Lighting and Mechanical Progress in Universities

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ILLUMINATION PRACTICE is presently at a low ebb. Illumination engineering has been dropped from the engineering curriculum, teachers of illumination are nearly a departed breed, and the expertise available to architects lies in the commerical engineering firms. These firms are largely geared to the demands for dramatic lighting required by the commercial world, and lighting quality is of little consequence to them. As a result, very few libraries built since the war have good lighting.

This fact is ironic since illumination engineering is an exact science, and the basics of handling lighting equipment to achieve good quality illumination have been available since 1948 in a simple forty-page pamphlet, written for the nonspecialist, entitled *American Standard Guide for School Lighting.*[1] Since then similar information has been easily available in other publications.

The physiological problem is simple. The pupil of the eye contracts in the presence of glare, which causes visual discomfort. Two procedures can then be followed—the glare can be reduced to an acceptable level so that at comparatively low intensities enough light gets into the eye for effective vision, or the intensity of illumination can be increased to the point where enough light will get into the eye, even though the pupil is nearly closed. Reasonable men prefer the former procedure; lighting companies the latter. For the past decade, library lighting practice has been running heavily in the direction of the lighting companies. While severe glare is the condition of most library lighting, the tendency to provide ever higher levels of intensity, running upward of 100 foot-candles, has greatly increased, and this has exaggerated even more the glare problem.

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Glare is of two kinds—reflected, which reflects light sources immediately overhead from the work task, and direct, from light sources in the line of vision. It is impossible to eliminate glare completely, but it can easily be controlled. Reflected glare can be controlled by interposing a translucent panel, in the form of a lens, between the light source (the bulb or tube) and the work task. If you use open-bottom eggcrate louvres or incandescent down-light cans, it is impossible to control the reflected glare. Since the intensity of the source in down-light fixtures is usually greater, and its light diffusion is poor, it is the worst possible kind of fixture for library areas.

The lens used must be far enough from the light source (at least four and one-half to five inches) so that the bulb or tube image does not show through the lens to any marked degree. If it does, reflected glare can be nearly as intense as that of an unshielded source. In addition, the lens must be of a material that diffuses light from the source extremely well. (Buildings incorporating many of the mechanical and electrical features mentioned in this article are listed in Appendix I.) Properly constructed fixtures with good diffusing lenses, which control reflected glare, can still have a good deal of direct glare if the lenses used are of high surface brightness. The lenses must be of low surface brightness, and it is possible for most people to determine whether the brightness of a lens produces visual discomfort merely by looking up at it. Opalescent lenses, of glass or plastic, diffuse well, although the quality of diffusion varies, and glass lenses are the more expensive. Prismatic lenses made of glass are useless because the tubes show through them badly and they have an extremely high surface brightness.

Plastic prismatic lenses can be extremely effective, if they have low surface brightness. Many of them do not, and the fixtures proposed for a library must be inspected in a mock-up of at least four units, spaced as proposed in the plans, and containing exactly the same kind and the same number of tubes as proposed in the plans. Lighting plans must not be approved before determining that the basic fixtures in them are satisfactory.

Recently, there has been a tendency to use plastic diffusing lenses of a flat, translucent kind, above eggcrate louvres, and while this reduces the efficiency of the fixture, it solves the problem of surface brightness since the louvres effectively conceal the lenses from the eye. Parawedge louvres which have a 45 degree cut-off for the light, effectively control the surface brightness of even large or total areas of ceiling, but they produce an uncomfortable feeling since there is absolutely no light visible on the ceiling or upper walls of the room. These are open-bottom louvres, and, as in the case of eggcrate louvres, must be used in combination with a translucent lens to control reflected glare.

Good quality fixtures used only in limited numbers present a shadow problem. In present day libraries which use freestanding carrels with baffles, bookshelves, and often side-baffles, lighting that casts shadows makes readers feel that they are in a cell. Shadows can be dispelled by using a large number of light sources, rather than a few, high-powered sources.

