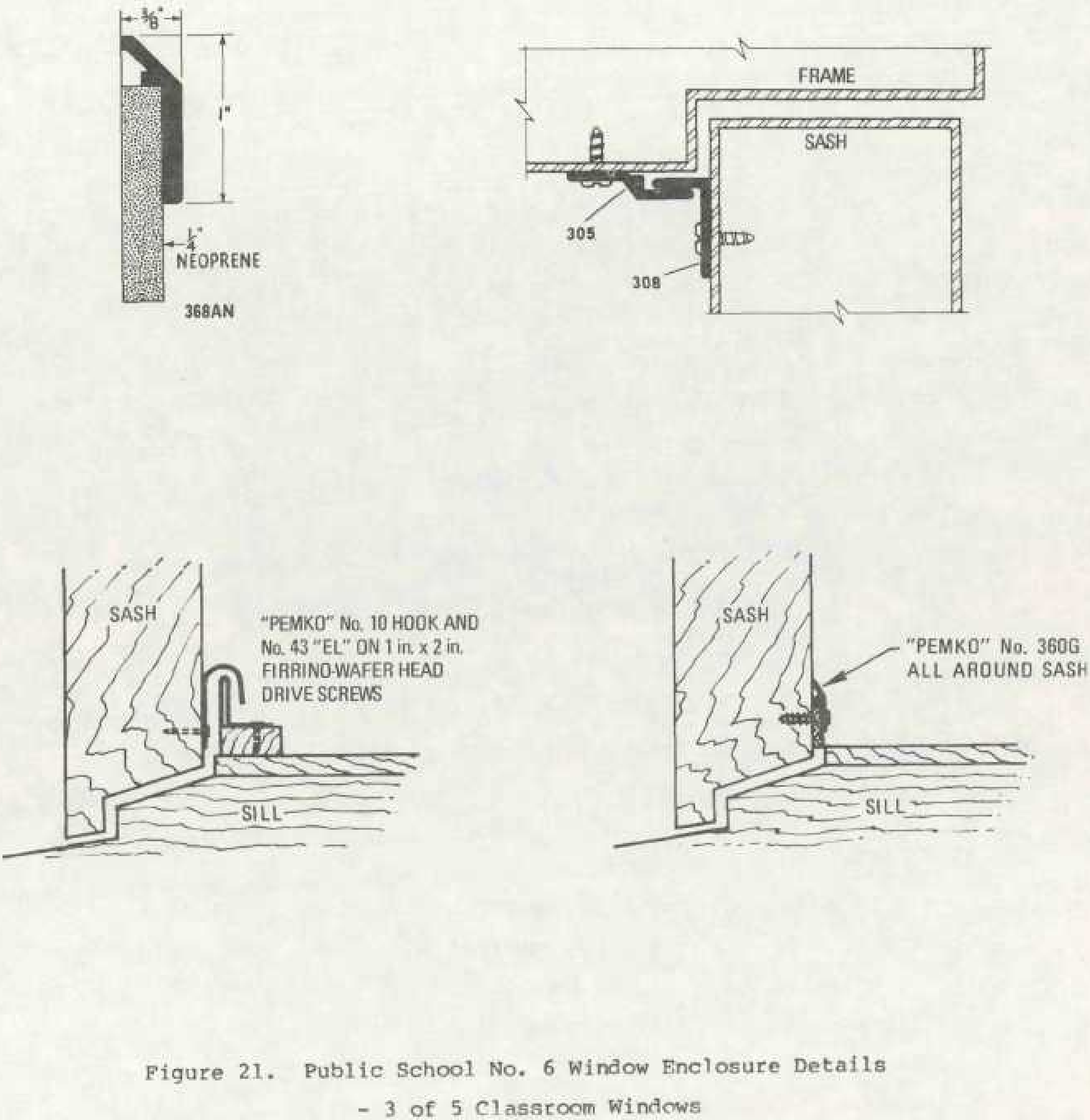


Figure 21. Public School No. 6 Window Enclosure Details
- 3 of 5 Classroom Windows

Figure 22 shows a typical classroom after installation of the translucent Lexan sheet in the first, third and fifth windows. The clear glass of the still-operable second and fourth sections is evident in the figure.

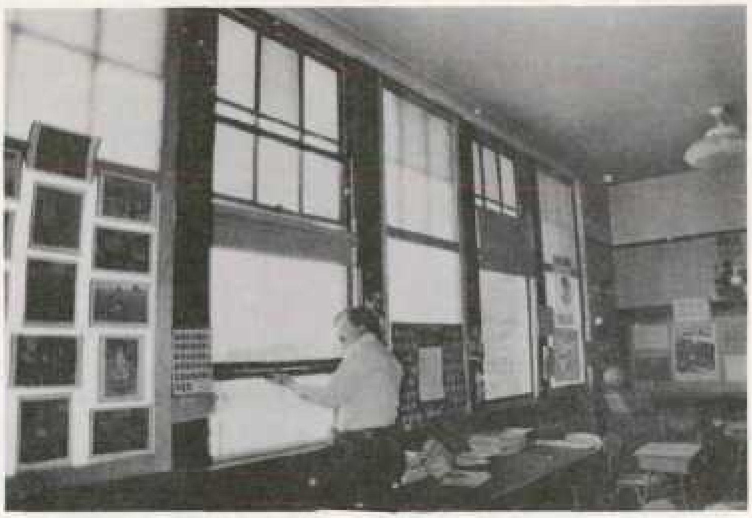


Figure 22. Public School 6
Classroom Windows After Installation of Lexan Plastic Sheet

Windows in other parts of the building that had not been previously weather stripped were equipped with lower-cost felt weather stripping which provides a sliding friction seal appropriate for limited use. This arrangement is shown in Detail 3 of Appendix B-4.

3.3.1.3 Key Events

Construction drawings of the caulking, closure, weather stripping, and covering details were prepared by J.A.B. Associates. (See Appendix B-4.) After approval by local officials and by Aerospace, the drawings were sent to the New Jersey State Board of Education for approval.

The drawings were approved by the State as meeting New Jersey State Department of Education requirements (September, 1976).

City Council approval for procurement of materials was obtained (in accordance with the Revised Procurement Procedures, Appendix A-2), and the materials (lumber, Lexan plastic sheet, weather strip and caulking compound) were ordered.

Installation by Board of Education crews began in late 1976. By early December, although weather stripping had not yet been delivered, the window area reduction work was nearly completed on the third floor, and occupants of the building were commenting favorably on the already noticeable improvement in comfort.

Delays in delivery of weather stripping and frequent reassignment of work crews to other jobs interfered with the progress of the work. Consequently by the end of the winter of 1976-1977 the project installations were only about 50 percent completed.

It had been found, meanwhile, that the entire original pneumatic thermostat system of Public School No. 6 did not work; this condition had apparently been obscured by the generally uncomfortably-cold room temperatures prior to the project initiation. The boilers were being continuously adjusted by the firemen in an attempt to control average building temperature. This procedure is at best very inexact.

However, because of the enormous heat losses from the windows, excessive temperatures had not been a problem. It became obvious as the experiment progressed that overheating and severe occupant discomfort would become serious problems as building heat losses were further reduced.

Board of Education personnel were notified of this prospect with the recommendation that immediate action be initiated to repair or replace the existing inoperative thermostat control system. Specifications for such repair or replacement were prepared, and proposals were solicited and received.

The Jersey City Board of Education requested approval of the State Department of Education for a bond issue which, among other things, would provide money for the temperature control system rehabilitation or replacement.

By the summer of 1977, work on the windows was only about half completed, and there were no indications that the Board of Education was giving the project the needed priority. The Technology Agent, who had local responsibility for the DOE project, wrote a letter to the Board of Education expressing concern over the delays and lack of action. A copy of this letter went routinely to the newly elected Mayor, Thomas F. X. Smith, who was a member of the Board. Mayor Smith expressed by letter his concern that the city meet its commitments, stressing need for immediate action on the project. The sealing work was resumed thereafter, and it was completed prior to the start of school in the fall of 1977.

The proposed bond issue was disapproved by the State Board of Education in November 1977. However, some money still remained uncommitted in the $95,000 equipment fund of the DOE Jersey City Program because of changes in some projects. To help meet the Public School No. 6 needs for a thermostat system, $7500 of the DOE program money was offered to the Board. With this support, the Jersey City Board of

Education was able to find the necessary additional funds. City Council approval for the procurement (based upon the originally obtained bids) was obtained in November 1977, and a contract (for $33,600) was let at once for a new pneumatic thermostat system with: a night-setback feature; new thermostats and air compressor; new steam control valves on all radiators. In addition, all radiator steam traps in the building were also to be replaced under the contract.

Difficulties arose at once. Deliveries of the steam control valves selected by the contractor were slow. Through the winter, cutting off the boilers to permit work on the steam lines was not feasible during the normal workday because of concern for occupant warmth. Work in non-school hours was not feasible because of union rules and the lack of premium-pay funds. As a result, the winter of 1977-1978 passed with little work done on the temperature control system and with no automatic control of building heat anywhere in Public School No. 6.

Discomfort of Public School No. 6 occupants was extremely high in the winter of 1977-1978, with classroom temperatures frequently in the 90's. Use of open windows to cool off the now well-sealed classrooms was common practice.

3.3.1.4 Results

Data Obtained

It was recognized that overheating and temperature modulation by opening of windows were wasting great amounts of heat in the winter of 1977-1978. However, there were some indications that, even under these conditions, significant savings of energy might have resulted from the project. Accordingly, a comparison was made of oil consumption rates before and after the sealing of the building shell.

Table 6

PUBLIC SCHOOL No. 6 FUEL OIL CONSUMPTION
BEFORE, DURING AND AFTER BUILDING SEALING

Date Interval	Total Oil Gal.	Total Degree Days in Data Interval	Gallons Per Degree-Day
1975-1976 (before project)	54,170 (1)	4571	11.85
1976-1977 (during installation)	61,630 (1)	5637	10.93
Nov '77 - Jan '78	23,760 (2)	2667	8.91 (3)

(1) Total deliveries in season with no allowance for end effects.

(2) Actual

(3) No allowance was made for the holiday season; however, December oil consumption rate was very near the average, so the effects of the holidays are believed to be minimal

Oil consumption data were recorded for Public School No. 6 before, during, and after sealing. Results are given in Table 6.

Evaluation of Data

As shown by Table 6, in spite of inadequate temperature control, the building sealing activity reduced the oil consumption rate markedly. Even before the defective temperature controls had been repaired or provisions made for night setback of temperature had been made, and with general use of open windows for temperature control, oil consumption was reduced from 11.85 to 8.91 gallons per degree-day, or by 2.94 gallons per degree-day. This amounts to 14,700 gallons of oil saved for an average year of 5000 heating degree-days. At 36 ¢ per gallon, the dollar saving would be $5290.

Costs of the building sealing operation were about $7100 for materials and $16,500 for labor, or $23,600. Thus, even in its present imperfect and very unsatisfactory state, the project shows a simple payback (cost divided by benefit) of about 4.5 years. It is highly probable that fuel consumption will fall by another very significant amount when the temperature control system is working. These benefits, with classroom comfort, should prevail in Public School No.6 in the 1978-1979 winter season.

3.3.1.5 Observations and Lessons Learned

It must be noted that a large part of the savings observed and to be observed on this project arise from the compensation for past errors: neglect of the exterior finish of woodwork and deterioration of radiator steam traps and the thermostatic control system. Nevertheless, savings attained by sealing Public School No. 6 and by the reduction of single-glazed window area are impressive. From this and other data, it seems clear that actions to reduce infiltration losses are among the most cost-effective measures which can be used in poorly maintained buildings for energy conservation.

As noted in other instances, nothing should be taken for granted as to the condition or operation of an old building. The inoperability of the Public School No. 6 thermostat system and radiator steam traps was not readily apparent prior to initiation of the program. In cases of apparent neglect of building maintenance, all elements of the systems involved in the conservation program should be investigated thoroughly.

Delays in getting installations made must be anticipated, especially in programs involving major building renovations. It is easy at the inception of a program for high-level administrative personnel to commit maintenance crews in principle to a major installation effort in the far-distant future. However, it is much more difficult for the immediate supervisors of maintenance personnel to actually undertake project work and still meet the day-to-day needs of an organization.

Some types of weather stripping are susceptible to damage in use. For example, Figure 23 shows a damaged section of a PEMCO No. 10 weather strip. Damage to the sash-mounted PEMCO No. 10 "hook" strip occurred when the sill-mounted No. 43 "el" strip was bent outward and caught the edge of the sash-mounted strip. This is apparently a damage-prone combination, and it is not one recommended by PEMCO. This suggests that unusual combinations of components (weather strip or other) should be tried experimentally before large-scale adoption.

3.3.2 Modernizing Classroom Illumination

3.3.2.1 Conservation Opportunity

Original Condition

Classrooms in Public School No. 6 were each lighted by four pendant flashed-opal glass diffuser fixtures with (nominally) a 300W incandescent bulb in each, as shown in Figure 24. Thus, 1200W of

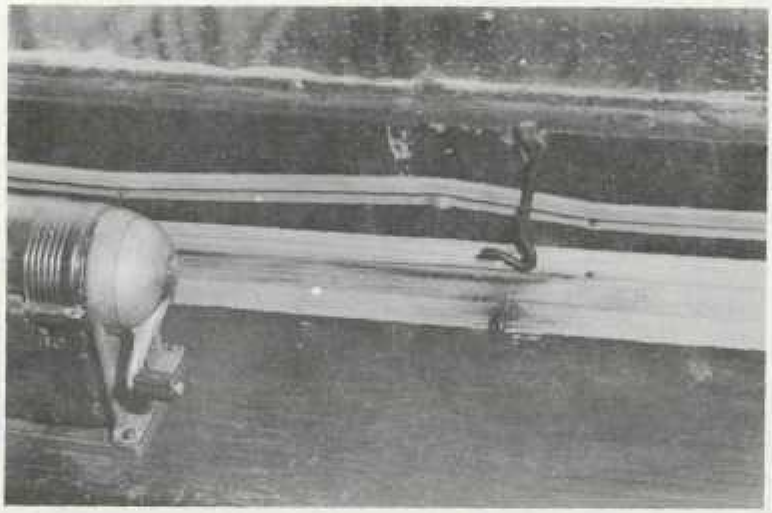


Figure 23. Public School No. 6

Damage to Weather Strip on Window

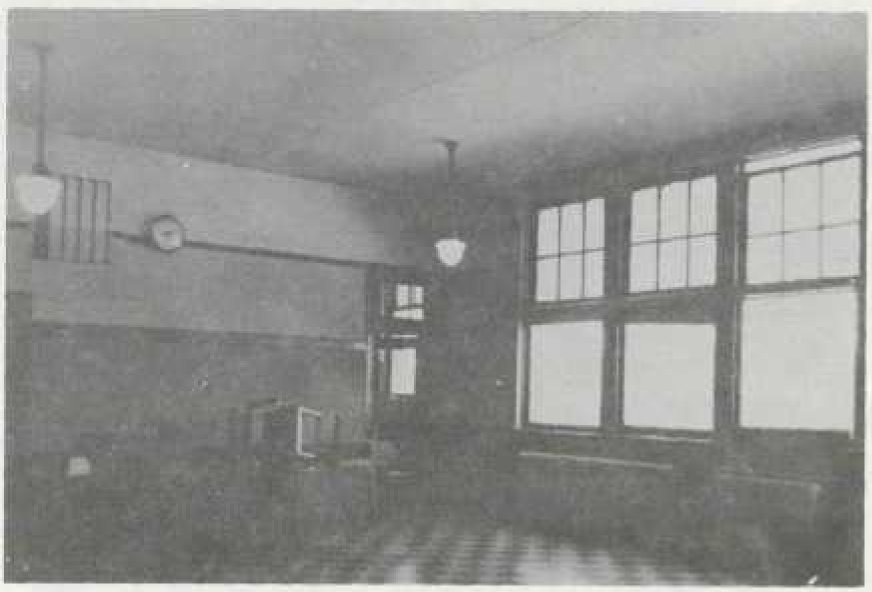


Figure 24. Public School No. 6

Original Classroom Lighting Fixtures (four-300 watt diffusing pendants) incandescent lighting was theoretically utilized per classroom. About 10 foot-candles (fc) average illumination at the desktop (without daylight from the windows) was provided by the four lights prior to the program's initiation. The desktop illumination level recommended by the New Jersey State Board of Education is 50 fc: five times the average illumination levels in the classroom prior to initiation of the program.

The Public School No. 6 building wiring was undersized for even the old electrical lighting load. Approximately 12 amps were required for the incandescent lamps in each classroom and its adjoining cloakroom, which was carred by 14-gage copper wire. This was marginally sized wiring. The fusing level of the system had been selected so that blown fuses were a serious inconvenience under the nominal electrical load of the lighting circuits. Figure 25 shows a typical wooden switch and fuse box with exposed knife switches, mounted in hallways to control classroom lights. It suggests the technology available during the period of this building's construction.

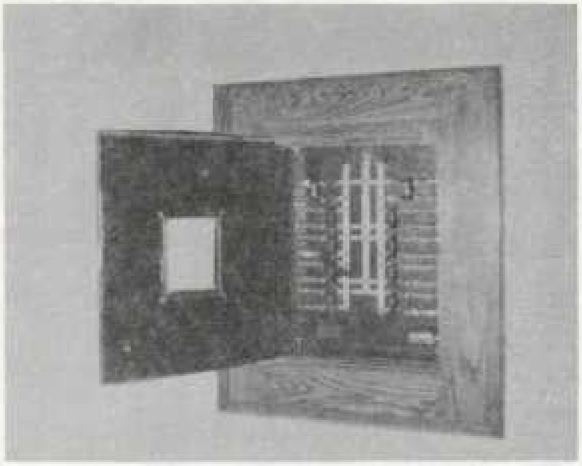
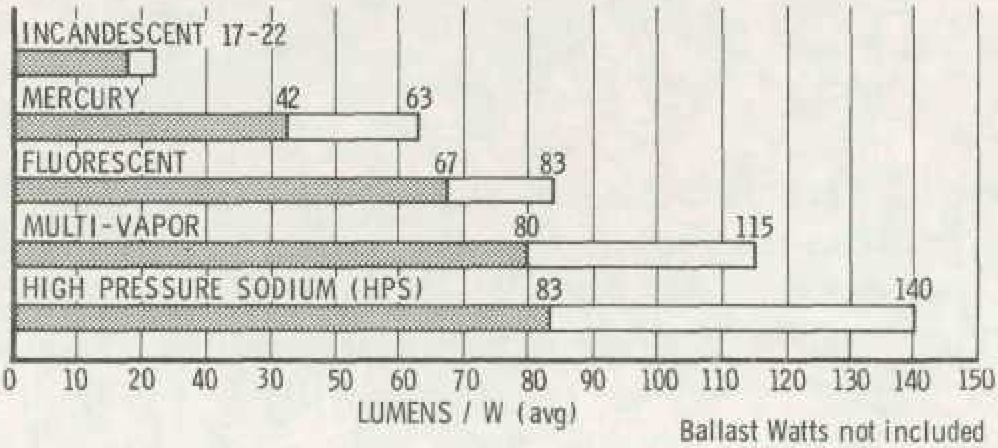


Figure 25. Public School No. 6
Typical Wooden Switch and Fuse Box

School personnel were anxious to improve the classroom lighting level of Public School No. 6 and to eliminate the marginal wiring condition. Extensive rewiring was outside the scope of the ERDA/DOE-sponsored conservation demonstration. However, the retrofitting of classrooms with more efficient light sources was recognized to be a potentially useful conservation demonstration. The experiment would evaluate whether acceptable levels of desktop illumination could be provided without rewiring the building, with a corresponding "effective" conservation of energy.

A comparison of the efficiencies of commonly available lamp types is shown in Figure 26. A preliminary check indicated that if either fluorescent lights or 250W high pressure sodium (HPS) units were used in sufficient numbers to provide the state-required 50 fc illumination in a classroom, the resulting electrical current requirements would overload the old wiring. Including power required by their ballast units, neither fluorescent nor 250W HPS lights would provide lower line currents than those of the original system.



Note: Courtesy, General Electric Company

Figure 26. Relative Efficiencies of Commonly Available Electric Lamps

Recommended Project

After investigation and test, it was determined that direct replacement of the four 300W incandescent bulbs and fixtures in each classroom with four 150W HPS bulbs in suitable fixtures would provide improved illumination together with nominal energy savings, while reducing the current in existing substandard wiring. The HPS fixtures could be mounted directly on the existing ceiling boxes. The fixture selected are shown in Figure 27.

Figure 27. Public School No. 6
HPS Light Fixture Selected (General Electric #C653G001-120v
with Pendant Hardware #C740G 546, Ceiling Canopy)

Some preliminary measurements indicated that the use of these units in a classroom would provide about 35 fc at desk level (with operating ballast and cloakroom incandescent lights) and impose a total electrical load on each classroom circuit of about 900W or 8 amps. In a test installation, desktop light levels with four 150W HPS lamps were measured at 40 fc or more. Comparable measurements with the incandescent lights had shown an average of about 10 fc at the desktops. With augmentation by window lighting, the 150W HPS units provided well over the minimum requirement of 50 fc. Given these data, the State Board of Education approved the retrofit of Public School No. 6 classrooms with four 150W HPS lamps each to replace the existing incandescent lights.

It was recognized that the yellowish color of the HPS light might be objectionable, although it provided a much more uniform color balance than the nearly monochromatic orange light of the familiar low-pressure sodium lights used for parking lot and highway illumination. It was believed that the improved levels of illumination in Public School No. 6 would more than compensate for the moderate color distortion.

Predicted Costs and Savings

HPS luminaires with bulbs were expected to cost about \$500-\$550 per classroom including installation costs. Assuming that lights were "on" throughout every school day (7 hours per day), with a saving of 0.5 kW (0.7 kW for HPS versus 1.2 kW for existing incandescent), for 180 days per school year, then annual savings per classroom should be 630 kWh per classroom per year or, at 5 per kWh, \$31.50 per year per classroom. This connotes savings of over \$1300 per year for the school. Taken alone, these early estimates did not indicate that HPS lights would be a particularly attractive energy-conservation option. The calculated return is only about 6 percent of investment and does not cover present money costs. However, this appraisal neglects the following observations: It was necessary to improve the desktop light level of Public School No. 6; and (2) The old wiring system was underdesigned, even for its original use. Thus, use of 300W incandescent bulbs to achieve the required 50 fc would have required: over 6kW of lighting per room; fixtures for five times the original number of bulbs; and nearly complete rewiring of the building. Use of fluorescent lights would have required lamps consuming about 1800W per room, 10 to 12 new fixtures, and complete rewiring. HPS installation to fully achieve the nominal state requirement of 50 fc would have required four 250W lamps, consuming about 1200 watts (with ballast). This choice would have slightly exceeded the required light levels, but it would not have been compatible with the old wiring system.