Blackwell has shown that the quality of lighting improves as the portion of the ceiling covered with light increases.[2] In the case of a luminous ceiling, in which the entire ceiling produces light, there are no shadows at all. (One must not confuse a ceiling composed of open eggcrate louvres, which is rife with reflected glare, with a luminous ceiling that uses a shield under the tubes.)

The effectiveness of luminous ceilings depends heavily on the interreflection of light within an area, as it bounces endlessly from one surface to another in a compound way. This interreflection, which begins with multiplication of fixtures, depends greatly on the reflectances of the surfaces in the area—ceilings, walls, floors, equipment, furniture—and these themselves can be a source of undesirable glare. Reflectances should be between 30 percent and 80 percent for all surfaces, none of which should be glossy. Matte finishes should be used. Carpeting, which is entirely free from glare, is preferable to any other floor surface from this point of view alone.

The centrality of quality in lighting was brought sharply to the fore by H. Richard Blackwell in papers published in 1959 and subsequently.[3] While his discoveries were not radically new, his impressive claims for the superiority of multi-layer polarized lenses to produce high quality lighting resulted in unprecedented interest in this type of lens.

The past decade has produced attacks on his contentions that cannot be ignored, notably by Crouch and Kaufman in *Illuminating Engineering*,[4] and by Fairbanks in two papers delivered in 1963.[5] The evidence indicates that polarized panels are not the ultimate solution that Blackwell thought them to be.

Multi-layer polarized lenses cut illumination efficiency by about 50 percent, which requires a much higher wattage in the light sources than comparable general diffusing lens fixtures. This adds greatly to the heat load, to the cost of air-conditioning equipment, and to the cost of power for maintaining the lighting system. All this is in addition to an initially high premium cost for installation of these lenses.

Nonetheless, these lenses have been installed in the libraries at Austin Peay State College, the University of Nevada, the University of Northern Iowa (Cedar Falls), Miami-Dade Junior College, and the Meyer Undergraduate Library at Stanford. At least two of these installations maintain intensity at ninety foot-candles. I have studied the installations at Miami-Dade which is pleasant and comfortable, and at Stanford, where the lighting, although of reasonably good quality, contains a noticeable amount of glare. Stanford uses three-foot square fixtures, and recent research indicates that larger fixtures produce greater visual discomfort. But, as Fairbanks makes clear, polarization of light results in two different kinds of polarized light, one of which is not yet coped with by any commercially available lens.

It is not necessary to use polarized panels to obtain totally good quality lighting. To achieve this with other kinds of lenses requires exploration with the aid of good consultation. The architect will probably be of little help. If one is totally dependent on the architect, and can afford it, he can be reasonably sure of getting good quality lighting by the use of multi-layer polarized panels. But because they will hold higher intensities is no reason to go above seventy foot-candles for reading areas.

After well-designed luminous ceilings, indirect lighting produces the best quality lighting, but it is used infrequently. It, too, requires proper design to avoid glare on the ceilings, which becomes the immediate source of light; it is of great importance to keep dust off the ceiling surface. Indirect lighting appears in the form of cove lighting in some buildings, but used improperly it can produce great irregularities of intensity.

While problems of quality in lighting are easily resolved, problems of desirable intensity are not. Keyes Metcalf indicates clearly that response to lighting intensity is a cultural phenomenon, conditioned by expectations generated by lighting intensities in other buildings.[6] Wide variations of opinions exist, and it is not clear whether they are based on experience with good quality or bad quality lighting. In my opinion, in the kind of large, open areas that characterize reading and stack areas of libraries, less than fifty-five foot-candles of good quality lighting produces a feeling of dullness in the decor; more than seventy foot-candles is a waste of money. Either produces good reading light.