Selection of 150W HPS lamps provided clear economic advantages over all other feasible ways of providing the needed improvement in classroom illumination.

3.3.2.2 Project Implementation

There were few problems in implementing the light project. Installation of the new light fixtures was made by Board of Education personnel. Figure 28 shows a typical classroom installation.

Figure 28. Public School No. 6
Typical Classroom with HPS Lights

The following data were obtained for evaluation of the HPS lights and their energy savings:

(1) Before-and-after electrical billings to determine savings
(2) Elapsed time meter readings to measure on-time of lights
(3) Teacher attitudes towards HPS lights as determined from a questionnaire, Appendix C-1.

3.3.2.3 Results

Pertinent measured and calculated data for the experiment, with the arithmetic used, are given in Appendix C-2 and summarized in Table 7. Teacher attitudes towards the HPS lights, as revealed by the response of 32 questionnaires returned, have been summarized in Table 8. The data show that HPS lights were considered acceptable by the teachers of Public School No. 6, and their advantage over any alternative for energy economy and convenience of installation is clear. Although the power - consumption results from Public School No. 6 were inconclusive, HPS lights have been shown to provide nearly double the light output of fluorescent tubes for a given power input. Accordingly, where color discrimination is not a first-order requirement, they are highly recommended for retrofit and for original installations.

Evaluation of Power Consumption Data

Direct comparison of electrical power consumption by Public School No. 6 was to be the primary means of evaluating the energy and cost savings due to use of HPS lights. Such a comparison is shown in Appendix C-2, Section 4. Initially, the period of October 1, 1975 to February 29, 1976 was taken as the "before" time and the period of October 1, 1977 to February 28, 1978 was taken as the "after". Since the power consumption figure for February 1976 is clearly anomalous, February was eliminated from both cases, and only the periods of October-January inclusive were considered. These show an average total monthly power consumption of 19,795 kWh (before) and 19,797 kWh (after). The expected savings due to HPS lights--about 2500 kWh per month, as shown in Table 7-- were not evident in power billings, although school officials stated that there had been no significant change in the kind, level, or time of activities in the school between these evaluation periods.

Discussions with maintenance and operating personnel indicated that burned-out 300W incandescent bulbs were often not replaced promptly, and that 150W bulbs were often used as replacements in order to prevent the frequent blowing of fuses. Thus, it appears that Public School No. 6 classrooms were, in fact, operating at light and power levels which may have been as low as half of those estimated and discussed above. The actual incandescent bulb complement under which the average 10 fc measurement was made could not be determined.

Evaluation of energy savings by HPS lights on the basis of before-and-after electrical billings, as planned, was clearly not appropriate. An evaluation based upon nominal pre-experiment electrical ratings and average measured usage times, believed to be realistic and accurate, has been presented in Appendix C-2, Section 8, and summarized below.

Calculated savings for 150W HPS units compared to 300W incandescent units for an average 20 school-day month, in 40 classrooms of four fixtures each are given in Table 7. Classroom lights were observed to be "on" for an average of 6.4 hours per school day. Electrical power costs are 6.3¢ per kWh. 150W HPS lights consume about 175W each with ballast power. For purposes of comparison, each classroom is assumed to have had the nominal original complement of four 300W incandescent bulbs. In addition, bulb costs, including replacement costs, are much lower for HPS lamps than for incandescent.

Table 7

PUBLIC SCHOOL NO. 6

Expected Comparative Monthly Costs
High Pressure Sodium Lamps vs Incandescent Lights

Lamp Type	a Monthly Power Consumption Lights Only	b Monthly Power Cost	c Apportioned Bulb Cost	d Total Monthly Cost of Classrm Lights (b+c)
300 Watt Incandescent	6144	$387.10	$74.34	$461.44
150 Watt HPS (plus ballast)	3584	225.80	17.90	243.70
Monthly Saving:	2560	$161.30	$56.44	$217.74

(Data Summarized from Attachment C-2)

Average monthly savings attributable to the use of HPS lights for Public School No. 6 under the assumptions described are $217 per month or 47 percent of operating costs for the 300-W incandescent installation above. This represents an overall saving of $1953 for the entire school over a 9-month school year.

Actual cost of the Public School No. 6 HPS light installation was $160 per fixture, or $25,600. Thus, the annual return of HPS-light power savings is 7.6% on investment. It is apparent that the improvement of classroom illumination level, which was the basic objective of the project, is its major benefit. However, this improvement has been made with some energy saving and without major rewiring or other costly renovation work.

In this case, the HPS lights have provided an economical and functionally adequate solution to a problem of inadequate illumination. Energy savings are a bonus feature of the project. The HPS lights have, in this case, provided considerable savings over both the energy and in the installation costs which would have been imposed by other choices.

Teacher Appraisal

Results of the teacher questionnaire given in Table 8 seem to indicate indifference by the teachers with only a slight positive bias. Out of 32 respondees, four more teachers liked than disliked the lights. However, questions reviewed in Table 8 were posed over 1 year after the installation had been completed. It seems likely that the dim classroom lighting levels which prevailed with the old lights may have been forgotten in that period, so that questionnaire responses are probably less enthusiastic than they might have been earlier.

3.3.2.4 Conclusions

Utility of HPS Lights

This demonstration has confirmed that HPS lights provide generally acceptable illumination for classrooms with the advantages of very high efficiency (lumens/watt), low bulb cost, and relatively easy retrofit in buildings with inadequate wiring by current standards.

Color Discrimination

Immediately after the lights were installed, one third-grade teacher was quite vehement in objecting to the poor color discrimination which they afforded. In using colored crayons, her pupils were having special problems in identifying reds positively.

Table 8

TEACHER ATTITUDES REGARDING HIGH PRESSURE SODIUM (LUCALOX) LIGHTS

Summary of 33 Questionnaires Returned

Number of Responses to Questions:

1.	I find the color of the lights:	Pleasant	6
		Acceptable	10
		Slightly Unpleasant	13
		Very Unpleasant	3
2.	The affect of the lights on class alertness has been:	None	11
		Slightly Favorable	9
		Slightly Unfavorable	9
		Strongly Favorable	2
		Strongly Unfavorable	0
3.	What (if any) effect upon student tension and "fidgets" have you observed?	None	20
		Slightly Favorable	3
		Slightly Unfavorable	6
		Strongly Favorable	0
		Strongly Unfavorable	2
4.	Overall, how do you feel about the lights?	Like	14
		Indifferent	9
		Dislike	10

Comments

FEATURES OR EFFECTS OF LIGHTS LIKED:	
Brightness	10
Lack of shadows	1
Color	1
Physical appearance	0
Less glare	1
More even light	2
More reliable than old lights	1

FEATURES OF LIGHTS DISLIKED:	
Slow warmup	13
Slow turn-on response makes intermittent use of visual aids in classroom difficult	2
Color distortion	20
Slow response in getting service (mainly bulb changes)	13
More glare	4
Makes dirty walls more evident	1
Eyestrain due to color	1
Teacher had headaches initially	1
Children had headaches after board work	1
Children ask to leave lights off in afternoon	1
Not bright enough on dark, dismal days	2
Too bright	1

"Children love to guess which (of the four) will light first!"

If coloring activity is important, it seems reasonable that, a special classroom--such as one in Public School No. 6 which had been retrofitted with fluorescent lights for some previous program--might be designated for this activity.

Stroboscopic Effects

Gas-discharge lights, such as HPS, fluorescent, and mercury vapor, produce a flickering or stroboscopic effect at 120 light pulses per second. Concern was expressed by some people that this effect might accentuate student fatigue and eyestrain. Questions 2 and 3 of the teacher questionnaire were designed to explore the possibility of such a problem without suggesting it explicitly. Responses to these questions (Table 8) seem to indicate that eye fatigue due to stroboscopic or other effects from HPS lights in these classroom situations was not a problem. It is not clear that this conclusion would apply to such situations as handicraft or assembly operations which require high visual acuity with observation of rapid motions. However, a few written comments by teachers attributed teacher and student headaches to the lights and suggested that students sometimes preferred to leave the lights off when daylight levels were adequate.

3.4 PUBLIC SCHOOL NO. 24

Public School Number 24 is a typical 1920's school building of yellow brick construction (see Figure 29). Some features of the building are given in Table 9. It is an elementary school, housing kindergarten through eighth grade classes, with an interior 2-story 1000-seat auditorium. Public School No. 24, like Public School No. 6, which is of about the same age and construction, had badly weathered, poorly maintained window frames and sashes with consequent high infiltration rates. At the inception of this project, the Public School No. 24 oil burners for space heating had essentially no working automatic controls. The obsolete and partially defective oil burners of Public School No. 24 appeared to afford an attractive opportunity for energy savings.

Figure 29. Public School No. 24 Exterior View

3.4.1 Energy Conservation Opportunity

Fuel oil consumption at Public School No. 24 was excessive, in part because of worn-out, obsolete oil burners.

Original Condition

The two rotating-cup oil burners in Public School No. 6 were worn out and obsolete. They were set permanently in a high fire-rate condition; and both secondary and primary air dampers were fixed. The operator manually adjusted the fuel flow in the boilers daily, usually without adjusting the combustion air flow. Secondary dampers remained open when boiler firing was terminated, so that down-time losses (heat losses due to cooling of the boiler by natural stack effect when the flame was shut off) were correspondingly high. In normal winter operation, both boilers were continuously fired in tandem, rather than using one boiler to carry the base load with the other supplementing it as required. The front breeching doors were not tightly closed, and the tightening lugs were broken. The resultant leakage increased the heat losses during periods when the boiler was shut off, and decreased generation capacity when it was fired. In combination, these several deficiencies were clearly wasting fuel.

Consumption of No. 4 fuel oil in the 1975-76 season of 4570 heating degree-days was 45,000 gallons at a cost of approximately 35¢ per gallon, totaling $15,750. Adjusted to the average Jersey City year of 5000 heating degree-days, the corresponding average oil consumption rate of Public School No. 24 prior to installation of the new burners was 49,200 gallons per year, for an overall consumption rate of 9.85 gallons per degree-day.

Table 9

PUBLIC SCHOOL NO. 24 FEATURES
(Prior to Conservation Demonstration Project)

BUILDING	
Year of Construction:	1920
Number of Floors:	three
Total Area	50,500 sq. ft
Type of Construction:	brick and block
Number of Classrooms	40
HEATING SYSTEMS	
Type:	steam, low pressure
Boilers:	two 2-pass Scotch Marine, Titusville
Burners:	Petro, rotary cup (mfg. 1950)
VENTILATION:	natural, open window
ELECTRICAL SYSTEM	
Lighting:	fluorescent, upgraded

During tests and observations incidental to the selection of Public School No. 24 as an experimental site, typical operations were observed. The number one boiler (of two) was initially fired up with the fuel flow rate too high for the fixed air flow. This resulted in fuel-rich combustion and an abnormally low stack temperature of 250°F. The operator, when informed of the condition, manually adjusted the fuel rate. Thereafter, stack-gas measurements indicated an absorption efficiency of 73%. This efficiency figure is at best an approximation to the average conditions prior to the Jersey City program, since fuel settings were then made in a largely random manner.

Recommended Project

It was recommended that the unmodulated rotating-cup oil burners of Public School No. 24 be replaced with modern pressure-atomizing, fully modulated burners of the same firing rate. It was also recommended that as a part of this retrofit, defective lugs on the breeching access doors be repaired so that the breeching could be properly sealed.

Rationale

Modern atomizing burner equipment, as recommended for this project, can operate reliably, fully modulating, at an absorption efficiency of 83 percent (12-14 percent CO_2 and 25 percent excess air) with zero down-time losses. This upgrade of the absorption efficiency from the assumed average of 73 percent would represent an improvement of 13.7 percent. In addition, the new burners would eliminate smoke, which was sometimes produced by the old units.

Predicted Costs and Savings

Costs were estimated at $5000 per unit plus $3000 installation, or $16,000 total cost for the two-unit installation.

Heat losses during periods of burner shutdown are important for an unmodulated (on-off) burner in a boiler without dampers, but actual down-time was not well known and was variable over the year. Actual pre-experiment down-time loss in Public School No. 24 losses could not be measured because project planning was done in the summer. Two cycles of down-time were assumed and analyzed: one cycle was 20 minutes "on" followed by 10 minutes "off", and the other had 10 minutes "on" followed by 10 minutes "off". Down-time losses for these conditions were calculated to be 5.2% and 10.4% respectively. These conditions were assumed to be extremes spanning actual operating conditions.

Savings with the new burners were calculated as 13.7% for improved absorption efficiency and (as indicated above) from 5.2% to 10.4% for elimination of down-time losses. Predictions of cumulative fuel savings ranged from 18% to 23%. Based on the average yearly oil consumption of 49,200 gallons, savings were predicted of from 8860 to 11,300 gallons of oil per year. At present fuel costs of 36¢ per gallon, this fuel reduction represents a cost saving of approximately $3000 to $4000 per year.

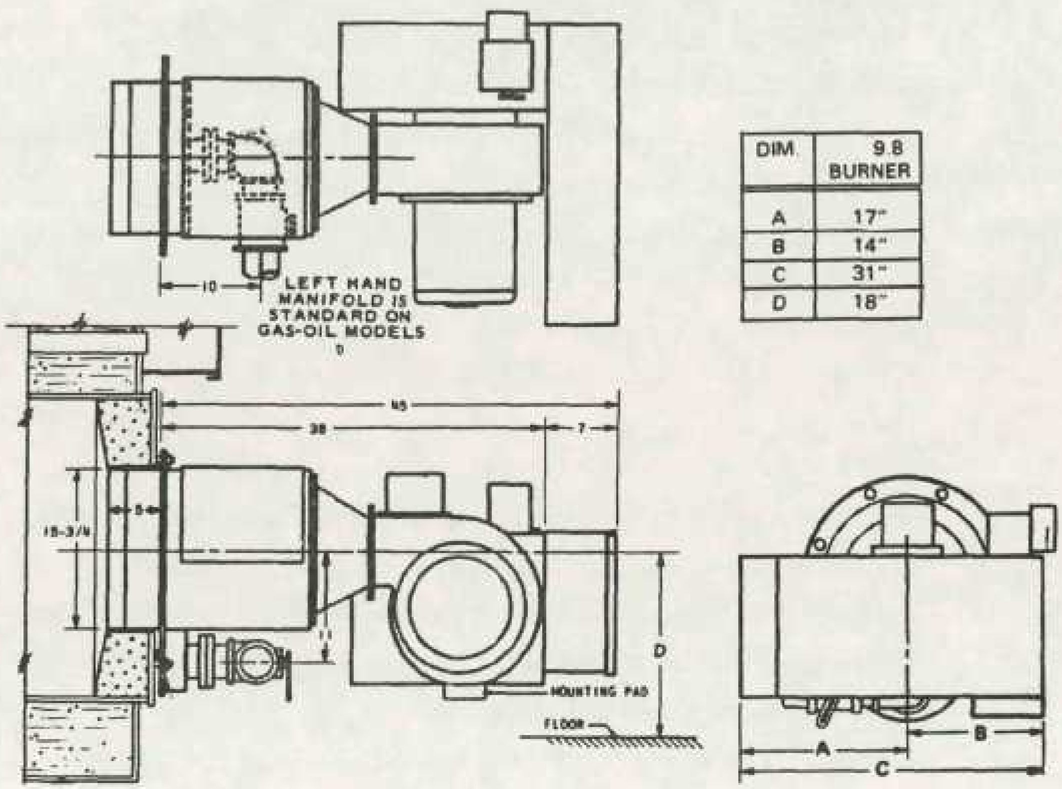
For the estimated total installation cost of $16,000, these predicted savings would provide simple payback times of from 4 to 5.2 years, if the estimated price of No. 4 oil hold constant at 36¢ per gallon. The likelihood is that oil prices will increase and payback times will be reduced correspondingly.

3.4.2 Project Implementation

The project was selected for implementation and agreed-upon Jersey City procurement procedures (Appendix A-2) were initiated; these were a straightforward matter of advertising for bids, selecting the lowest qualified bidder, and letting the contract.

Burners selected were Iron Fireman pressure-atomizing, type PAO-4-9.8, having a maximum firing rate of 70 gallons per hour (gph) with either No. 2 or No. 4 fuel oil. These are fully modulated units (3:1 modulation rate) with 7.5 hp motors and 5 kW heaters for use with No. 4 oil. The manufacturer's drawing is given as Figure 30. Figure 31 is a photograph of the installation.

The burners were installed in December 1976.



DIM.	9.8 BURNER
A	17"
B	14"
C	31"
D	18"

Figure 30. Public School No. 24
Atomizing Oil Burner, Iron Fireman Type PAO-4-9,8
Manufacturer's Drawing

Figure 31. Public School No. 24
Atomizing Oil Burners Photograph of Installation

3.4.3 Results

The new atomizing oil burners were installed in the midst of the 1976-77 heating season. Accordingly, for evaluation of the resultant savings, the "before" condition was taken as the 1975-1976 heating season, in which 44,977 gallons of No. 4 fuel oil were consumed. These are total delivered gallons. Contents of the tank before and after the heating season are unknown. There were 4571 heating degree-days in this season; the resultant consumption rate in this season was 9.84 gallons per degree-day.

The "after" period was taken as November 1977 through February 1978, for which daily oil consumption data were taken. Burners were adjusted and checked at the beginning of this period, with a resulting average of 81% boiler absorption efficiency. There were no down-time losses because the modulating burners operated virtually continuously over the wide range of conditions experienced during the test period. During this period there were 3741 heating degree days, and 31,147 gallons of oil were consumed, averaging 8.4 gallons per degree-day (versus 9.84 previously). Savings attributable to the new burners were, therefore, 1.44 gallons per degree day or 7200 gallons per average (5000 degree-day) year. At the 1977-1978 season oil contract price of about 36¢ per gallon, this represents a saving of $2592 for an average season.

As a check, savings were also calculated on the basis of absorption efficiency and down-time losses, using the observed 73% absorption efficiency figure as an average value for 1975-1976 served, adjusted for the calculated 5.2% and 10.4% extreme values for down-time losses. Under these assumptions, corresponding 1975-1976 boiler operating efficiency would range from 69.2% to 65.4%. For the equivalent assumptions for the 1977-1978 period, 81.1 percent absorption efficiency and no down-time losses, the corresponding percentage savings over the 1975-1976 condition are:

$$\frac{(81.1 - 69.2)}{69.2} \times 100\% = 17.2\% \text{ (for 5.2\% down-time losses); and}$$

$$\frac{(81.1 - 65.4)}{65.4} \times 100\% = 24\% \text{ (for 10.4\% down-time losses).}$$

Computing from a 5000 degree-day season in the "before" period (9.84 gallons oil consumption per degree-day, or 49,200 gallons per season), these correspond to calculated oil savings with the new burners of from 8477 to 11,808 gallons.

Thus, the predicted savings (8477 gallons or more, or $3052) were not quite met by the actual savings, based upon observed average annual fuel savings of 7200 gallons at $2592. The difference is reasonable, considering the uncertainties in the data being compared.

Installed costs of the two atomizing oil burners were lower than predicted: $13,147 rather than the predicted $16,000. Consequently, the simple payback time (cost divided by measured annual savings in oil usage) is 5 years versus 3.76 to 5.25 years for the early estimates.

3.4.4 Observations and Comments

This demonstration has shown the considerable benefits that can be obtained and the short payback time for replacement of worn-out, obsolete, non-modulating oil burners with modern atomizing and fully modulating equipment.

Performance tests and tune-up of the burners and boilers in Public School No. 24 were provided at the beginning of the 1977-1978 season, and they showed that significant degradation in efficiency occurs over a season of use, even with new and modern equipment. For full efficiency, heating systems, including burners, should be given a complete check and tune-up at the beginning of every heating season.

3.5 FERRIS HIGH SCHOOL PROJECTS

Ferris High School is a modern (1969) school building of brick and concrete block construction. It was initially selected as a demonstration site in which energy conservation measures appropriate to buildings of recent design might be explored.

The projects originally planned for Ferris High School, with one exception, were not undertaken in that school. Transfer of projects from Ferris High School was found necessary because of the very high incidence of vandalism there. It became clear that any demonstration equipment installed in the classrooms and hallways would probably not survive until completion of an experiment. Some of the projects proposed for Ferris High School were eliminated, and others were transferred to Public School No. 40.

3.5.1 Deactivation of Air Conditioning System

3.5.1.1 Energy Saving Opportunity

Original Condition

The lithium bromide air conditioning system of Ferris High School was identified as a major instrument of energy losses. Air conditioning for Ferris High School is provided by a central lithium bromide absorption system via circulating cold water to perimeter coils in the various zones of the school. The single-stage lithium bromide absorption air conditioning process requires exorbitant amounts of hot water to achieve a relatively small cooling effect.

All four boilers are operated to provide air conditioning power during regular and summer sessions. Two hundred gallons of fuel oil are consumed per hour of operation in summer, almost all for air conditioning.

Such systems may have been economically feasible when fuel costs were low, but the current high oil prices favor more efficient cooling systems such as the mechanical vapor compression (Freon) cycle.

The cooling season during the regular school year is short, estimated at approximately 30 days during April, May and June, and approximately 20 days during September and October. This, with very low building utilization during summer sessions, (10 classrooms were used during the summer of 1975) suggests that more economical means than this absorption cooling system should be used to maintain comfort in the building on the occasional hot days: opening classroom windows to provide air circulation and providing forced ventilation in windowless areas such as the auditorium.

Recommended Project

It was recommended that the absorption air conditioning system be deactivated and that building blowers and HVAC system dampers and their controls be modified to provide forced ventilation of such areas as the auditorium, gymnasium and cafeteria in summer. Summer session classes are held in the morning. If these classes were held in classrooms having northern exposures, the normal building ventilation should be sufficient to maintain comfort. Window fans could also be obtained to increase ventilation flow and comfort.

Predicted Costs and Savings

Deactivation of the absorption air conditioning system was estimated to require approximately 20 hours of labor (about $150) and no materials. The modification to the blowers, dampers and thermostats was estimated to require approximately $600 in materials and 150 hours of labor by City personnel for installation and modification work for a labor cost of approximately $1000. Window fans would cost about $100 per classroom, if needed.

Deactivating the air conditioning and thereby saving approximately 200 gallons of oil per hour at 35¢ per gallon (in 1976), assuming 8 hours use per day over the 40-day summer session period, would provide savings of approximately $23,000 per year. Any needed window fans could be quickly written off by energy savings.

Data for Requirements

For project evaluation, it was planned to use "before" and "after" oil consumption data, adjusted for cooling degree-days.

3.5.1.2 Results

The proposed deactivation of the absorption air conditioning system was initially opposed by people in the school system, and it was understood that the scheme had been permanently rejected. Project interest and activity shifted away from Ferris High School to Public School No. 40, and project personnel were not aware that the Board of Education elected to follow the recommendation developed in this program for deactivating the Ferris High School absorption air conditioner. Accordingly, the detailed record-keeping which had been planned originally was not undertaken.

However, three (of four) boilers were shut down through the summer of 1977 with savings estimated at over 150 gallons of No. 4 oil per hour, 8 hours per day, for 40 days of the summer session: a total of 48,000 gallons. At an approximate contract purchase price of 36¢ per gallon, this represents a saving of more than $17,280 for the two-month summer session.

3.5.2 Installation of Gas-Fueled Pool Heater

3.5.2.1 Energy Conservation Opportunity

During the summer vacation period, the swimming pool of Ferris High School is used by the City as a facility of its public recreation program. Pool heating is necessary, and it is provided by one of the four oil-fired boilers of the school, operating at low firing rates and correspondingly low efficiency, consuming about 240 gallons of oil per day for pool heating.

It was proposed that a 200,000 BTU/hr gas boiler be installed in Ferris High School to assume the summer pool-heating load with more nearly optimum efficiency than the large oil-fired boiler now being used can provide. A cost advantage could also be obtained by use of off-peak gas rates, since the thermal inertia of the pool permits heating it at infrequent and, if necessary, irregular intervals.

3.5.2.2 Action Taken

This project was transferred to Public School No. 40; it was subsequently dropped because gas service was ultimately refused. (See Section 3.6.4).

3.5.3 Classroom Ventilation Control

3.5.3.1 Energy Conservation Opportunity

Original Condition

Ferris High School classrooms employ unit cabinet ventilators for classroom heating, ventilating and air conditioning. Outside ventilation air is admitted via controlled dampers in the unit ventilators at the formerly required rate of 0.5 cubic feet per square foot of floor area per minute (1) or on an average 15 cubic feet per pupil per minute.

Also, in Ferris High School, the ventilation rate requirements are being met throughout the school day in every classroom, even when they are empty.

Recommended Project

A very simple modification was proposed. A timed on-off switch with a 40-minute "on" duration was to be installed in each classroom for ventilation damper control. Upon entering the classroom, or at the start of a class, the teacher was to turn the damper timer switch on, which would allow the ventilation damper to operate normally according to a preset position schedule under control of the room thermostat system. At the end of 40 minutes, the ventilation switch would open the damper control circuit, driving the damper to the fully closed position. With this arrangement, ventilation would be provided for the duration of each class but not between classes or during times of the day when the classroom is unused.

Predicted Costs and Savings

Costs were estimated to be $10 per timer switch unit and $15 for installation: $25 per classroom.

Expected benefits from the saving of both heated and cooled air were not specified quantitatively. However, the use of a timer was expected to cut the time duration of ventilation air flow by about half. Subsequent calculations suggest that this would save about 48 gallons of oil, or about $17.50, per timer-equipped classroom per year.

3.5.3.2 Project Implementation

This project was recommended for implementation in Public School No. 40 rather than in Ferris High School as originally planned because of concern for vandalism. However, after the project was committed to Public School No. 40, it was found impossible to run a controlled ventilation experiment there; see Section 3.6.3.

3.5.4 Zone Control Master Switching

3.5.4.1 Energy Conservation Opportunity

Cleaning crews work throughout the buildings after school hours and into the evening hours, moving from room to room and corridor to corridor. All lighting switches are inconveniently located in a single central location so that lights throughout the school are left on for the entire duration of the cleaning and maintenance work, although most areas are actually unoccupied at any given time during this work. Rewiring the lighting system to establish switching zones was considered. Each such zone would include one corridor with its classrooms, and each would have its light switch within the zone.

The lighting electrical load of Ferris High School is estimated (from the profile of total electrical demand) to be about 425 kW. Accordingly, 2 hours daily use of the full light system by custodians costs $1070 per month at current rates. By the zone arrangement considered, this could be reduced by 80 to 90 percent with no inconvenience or added inefficiency.

At a money cost of 10% per annum, each $100 per month of saving can amortize an investment of about $7700 in 5 years. Accordingly, the predicted savings in Ferris High School could have justified (by 5 year amortization) an outlay of $82,000 for zone control of lighting.

3.5.4.2 Disposition

This project was deleted when detailed study showed that costs for the rewiring were beyond the financial resources of this program.

3.5.4.3 Recommendation

Zone lighting controls should be carefully considered for all new construction and for building retrofit in cases where inconvenient locations of lighting switches lead to a major waste of electrical power by building maintenance people or tenants.

3.5.5 Photocell Control of Classroom Perimeter Lights

3.5.5.1 Energy Conservation Opportunity

Ferris High School classrooms are each illuminated with three rows of fluorescent fixtures. Each row is controlled by a separate switch. Normal teacher practice is to switch all lights "on" upon entering the classroom and to leave all three banks on through the school day and until custodial work has been completed. Even at times when daylight can provide adequate desktop illumination near the windows, the outer bank of lights is not ordinarily turned off.

It was proposed that photocell light controllers be installed at classroom windows and wired to turn off the outer bank of fluorescent lights when outside brightness was adequate to maintain required desktop illumination.

3.5.5.2 Action Taken

This project was changed to Public School No. 40 because of concern for vandalism of equipment at Ferris High School. For a description of results at Public School 40, see Section 3.6.2.

3.6 PUBLIC SCHOOL NO. 40 PROJECTS

Public School No. 40 is a modern elementary grade school typical of those constructed in the sixties. Classroom windows (Figure 32) comprise a large portion of the wall area. Special features include a full-size indoor heated swimming pool which is used during the summer months as a facility of the city's recreational program. Other features of Public School No. 40 are listed in Table 10; a view of the building front is shown in Figure 33.

Many of the conservation demonstration projects installed in Public School No. 40 were originally planned for Ferris High School but were transferred to Public School No. 40 because of the reportedly high probability of vandalism at Ferris. The conservation projects planned and conducted included: (1) boiler modification to improve efficiency; (2) photocell lighting controllers for reducing unecessary classroom lighting; (3) automated ventilation air controllers to reduce excess air heating requirements; and (4) installation of a gas-fueled pool heater to improve boiler utilization factors and efficiency during summer months.

Figure 32. Public School No. 40
Exterior View - Classroom Windows

Figure 33. Public School No. 40
View of Building Front

3.6.1 Turbulators in Boilers

3.6.1.1 Conservation Opportunity

Original Condition

Combustion gases from conventional two-pass boilers, such as those of Public School No. 40, typically exit from the stack at a high temperature, indicative of wasted heat and correspondingly high fuel costs. Stack temperatures of the boilers of Public School No. 40 were originally found to be 590-615^{o}F, indicating absorption combustion efficiency for these boilers of about 73 percent at the beginning of the program. Reduction of stack temperatures by increasing the heat absorption in the boiler tubes was recognized as an evident mechanism to improve the boiler efficiency and the fuel economy.

Table 10

PUBLIC SCHOOL NO. 40 FEATURES

BUILDING

Date of Construction:	1963
Number of Floors:	Three, Plus Basement
Total Area	122,500 sq. ft.
Type of Construction:	Brick and Block
Number of Classrooms:	45

HEATING SYSTEM

Boilers:	Three, Steam, Low Pressure, Pacific Scotch
Burners:	York-Shipley, Rotary 60 gph, #4 Oil
Domestic Hot Water:	Heat Exchanger, from Steam

VENTILATING SYSTEM

Type	Perimeter Unit Ventilators, Interior Central System, Exhaust Fans and Open Windows

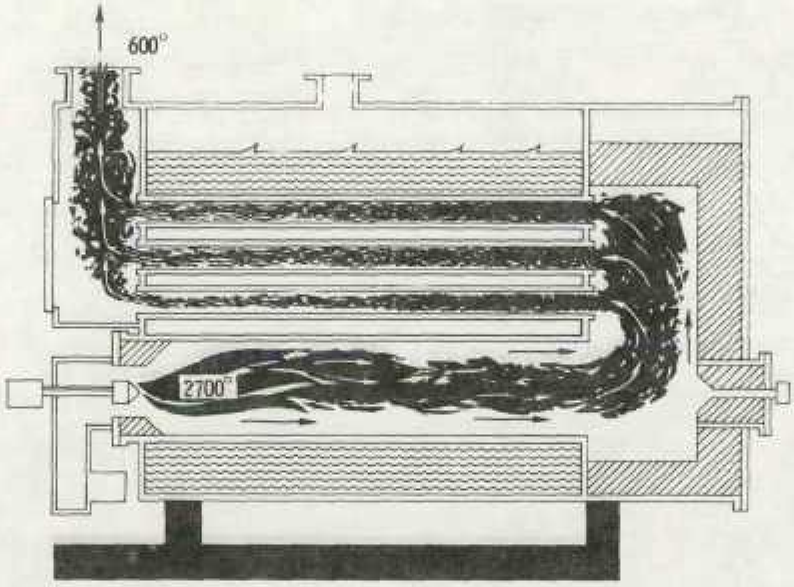
Brock Turbulators are "zig-zag" steel strips which are slipped into the boiler tubes and retained by friction fit. They are engineered for a particular boiler application by the choice of length, width and number of strips. The manufacturer states that Turbulators will increase boiler efficiency by reducing laminar flow in the tubes and by promoting heat transfer to the walls through increased turbulence. Suitably tailored for the application, they help balance the flow of gases in the boiler tubes so that the lower tubes, which ordinarily carry a lesser flow than the upper, are made to perform as effectively in heat transfer as the upper. Figure 34a shows a cross-section of a typical two-pass boiler. The uneven heat distribution among the tubes and the increasing degree of laminar flow at the exit end of the tubes is shown schematically in the figure. Figure 34b shows a similar schematic representation of the equalization of flow between tubes and the turbulent flow produced by suitably designed Turbulators. The manufacturer of the Turbulators will, under many conditions, guarantee significant fuel savings by their use. For the case of Public School No. 40, an 8 percent improvement was specified in the purchase order as a requirement.

Recommended Project

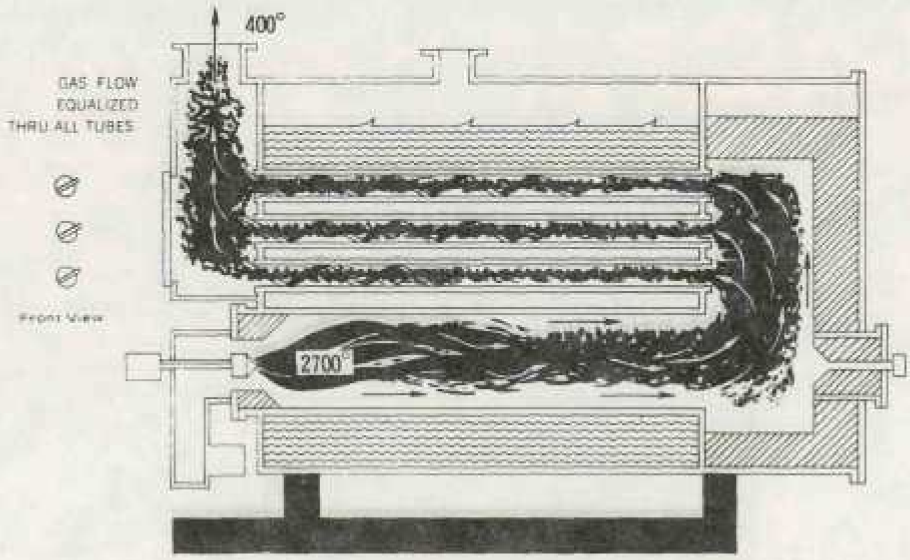
Installation of Brock Turbulators was recommended for all three boilers of Public School No. 40.

Predicted Costs and Savings

The cost of installing Turbulators was estimated at $2000, and the expected annual benefit was $2000, implying a 1-year payback period.



a - Representative 2-pass Scotch Boiler Cross-Section Showing Unequal Flow Between Tubes and Increase of Laminar Flow Along Length of Tubes



b - 2-pass Scotch Boiler with Typical Turbulator Installation Showing Equalized Flow of Gases and Turbulence Along Entire Length of Tube

Figure 34. Boiler Before and After Turbulators
Courtesy, Fuel Efficiency, Inc.

3.6.1.2 Project Implementation

A purchase order was placed for Brock Turbulators with the specifications given in Appendix B-5. A Public School No. 40 boiler with Turbulators is shown in Figure 35. Some of the zig-zag Turbulator strips have been pulled out of the tubes slightly for illustration in the figure.

The evaluation was planned on the basis of both measured combustion efficiency and comparison of "before" and "after" fuel oil consumption.

3.6.1.3 Results

<u>Data Obtained</u>

Actual installed costs of Turbulators for the three boilers was $1906.

Figure 35. Public School No. 40 Turbulators in 2-pass Boiler
- Three are pulled out partially for illustration

Before installation of Turbulators, the boiler combustion efficiencies averaged 73 percent after tune-up. The annual pre-experiment fuel usage rate was 17.2 gallons per degree-day (1975-76).

With Turbulators, combustion absorption efficiencies (after tune-up and adjustment) averaged 82.5 percent in 1976 and 80 percent in 1977, for an overall average of 81.3 percent. Annual fuel usage was at the average rate of 14.6 gallons per degree-day with Turbulators.

Evaluation

For evaluation, all data were adjusted for the average heating year of Jersey City of 5000 degree-days. Savings were calculated from: (a) the change in the oil consumption rate; and (b) the measured change in combustion efficiency.

a. From measured oil consumption, the saving due to Turbulators is 2.6 gallons per degree day (13,000 gallons of oil per average year) or, at the current contract price of about 36¢ per gallon, $4680 per year, for an overall saving of 15.1 percent of the previous annual consumption.

b. Based upon the average combustion efficiency figure of 81.3 percent with Turbulators and 73.0 percent without them, the measured savings were:

$$\frac{81.3 - 73.0}{73} \times 100\% = 11.4\%$$

For an average year, this represents savings of 9,800 gallons of oil or $3530 per year. This is a saving of about 25 percent less than that calculated from measured oil consumption. The combustion efficiency data are approximate, so the results are in reasonable agreement.

Discussion

The savings computation based on measured oil consumption does not depend upon any assumptions. Accordingly, the simple payback time was less than one-half year: much better than that predicted. Clearly, devices such as turbulators represent one of the best conversion investments which can be made with two-pass boilers and others having higher-than-minimum stack gas temperatures.

Application of Turbulators is ultimately limited by the necessity of holding minimum stack gas above the dew point of the sulfur compounds in the gas in order to avoid corrosion. Minimum stack temperatures which usually provide trouble-free operation are:

Fuel	Sulfur,%	Minimum Actual Stack Temperature, °F
Diesel type	1	280
Heavy Oil	2.5	310
Heavy Oil	3.5	320

It should be remembered that minimum gas temperatures will be locally affected by temperatures of metal surfaces exposed to the gases. Ductwork, for instance, may be much cooler than the flue gases it contains. Such low temperature surfaces must be maintained above the dew point.

3.6.2 Photo-Controllers for Outer Classroom Lights

3.6.2.1 Conservation Opportunity

Original Condition

Observation of lighting practices by teachers in Public School No. 40 and other schools indicated that they did not make full use of natural outside light. In Public School No. 40, each classroom is lighted with four rows of fluorescent fixtures parallel with the outside wall. Each row of lights has a separate wall switch at the classroom door. It was observed that most teachers routinely turned on all four banks of lights when they entered the classroom and left them on thereafter. In many classrooms, window blinds are left down most of the time. This may have been in part caused by the large proportion of inoperative window blind mechanisms in the building, but there were indications that thoughtlessness and the lack of administrative action to make potential economics known were also reasons for these lapses.

Recommended Project

A series of light measurements made at the classroom desktops indicated that outside light from the windows was capable of providing the required minimum level of 50 footcandles (fc) or more at the desktops of the outer desks for an average of about 60 percent of the daytime hours of school operation.

Accordingly, it was proposed to install a photocell controller for the outer two banks of lights in the windows of each of 10 classrooms. The controller would automatically turn off the fluorescent lights in the outer two banks whenever outside light (as measured at the windows) was sufficiently bright to provide 50 fc at the outer desktops.

Rationale

The rationale for this project was that attainable savings by use of outside light appeared to be significant. However, such savings were not being implemented by administrative ruling or by special requests to teachers. Such actions are apparently not customary in Jersey City, where they seem to be regarded as challenges to the authority and prestige of the teacher.

Predicted Costs and Savings

The photo controllers were expected to cost $97 each, and the predicted annual saving was about $40 per classroom, based upon an estimated average saving of 3 hours for 2 lamp-banks of about 1.6 kW each, 180 days per school year, and (in 1975) 5¢ per kWh electrical costs.

Data Requirements

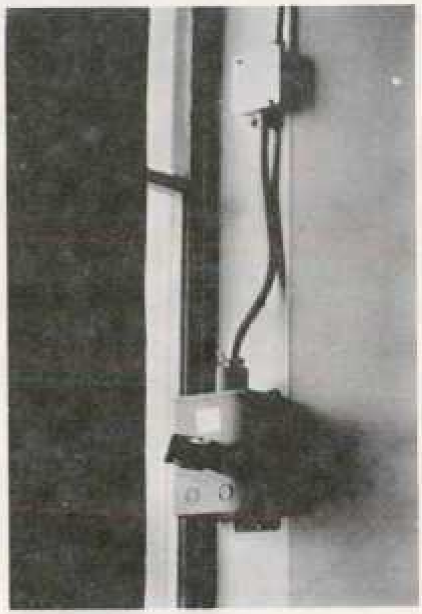
The saving in electrical energy due to use of the photo-controllers was to be computed from the total power consumption of the outer banks of lights during the time period which they were held "off" by the photo-controller. Power consumption was derived from ratings of the lights. The time difference was provided by a pair of elapsed time meters (installed with each photo-controller) to show (1) total time that the inner (uncontrolled) banks of lights were on, and (2) total time that the photocell-controlled lights were on. It was assumed that without photocontrollers the outer lights would be on for the same total time as the inner. This assumption is consistent with earlier observations. The difference between the ellapsed time meter readings accordingly represented the increment of outer bank operating time saved by the photo-controller.

3.6.2.2 Project Implementation

It was necessary to establish a correspondence between desktop illumination and the light levels incident upon a photo-cell mounted at a classroom window to look at the sky. Limited data taken in September 1976, showed that, with the inner two banks of lights on, an outside brightness of 400 fc at the windows (measured looking about 20 degrees above the horizon) would provide minimum requisite desktop light levels. The northwest-facing rooms, however, did not experience direct sunlight, as did those facing southeast. On a clear day, the skylight produced at the windows of the northwest-facing rooms (860 fc) was about twice the 400 fc level which was selected as the switching level for the lights. Under these conditions, adequate desktop light levels were provided by the indirect skylight. On an overcast day, the skylight illumination levels fell to 340 fc (3:00 pm) in the northwest facing rooms, making desktop levels marginal. For the southeast facing windows, on a bright day in direct sunlight, the controller location at the windows received 8400 fc. However, on an overcast day in the afternoon, even in southeast facing rooms, skylight measured at the windows decreased to about 380 fc, with correspondingly marginal desktop natural illumination levels.

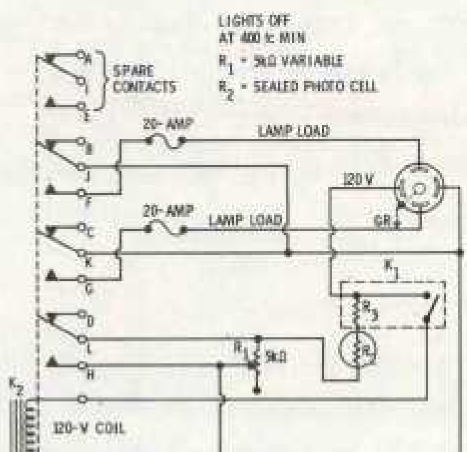
Key specifications for the desired photo sensor/controller were: that it be reliable, stable, and as nearly tamper-proof as feasible; that it control an approximately 12-amp 115-v ac load; that it be readily mounted at the classroom window with an uninterrupted field of view of the sky; that its sensitivity be adjustable to provide the desired switching at required desktop minimum illumination levels for various outside conditions; that the circuit be designed to prevent annoyance caused by too-rapid switching of the lights; that it draw operating power from the 115-v line; and that its design be approved by the State of New Jersey Department of Education for experimental use. A manufacturer, Area Lighting Research, Inc. (ALR), Hackettstown, N.J., was found with a uniquely applicable sensor/controller device. A description and a schematic of this sensor/controller are given in Appendix B-6. A photograph of an installed controller is given in Figure 36a and a schematic diagram in Figure 36b. Key features shown in the photograph are:

- The sensor/controller assembly, mounted at a classroom window
- The sensor housing, mounted on the face of the larger box so that the sensor aperture faces the sky
- The electrical terminal box and BX cable pigtail connecting to the room wiring.



36a - Public School No. 40

Photocell Controller for Classroom Lights



36b - Public School No. 40

Photocell Controller Schematic Diagram

3.6.2.3 Narrative of Key Events

The needed configuration for the photo-controller was defined and a vendor identified, as described above.