There is no practical necessity for varying intensities throughout the building if it has good quality light; and there are good reasons for not doing so. Many people have tolerance of a range of intensities, but I have yet to meet anyone who prefers a given level of intensity. Those who have complained about high intensity light in buildings on which I could check have been referring to heavily glaring light. At 120 foot-candles in Yale's Beinecke Library reading rooms, readers find it comfortable to study for full days on end. I have heard many complaints about low intensity light, below forty foot-candles. If intensities change between public areas, it is psychologically irritating to be constantly adjusting. In a library, where a reader wanders throughout the entire stack area to get books, it is confusing to have to pick out an intensity of lighting from more than one.

Stack lighting should not be centered on stack aisles except in large research collection stacks where it is virtually certain that the stacks will never be moved. There is now a stack lighting fixture that uses two-way parabolic baffles with a 39 degree cut-off, which distributes light with reasonable evenness over the seven stack shelves. However, these are very bad fixtures for reading areas, and if they are used, it will not be possible to convert the stacks to reading without changing the fixtures. The same kind of lighting should be used in stack areas as in the rest of the building, except in research stacks.

Rare book areas require Verd-a-ray Fadex tubes, or the use of UFII or III Plexiglas to prevent book and paper damage from the ultra-violet light from fluorescent tubes. All fixtures in these areas should have fused ballasts, to prevent the dripping of hot liquids that often accompanies the burning out of ordinary ballasts.

There has been a movement for some time to set up practical measurements that will assure the installation of quality lighting in schools. In 1962, the Illuminating Engineering Society introduced the scissors curve graph as a test for discomfort glare.[7] Present work on a revision of the *American Standard Guide for School Lighting* will present, as successor to the scissors curve, an equal-area equal-glare effect diagram. Research in the field on loss of contrast between the print and the page due to veiling reflectances from overhead fixtures is underway to determine criteria for reducing it. Also underway is research on a visual comfort probability index in the direct glare zone. These three criteria, when established and used together, will allow the determination of which fixtures are acceptable for good quality lighting and how they should be laid out.

While it is possible for an earnest layman to learn to recognize glare as soon as encountered, to distinguish by eye degrees of comparative glare, and to recognize lenses too bright for comfort, the use of an expert lighting consultant is essential in the development of lighting design for a library. The library must have a lighting consultant to represent its interests in addition to the consultant working for the architect's electrical engineers.

The consultant should be involved as soon as the basic fixture is proposed for the building. He must review lighting layout plans coded for fixtures and review independent testing laboratory spectromatic data on each fixture. He should be involved in approving samples of the actual fixtures to be used.

Specifications for the building must specify by manufacturer and number all fixtures to be supplied in the contract. If substitutions are proposed under an "or equal" clause, the consultant must be reinvolved until final acceptance is completed. Architects are remarkably inept in evaluating lighting. They work primarily with the advice of commercial firms whose main concern is selling the product; nothing is adequate to assure good lighting short of the most intensive efforts on the part of the client.

Turning now to power requirements, the most significant factor is that access to power may be required in the future at any point in the building. Total flexibility can be achieved by providing a double (hollow) floor, but the cost is prohibitive for such a floor strong enough to hold a load of 150 pounds per square foot. The alternative is to put in as much underfloor conduit as the library can afford when building in hopes that it will be sufficient for future needs. The demand for larger size conduit increases, the largest space demands coming from cables. Coaxial cable for television and low voltage wiring for some audio systems must be shielded if they are run in the same conduit with standard electric wiring; this takes even greater space. Requirements for two inch diameter conduit are not unusual, and future prospects probably make advisable the installation of something like Walker ducts, about three inches deep and six inches wide.

Although machines that require 220 volts are still used in libraries, nearly everything, including computers,[8] is headed for lower voltage (ordinary house current) requirements; but there are requirements for higher amperage connected with many machines, and heavier wiring must be used. An increasing number of machines require single lines (private wires, as it were), to avoid surges in the power supply. This is true for Xerox machines, Sentronic machines, and especially computers. A large number of audio-visual machines are becoming transistorized, freeing them from dependence even on electric plugs. These devices, plus wireless transmission from tape decks to local earphones, will probably make dial access capabilities not worth the cost within the foreseeable future.