Approval of the State Board of Education for installation of the photo-controller experiment was requested. Approval was granted on the basis that the system would maintain the state-required level of 50 fc at desktops. Since the photo-controller assemblies are not approved by the Underwriters Laboratories (although they are fabricated from UL-approved parts), approval was contingent upon the internal fusing of all circuits and upon obtaining approval of the Board of Education insurance carrier for their use. This approval was obtained without difficulty.

Initial installation of 10 photo-controllers with elapsed time meters was made in early 1977.

After some time in use, light meter measurements showed that the sensor calibrations were incorrect, and the sensors were returned to the manufacturer for recalibration. Thereafter, elapsed-time meter readings were taken at intervals. Eventually (in late 1977) it was concluded that some units were not functioning properly. Consequently, they were all returned again to the manufacturer for functional check and repair. Several damaged units were found. In one, the sensor housing aperture had been rotated away from the window. Two power relays had fused contacts, indicative of an unexplained electrical overload. (How this happened without blowing the self-contained fuses is not clear.) On one unit, the optical polarizer filter adjustment for sensitivity had been broken off, and in other units, the case had been opened and the hysteresis control (Appendix B-6) had been changed.

Upon investigation, it appeared that expressions of dissatisfaction by teachers with controllers might be due to defective window blinds in the classrooms. Many shades were found which could not be raised conveniently. Use of natural light was clearly not possible in classrooms with lowered and inoperable window blinds. In such cases, the action of the photo-controller would only cause unacceptably low light levels. It appears that some tampering may have resulted from teacher efforts to obtain adequate light when the controller was turning outer banks off and shades could not be opened to provide window light.

Units were again recalibrated; defective relays were replaced; improved polarizer-attenuators were installed; the sensor housing was secured more rigidly to the unit case; and access to the hysteresis control was made more difficult. Efforts were initiated to provide operable window blinds in the classrooms.

It was noted that, because a female type connector had been used originally on the controller housing for external connection, a male connector with exposed pins, potentially at line voltage, was necessarily used on the pigtail connector from the classroom wiring. Accordingly, when the sensor/controller was removed, as for servicing, the exposed pins of the pigtail connector were a potential source of electrical shock and an unacceptable classroom hazard. During rework, the units were retrofitted with connectors having male pins, and the pigtails were fitted with female connectors so that potential hazard was eliminated.

Upon reinstallation after factory recalibration and repair, window shades were still defective, so temporary disabling covers were placed over the photocell sensors. They were retained in this condition until window blinds were reported to be repaired.

After classroom window blinds were reported to be repaired in late March 1978, the photocell covers were removed on March 29. Elapsed time meter readings were taken then and on April 19. The intervening time was taken as the test interval. Although this interval was undesirably short, the period was dictated by: (1) the long time required to get a working combination of shades and photo-controllers in the classrooms; and (2) the imminent end of the program.

As previously noted, ten photo-controllers were installed with elapsed time meters. Data was not obtained from one classroom (No. 223) in the last set of readings. Data from the other nine classrooms were examined when taken, and four data sets showed little or no difference between the total on-time of controlled and uncontrolled lights. These controllers were evidently not turning off lights as intended. A check revealed that one photocell still had the disabling cover unremoved. No visible fault was found with the other three. A subsequent factory check indicated that they were functioning within specifications. These three were all from classrooms on the west side center of the main building, on the second and third floors (Nos. 224, 323, and 324). The units were those which maximum illumination at the window had earlier been observed to be low (860 fc at mid-morning on a clear day).

3.6.2.4 Results

Data Obtained

Table 11 shows that, for the five photocontroller installations which appeared to function properly, total on-time saved was 117 hours, or an average of 23.4 hours each. The averaged on-time for inner classroom lights over the same period was 68.8 hours each. Thus, the controllers saved 34 percent of the electrical energy the outer two banks would otherwise have used, or 17 percent of total classroom (four banks) lighting power.

A questionnaire (Appendix C-3) was given to those teachers using the photo-controllers to obtain their subjective reactions to the experiment. Apart from instances of actual malfunction, they report the photo-control systems as unobtrusive. The mixing of artificial light and outside light was considered acceptable. Light levels were adequate, and blackboard glare was no problem, when useable shades were available to control it. It was also revealed in the questionnaire that window blinds in test classrooms which had been reported to be repaired were not all operating.

3.6.2.5 Evaluation and Conclusions

For a school year of 180 class days with the measured average on-time of 5.6 hours per day, 1.6 kW load for outer lamp banks, of which 34 percent is saved, the annual energy saving per classroom is 548 kwh. At the current applicable Jersey City rate of 6.3¢ per kWh, this represents a dollar saving of $34.50 per classroom. As shown below, the installed cost was about $140 and might be lower if the units were in quantity production. Thus, for classrooms with adequate skylight or direct sunlight levels, the photo-controllers provide a payback time of about four years. Use of the photocontrollers may be inappropriate for some rooms, especially those with shadowed or predominantly north-facing windows.

Discussion and Interpretation

The data interval was short, and no adjustment was made for cloud cover or percentage of time the sun shone because these data are not available. However, a check of historical sunshine and cloud statistics indicates that the results are reasonably representative of those which would be obtained if the test were conducted over the entire school year.

Costs of recalibrating and reworking the photo-controllers is considered an experimental expense and has not been included in the fixed costs. Accordingly, the photo-controllers cost $97.50 each; unit installation costs were about $40 (one-half man-day plus materials); the per-unit installed cost was approximately $137.50. Unit costs might be somewhat lower if the controllers were in quantity production.

Simple payback time for the photo-controller is, therefore, $137.50 divided by $34.50, or slightly under 4 years when used in appropriate classrooms.

Table 11

PUBLIC SCHOOL NO. 40

Classroom Light Photocontrollers Light On-Times (Hours)

Between 3/29/78 and 4/19/78

Room	Inside Light Banks Cumulative Hrs		Outside Light Banks Cumulative Hrs		Change Operating Inside Banks	Change Operating Outside Banks	Hrs Saved	
	3/29	4/19	3/29	4/19				
202	989	1064	529	581	75	52	23	
203	1026	1096	654	703	70	49	21	
302	540	592	334	375	52	41	11	
304	806	876	455	497	70	42	28	
309	582	659	322	365	77	43	34	
				Total:	344		117	
				Average:	68.8		23.4	
223	1111	No Readings	1028	No Readings	-	-	-	Note 2
224	1004	1069	795	857	65	62	3	Note 2
225	1016	1087	981	1052	71	71	0	Note 3
323	617	690	598	666	73	68	5	Note 2
324	685	762	614	691	77	77	0	Note 2

Notes:

1. Between 3/29/78 and 4/19/78 there were 13 school days.
2. Illumination levels in sensor field of view may be inadequate.
3. Sensor cover had not been removed.

3.6.2.6 Observations and Lessons Learned

The photo-controllers used in this experiment were experimental units made from readily available parts. They are physically larger than production units would likely be. Production units would incorporate standardized calibration procedures, would probably be less susceptible to tampering than were the experimental devices, and might be less expensive than the experimental units. Area Lighting Research, Inc. did not, at last report, plan to manufacture or to obtain Underwriter Laboratory approval of these devices. They do plan to manufacture a functionally similar controller with lower electrical load capability. This device, augmented with a power relay of suitable capacity, could serve for light-level control applications with large electrical loads.

Satisfactory use of classroom light photo-controllers of the sort tested at Public School 40 will only be attained with a fully operable set of window shades. Shades which are disfunctional in the down position leave the room too dark; while those which are permanently up do not provide necessary means for control of blackboard glare.

Blackboard glare imposes need for the occasional use of classroom window shades. Given normal human inertia, such use can gradually deteriorate into a situation wherein the easiest course of action is taken: shades are always be down; classroom lights are always on.

The classroom light photo-controller experiment, in common with some other experiments in this program, represents an effort to substitute mechanical devices for administrative and motivational forces to conserve energy. Best results are evidently obtained when technological methods for energy conservation are closely coupled with administrative and motivational methods.

It appears that illumination levels were inadequate for some of the installed sensors (those in rooms 224, 225, 323, 324, and possibly 223) -- probably because their view of the sky is to the northwest and partially obscured and/or shaded by the west-wing of the building during this season of the year. A check of illumination level data taken early in the program confirms that distinctly lower light levels were measured in these northwesterly windows.

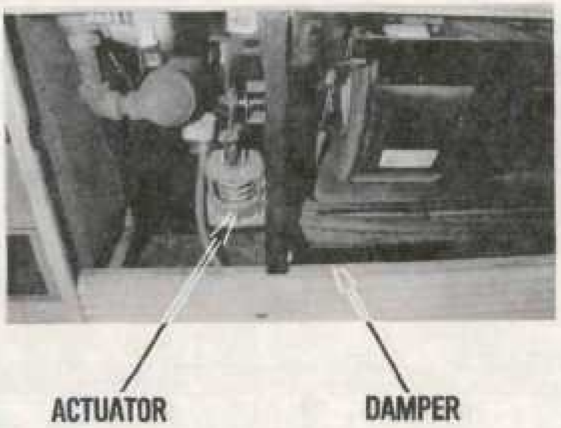
The skylight brightness available at the windows of rooms which are potential photo-controller sites, should be checked over a full season to identify rooms where the photo-controllers may be best used and the appropriate threshold settings.

This experience demonstrates the necessity for (1) careful measurements of the average exterior illumination levels to verify the adequacy of illumination for proposed photo-controller locations; (2) determining the switching threshold setting appropriate for each; (3) need for sociological studies which are strongly concerned with human behavior and important subjective reactions to be conducted concurrently with the technological programs for energy conservation.

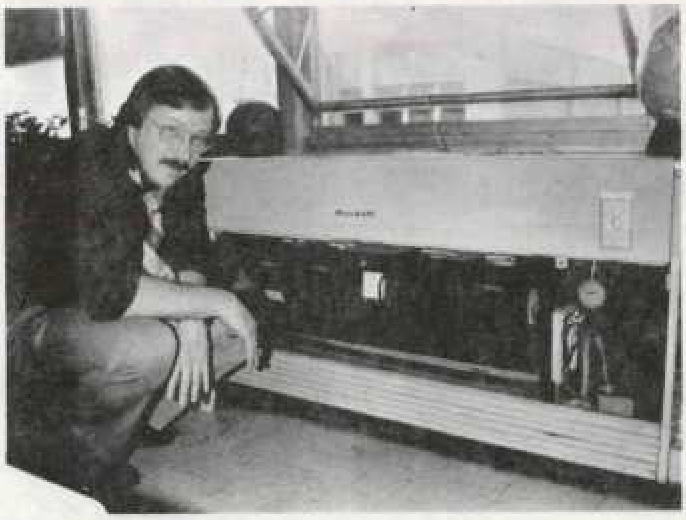
For extensive use of photo-controllers, simple instrument and/or test instructions should be developed and made available for use by local personnel to (1) take long-term average readings of available light at representative classroom windows to select appropriate locations for controllers, and (2) to provide means for setting the triggering threshold locally, according to measured skylight levels.

3.6.3 Classroom Ventilator Experiments

The Public School No. 40 heating and ventilation (HV) system consists of: an individual pneumatically-controlled steam heating and ventilating cabinet (Figure 37a and b) in each classroom; large



a - Classroom Unit Ventilator
Detail - Ventilation Damper Actuator



b - Classroom Unit Ventilator
(Key-actuated ventilation timer shown on right side of panel)

Figure 37. Public School No. 40 Ventilator Projects

building exhaust fans in several locations; a central time-programmed controller and a central air compressor; and individual two-level (daytime and night set-back) thermostats in each classroom. Each HV unit cabinet has a finned-pipe radiator, a pneumatically actuated control damper, a 4-drum motor-driven blower, and an outside air intake for ventilation.

Two ventilation experiments for energy conservation were attempted at Public School No. 40. One provided a reduction in the ventilation flow rate of individual classrooms, consistent with recently lowered State requirements. The second involved installation of key-set timer switches in classroom unit ventilator cabinets to activate the pneumatic ventilation dampers. These timers were intended to provide normal ventilation flow as needed; the need was signalled by teacher actuation of the timer and subsequent thermostat action. The damper which admits outside ventilation air into the classroom was to be closed at all other times.

These two arrangements have energy-saving potential for any building in which the ventilation air flow rate may be greater than necessary, or where ventilation is maintained at times when it is not needed and when the building design permits individual, selective control of ventilation flow.

A detailed description of these experiments is provided below. Although installation of the equipment for the experiment was made in Public School No. 40, factors beyond the control of the program personnel rendered the results indeterminate and their evaluation impossible.

After installation of the experiments, flow tests were attempted at representative classroom unit ventilators, and measured ventilation air flow was very different from the design value. Investigation revealed that the ventilation exhaust fans were not operated continuously during building use, as intended in the building design. Instead, the building custodian was turning the fans off and on arbitrarily in response to requests and complaints from teachers. Accordingly, measurements and evaluations of ventilation flow rates--or of actual energy savings (derived from flow rate data)--were infeasible in Public School No. 40.

3.6.3.1 Reduced Ventilation Flow Rate

Energy Conservation Opportunity

Public School No. 40 was designed in 1963 when ventilation air flow requirements for New Jersey schools were greater than those now in force. Since the ventilation air must be heated, a reduction in ventilation flow to present-day minimum requirements would save energy.

Recommended Project/Rationale

When Public School No. 40 was designed, the State requirement for classroom ventilation air was 0.5 cubic feet per square foot of floor area per minute (Reference 5, Section 700, Table II). This requirement has subsequently been cut in half (Reference 6, p. 4 of Attachment).

It was proposed to reduce ventilation air flow in classrooms from the old required minimum level of 0.5 cubic feet per square foot per minute to the new minimum standard of 0.25 cubic feet. This would halve the flow of ventilation air, which must be heated by an average temperature increase over the school year of over 16°F.

Predicted Costs and Savings

Estimated costs of this change were low. Depending on design details, the desired flow reduction was to be accomplished by some simple combination of reducing blower motor speed, throttling unit vent and/or exhaust fans by partial closure of the flow path, or by removing one or more of the four blower drums from each unit ventilator motor shaft. In Public School No. 40, the simplest change of all those possible -- reduction of classroom unit ventilator blower speed -- was possible at essentially no cost by use of an existing voltage change switch.

It was predicted that reduction of ventilation air flow from the old to the new minimum requirement would save 201 gallons of No. 4 fuel oil annually, worth $72, for each classroom, corresponding to 9000 gallons or (at 36¢ per gallon) $3240 for the entire 45 classrooms of Public School No. 40. Detailed estimates of the conservation potential are given in Appendix B-7.

Project Implementation

In implementing this project, a trial was planned of each of several proposed hardware changes. In order to evaluate the several concepts, adjustments were to be made in the classroom equipment until the desired results were obtained.

The first effort was to be a reduction in blower motor speed, using the built-in provisions of a tapped autotransformer with a voltage- change switch, as previously noted. A schematic diagram of this circuit is given as Figure 38. The switch, initially at the high-speed position, was shifted to "lo" with a definite reduction in fan speed.

At this point in the investigation, flow measurements were made which revealed that the overall Public School No. 40 system was not being operated as designed. Additional efforts to reduce vent flow would have utilized either a partial barrier to restrict the intake grill opening or, perhaps, a change in the pulley ratio of the belt-driven building exhaust fans which also influenced flow of the ventilation air for the overall school system.

3.6.3.2 Timed Control of Classroom Ventilators

Energy Conservation Opportunity

Classroom ventilation is neither required nor desired when the room is unoccupied, yet the existing system in Public School No. 40 (and in most such buildings) is designed to introduce and heat outside air during the entire time that the master controller of the building is in the "daytime" mode. Thus, energy is wasted prior to and after regular classroom hours, between classes, at lunchtime, and during class periods when the rooms are unoccupied.

Recommended Project

A timer-controlled switch was proposed for installation in the individual classroom ventilator damper control circuit so that the damper would remain closed and no ventilation air would be admitted unless the timer had been actuated. The plan provided that, upon entering the classroom, or at the start of a class, the teacher would activate the classroom ventilation timer, which would cause the unit ventilator to operate normally and to respond to the installed thermostat system during the timed cycle. At the end of the timed cycle, the timer would open the damper control circuit, causing the damper to close. Accordingly, ventilation would be provided for the duration of each class but not between classes or at other times when the classroom was not in use.

Such a restriction of ventilation air flow to times of actual need is provided in modern buildings by a centralized computer/controller. Retrofit of an existing building with such a system is worthy of consideration but costly, primarily because of need to provide control circuits for each classroom ventilation unit. The recommended timer arrangement represents an attempt to provide the savings of such centralized computer control by utilizing a degree of teacher responsibility in lieu of costly full automation.

Predicted Costs and Savings

Unit costs for this modification were estimated as $15.00 for the timer switch and $8.00 for the installation, for a total cost per classroom of $23.00. Estimates (see Appendix B-7) suggested that timer control of ventilation air, as proposed, could save fuel costs by eliminating ventilation air flow for about 3 1/2 hours of each 8-hour school day: a reduction of 44%.

This would result in savings of approximately 88 gallons of oil, or (at 36¢ per gallon) $32 per classroom, when utilized in conjunction with the new, reduced ventilation flow rate (0.25 cubic feet per square foot per minute). This corresponds to 3960 gallons of oil or $1425 for the 45 classrooms of Public School No. 40 in one year. When compared with the old ventilation requirement to which Public School No. 40 was designed (Section 3.6.3.1), the savings would be double this: i.e., 177 gallons of oil per classroom, at $63.60, or 8960 gallons of oil or $2870 for the school.

Project Implementation

A simple arrangement was needed to provide timed activation of ventilator damper controls. Controls for the system were to be readily available to teachers; yet not subject to tampering by students.

The damper control is a compressed-air activated cylinder (pneumatic motor) operating against a calibrated compression spring so that the damper position is controlled by the air pressure, which is in turn controlled by the room thermostat and the night setback system. These items are shown in Figure 37a and a general view of the open vent cabinet is shown in Figure 37b. An electrically-actuated air valve in the cabinet controls the compressed air flow to the pneumatic damper

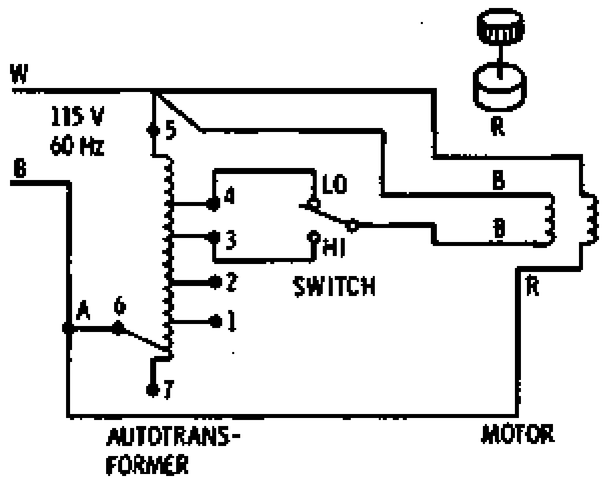


Figure 38. Public School No. 40
Integral Unit Ventilator Blower Motor Speed Control Circuit

actuator. A switch installed in series with the air valve solenoid coil can override all other controls. When the switch is open, the ventilator damper is closed, and no ventilation air flows. When the switch is closed (timer switch actuated) the ventilation damper responds normally to the building controls, following the performance profile of Figure 39. A manually-actuated clockwork timer switch was installed in each (of 10) unit ventilator cabinets with the switch in series with the pneumatic valve controlling the ventilation damper. For tamper-resistance, timer actuation required the use of a removable key.

Results

Upon discovery that the building ventilation system was being operated arbitrarily, efforts to continue this experiment were terminated.

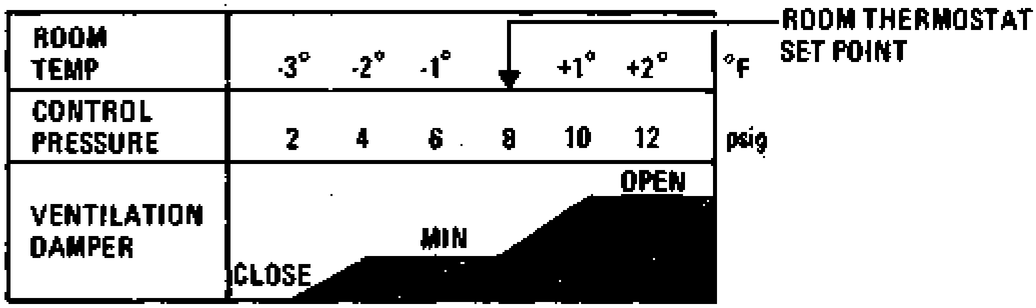


Figure 39. Public School No. 40
Classroom Unit Ventilator Damper Performance Profile

3.6.3.3 Observations and Lessons Learned

Ventilation air flow represents a significant but inconspicuous channel for energy waste. Any efforts at energy conservation in existing buildings should include a check of actual ventilation flow against the real need, with actions to correct for any important differences. A large fraction of the exhaust air heat may sometimes be saved by use of economizer devices such as the heat wheel or by heat pipe exchangers to warm intake ventilation air. The practicality of retrofitting with such devices should be investigated also.

Existing requirements for ventilation should be checked to determine whether they are current and whether they have been examined under the new reality of growing energy costs.

Restriction of ventilation flow in any room to the times it is occupied is clearly a conserving tactic, but it is also important that ventilation be provided when needed. It is probable that, had the timed ventilation experiments been conducted as planned, manual activation of the ventilator system would frequently have been forgotten.

Recent observations at Public School No. 40 indicate a extensive tendency to open classroom windows for ventilation. Since this is conventional practice, it is not certain that use of a special key to initiate mechanical ventilation action would have supplanted the habitual, visible and wasteful use of the open window.

Thermostat settings in Public School No. 40 (which are made by the custodian with a special key at the teacher's request) were commonly set to temperatures well over the normal; often 76 degrees or more, with night setback temperatures frequently at or above normal daytime settings. These excessive thermostat temperature settings must have contributed in a substantial way to the use of open classroom windows.

Public School No. 40 was originally designed with finned-pipe perimeter steam radiators extending from the central HV cabinet, under the window, along the entire outside classroom wall. Due to some design deficiency, these perimeter units had a pronounced tendency to freeze and burst. As a consequence, most were disconnected long ago. It is possible that loss of these units has contributed to occupant dissatisfaction by causing drafty conditions and inadequate heat distribution.

An essential rule for energy conservation retrofit or experiments in existing buildings was confirmed in the Public School No. 40 work: Verify everything and assume nothing, either as to the physical design or as to the use of expected or conventional practices in operation and maintenance of the building.

Also: custodial personnel will tend to act to minimize the environmental stresses to which they are subject, particularly in a loosely administered situation. Specifically, unless operation by the

Before the definitive design was prepared--or the clear need for additional funds had been addressed--a letter (February 25, 1977) was received from PSG&E announcing termination of their commitment to provide gas to Public School No. 40, effective March 1, 1977. Continuing curtailment of gas from pipeline suppliers was cited as the reason. This effectively ended the project to install a gas furnace for pool and shower water heating at Public School No. 40.

As backup, a check was made of the possible utility of a 200,000 BTU/hr oil furnace for the application. This was found to be uneconomical. Use of oil sacrificed the savings (9¢ per therm) based upon comparatively low energy costs of off-peak gas. Although the cost of an oil-fired boiler was about the same as that for a comparably-sized gas unit, oil-fired boilers of the desired size were available only for No. 2 fuel oil, whereas the existing oil storage facilities at Public School No. 40 were committed to No. 4 oil; accordingly, a considerable added cost and complication would arise if new storage provisions were built for No. 2 oil. Moreover, the energy costs of No. 2 oil were slightly higher than those for the No. 4 oil to be displaced. Therefore, no advantage of energy saving or of cost saving could be attained from the addition of a small oil-fired boiler for the Public School No. 40 pool and showers. The project was dropped.

by an optimally sized gas-fired boiler. The thermal inertia of the pool water is high, so that pool heating could be timed for off-peak gas usage at very advantageous energy rates. Public School No. 40 already had an insulated 2000 gallon tank for shower hot water. Consequently, shower water could also be heated at off-peak times, utilizing off-peak gas rates, and stored in adequate quantities for summer use.

Rationale

The justification for this project lay in: (a) Anticipated energy savings from substitution of an optimally-sized gas boiler for the existing oil-fired boiler, which operated infrequently under the summer pool heating loads with corresponding low efficiency and high down-time losses; (b) projected monetary savings due to the observed lower cost of energy from gas at off-peak rates as compared to No. 4 fuel oil at market prices. It must be noted that these savings are derived from current regulated prices for natural gas. Accordingly, this lower cost of natural gas energy has regulatory rather than an economic basis. Moreover, the price differential may be a temporary phenomenon.

Predicted Costs and Savings

It was initially assumed that savings (in efficiency) could result from use of the gas-fired boiler (at about 80% combustion efficiency) as compared to the existing oil-fired furnaces at about 70% efficiency. (However, this estimate did not take into account the effects of the Public School No. 40 turbulator experiment in improving efficiency of the Public School 40 main boilers. Turbulators (see Section 3.6.1) actually increased the combustion efficiency of the Public School No. 40 oil-fired boilers to about 81%). Off-peak gas rates of $0.176 per therm (one therm equals 10^5 BTU), compared to $0.267 per therm for No. 4 oil (at 36¢ and 1.4 therms per gallon) provides about 9¢ per therm saving. This project was expected to provide annual savings of about $4000, obtainable for an investment of about $10,000, the estimated price of a 200,000 BTU/hr gas boiler, with piping and installation.

3.6.4.2 Narrative - Events and Actions to Implement

Approval of the project by the State Board of Education was required. Preliminary plans were prepared, and a request for approval was submitted with the plans. Approval was granted on December 6, 1976.

A request for service was made to the Public Service Gas and Electric Company (PSG&E), and the utility showed extreme reluctance to provide the service.

Paul Jordan, M.D., Mayor of Jersey City, wrote a letter June 18, 1976 to the New Jersey Public Utilities Commission, requesting that they consider the matter and comment to him by July 12, 1976.

On September 15, the State of New Jersey Department of Utilities wrote to Mayor Jordan that they were authorizing the PSG&E to provide the requested service.

Action was undertaken by the project engineer, J.A.B. Associates, to prepare definitive drawings for implementation of the project. This called for several meetings with PSG&E personnel, including meetings at the site. There were two gas mains adjacent to the Public School No. 40 site, either of which could have served the needs of the proposed program. The choice between them, an essential for design, depended upon details of relative costs, involving such considerations as the lengths of the gas lines required, necessity for a pressure booster, etc. The meetings with PSG&E personnel did not provide a clear position by the utility as to the choice of gas main to be used. The utility also insisted that some equipment for the project would have to be installed outside the school building proper. This imposed added project costs for an auxiliary building, or lean-to, a need which had not previously been identified.

project rules is verified and enforced, prescribed procedures will be modified under pressures from the "informal organization": that unapproved, undefined interaction process which exists and operates within any formal organization.

3.6.3.4 Recommendations

It is recommended that: (1) Public School No. 40 be restored to its nominal design conditions, based upon the current reduced ventilation requirements (Ref 5); (2) that temperature and ventilation system controls be operated according to standard practices thereafter; and (3) that the installed timed ventilation equipment be put to use for the economy it can provide.

3.6.4 Installation of Gas-Fueled Pool Heater

This project was originally planned for Ferris High School. Concern for the high rate of vandalism at Ferris led to transfer of all work originally planned for that school to Public School No. 40.

3.6.4.1 Energy Conservation Opportunity

Original Condition

The indoor swimming pool of Public School No. 40 is used in the summer as a facility of the Jersey City summer recreational program. The pool requires heating in summer usage and hot water for showers. In the past, pool heating and shower hot water have been provided by use of the main school boilers, oil-fired with No. 4 fuel oil. This summer application represents a very light (hence, an inefficient) load for the boilers.

Recommended Project

It appeared that significant savings could be effected if the summer requirements for heating the pool and showers could be assumed

4.0 CONCLUSIONS AND RECOMMENDATIONS

Prior to the inception of this program, the Technology Agent of Jersey City had made an investigation in depth of energy usage in the municipal and school buildings of Jersey City. He had identified many opportunities for savings. Some of these conservation opportunities were selected for the experiments of this program.

Investigations by Aerospace, the Jersey City Technology Agent, and others had identified materials, devices, and techniques, applicable for energy-saving opportunities, for which applications testing and verification was needed.

This demonstration program has confirmed that such opportunities are real and that they can be profitably exploited in the saving of energy and the costs of energy. An outstanding example is the use of Turbulators in Public School No. 40 boilers, which provided full payback in less than a year.

A key feature of the program has been the diversity of considerations which entered into the selection of projects and into their conduct. With some experiments (such as the timed garage door closers in the Public Works Shops) unexpected complications were encountered. Other projects appeared to promise significant energy savings in conjunction with a retrofit which would have been essential in any case: for example, the installation of high-pressure sodium lights in Public School No. 6 to replace dim and obsolete incandescent bulbs with lamps providing higher intensity lighting while continuing to use existing (1920's vintage) wiring.

For some projects (such as the City Hall steam system modifications and updating), the present benefits are in question.

Future benefits appear to depend upon achieving a change in worker habits: i.e., controlling room temperature by use of the newly installed thermostatic valves rather than by opening and closing windows. One conclusion seems inescapable; there were (and are) in Jersey City and its schools, and by reasonable analogy, there are in other local governments (counties, cities, school districts, special districts and authorities) many opportunities for very significant, feasible, and cost-effective energy savings.

Such savings may be attainable through use of technical devices (which was emphasized at Jersey City), or by administrative procedures and by motivational programs, or by some combination of technical, administrative and motivational actions. Of the wholly technical means for energy conservation, only the purely passive measures such as in-wall insulation, can be installed with confidence that their potential for energy conservation will be realized without the conscious purpose and cooperation of the users.

It seems clear that neither administrators nor technologists can organize and operate an optimal program for energy conservation alone. Administrative, technical, and sociological talents are all needed, working together, for an effective energy conservation program -- in pre-planning, initiation, and program conduct.

Perhaps the most fundamental lessons learned during the conduct of this program concern the importance of active support by people participating in a program for conservation. For the savings potential of energy conservation measures to be realized, individual employees must be convinced that the consumption of energy which they influence -- often in seemingly small ways -- can be reduced without great inconvenience or hardship, and that it is worthwhile to do so. In a similar vein, the selection of a specific energy-saving technology, design of the application, and selection of the way in which it is used on the local scene must be made with concern for the personal involvement of local people. People must be led to awareness of their energy usage and hence persuaded to change from present wasteful habits. Continuing indoctrination in the simpler technical and economical facts of energy usage will be useful, but it is most important that people in the programs (and experiments) become true participants. Their desires and feelings must be recognized and considered in program planning and they must be helped to become involved personally and emotionally in day-to-day activities promoting energy savings.

A system of rewards -- not necessarily all of them formally bestowed -- should be provided for individual acts of conservation. Such rewards may be tangible or intangible, material or psychic. In the practical case, most such rewards will surely be psychic: the personal satisfaction of knowing that one has behaved in a constructive, altruistic fashion which merits approval and which elicits favorable social attention.

To establish an environment which fosters such attitudes is the greatest challenge presented by the need to conserve energy. The need for such a public attitude is nationwide, and this need has not yet been met at the national level. The current high degree of public apathy regarding energy conservation exacerbates the difficulties of starting and maintaining an effective conservation activity within a local government organization.

Press agentry and exhortative posters will surely not meet the need; in fact, such PR-type propagandizing within the organization is often an empty gesture offered by incompetent administrators in lieu of constructive actions. We have come to believe that an effective program of energy conservation will come into being only through personal conviction and participation on the part of most of an organization's people at all levels. Such conviction and involvement by all levels in the employee/employer chain of authority is necessary, since the personal attitudes of management and workers has a decisive effect in establishing energy-saving concern as an element of socially acceptable behavior within the organization.

4.1 OBSERVATIONS

A diverse set of conclusions may be drawn reasonably from the experiments and associated experiences of the Jersey City program. Some of these conclusions follow.

4.1.1 There are many opportunities for important energy savings in the existing physical facilities of most (and probably all) local governments.

4.1.2 Such opportunities may utilize both technical means and operational or managerial methods, singly or in combination, for conserving energy.

4.1.3 Technical conservation measures may include installation, retrofit, refurbishment, or replacement to improve, restore, or replace inefficient equipment and facilities. For the purposes of this report, we exclude new construction from consideration.

4.1.4 Technical conservation measures may emphasize either development actions of an experimental nature (usually as sample installations in an exploratory, R and D project), or proven conservation measures, involving applications of well-understood technologies, often on a large scale, or both.

4.1.5 Most technical measures for energy conservation will not serve their intended purpose without continuing active human involvement.

4.1.6 Technical means for energy conservation should not usually be installed to compensate for lack of simple human actions or for ignorance or lack of motivation, unless there is some reason why normal good managerial practice and leadership cannot bring about the needed alertness and concern to save energy. There are very few instances where purely technical means can compensate for lack of the needed human attributes.

4.1.7 Demonstration experiments and conservation installations should be performed with dispatch. Procrastination leads to deferral of potential savings and -- more important -- to loss of interest and conviction on the part of users and participants in energy conservation projects.

4.1.8 For success in energy conservation, human involvement is essential at all organizational levels. This active participation should provide needed information, skills, examples, motivation, and inspiration. Human awareness and purpose are essential elements of operational conservation, which serves to save energy by care in the use of existing facilities. These same qualities are also needed in the test and application of new technologies for conservation.

4.1.9 Most local government organizations are not well equipped to plan for and administer either the technical or the behavioral/motivation aspects of an energy conservation program. The skills needed for such a program must usually be provided initially from an outside source.

4.1.10 For an energy conservation project to be effective, it is essential that it be planned and supervised by a person or a team who are technically and administratively competent, who are directly involved, and who are frequently present at the project site in communication with participants.

4.1.11 Each locale for an energy conservation program is unique; few "off-the-shelf" ways to conserve energy attain their potential without the use of specialized attention and skills to adapt and apply them to local conditions.

4.1.12 It is usually not wise to rely upon local maintenance crews to make new installations on any kind of a preconceived schedule. Their schedules are usually full with the normal work load. In the rare exception, there is likely to be strong reluctance to confirm the existence of open time by responding to extraordinary tasks.

4.1.13 Local governments having well-developed energy conservation programs could serve as a nucleus having the skills, examples, and stimulus to initiate and support community-wide conservation programs.

4.2 ENERGY CONSERVATION OPPORTUNITIES IN LOCAL GOVERNMENTS

The term "local governments" is commonly taken to include all state chartered, tax-supported public-service agencies, including counties, cities, school and special districts, and authorities. For pragmatic reasons, the Jersey City project was restricted to projects for conservation in buildings and to only a sample set of city administration and public school buildings. Accordingly, the projects conducted in Jersey City, described in Section 3.0, have far wider potential applications in Jersey City than were addressed under this program. Many other energy conservation opportunities in city buildings, schools, the Jersey City Medical Center, and in public housing were identified as having a high payoff potential. Substantial energy savings may also be attainable in non-building uses such as processes and transportation. By analogy, a similar diversity of cost-effective energy-saving opportunities exists in the local governments of other communities.

Summary data on the national or regional energy consumption of local governments (other than schools) does not appear to exist at present, so that accurate characterization of the energy consumption of local governments is not feasible. One ERDA document (Reference 7, Exhibit 2, p. 6) ascribes 2.2% of total U.S. energy consumption to local governments in 1972 (and 0.4% to state governments). This figure excludes hospitals and universities, but it appears to include local school systems.

DOE reports the total 1977 national energy consumption to have been 75.75×10^{15} BTUs. (Reference 8); the equivalent total consumption by local governments as defined is 2.2% of this, or 1.67×10^{15} BTUs. For fuel oil at 1.4×10^{5} BTU per gallon, 36¢ per gallon, and 42 gallons per barrel, this is equivalent to 1.2×10^{10} gallons, $4.3 billion, or 286 million barrels. These are the gross amounts upon which estimates of possible savings by local governments are to be applied.

The potential for major energy savings through conservation measures is not confined to those local governments which are in economically disadvantaged communities, such as Jersey City.

Officials in Portland, Oregon, using present costs, estimate that straightforward improvements in energy management and a $200,000 one-time investment can save Portland over $4.0 million in building energy costs for the city administration and schools over a period of 5 years, which representa a feasible saving of more than 50% in Portland's present annual energy budget for city buildings and schools.

Conservation estimates from several reputable sources seem consistent in the view that in most local governments, management controls can save up to 20% of current building energy cost with essentially no outlay, and up to 20% additionally by investments having no more than a 5-year payback period.

4.3 CONDITIONS AND CHARACTERISTICS FOR ENERGY CONSERVATION IN LOCAL GOVERNMENTS

For a successful energy conservation program anywhere, management must first develop and make known its conviction that energy saving is essential. It must thereafter set a visible example and educate employees on the need for energy conservation and on specific conservation techniques. It must provide the needed resources: energy-saving equipment, technical information, and personnel to plan, implement, and evaluate specific conservation measures. Most important, management must provide feedback about results and current problems so the people know how to direct their attention and efforts and so that the general perception of energy conservation as an important matter and as an element of socially commendable behavior is reinforced.

Local governments generally are limited in their capability for undertaking comprehensive energy conservation programs. These limitations include:

a. Lack of a tradition of energy conservation;

b. Lack of the technical skills and resources needed for energy conservation;

c. Lack of specific political pressure for energy conservation;

d. Absence of an impetus to initiate purposeful energy conservation measures;

e. The self-image of local governments as task-oriented or caretaker kinds of organization; and

f. The short-term perspective from which most local government decisions are made.

These limitations are not universal among local governments, but they are typical. Most were true of Jersey City before it acquired a Technology Agent, and many still are largely true. There are clear signs of changed attitudes and a commitment to energy saving in Jersey City; these are surely attributable in part to participation in this DOE demonstration program.

This list of typical local government limitations for implementing energy conservation forms the basis for the recommendations which follow. The nature of most local governments as caretaker, task-oriented (as distinguished from change-oriented) organizations is the basis for much of the apparent inertia in local governments, and a principal reason why they need help in undertaking new roles.

These organizations, whether county or city governments, schools or special-purpose authorities, have well-understood traditional roles and missions which they pursue with determination. There may be much internal debate in a city or school system about how an established mission or a function associated with such a mission is to be performed in the future, or who will perform it, or with what resources. However, serious active consideration of adopting major new functions, such as energy conservation, with priorities like those of the traditional missions, is infrequent. Local governments usually accept their own primary roles uncritically as being established by tradition. Typically, they and their constituents are preoccupied with the direct and visible effectiveness of such functions as street maintenance or snow removal or classroom teaching; they are not searching to find and adopt new roles. Pressures for economy are always present, but they are usually generalized and directed along fairly obvious lines, rather than towards the development of new roles and functions specifically to promote economy. The idea of a new function for the organization will normally come from an outside initiating force. This is particularly true when the proposed new function concerns housekeeping or other matters which are considered to be peripheral to the central mission of the organization.

This task orientation of local governmental bodies has dimensions in time, also. Since local governments' main responsibilities are generally perceived as well understood and stable, most changes in function occur as incremental and evolutionary adjustments rather than as large and discontinuous shifts. Accordingly, these organizations are attuned principally to pressures for short-term, small-scale actions. With the exceptions of land use and physical plant projections, which have become routinized as tasks in the accepted structure, the planning horizon usually extends no further than the next budget-planning period or the next election.

These characteristics of local governments are very significant for local energy conservation programs because of their influence on local perspectives: there is little concern by city or school organizations to identify possible new major needs, such as energy conservation. That alertness to possible change and its implications which is the essence of (for example) a research or system development organization is largely missing in local governments--to the extent that innovation is often resisted, and needed major changes in role and function are accepted slowly and, at first, partially.

The introduction of a policy of energy conservation is just such a major change. It was first accepted and sponsored in Jersey City by political leaders who presumably saw both community and personal political benefits to be attained by a new policy of conservation. In the lower echelons, reactions varied from acceptance to passivity; in a few cases, covert opposition was suspected. Yet there are signs that the program has had effects beyond the matter of dollars and energy saved or not saved. An awareness and a concern for energy waste, which was surely not present before, became evident in our talks with schoolteachers and public employees. The current Jersey City administration plans to hire a full-time professional, locally funded, to continue the energy conservation activity which started in this demonstration program.

The initial absence of a tradition of energy conservation awareness in local governments imposes serious limitations on what can be done at first. The traditional concern for economy and efficiency in local government would at first glance appear to lead very directly to awareness of energy conservation as a means of economizing. In fact, residual effects of the Economy and Efficiency Movement, which strongly influenced municipal governments several decades ago, commonly have emphasized meticulous accounting procedures and other measures designed to disclose and prevent dishonesty or fiscal irregularity. Attempts to discover new economies which can be achieved by changing accepted habits or facilities are not often made.

Two possible courses of action are conceivable for promoting energy conservation by local governments. One is, of course, to induce each local government to change from its present task-oriented role to a more inquisitive and aggressive stance, seeking to identify new or future needs and to act upon them. This approach is clearly fraught with difficulty, for it must surmount great inertia both in habits and in perspective.

A more realistic way is to provide a nationwide, federally-supported plan for a program of energy conservation which is compatible with the needs, methods, and self-image of present-day local governments. To be accepted and useful, the approach taken for energy conservation must be appealing to local leaders and saleable by them to local government employees and citizens.

Such a program would seek to incorporate concern for energy conservation by institutionalizing it through: (a) patiently working at the local level to develop awareness and tradition; (b) defining tasks and establishing a role, position and title for the lead person(s); (c) providing guidelines and (where possible) criteria at the federal level for the development and conduct of energy conservation activities at all levels of government and at the citizen level as well; (d) providing sources of leadership, information, and counsel which can support local people in starting programs and in dealing with unusual or especially difficult problems thereafter; and by including R and D -- exploratory or demonstration programs -- to evaluate, develop, or demonstrat new technology or management methods. There should be a provision for the exchange of conservation information between local governments and with the Federal government. Such a program should include an occasional audit of the local conservation organization and its work by a competent unaffiliated outside agency. This may appear counter to the principle of local autonomy, but it need not be so. Means must be found for obtaining skilled energy conservation leaders for assignment to participating communities, and/or provision for selecting and training people from local governments in energy conservation must be arranged.

4.4 RECOMMENDED ENERGY CONSERVATION PROGRAM IN AND BY LOCAL GOVERNMENTS

Some characteristics and peculiarities of local governments which bear upon the design of a large-scale program of energy conservation in local governments were described in the preceding sections. The program recommended below is not necessarily the only feasible way to implement energy conservation in local governments. It is, however, a program consistent with the lessons learned in Jersey City and with the recognized nature and functioning operations of local governments. Key features of such a program and some precautions to be taken in planning and operating it are described below.

In developing the program concept described in the following sections, constructs have been borrowed from: the U.S. public school system; the U.S. Departmental Agriculture agriculture extension service; the National Science Foundations' experimental Urban Technology System; and some aspects of the U.S. Department of Housing and Urban Development's program for support of local housing authorities (which are local governments), as the operations of these agencies suggest workable relationships between a federal program sponsor and local governments recipients. These and other examples of intergovernmental operations are valuable models which may be adapted and adopted for present needs.

The Jersey City demonstration program has not provided the entire range of experience necessary to define a full-scale program in detail. Clearly, a gradually expanding program starting with a modest number of participants -- say, 20 to 40 communities initially -- would provide an opportunity for developing the concept while getting the job under way.

4.4.1 Goals for the Recommended DOE Program

The fundamental goal of the recommended program is to conserve energy, since energy is both a limited national resource and a factor in national economic health by way of the U.S. international trade balance. The program has been conceived as being implemented by local governments with limited federal support as may be authorized and arranged.

Derivative goals are: (1) to aid in the identification, development, and sponsorship of local programs which will serve as instruments for such energy-saving; (2) to assure a source for the needed technical, administrative, and behavioral sciences talents; (3) to assure that the auxiliary resources needed for such a program are made available; (4) to monitor the program and its progress towards the fundamental goal; (5) to make adjustments to the overall federal program as necessary to guide and support needed modifications in local programs; and (6) to perform R and D explorations in the program as may be necessary to identify needs for and to confirm new technology or to optimize designs for conservation measures as being most compatible with needs of the users.