More than ever these facts place a premium on writing a building program that details completely the equipment to be used in every room. It is almost mandatory to consult equipment suppliers for power and conduit requirements when writing the program. A separate detailed program sheet should summarize the special electrical requirements for each room in the library building that requires them.

Ventilation systems using overhead duct-fed diffusers, which have long been used, are now rivaled by air-supply ceilings. These hang acoustical tile to form a ceiling cavity into which tempered air is introduced under pressure. It then descends into the room through holes in the tile. Tiles which provide one-eighth inch round holes should be avoided since they tend to clog with dust. Slotted tiles or slots in the splines on which the ceiling hangs are preferable.

This ceiling must be made completely air-tight. It is therefore unsuitable if the ceiling contains much ductwork, pipes, or conduit which require frequent repair, since it is impossible to maintain air-tightness under such conditions. An air supply ceiling prevents use of the ceiling cavity as an air return plenum, which is often done to remove 30 to 50 percent of the heat generated by the light fixtures before it gets into a room.

Air-supply ceilings are just as difficult to balance as those using duct-fed diffusers, and hot and cold spots result as often in the one system as in the other. However, air-supply ceilings are comparable in cost to duct-fed diffusers, and they have the advantage of being able to supply a large volume of air with minimal noise. They should be considered for high heat-generating rooms, such as computer rooms.

Overhead radiant heating systems are available which use running hot water or electric coils as a source. The former is installed above the outer bay areas in the nearly completed library at Towson State College, Maryland; the risk of water damage will, however, make most libraries hesitate ever to place stacks under them. Both systems suffer the disadvantage that the feeling of heat radiating from overhead systems is oppressive, and that the ceiling area occupied by such equipment is not available to provide cooled air in the summer. Infra-red radiant heating is occasionally mentioned in library literature even though it is most intensely uncomfortable when radiating, and only crudely controllable.

Tempering systems for the periphery of the building include floor-distributed air systems, fin tubes, induction units, and fancoil units. Electric radiant heat can be supplied through baseboard units. If used, they should be far enough from feet to be comfortable. Fin tubes do not supply enough heat rise in very cold weather in any building I have observed. On exterior window walls, where they tend to be used, they induce convection currents that are extremely drafty.

Combinations of air-diffusion and return with light fixtures have been used in some libraries. There is an advantage in using the heat of the fixture as a supplement to the general heat source in winter, and in preventing heat from coming into the room in the summer, but in my experience the great sophistication required to take advantage of either of these factors economically has prevented any such system from providing completely good ventilation conditions. It generates a considerable problem in distributing dust over the lenses of the lighting fixtures.

The future will offer systems that use water-cooled light troffers and window blinds (see Appendix II) to reduce these two sources of heat, and the use of heat from the lighting system to produce thermo-electric cooling.

Experience with current technology as it relates to buildings makes it clear that a good ventilation engineering consultant should be used on all library buildings, beginning with the design development stage of architects' drawings and that a professional air-balancing firm should be hired to make sure that the system as installed is as specified (very many of them are not), and that it is working to its maximum capacity. The ventilation system costs about 20 percent of the total building cost, and operating it at 30 percent effectiveness is a fantastic waste of money.

Our knowledge of psychological acoustics—how people react to sound levels—is rudimentary indeed. I have seen a student studying intently for some time about twenty feet removed from a jackhammer actively tearing out an interior fieldstone wall. In an experiment with music piped through the Pennsylvania State University Library, the response of the graduate students was heavily favorable. However, most librarians over many years have had experience with the large number of students who object to sound distractions.

Sound can be masked, and it should be standard library practice to program into its ventilation system a low backgroud noise to mask traffic noises, light-ballast hum, and quiet conversation, all of which occur in a library. Noise that originates from machines (elevators, duplicating machines, typewriters) can be controlled by removing the noise source from the distressed area, baffling it, or absorbing it.