4.4.2 Participating Local Governments

The recommended program for energy conservation in and by local governments as visualized would ultimately be nationwide. Though federal incentives would be provided, participation by local governments would be voluntary; selection of participants would be on the basis of criteria suggested below. Joint participation by several cooperating local governments (as, in Jersey City, by both the City and the Board of Education) should be encouraged. Since the recommended program would be supported in part by Federal (DOE) funds, it should be the prerogative of the DOE to set minimum standards and to monitor and publicize results. It is essential that this be done without intruding upon local sensitivities or upsetting the local exercise of initiative. It will be recognized, that, while one of the primary goals of the DOE is to conserve energy on a nationwide level and to develop the habits, the machinery, and the awareness of conservation, most local governments will be motivated by primarily by dollar economies. Accordingly, the popularity of the program among participating local governments will depend on dollars saved and, to some extent, upon grants received. Fortunately, there appear to be many opportunities in every local government operation for a good return on investment through energy conservation.

Setting criteria for the selection of local government participants is a matter of fundamental policy. Such criteria might include: (a) existence of a significant potential for saving energy; (b) evidence of prior efforts for energy conservation on the part of the candidate governments; (c) evidence of local support of the program by local political and community leaders; (d) willingness to assume progressively greater local responsibility as the program progresses; and potential for eventually assuming full financial support of the program.

4.4.3 Elements of the Recommended DOE Program

-Program Plans

A program plan will be needed for the DOE activity as a basis for funding approval and for program implementation. A lower-tier specimen program plan for local governments which can be adapted to the special needs of individual participating local governments will also be required. Finally, each local government or consortium of local governments should be aided in preparing a detailed program plan and updating it periodically.

-Personnel and Training

The necessity for recruiting and/or training personnel with the combination of skills and background needed to lead the efforts of local governments is a significant problem. Such persons should have a general technical background, preferably energy-related, with an inclination towards practical applications. They should understand the workings of government bureaucracies and be able to work effectively within these bureaucracies. They should have initiative, curiosity, innovative tendencies, and oral and written communicative abilities. Engineers are obviously candidates, but a lower level of technical training than the baccalaureate degree might often be adequate, if the individual were strong in the creative and communicative areas and if the recommended technical consultant resources were made available.

Selection of lead individuals from the available employment pool of expert or professional workers may be feasible for a moderate-sized initial program. However, if larger, nationwide program is ever to be undertaken, special provisions for training or supplying qualified people will be needed. Short, intensive training sessions may be adequate to fit college-trained technical people for energy conservation work with local governments. Well-designed two-year junior college courses should be adequate preparation for most assignments. Updating and reorientation courses would be needed to support a major conservation effort.

The selection of people to man the recommended program has other dimensions than those of skill, luck and experience. The agent of change in a task-oriented organization frequently must take unpleasant or controversial stands in order to get the job done -- generally at the cost of reduced popularity and the possible alienation of local people whose goodwill may eventually be needed.

The professionally-oriented non-local leader may tend to drive hard to achieve program goals with cumulative loss of good will and reduced effectiveness in interpersonal relationships. A local person, on the other hand, might tend to maintain good relationships, even at the cost of reduced program effectiveness.

For local conservation programs, the optimum manning strategy may be sometimes to assign professionally trained people from outside the community initially as leaders of local programs in the knowledge that, in getting the program started, they are likely to lose their effectiveness locally. When the program is well under way, a local person -- perhaps after on-the-job training in a subordinate role -- can be assigned the top job in a primarily maintenance role, rather than as an agent of change.

-Starting Force and Motivation

Some starting force is needed to initiate local actions for energy conservation. The initial motivation will likely come from perception by local leaders that the DOE program offers ways by which their own ideas and ends for energy conservation and economy in government may be realized. Such motivation will include both the potential fiscal benefits to the community and the political benefits which may occur to leaders who seize the opportunity. In the medium long term, the continuation of any such program will be justified only by the visible benefits it brings and by favorable attitudes of local people.

-Advisory and Information Sources

Technical and motivational advisory resources, information exchange provisions, and an organizational mechanism for the impartial periodic appraisal of local activities should be provided at a local or regional level.

Expansion of the program scope to include an advisory service to the public -- after the fashion of the agricultural extension service -- may be undertaken at any time. Such a service may present troublesome political problems, however; it may be in competition with commercial consultant and engineering operations. There is a question of how widely such services shall be made available: if to homeowners, then also to proprietors or occupants of rental property? If to housing, then to commercial activities?

-Program Monitoring

There could be great benefit in the recommended DOE program from periodic evaluations of local energy conservation programs by a qualified outside group. Reports from such evaluations could provide valuable objective guidance to local people responsible for the program and expert testimonial to the local government and the community as to the benefits of the program.

-Program Management

Careful planning and continuing management of the program by DOE will be essential for success. The organization(s) responsible for planning and management should be active participant(s) in the beginning of local programs, with an on-going role in maintaining cognizance of work done under the programs and, in evaluating applications for participation or renewal, with recommendations. The management organization should be held to a monitoring and advisory role. It should plan, arrange for, and perhaps provide needed program facilities such as an initiating and advisory service for participants; an information clearing house and product advisory service; a conservation library. This organization should have troubleshooting capability (technically and managerially) or be able to provide it. It should identify pertinent trends and new needs, recommending the action necessary to respond to them. The monitoring group should plan for and prescribe training and curriculum requirements. It should be equipped and required to make thorough periodic or emergency reviews of local government programs to advise the local group as may be appropriate, and to apply lessons which come from such detailed visibility to the needs of others.

4.4.4 Epilogue

The DOE program recommended is similar in general form to the Urban Technology System (UTS) program, initiated by the National Science Foundation. In the broad view, the programs have generically similar clients and purposes. Both the Aerospace Corporation (serving as a technical resource) and Jersey City (as a participant) were active in the UTS. However, some differences between UTS and the recommended DOE program are evident. A DOE program, as proposed, will be limited in scope to energy conservation, with consideration of pertinent non-technical factors, whereas the UTS had unlimited scope among the technologies which are pertinent to city needs.

Current NSF actions to evaluate the UTS program should be monitored by DOE for any added insight which may become available. Interviews with UTS, NSF, and PTI participants in UTS may be very useful as providing inputs for planning the DOE program. The UTS Technology Agents who were assigned to work in and for local governments are likely to be especially fruitful sources of ideas and commentary.

Conceptually, the recommended program has roots in the U.S. Department of Agriculture extension service. It is likely that the experience of the Extension Service in providing local technical support may be helpful in planning a DOE program.

Public schools, public or public assisted housing, and urban renewal activities are local government activities which are sponsored at the federal level by the Departments of Health, Education, and Welfare (HEW) and Housing and Urban Development (HUD). A local energy conservation program could likely be more effective and more efficient if it included these local activities and were supported at the federal level cooperatively by the DOE, HEW, and HUD.

The period of Federal support commitment for each community should be specified. We suggest strong initial Federal support and gradual phaseout, although some flexibility is needed for unusual considerations. Initially, such support can provide the motivation and impetus to get a program started. Over the mid-period of support, it can help develop working methods, awareness of need for energy conservation, information exchange, alertness to the opportunities for conservation, and the necessary local tradition of conservation. Eventual local support of the program is assumed to be justified by demonstrated benefits; local organizations could readily be maintained as functions assigned to local councils of governments.

A goal of the program should be to foster the development of such local interest, and initiative responsibility. This suggests need for strong (but not restrictive) DOE guidance and support in the initiation of the program, ultimately diminishing to a low level of support in matters such as information exchange. DOE participation should be planned so that it can taper down to a low minimum after the program is under way, with a commensurate increase in local responsibility.

It may be that, in the very long term, even the technical advisory, monitoring and data exchange functions which are advocated may be relegated to some non-DOE organization supported cooperatively by participating local governments.

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The documents listed are latest issues of which we are aware; newer editions may be available.

Documents can usually be obtained from originators. Many of those listed can be obtained through libraries, especially those having interlibrary loan ties with large technical libraries. The National Technical Information Service (NTIS) of the Department of Commerce is a valuable archive. Current U.S. government publications may be obtained from the cognizant agency or from the U.S. Government Printing Office.

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Appendix A-1

Agreement Between The Aerospace Corporation The City of Jersey City, and The Board of Education of Jersey City

(1 March 1976)

Agreement made this 1 day of March, 1976 between The Aerospace Corporation of El Segundo, California ("Aerospace"), and the City of Jersey City, a municipal corporation of the State of New Jersey, 280 Grove Street, Jersey City, New Jersey ("City"), and the Board of Education of the City of Jersey City, a municipal corporation with offices at 2 Harrison Avenue, Jersey City, New Jersey ("Board").

WHEREAS, the City of Jersey City, the Board of Education of the City of Jersey City and The Aerospace Corporation of El Segundo, California have agreed to jointly conduct A Local Government Buildings Energy Conservation Program funded by The Energy Research and Development Administration (ERDA) and as described in the Aerospace Proposal dated July 18, 1975 entitled, "Energy Conservation Demonstration in Jersey City's Government Buildings."

WHEREAS, the parties contemplate that Aerospace will assume the primary responsibility for the application engineering, development of procurement specifications, technical guidance for equipment installations, evaluation of the conservation demonstration results and dissemination of the resultant technical findings.

WHEREAS, the parties contemplate that Jersey City will provide the services of its designated Energy Conservation Coordinator and various other related personnel employed by Jersey City, facilities, and procurement expertise for the several procurements defined in the Aerospace proposal.

WHEREAS, the parties contemplate that it will be necessary to engage the services of an Architect-Engineer in the performance of work hereunder.

NOW, THEREFORE, in consideration of the mutual benefits to be derived hereunder, the parties do hereby agree as follows:

A. GENERAL STATEMENT OF WORK

1. The respective parties will perform the work described in Sections II and III of the Aerospace proposal dated, July 18, 1975, which was submitted to the United States Energy Research and Development Administration and which is hereby incorporated into this Agreement.

2. Aerospace shall be responsible for the following:

(a) Application engineering for all Tasks (Section III, Task I through IV) outlined in the Aerospace proposal.

(b) Preparation of all technical and procurement specifications.

(c) On-going technical assistance during the installation of all energy conservation equipment.

(d) Evaluation of all results of this project and preparation and dissemination of all technical reports.

B. RESPONSIBILITIES OF AEROSPACE

Aerospace may perform all or part of the above services. Aerospace may engage the services of a licensed Architect or Engineer to perform all or part of the services enumerated above; provided however, that the engagement of such Architect or Engineer shall not relieve Aerospace of any of its responsibilities under this Agreement.

C. RESPONSIBILITIES OF CITY AND THE BOARD

The City and the Board shall be responsible for the procurement and installation of all energy conservation equipment to be installed under this project. Such installation may be done by employees of the City and the Board, where the City and the Board find this to be feasible, or by contractors to be engaged by the City and the Board. All contracts for the procurement of goods and the installation of eouipment under this Agreement shall be subject to Section G.

D. PLANNING AND SCHEDULING

1. Within 14 days after the execution of this Agreement the parties shall designate one or more representative who shall cooperate in the planning, scheduling and conduct of all business necessary to the successful completion of this project, including the purchase of all goods and services required for the completion of the work. The purchasing agent of the City of Jersey City is hereby designated the purchasing agent in behalf of the City and the Board for the purchase of all goods and services required by this Agreement.

2. Prior to the performance of any work under this Agreement, representatives of Aerospace, the City and the Board shall prepare mutually agreeable schedules for each Task outlined in the Aerospace proposal. Such schedules shall include a proposed target date for the completion of each Task of the project and may be revised from time to time by mutual agreement of the parties.

E. PERIOD OF PERFORMANCE

This Agreement shall become effective upon execution of all parties herein and shall remain in effect until all the work in Sections II and III of the Aerospace proposal has been completed or until termination in accordance with the terms of this Agreement or by written agreement of the parties.

F. PAYMENT

1. Aerospace will make direct payment to the Architect and Engineer and will also pay for the work and services furnished under contract to Jersey City; except that Aerospace shall have no obligation to pay for services performed by employees of the City or employees of the Board.

2. Each invoice for materials and/or services which does not exceed the sum of $2,500, shall be presented to a designated representative of the City for signature approval before it is forwarded to Aerospace for payment. Such signature approval will constitute verification that the work and/or services described in the invoice has been satisfactorily completed. Thereafter, as a further condition of payment by Aerospace, such invoice shall be presented to, reviewed, and countersigned for approval by a designated representative of Aerospace.

3. Procurement by the City of materials and/or services in excess of $2,500. each shall be subject to the provisions of Article G.1. and G.2. herein below. Aerospace approval of the contract award will constitute verification of City invoice to Aerospace for payment upon presentation. City voucher should accompany City request for approval.

G. PROCUREMENT BY CITY

1. Aerospace understands and agrees that all procurement by the City is subject to the provisions of the New Jersey Local Public Contracts Law (N.J.S. 40A:11-1 et seq.). City understands and agrees that neither this Agreement, nor Aerospace as a party thereto, are subject to the provisions of the New Jersey Local Public Contracts Law cited herein.

2. City agrees that all specifications for procurement of goods or services pursuant to this Agreement shall be approved by a designated representative of Aerospace prior to public advertising for bids and that no contract shall be awarded without the prior approval of Aerospace. Aerospace shall approve or reject all bids within ten (10) working days. after receipt of a copy thereof from the City by Aerospace.

3. All modifications for the renewal or extension of contracts or for the performance of any extra work or the procurement of any extra goods under any contract awarded by the City shall be preapred and recommended for approval by City, but shall not become effective until approved in writing by a designated rperesentative of Aerospace. All contracts awarded by City shall contain a provision that no additional compensation shall be allowed a vendor or contractor for any delays that may result in obtaining such approval.

H. TERMINATION

The City and the Board understands and agrees that the Energy Research and Development Administration (ERDA) will provide incremental funding for this project and may terminate funding for any Task or sub-task of this project. In the event that ERDA terminates any funding to Aerospace for this project, this Agreement may be terminated by Aerospace in whole or in part, at any time, by thirty (30) days written notice to both the City and the Board. Upon receipt of such termination sole liability of Aerospace shall be for those costs incurred through the specified date of termination by Aerospace or receipt of such termination by the City or the Board, whichever is later. Termination costs shall include any contractually committed costs incurred by the City or the Board prior to the effective date of termination.

I. AUDIT AND EXAMINATION OF RECORDS

City will maintain adequate records to permit substantiation of invoices, and shall make available at its office at all reasonable times during the period covered by this Agreement, and for a period of three (3) years thereafter, any of the records pertaining to performance hereunder. Aerospace may, at any time or times, have the invoices, vouchers, or statements of costs audited by an Aerospace representative. Each payment theretofore made shall be subject to reduction for amounts included in the related invoice or voucher which are found by Aerospace, on the basis of such audit, not to constitute an allowable charge hereunder. Any payment may be adjusted for overpayments or underpayments on previous invoices or vouchers.

J. BOARD OF EDUCATION APPROVAL

This Agreement and any modifications thereto shall be binding upon the Board only if approved by the New Jersey Department of Education, Bureau of Facilities Planning Service. Aerospace shall cooperate with the Board in the preparation of any information or presentation necessary to secure the approval of the Bureau.

K. GOVERNING LAW

This Agreement and any modifications thereto shall be governed by the laws of the State of New Jersey.

L. NOTICE

All notices effecting the rights and duties to the parties of this Agreement shall be sent in writing to the following:

(a) City of Jersey City
John Ewen,
Technology Agent/UTS Program
280 Grove Street
Jersey City, New Jersey 07302

(b) Board of Education
John Ewen,
Technology Agent/UTS Program
280 Grove Street
Jersey City, New Jersey 07302

(c) The Aerospace Corporation
P.O. Box 92957
Los Angeles, California 90009
J.D. Price
Bldg. A-1/3081

M. DESIGNATED REPRESENTATIVE

All designated representatives of the parties required under this Agreement shall be identifed by separate communication between said parties.

N. PROPERTY

Title to all equipment, materials and supplies, purchased, fabricated,or furnished by the Contractor, the cost of which is allowable as direct items of cost under this contract, shall, with respect to such purchased or fabricated items, vest in the owners of the buildings in which the installations are made, at the time of approval and payment of work and services, as described in Article F., Payment, of this document.

O. INDEMNIFICATION

Jersey City agrees to indemnify and save harmless The Aerospace Corporation and it's officers, agents, and employees from any and all claims and losses arising out of or in relation to the performance of this agreement. Aerospace shall have no obligation to remove the modifications accomplished under this Demonstration Program and shall not be responsible for any damage to or loss of the Public Buildings that may arise out of the performance of the work hereunder.

P. MANDATORY CONDITIONS REQUIRED BY ERDA IN ADDITION TO OTHER TERMS AND CONDITIONS

See Appendix 1.

APPENDIX 1

ERDA Appendix A.

Principles and Procedures for Use in Cost Reimbursement Type Non-Nuclear Supply and Research Contracts with Commercial Organizations.

ERDA Appendix B.

General Provisions, Cost-Type Supply and Research Development Contracts with Concerns Other Than Educational Institutions.

- Article 5 - Excusable Delays
- Article 7 - Accounts, Records and Inspection
- Article 8 - Examination of Records
- Article 18- Buy American Act
- Article 24a- Contract Work Hours and Safety Standards - Overtime Compensation
- Article 24b- Convict Labor
- Article 25 - Equal Opportunity
- Article 32 - Drawings, Designs, Specifications
- Article 34 - Listing of Employment Openings
- Article 36 - Payment of Interest on Contractors' Claims
- Article 37 - Employment of the Handicapped

ERDA Disputes Clause - (ERDA-PR-9-7-5004-3)

DISPUTES CLAUSE

(1) Except as otherwise provided in this Agreement [1] any dispute concerning a question of fact arising under this Agreement [2] which is not disposed of by agreement shall be decided by the ERDA Contracting Officer for the prime contractor's Contract No. E(11-1)-2820 who shall reduce his decision to writing and mail or otherwise furnish a copy thereof to the prime contractor and the Jersey City/Board of Education [3]. The decision of the Contracting Officer shall be final and conclusive unless, within 30 days from the date of receipt of such copy the City/Board [3] mails or otherwise furnishes to the Contracting Officer a written appeal addressed to the Administrator or his designee. The decision of the Administrator or his designee for the determination of such appeals shall be final and conclusive unless determined by a court of competent jurisdiction to have been fraudulent, or capricious, or arbitrary, or so grossly erroneous as necessarily to imply bad faith, or not supported by substantial evidence. In connection with any appeal proceeding under this clause, the City/Board [3] shall be afforded an opportunity to be heard and to offer evidence in support of its appeal. Pending final decision of a dispute hereunder, the City/Board [3] shall proceed diligently with the performance of the Agreement [2] and in accordance with the Contracting Officer's decision.

(2) This disputes clause does not preclude consideration of law questions in connection with decisions provided for in paragraph (1) above: Provided, That nothing in this Agreement [2] shall be construed as making final the decision of any administrative official, representative, or board on a question of law.

[1] Insert subcontract, purchase order, etc., as appropriate.
[2] Insert subcontract, purchase order, etc., as appropriate.
[3] Insert subcontract, seller, etc., as appropriate.

Per ERDA-PR 9-7.5006-3 - For Subcontracts

IN WITNESS WHEREOF, The City of Jersey City, the Board of Education and The Aerospace Corporation have executed this Agreement on the day and year first above written.

ATTEST:

Thomas F. X. Smith,
City Clerk

CITY OF JERSEY CITY

By:

Joseph J. Contreras,
Business Administrator

William G. Spedding, Director
Department of Public Works

By:

John Ewen,
Technology Agent/UTS Program

WITNESSED:

BOARD OF EDUCATION

By:

Secretary, Board of Education

WITNESSED:

THE AEROSPACE CORPORATION

2/10/76

C. M. Culver, Head
Contracts Management Department

By:

2/10/76

J. D. Price,
Director of Contracts

APPROVED AS TO LEGAL FORM

Assistant Corporation Counsel

CERTIFICATION

I, R. T. Jensen, certify that I am Secretary of the Corporation named as Contractor herein; that J. D. Price who accepted this Contract on behalf of the Contractor was then Director of Contracts of said Corporation, that said Contract was duly signed for and on behalf of said Corporation, by the authority of its governing body, and is within the scope of its corporate powers.

IN WITNESS WHEREOF, I have hereunto affixed my hand and the seal of said Corporation this 12th day of February 1976.

R. T. Jensen

SEAL

AMENDMENT No. 1

AEROSPACE/JERSEY CITY/BOARD OF EDUCATION AGREEMENT

D. PLANNING AND SCHEDULE

ADD:

3. Representatives of Aerospace, the City and the Board shall prepare mutually acceptable procedures to make funds available to the City for purchases required under Section G, in accordance with the requirements of the New Jersey Local Fiscal Affairs Law and the Local Budget Law.

O. INDEMNIFICATION

REPLACE WITH THE FOLLOWING

Jersey City/Board of Education agrees to indemnify and save harmless The Aerospace Corporation, their officers, agents, and employees from any and all claims and losses resulting or accruing to Jersey City/Board of Education or their officers, agents and employees in connection with the performance of this Agreement, where such claims and losses are due to Jersey City/Board of Education's negligence, provided however that should liability be imposed as a result of the acts of the parties hereto jointly, said liability shall be apportioned between the parties hereto according to the percent of fault of each party. Aerospace shal have no obligation to remove the modifications accomplished under this Demonstration Program and shall not be responsible for any damage to or loss of the Public Buildings that may arise out of the performance of the work hereunder.

AMENDMENT No. 1

IN WITNESS WHEREOF, The City of Jersey City, the Board of Education and The Aerospace Corporation have executed this Amendment on the day and year of the original Agreement.

ATTEST:

Thomas F. X. Smith,
City Clerk

CITY OF JERSEY CITY

By:

Joseph J. Contreras,
Business Administrator

William G. Spedding, Director
Department of Public Works

By:

John Ewen,
Technology Agent/UTS Program

WITNESSED:

BOARD OF EDUCATION

By:

Secretary, Board of Education

WITNESSED:

2/10/76

C. M. Culver, Head
Contract Management Department

THE AEROSPACE CORPORATION

By:

2/10/76

J. D. Price
Director of Contracts

APPROVED AS TO LEGAL FORM

Assistant Corporation Co...