A basic factor in acoustics, therefore, is the layout of the library elements, and if an acoustical consultant is to be used on the building (very few libraries have hired such consultants to represent them), he should be brought into the planning early in the floor plan stage. Noises in the ventilation system which can easily be prevented during the design stage, if reviewed by a consultant, can be remedied only at great cost after the building is completed.

If sound-producing areas are adjacent to areas requiring quiet, the walls separating them can be specially designed to prevent passage of noise. Frequently rooms containing dropped ceilings are so treated, with no provision for preventing the passage of noise through the dropped ceiling above the wall barrier.

The bounce of noise between the floor and the ceiling is one of the greatest noise sources. The greatest single acoustical treatment in a building is floor carpeting (which also, in one stroke, removes a major source of illumination glare). If carpeting is used, it is possible to omit acoustical treatment of the ceiling with no great hazard. Most libraries take the precaution of treating the ceiling anyway, either with sprayed acoustical plaster, acoustical tile, or perforated metal pans lined with insulating materials.

If rooms are provided in which students can generate noise—easily available small group conference rooms, smoking lounges—it reduces the incidence of distracting conversation levels in reading areas. The greatest myth in controlled acoustics in libraries is the typing carrel—an open carrel, with front and side baffles faced with acoustical absorbing materials, placed in open stack areas; it never works. If typing noise is to be confined, it has to be contained in a room, which must either be remote from reading areas or specially treated acoustically.

Vertical transportation has become a more important factor in the number of high-rise library buildings recently built. The largest yet planned, twenty-nine stories, is at the University of Massachusetts, Amherst. A system of high speed elevators which specialize in the floors at which they land, long tested in commercial buildings, is used in these libraries. In addition, contemporary elevators which are connected to the equivalent of a baby computer have capabilities of sophisticated manipulation. They can search and creep, when not being called, two floors, three floors, whatever is desired; they can return to fixed floors; they can accept only down calls or up calls, etc.

It is extremely important to spend a great deal of time programming requirements for elevators if they are complex at all. Initial wiring of elevators is time consuming and expensive, but along with the basic wiring can be included a wide range of special requirement wiring at comparatively little extra cost. After the installation is made, changes are very costly.

Since libraries tend to accumulate the facilities receiving the greatest use on the main, second and lower floors, the use of escalators to connect these three floors can help solve problems of heavy elevator traffic. Escalators are used for this purpose at the University of Miami, Coral Gables; in the Columbia Law School building they connect the main floor with the library on the third floor in one unbroken rise. Escalators can move a very heavy volume of traffic (such as classroom surges) very rapidly. They cost less to install than elevators, and are cheaper to run.

A two-way escalator connecting two floors, however, uses more square footage than an equivalent of eight elevators. Both ends of it must mesh logically with all other traffic patterns on both floors—a very difficult goal to achieve—and it adds one more long immovable space to the inflexibilities of a building making it mandatory that it be part of a service core area. Careful choice of the equipment is necessary to assure silent and vibrationless operation. Escalators, of course, cannot be used for the transport of books or booktrucks.

Freight elevators, capable of lifting very heavy weights very slowly, are of little use to a library which requires all of its elevators to move at passenger speed. Book lifts which require loading books in and out of the lift are a waste of time, compared to moving loaded booktrucks on elevators. For small installations it is possible to supply tiny elevators able to move only a single truck at a time, very cheaply.

A large volume of circulation in university libraries calls for the use of automatic book conveyor systems. Endless chain conveyor baskets have been used in libraries since the early 1920's. The one in the New York Public Library is a simple vertical chain; those installed in the Yale University Library and the main building of the Library of Congress at a later date combine both vertical and horizontal movement. Endless chains with the capability of popping out book containers at pre-prescribed floors are in use in a number of libraries. Vertical transportation of books between branch libraries, using pneumatic tubes, was first installed between the Library of Congress's main building and annex. It is extremely fast but hard on books transported. A similar system installed between the main library and the Graduate Research Library at the University of California, Los Angeles, has apparently solved the problem of book damage.

The Mosler Safe Company has recently announced a European-Mosler/ Telelift (see Appendix II), which sounds extremely interesting. It uses electrically powered, self-propelled cars, with inside dimensions of five by twelve by fifteen inches, that run on flanged tracks and can be set to move from any station to any other station in a system of up to 1,000 locations. Since the tracks run on walls or ceilings, vertical openings in floors are very small compared to any other conveying system. There are as yet no installations in the United States.

Two-way communication in libraries is possible through closed circuit television, which is far too expensive to be practicable. Communication is mostly restricted to variations of old established devices. Clumsy intercom phone devices have largely disappeared with the spread of Centrex telephone systems which provide quick direct dialing within the building. Many libraries now provide telephone jacks in the face of their card catalogs to allow reference librarians to answer questions from the catalog drawer open in front of them.

Staff, faculty or patrons can be summoned to answer stack-located telephones by the use of a gentle chime signal system which is activated by an automatic code-setter, or by carrying a small radio receiver the size of a cigarette package, which gives out a beep tone only in the one signal receiver. These devices have a five-mile receiving radius, but women who lack pockets take less kindly to them than men. Similarly coded mono-receiving units can receive voice messages audible only to the carrier of the unit.

One- or two-way radios or line-connected intercom systems can be used between circulation offices and stack attendents, but the noise they produce at the stack end must be carefully controlled. Public-address systems throughout the building for announcing closing time are more effective than Klaxon horns, but their transmitter must be secured to keep students from playing with it. Audio systems have been used to play music in parts or all of library buildings, with mixed results.

Transmission of written messages or call slips through cylindrical pneumatic delivery tubes has long been used, and it is now possible to deliver IBM-type call slips to stack attendents by blower systems. Light-alarm panel boards can detect the opening of any of a number of fire exit doors required on the lower level of large university libraries.

An ingenious bibliophone system in a fixed location library, the Technische Hogeschool, Delft, Netherlands, allows the patron, by dialing his book number to signal the stack page the exact book required.[9] The system combines a dial phone and a small computer. The book is then delivered by a clever, spiral, book chute (an inverted arc in cross section) which delivers books of any weight from the stack floors to the circulation desk at a uniform, non-accelerating, rate of speed. It sounds fascinating, and a great space-eater.

A telephone located in the vestibule to give general directions about using the Delft Library has been adapted in an instructional telephone system at the Hofstra University Library. By lifting a telephone, labeled for its use, the student receives instructions on general layout and services of the library, or how to use the card catalog (accompanied by a model set of catalog cards), or how to use periodical indexes. The phones are separately connected to continuous loop tapes which are activated by lifting the telephone.

Mechanical security systems are now available to prevent the theft of books. Two now in use work on a magnetic principle; a metal wafer is placed in each book and magnetized when sent to the shelves. In the Sentronic system, it is demagnetized when the book is charged out. If anyone tries to take a magnetized book past the sensing posts at the library exit, an electric current is activated, and can be used to activate anything responsive to electricity. The most effective device is a turnstile that locks when activated by an illegal (not-demagnetized) book. In the Checkpoint system, the book is not demagnetized, but handed to a library staff member who passes it around behind the sensing posts. Illegal passage can be blocked in the same way as in the Sentronic system. Over a period of years, these systems are cheaper than the cost of a human guard system.

The bug in both these systems arises from the fact that a number of objects commonly carried by readers contain enough metal, which has been magnetized in the manufacturing process, to activate the sensing posts. Consequently, large numbers of false alarms occur, with the expected subsequent difficulties with outraged patrons.

A new system offered by the Monere Corporation (see Appendix II) works on a non-magnetic principle. The company states that it involves radio transmission, and shorting out the transmission. In the active state, it will activate sensing posts at the exit as in the other two systems, but false alarms from metal frames are not possible. This system has not yet been tested in libraries, and it is more expensive than the other two. None of these systems can satisfactorily guard current issues of periodicals, one of the most vulnerable parts of the library.