CERTIFICATION

I, R. T. Jenson, certify that I am Secretary of the Corporation named as Contractor herein; that J. D. Price who accepted Amendment No.1 on behalf of the Contractor was then Director of Contracts of said Corporation, that said Contract was duly signed for and on behalf of said Corporation, by the authority of its governing body, and is within the scope of its corporate powers.

IN WITNESS WHEREOF, I have hereunto affixed my hand and the seal of said Corporation this 13th day of February 1976.

R. T. Jenson

SEAL

PATENT INDEMNITY

If the amount of this contract is in excess of $10,000, the Contractor shall indemnify the Government and its officers, agents, and employees against liability, including costs, for infringement of any United States letters patent (except letters patent issued upon an application which is now or may hereafter be kept secret or otherwise withheld from issue by order of the Government) arising out of the manufacture or delivery of supplies or out of construction, alteration, modification, or repair of real property (hereinafter referred to as "construction work") under this contract, or out of the use or disposal by or for the account of the Government of such supplies or construction work. The foregoing indemnity shall not apply unless the Contractor shall have been informed as soon as practicable by the Government of the suit or action alleging such infringement, and shall have been given such opportunity as is afforded by applicable laws, rules, or regulations to participate in the defense thereof; and further, such indemnity shall not apply to (i) an infringement resulting from compliance with specific written instructions of the Contracting Officer directing a change in the supplies to be delivered or in the materials or equipment to be used, or directing a manner of performance of the contract not normally used by the Contractor, (ii) an infringement resulting from addition to, or change in, such supplies or components furnished or construction work performed which addition or change was made subsequent to delivery or performance by the Contractor, or (iii) a claimed infringement which is settled without the consent of the Contractor, unless required by final decree of a court of competent jurisdiction.

Appendix A-2

Revised Purchasing Procedures
Aerospace/Jersey City/Board
of Education Agreement
June 15, 1976

REVISED PURCHASING PROCEDURES

Aerospace/Jersey City/Board of Education Agreement

Energy Conservation Demonstration Program

WHEREAS, on March 1, 1976 The Aerospace Corp. of El Segundo, California (Aerospace); the City of Jersey City (City); and the Board of Education (Board) entered into an agreement to conduct jointly a Local Government Buildings Energy Conservation Program to be funded by the Energy Research and Development Administration (ERDA);

WHEREAS, paragraph three of Section D of the subject agreement as amended by Amendment #1 requires that representatives of Aerospace, the City and the Board prepare mutually acceptable procedures for the procurement of goods and services for the program;

WHEREAS, New Jersey law requires public bidding for procurements in the amount of $2500.00 or more.

A. INFORMAL PURCHASING PROCEDURES FOR PROCUREMENTS AMOUNTING TO LESS THAN $2500.00

1. The Technology Agent of Jersey City shall notify Aerospace prior to each procurement in connection with the Aerospace/Jersey City Energy Conservation Program. Aerospace shall prepare written specifications for the items of procurement, if such are required, and forward these to the contracting agent of Jersey City or his designee.

2. Upon receipt of specifications the contracting agent shall solicit at least three (3) quotations, whenever practicable, for each item of procurement. Records shall be kept of all quotations solicited and received.

3. The Technology Agent shall review all quotations and tentatively select a vendor for each item. In accordance with New Jersey law, goods or services the estimated cost of which exceeds $500.00 shall be purchased from the vendor submitting the lowest quotation which complies with the specifications. The contracting agent shall forward the names of the vendors selected together with all other quotations to Aerospace.

4. Upon receipt of quotations Aerospace shall review, approve and sign an authorization to purchase.

5. Upon receipt of Aerospace's authorization the contracting agent shall prepare a purchase order and encumber the necessary funds in accordance with New Jersey law.

6. Upon receipt of a copy of the purchase order, Aerospace shall transmit the required funds to the contracting agent.

7. The Technology Agent of Jersey City shall be responsible for the verification that all goods and services delivered are in accordance with specifications. Written copies of such verifications shall be forwarded to Aerospace. Goods received which are unacceptable shall be rejected immediately and returned to the vendor for replacement or rework.

8. Shipping invoices for goods and statements of receipt of services shall be forwarded to Aerospace.

9. If it is the decision of the Technology Agent and Aerospace not to select the lowest quotation, the contracting agent shall arrange an informal hearing with the vendor submitting the lowest quotation. Hearings shall be scheduled to take place forty-eight (48) hours after notification of the vendor. The final decision of the vendor to be selected shall be made by Aerospace, which shall substantiate its decision in writing.

B. FORMAL PURCHASING PROCEDURES FOR THE PROCUREMENT OF GOODS AND SERVICES ABOVE $2500.00

1. Prior to each procurement Aerospace shall prepare and submit the appropriate specification to the City. Specifications for goods may specify a trade name "or equivalent."

2. The contracting agent shall advertise for, and receive bids in accordance with the New Jersey Local Public Contracts Law.

3. Bids shall be received, opened and publicly read at a time and place specified in the advertisement. All bids shall then be sent to the Technology Agent for review and preliminary selection of the lowest qualified bidder.

4. The preliminary selection together with the other bids shall be forwarded to Aerospace for final selection and authorization to purchase.

5. If a decision is made to select other than the lowest bidder, the lowest bidder shall be accorded a formal hearing in accordance with New Jersey law. At the conclusion of such a hearing, the hearing panel shall make specific factual findings in support of its decision. All hearings shall be arranged forty-eight (48) hours after notification of the low bidder.

6. A resolution shall be drafted and included on the

Council agenda requesting Council approval for award of a contract to the selected bidder. Resolutions awarding contracts to other than the low bidder shall recite the factual findings supporting such decision.

7. After Council approval, the procedures shall be the same at those outlined in Section A, paragraphs 4-8 above.

New Jersey law requires that publicly advertised contracts be awarded thirty (30) days after the opening of bids unless the three (3) lowest bidders agree to an extension of an additional thirty (30) days, or unless the municipality chooses to reject all bids and readvertise. A decision to reject all bids must be based on sound public reasons, which shall be recited in the resolution rejecting the bids.

C. <u>ALL PURCHASING PROCEDURES</u>

Because of restrictions imposed by the State of New Jersey, Jersey City cannot carry an unbalanced revenue statement beyond the end of the City's fiscal year, which is coincident with the calendar year. Therefore, if goods or services are to be procured during the month of December, Aerospace shall transmit funds for such procurement to the City before the end of the fiscal year.

APPROVED:

Board of Education

Joseph M. Daley
Jersey City Purchasing Agent

JUN 15 1976
J.D. Price,
Director of Contracts
The Aerospace Corporation

TF:jpk
5/20/76

Appendix A-3

Sources of Equipment and Materials Used

The following list of trade names, vendors, manufacturers, and installers is provided as a convenience to the reader. Most were selected on the basis of low bids in response to publicized announcements. The Aerospace Corporation, as a matter of policy, does not publicly endorse products or vendors.

City Hall

- Radiator thermostatic steam traps:

  Dunham-Bush, Inc.
  170 South Street
  West Hartford, Connecticut 06110

- Radiator thermostatic control valves:

  Danfoss, Inc.
  McKee Drive
  Mahwah, New Jersey 07430

- Contractor:

  A and A Oil Burner Service
  9-11 Sheridan Avenue
  Clifton, New Jersey 07011

Public Works Shops

- Automatic timed door closers:

  Advance Industries
  Division of Overhead Door Corporation
  2002 French Road
  Appleton, Wisconsin 54911

- Timed lights controller:

  Touch-Plate Electro-Systems, Inc.
  16530 Garfield Avenue
  Paramount, California 90723

- Timer for timed heat:

  N. H. Rhodes Mark Time Company
  99 Thompson Road
  Avon, Connecticut 06001

Public School No. 6

- Weather Stripping:

  PEMKO Manufacturing Company
  1360 59th Street
  Emeryville, California 94608

- Calking compound:

  Various sources

- LEXAN:

  General Electric Company
  1 Plastics Avenue
  Pittsfield, Massachusetts 01201

- HPS lights:

  General Electric Company
  Lamp Division
  Twinsberg, Ohio

Public School No. 24

- Atomizing oil burners:

  Iron Fireman
  Dunham Bush
  178 South Street
  W. Hartford, Connecticut 06110

- Contractor:

  A and A Oil Burner Service
  9-11 Sheridan Avenue
  Clifton, New Jersey 07011

Public School No. 40

- Classroom light photocontroller:

  Area Lighting Research
  Asbury Road
  Hackettstown, New Jersey

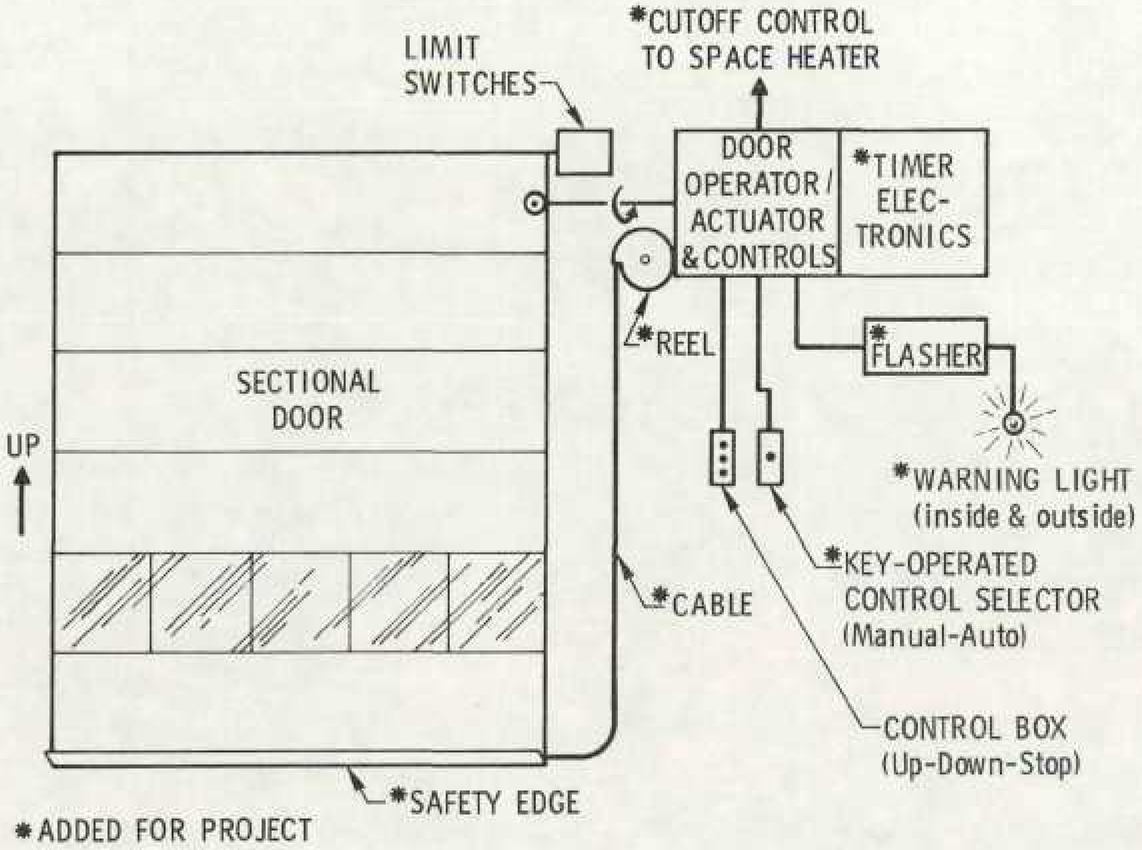
- Turbulators:

  Fuel Efficiency, Inc.
  131 Stuart Avenue
  P.O. Box 48
  Newark, New Jersey 14513

- Ventilator timers:

  N. H. Rhodes Mark Time Company
  99 Thompson Road
  Avon, Connecticut 06001

Appendix B-1. Public Works Shops Central Garage No. 1
Vehicle Door Timed Controller Design



FUNCTIONS OF VEHICLE DOOR CONTROL SYSTEM:

Manual Operation - Existing

Actuate door up, down, or stop by existing control box on inside wall.

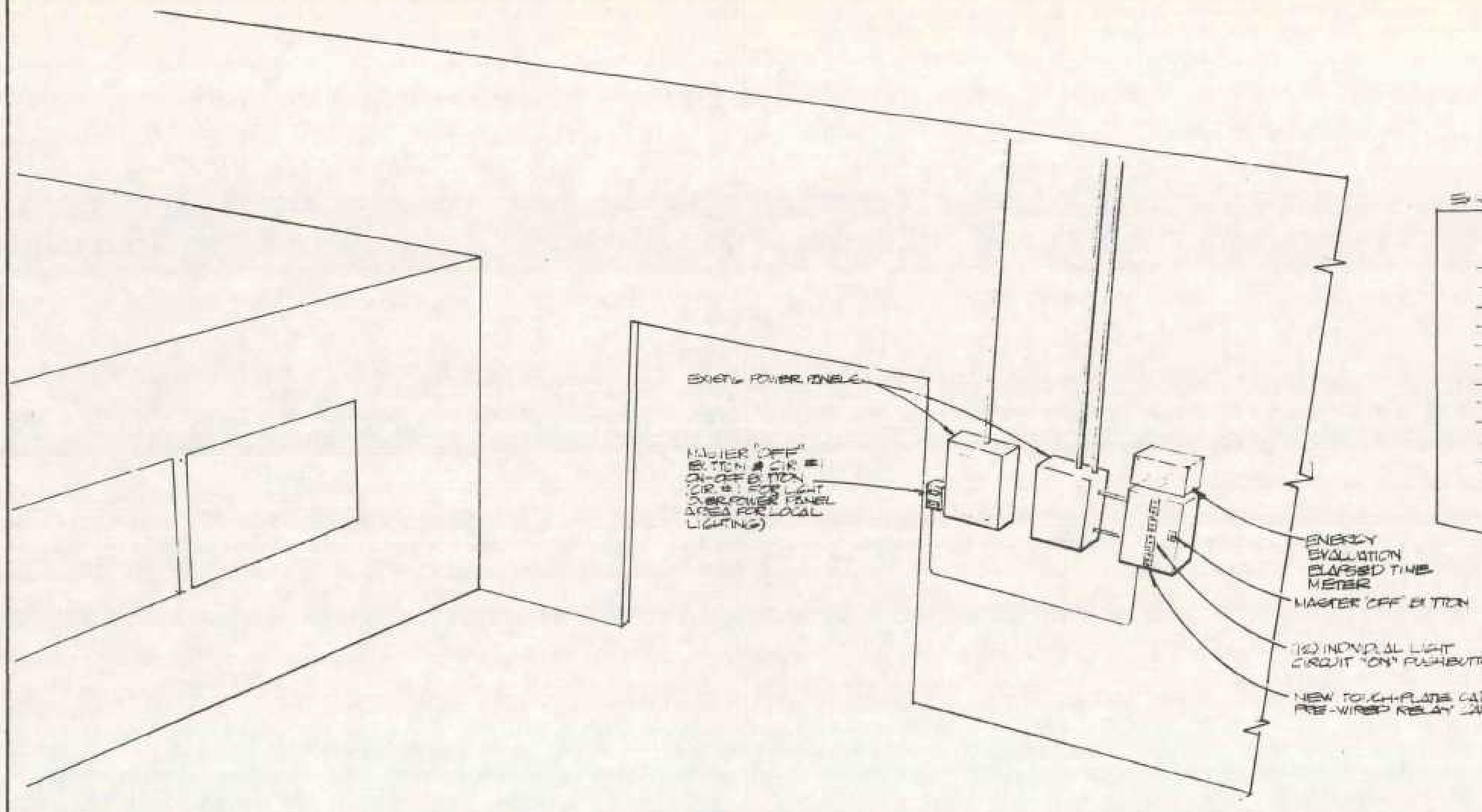
Added Features

Manual - Automatic mode selector switch (key-actuated)

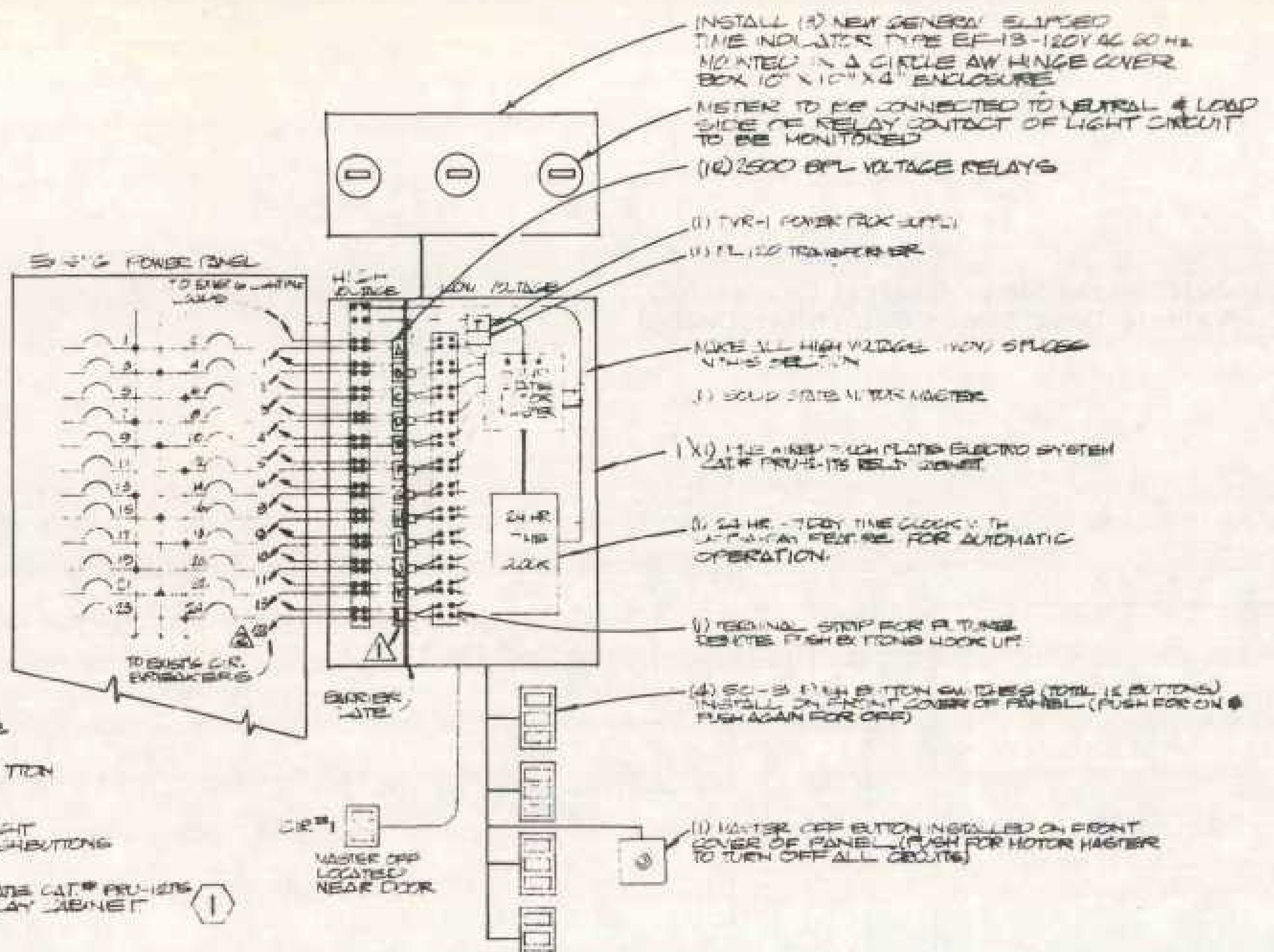
Automatic closing after set time open (1.5 min maximum when in automatic mode)

Automatic reversal when safety edge of descending door encounters obstacle

Warning light flashes continuously when door is in motion.



ISOMETRIC (A/2)



WIRING DIAGRAM

INSTALLATION SEQUENCE NOTES:

1. MOUNT TOUCH PLATE CONTROL UNIT NEXT TO EXISTIG LIGHTING POWER PANEL WITH (2) 2" NIPPLES ON CABINET CONNECTORS.
2. REMOVE ALL EXIST'G LIGHT CIRCUIT CONDUCTORS FROM CIRCUIT BREAKERS & ROUTE INTO THE HIGH VOLTAGE SECTION OF TOUCH-PLATE CONTROL UNIT.
3. INSTALL NEW #12 WIRE LEADS FROM EXIST'G APPROPRIATE CIRCUIT BREAKER TO THE APPROPRIATE 2500 BPL LOW VOLTAGE RELAY. (NOTE 8)
4. CONNECT EXIST'G LIGHT CIRCUIT LEAD TO THE APPROPRIATE 2500 BPL LOW VOLTAGE RELAY. (NOTE 8)
5. SELECT-SPARE 15 AMP CIRCUIT BREAKER IN EXIST'G PANEL (MAY HAVE TO INSTALL NEW) & POWER UP THE TOUCH PLATE UNIT.
6. SET TIME CLOCK & TEST UNIT.
7. INSTALL MASTER OFF PUSH BUTTON & LOCAL LIGHT CIRCUIT PUSHBUTTON NEAR DOORWAY.
8. CONNECT LIGHT CIRCUIT TO LOW VOLTAGE RELAYS AS PER LIST.