Fire control by sprinkler heads should be avoided in any book storage areas of a library, since water is a greater destroyer of books than fire. Rather, mechanical devices to detect combustion in its early stages should be used for fire protection. The fire station that will respond to a library's fires should be briefed in advance about precautions necessary in extinguishing fires in a library, especially in connection with rare book units.

Ceiling mounted heat- or smoke-detecting units are available from a number of companies. The most sensitive, which are also the most expensive, respond to changes in the ionization of air caused by combustion. They should be connected to a light indicator recording panel at the circulation desk, or some other prominent area in a large building, so that those responsible for protection of the building can immediately see where the fire is located. Heat detection systems that drop dampers and shut off ventilation fans should be mounted in strategic locations in the ventilation duct system. The entire system should be wired directly to ring an alarm at a local security station or a fire station to insure early response to the fire.

In the case of rare book vaults which require special protection, sophisticated automatic or hand-activated carbon dioxide discharge systems which flood the area with fire-smothering gas are available. The system installed in the Beinecke Library at Yale University can discharge two full charges and still have a small charge in reserve.

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APPENDIX I

Locations of Lighting and Mechanical Installations

Downlights: Brainboilers—Grinnell College Library (Circulation desk)
Swarthmore College Library (Circulation desk and top floor carrels)
Blinders—Mendel Gottesman Library, Yeshiva University
Beinecke Library, Yale University (Offices and card catalog room)
Bronfman Science Library, Williams College

Glass prismatic lenses: Loomis School, Connecticut (main floor)

Plastic prismatic lenses: Hofstra University (the lowest brightness I have ever seen)

Combination plastic panel and eggcrate louvres: Beinecke Library, Yale University (reading room)

Parawedge louvres: Banker's Trust Building, 280 Park Avenue, N.Y.

Luminous ceiling: Miami-Dade Junior College, Florida

The best quality lighting installation: Colorado College Library, Colorado Springs
It cost $28.00 per fixture, including the two tubes, in 1960, thanks to Prof. John O. Kraehenbuehl.

Indirect lighting: Groton School Library, Massachusetts (reading room)

Cove lighting: Los Gatos High School Library, California

The best presently available stack light: Rice University Library Addition
Countway Library, Harvard University, where the baffles are of white enamel. It is run at right angles to the stacks, and this fixture does not work well that way.

Verd-a-ray Fadex tubes: Huntington Museum, Long Island
Metropolitan Museum of Art, N.Y.
Smithsonian Institution

Air-supply ceiling: Adelphi University

Peripheral induction air units: Cornell University, Olin Library
Brown University, Rockefeller Library

Fancoil units: Hofstra University Library

Typing carrels: Brown University, Rockefeller Library

Appendix I

Endless chain systems: N.Y. Public Library (vertical)
Library of Congress, Yale University Library (vertical and horizontal)

Pop-out box system: Brown University, Rockefeller Library
University of California Library, Berkeley

Telephone jacks at catalogs: Brown University, Rockefeller Library
Hofstra University Library

Chime system: Colorado College Library
Hofstra University Library

Beep-tone system: Countway Library, Harvard University
Cornell University, Olin Library
Williams College Library

One-way radio receivers: Brown University, Rockefeller Library

Light-alarm exit detector panel: Hofstra University Library

Sentronic exit control: Western Michigan University Library
Miami-Dade Junior College Library

Checkpoint exit control: Free Library of Philadelphia, Frankford Branch
Yale Medical Library

APPENDIX II

New Mechanical Systems for Libraries

Water cooled troffers and blinds: Lite-Therm, by Environmental Systems Corp., Conyers, Georgia

Automatic vertical and horizontal conveying system: Mosler-Airmatic Systems Division
415 Paterson Hamburg Turnpike
Wayne, N.J. 07470

Mechanical security system for library books: Monere Corporation
15 Hunting Hill Road
Woodbury, N.Y. 11747