LIGHT CIR.#	RELAY
1	A
2	B
3	C
4	D
5	E
6	F
8	G
9	H
10	I
11	J
13	K
23	L

OPERATIONAL NOTE:

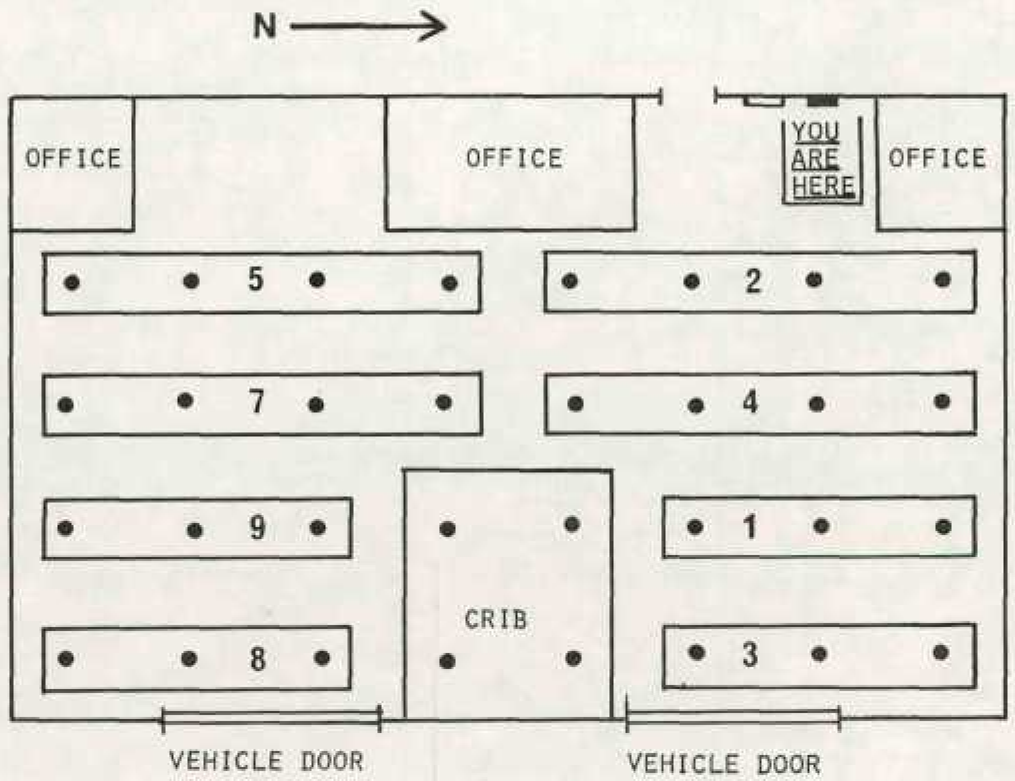
THE AUTOMATIC LIGHT TURN OFF CONTROL ALLOWS 12 LIGHTING CIRCUITS TO BE TURNED ON OR OFF BY PRESSING INDIVIDUAL ENGRAVED PUSHBUTTON LOCATED ON FRONT COVER OF THE CONTROL CABINET OR BY PRESSING ONE MASTER OFF BUTTON TO TURN OFF ALL LIGHTING CIRCUITS THAT ARE ON.

THE AUTOMATIC FEATURE OVERRIDES ALL MANUAL OPERATION BY PROGRAMMING THE 24 HR TIME CLOCK. TO PULSE THE MASTER MOTOR CONTROLLER TO TURN OFF ALL LIGHTING CIRCUITS THAT ARE ON. SUGGESTED PROGRAM, SET THE TIME CLOCK TO SEND TURN OFF PULSE TO THE MOTOR MASTER TO TURN OFF LIGHT AT 2 HR. INTERVALS DURING WORKING HOURS AND 1 HR. INTERVALS DURING NON WORKING HOURS, SUCH AS 1, 2, 3, 4, 5, 6, 8, 10 A.M., 12 NOON, & 1, 3, 5, 6, 7, 8, 9, 10, 11 P.M. & MIDNIGHT. THIS SEQUENCE OF TURN OFF TIMES WILL HOLD THE INTERRUPTION OF THE WORKMEN TO A MINIMUM.

Appendix B-2. Public Works Shops Central Garage No. 1 Experimental Timed Light Controller Design

RELEASED FOR CONSTRUCTION	ENERGY CONSERVATION JERSEY CITY PUBLIC WORK SHOP LIGHTING CONTROL	
DATE	AEROSPACE CORPORATION INDUSTRIAL ENGINEERING	
REVISIONS: MARK / DATE / BY / DESCRIPTION	DESIGNED: C. G. ALBIN / SCALE: NONE	SHEET
1 — LETTER RELAYS	DRAWN: EW / DATE: 7/1978	E2
2 — RW — CORRECT RELAY NUMBERING		

Appendix B-3. Public Works Shops
Explanatory Placard, Timed Lights Control Panel



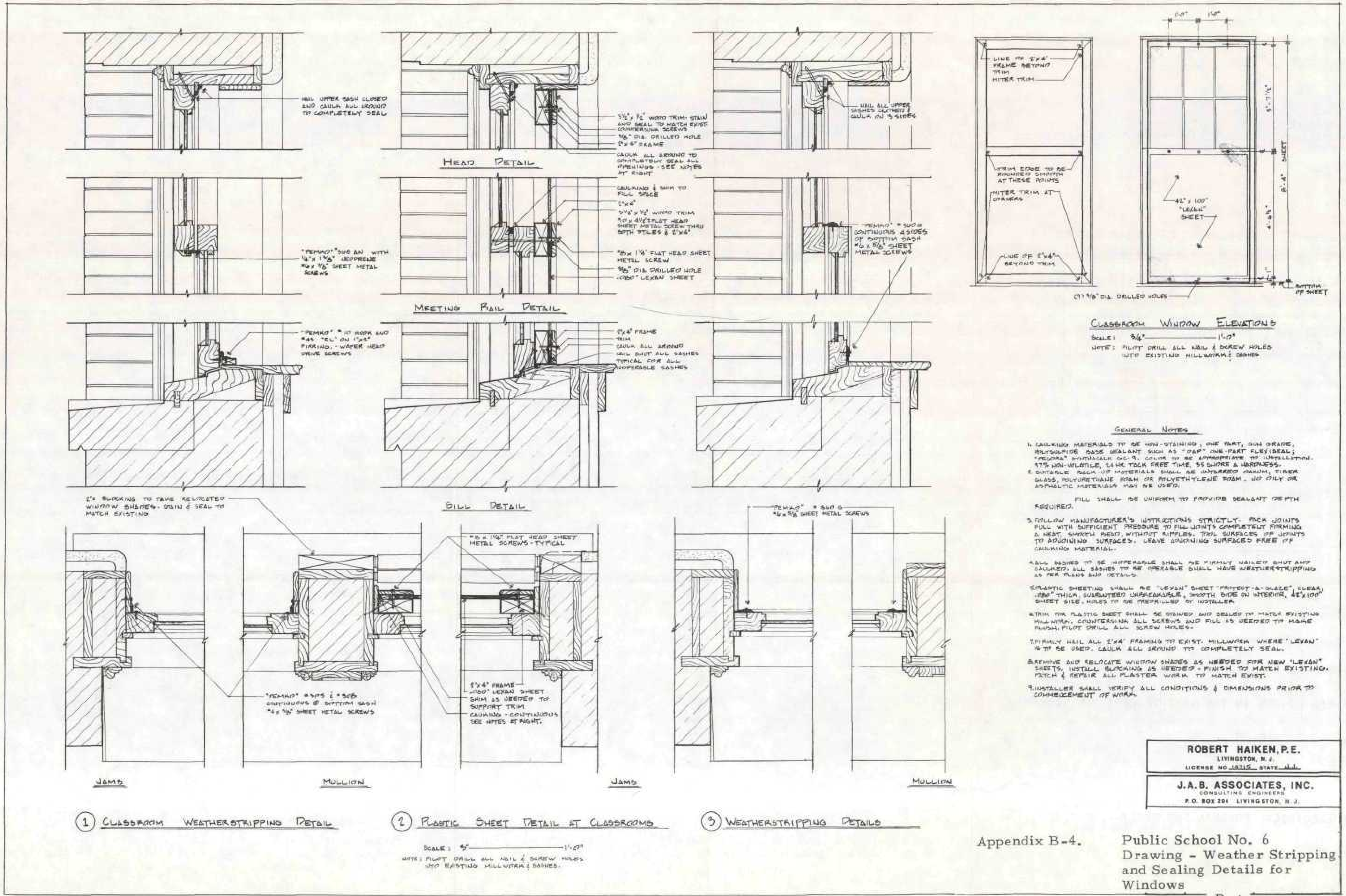
TO TURN LIGHT ON OR OFF: LIGHTLY PUSH ITS BUTTON ONCE

THE NUMBER OF EACH LIGHT CLUSTER IS THAT OF ITS PANEL CONTROL BUTTON

THIS EQUIPMENT TURNS OFF OVERHEAD LIGHTS IN THE BAYS (EXCEPT THE TOOL CRIB) AT:

10:00 AM	5:00 PM
12:30 PM	9:00 PM
3:00 PM	12:00 PM

NOTE: IF BUILDING POWER GOES OFF, THE TIMING SCHEDULE WILL CHANGE. WHEN THIS HAPPENS, NOTIFY THE ELECTRICAL FOREMAN FOR RESET.



Appendix B-4. Public School No. 6 Drawing - Weather Stripping and Sealing Details for Windows

Appendix B-5

Specifications
for
Brock "Fuel Saver" Turbulators
School #40, Jersey City, N.J.

FIRETUBE TURBULATORS

Furnish and install flue gas Turbulators of 14 gauge flat metal planes formed into radical 45 degree bends, which create a designed turbulence of hot flue gases to improve thermal heat transfer and balance heat release into all tube surfaces.

Turbulators shall be designed to fit inside of the boiler flue tubes, with varied lengths and positioning handle for installation and removal.

Turbulators shall be designed to not exceed 450° exit stack temperatures while the Pacific scotch marine boilers are being fired with full input of #4 fuel oil.

Fire tests shall be made by Industrial Combustion Associates' representative before and after Turbulators are installed in the boiler; the test report will include: high and low fire stack temperatures; high and low fire CO_2 content; high and low fire overfire draft. Submit (4) copies of fire test reports.

Turbulators shall be guaranteed for a period of five years and to save a minimum of 8% of fuel cost.

Appendix B-6

Photocell Controller for Outer Classroom Lights
Functional Description

This sensor system is diagrammed as Figure 36b. It consists of a cadmium sulphide photoresistive cell (R_s) in series with a resistance wire winding (R_3) which is intimately wound around a bimetal switch arm. The circuit is powered by 120v ac and the photocell resistance decreases under illumination. This increases the current flow in R_3, which heats the bimetal strip of the thermal relay, K_1, closing its normally open switch contacts at the desired light level. Closure of the K_1 contacts energizes the 4PDT power relay K_2, which controls the lights. Variable resistance R_1 is a built-in adjustable hysteresis element which determines the time required to actuate the thermal relay; it also affects the light response level of the system. K_2, when energized, effectively removes R_1 from the circuit so that illunination must drop well below the turn-on level before the relays open and turn the lights on.

Fuses were added at the request of the State Board of Education as a condition for use of the system in classrooms, since the system does not have Underwriter Laboratory approved. Adjustment of the illumination level at which the relays close is made by an adjustable optical attenuator composed of two polarizers, mounted over the photocell light aperture; the outer can be rotated with respect to the inner to provide adjustable light attenuation.

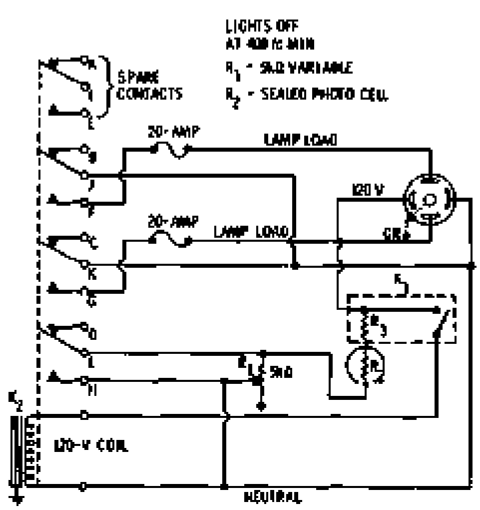


Figure 36b. Public School No. 40 Photocell Controller Schematic Diagram

(repeated for convenience)

QUESTIONAIRE RE LUCALOX LIGHTS, P.S. #6

PLEASE PRINT

Teacher name: ______________________ Date: ______________

Grade: __________ Classroom No: __________ No. Pupils: __________

Please check the appropriate responses:

1. I find the color of the lights:
   - _____ a. pleasant
   - _____ b. acceptable
   - _____ c. slightly unpleasant
   - _____ d. very unpleasant

2. The affect of the lights on class. alertness has been:
   - _____ a. none
   - _____ b. slightly favorable
   - _____ c. slightly unfavorable
   - _____ d. strongly favorable
   - _____ e. strongly unfavorable

3. What (if any) effect upon student tension and "fidgets" have you observed?
   - _____ a. none
   - _____ b. slightly favorable
   - _____ c. slightly unfavorable
   - _____ d. strongly favorable
   - _____ e. strongly unfavorable

4. Overall, how do you feel about the lights:
   - _____ a. like
   - _____ b. indifferent
   - _____ c. dislike

5. Please list the features or effects of the lights you like: ______________

6. Please list features or effects you dislike: ______________

7. Please write any special observations or comments which may help us evaluate these lights. ______________

PLEASE RETURN THIS FORM TO THE PRINCIPAL'S OFFICE WHEN COMPLETED.

Appendix B-7

Analysis of Classroom Ventilation

Energy Losses -- Public School No. 40

1. Reduction of Ventilation Air Flow

The average daytime outside air temperature during the school year (Sept. thru June) lies between the average maximum daily temperature (58 °F) and the average daily temperature for this period (49.3). Assume it to be midway between these values: 53.6 °F.

The average classroom temperature is not lower than 72 °F. Thus, throughout the school year, ventilation air must be heated through about (72 °F - 54 °F), or 16 °F.

The required nominal flow for P.S. No. 40 when built was 0.5 ft^3 per ft^2 of floor area per minute (Ref. 1, Section 700, Table III); this requirement has been changed to 0.25 ft^3/ft^2-min (Ref. 2, Attachment, p. 4), for a potential saving of one-half the original requirement: 0.25 ft^3/ft^2 - min.

For a nominal 900 square foot classroom, the saving is 0.25 x 900 or 225 cu ft per minute.

Total ventilation air flow per classroom for an 180-day school year would then be 225 ft^3/min x 60 min/ft x 8 hrs/day x 180 days, or 19.44×10^6 ft^3/classroom-year.

If outside air is assumed to be at 50% relative humidity, then the same air, heating to 72 °F, is at about 28% RH with a specific volume of about 13.5 cu. ft./lb. and an enthalpy of about 12.5 BTU/lb. (Ref 1, Figure 5-1, p. 102).

Thus, under the assumptions, heat which may be saved in one classroom-year by modernizing to current classroom ventilation requirements is:

$$\frac{19.44 \times 10^6 \text{ ft}^3 \text{ classroom year}}{13.5 \text{ ft}^3/\text{lb}} \times 12.5 \text{ BTU/lb air}$$

$$= 18 \times 10^6 \ \frac{\text{BTU}}{\text{classroom-year}}$$

To convert to savings in oil (at 36¢ and 140,000 BTU per gallon) and in dollars, assume 80% combustion efficiency and 80% distribution efficiency: 64% overall.

$$\frac{18.0 \times 10^6}{0.64 \times 140,000} \text{ gallons, or 201 gallons}$$

Thus, reducing ventilation flow from the old required level to present requirements will save about 201 gallons of No. 4 fuel oil <u>per classroom</u>, or about $72 per year. For the 45 classrooms of Public School No. 40, this would represent a total annual saving of 9,000 gallons of oil or (at 36¢ per gallon) $3,250.

2. Timed Ventilation Control

If the proposed timer-switch were used on each classroom unit ventilator so as to close the ventilation damper except when the classroom was occupied, it may be assumed reasonably that (of the 8-hour day), ventilation flow would <u>not</u> be required for:

lunch hour
one vacant period
15-minutes between-class periods for each of the remaining class hours,

or 3.5 of the 8 hours: about 44% of the time.

Annual savings for the timer switch would therefore be 44% of the remaining ventilation costs (which are equal to the savings -- 50% -- derived in Section 1 above). Thus,

- If the ventilator flow modification <u>has been made</u>, timers in all classrooms can save:

  88.5 gallons of oil or $31.80 per classroom-year.
  3980 gallons of oil or $1,433 for Public School No. 40 per year.

- If the ventilator flow modification <u>has not been made</u>, timers can save:

  177 gallons of oil or $63.60 per classroom.
  7,960 gallons of oil or $2,866 for Public School No. 40 per year.

Appendix C-2

Public School No. 6 Data

High Pressure Sodium Light Costs vs
Incandescent Light Costs

1. Installation Costs, HPS Lights:

Fixture and parts by part no:	
C653G001 -120	$111.23
C740G546	2.97
Bulb, LU/50/BU	18.92
light stems and canopies	2.12
Parts cost per unit:	$135.25
Labor: 352 hours at $7.82/hr divided by 158 fixtures	
Labor Cost per unit:	17.44
Total installed cost per fixture:	$152.69
Total installed cost, 158 fixtures	$24,125.00

2. Classroom lights on time:

From elapsed time meters showing total on time of 7 sets of classroom lights for period 8/23/77 to 4/19/78:

Average on-time per classroom: 847 hours
Total number school days in interval: 132
Total on time per classroom per school day: 6.4 hours

3. Approximate energy consumption
150 watt HPS bulb with Ballast: 175 watts

4. P.S. No. 6 total Power Consumption

Before and after installation of HPS lights (by month):

		Month	kWh	
a.	Before	Oct 1975	18,540	18,540
		Nov 1975	18,900	18,900
		Dec 1975	20,220	20,220
		Jan 1976	21,520	21,520
		Feb 1976	13,900*	
		Total (5 mos)	93,080	
		5 mos avg.	18,616/kWh/mo	
		Total (4 mos)		79,180
		4 mos avg.		19,795/kWh/mo

*Anomalous Data Point

		Month	kWh	
b.	After	Oct 1977	15,500	15,500
		Nov 1977	22,370	22,370
		Dec 1977	21,900	21,900
		Jan 1978	19,420	19,420
		Feb 1978	19,640	
		Total (5 mos)	98,830	
		5 mos avg.	19,766/kWh/mo	
		Total (4 mos)		79,190
		4 mos avg.		19,797/kWh/mo

It is evident that the datum for February 1976 is anomalous and should be discarded. Accordingly, the evaluation comparison utilizes data from the periods of October-January inclusive, 1975-'76 (before) and 1977-'78 (after); no significant change is seen in the power consumption billings which is attributable to the HPS lights.

5. Classroom Electrical Load vs Total Load

The monthly energy usage for 158 HPS fixtures (which is essentially the entire classroom electrical load) is calculated as:

$$20 \frac{\text{school-days}}{\text{month}} \times 6.4 \frac{\text{hours}}{\text{day}} \times 158 \text{ fixtures} \times 0.175 \text{ kw/fixture} = 3540 \text{ kw-hrs/mo.}$$

If the 200 watts load of cloakroom lights for each classroom is added, then the total monthly classroom light energy usage is 5560 kw-hr. This is slightly more than 25% of the total average monthly electrical usage during the school year.

Other elements of the total electrical load are: the gymnasium, often in use until 10:00 pm; woodworking and metal shops in nearly continuous use; the indoor pool with pump continuously on; furnace burners and blowers; lights in hallways; teachers' rooms; offices; outside area lights; miscellaneous load elements, such as coffee pots, other small appliances, janitorial and service power tools, etc.

6. Bulb Costs

Estimated labor cost for bulb replacement: $2.00 each

HPS (Lucalux) 150 watt (175 watt with ballast)

Bulb cost:	$18.92
Installation labor:	2.00
Total	$20.92

Average bulb life: 24,000 hours

Bulb cost per hour of life: 0.087¢

HPS Bulb cost per Kw-hr used is 0.50¢

<u>300 watt incandescent</u>:

Bulb cost	$0.75
Installation labor	2.00
Total	$2.75

Average bulb life: 750 hours
Bulb cost per hour of life: .367¢
Incandescent bulb cost per kw-hr used: 1.21¢

7. <u>Comparative costs per month:</u>

a. Original Nominal Configuration:

40 classrooms, each equipped with 4-300 watt incandescent bulbs:

40 rooms x 20 days/mo. x 4 bulbs per room x 0.3 kw/bulb x 6.4 hrs/day = 6144 kwh/month

Power cost per kwh:	$0.063
Bulb cost per Kwh (per Section 6) Section 6)	.012
Total costs per Kwh	.075

Total monthly costs 40 classrooms with 300-watt incandescent bulbs: $460.80

b. <u>HPS Configuration</u>

40 classrooms with 4-HPS @ 0.175 Kw each: 3584 Kwh/mo.

Power cost per Kwh:	$ .063
Bulb costs per Kwh (Section 6)	.005
Operating cost per Kw	$ .068

Total monthly costs, 40 classrooms with HPS bulbs $243.70

8. <u>Calculated Savings, Public School No. 6</u>

160 units 150 watt HPS lights vs 300 watt incandescent Per 20-schoolday month:

	Total power Consumed per month Kwh	Power cost	Apportioned Bulb Cost	Total Cost
300 watt Incandescent	6144	$387.10	$74.34	$461.44
150 watt HPS	3584*	$225.80	$17.90	$243.70
Difference (Saving)	2560	$161.30	$56.44	$217.74

*including 25 watts ballast power per bulb.

Thus, average monthly savings attributable to the use of HPS lights for Public School No. 6 under the assumptions described are $217 per month or 47% of operating costs for the original 300-watt incandescent installation. This represents an overall payback of $1,954 for a 9-month school year.

Appendix C-3

QUESTIONAIRE RE CLASSROOM LIGHT PHOTOCELL CONTROLLERS, P.S. #40

PLEASE PRINT

Teacher name: ______________________ Date: ______________

Grade: __________ Classroom: __________ No. Pupils: __________

Please check all responses you consider appropriate for the way the photo-controller works since repairs were made recently.

1. I find the blending of artificial and natural light by the photocontroller:
   - ____ a. acceptable
   - ____ b. pleasant
   - ____ c. unpleasant

2. The photocontroller action in switching the outer banks of lights is:
   - ____ a. noticeable
   - ____ b. not usually noticeable
   - ____ c. annoying
   - ____ d. too abrupt
   - ____ e. too frequent

3. The light level maintained by use of sunlight with the controller is:
   - ____ a. adequate
   - ____ b. too high
   - ____ c. too low
   - ____ d. too variable

4. With the controller, blackboard glare is:
   - ____ a. a minor problem
   - ____ b. a major problem
   - ____ c. no problem
   - ____ d. correctable by use of blinds

5. With the controller in use, I keep the window blinds:
   - ____ a. down all the time
   - ____ b. down some of the time
   - ____ c. up
   - ____ d. down when necessary to prevent blackboard glare

6. I offer the following comments and recommendations regarding the use and usefulness of the photocell light controller for school classrooms:

____

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____

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