EVALUATION OF
AN AIRPORT LIGHTING CONTROL AND DISPLAY SYSTEM

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FINAL REPORT

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NOTICE

This document is disseminated under the sponsorship of the Department of Transportation in the interest of information exchange. The United States Government assumes no liability for its contents or use thereof.
This report describes the techniques used and presents the result of tests that were conducted to evaluate an airport lighting control and display system to determine its suitability to control airport lighting. A mimic control and display system was developed and installed at the National Aviation Facilities Experimental Center (NAFEC). It was tested to determine its ability to: 1. expedite the operations of the air traffic controller, 2. reduce power consumption by airport regulators in the field, and 3. reduce training time. The result of the tests indicates that the mimic control and display system is very suitable for airport operations and that only economic considerations would be a determining factor in not using it. It was recommended that the system be used in any airport where multiple runways and taxiway paths exist, and also that a program be established to further determine any method that would reduce the cost of design and installation.
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INTRODUCTION

PURPOSE.

The purpose of this program was to develop a lighting control and display system to be employed in an operating air traffic control tower. This system would control the lighting systems normally operated by a Federal Aviation Administration (FAA) lighting control panel, FAA Advisory Circular 150/5345-3B, specification L-821. The system would be required to: 1. use minimal console space; 2. be extremely easy to operate; 3. indicate to the tower operator the status of the lighting on the airfield at a glance; 4. increase controller efficiency by speeding up operations; and, 5. reduce electric power consumption by allowing the air traffic controller to operate only necessary field lighting circuits.

BACKGROUND.

Lighting control panels in air traffic control towers have grown over the last 30 years to systems that encompass large sections of the control console but basically do not present to the operator a visual cue as to the operating functions of his runway and taxiway lights.

Figure 1 shows a panel presently used and considered satisfactory for operation by air traffic control (ATC) personnel. The complete disarray of controls and lack of reasonable man-to-machine interface is quite evident. This panel, although not an FAA specification L-821, is representative of others used in the field. Methods have been developed during the last 8 years to minimize console space requirements and to better organize lighting controls. Unfortunately, the methods developed, although generally satisfactory to the electrical engineer, do not present much background to the tower operator as to the overall field lighting. In addition, a learning period, sometimes excessively long, is required to determine the functions of specific controls. These statements are true for most airports that have multiple illuminated runways and various taxiway paths for aircraft operations.

DISCUSSION

THEORY OF OPERATION.

In this program for designing a mimic control and display panel it was decided that the only system of control that would satisfactorily meet all the operator's requirements would be one which operated directly on a "mimic panel." In such a system the controls, of which there would be a minimum number, would be situated on a display panel depicting the runways and taxiways they operated. In the case of runways, the display would indicate the activation of field lighting circuits by a light on the control located over the runway display. In the case of taxiways, the taxiway display operated would itself be illuminated, as well as the control.
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FIGURE 1. TYPICAL LIGHTING CONTROL SYSTEM USED IN AIR TRAFFIC CONTROL TOWERS
This display operation would be controlled by a voltage feed from circuits controlling the regulator used to operate that portion of the field in use. This would indicate that the regulator was at least energized by 120 volts alternating current. Although this would not indicate positively that the lights on the field were energized it would at least give an indication that portions of the system were activated. This was considered adequate since this is much more than is now available under the FAA specification L-821, which has no means of monitoring.

It was considered that full monitoring of the lighting systems at this time would be prohibitively costly, although not beyond the present state-of-the-art. It would be conceivable that such a system monitoring would be used for a category II and III airport. These would be specific cases and could easily be developed, but were not considered warranted for general airport lighting operations.

**DESIGN REQUIREMENTS.**

The construction and design of specific hardware for the mimic panel and the interfacing circuitry was assigned to A.S.E., Inc. of Pennsauken, N.J., under Contract DOT-FA72WA-3043. The following requirements were placed on the equipment:

1. A mimic panel would indicate the "ON-OFF" status of the runway and taxiway lighting.
2. Minimal brightness controls would be used; one control for runway operations and one control for taxiway operations.
3. The mimic panel and associated controls would operate all field lighting, other than approach lighting.
4. The panel would be minimal in size.
5. Individual taxiway segments that direct aircraft taxiing procedures would operate independently of one another and would be displayed upon the mimic panel.
6. The operation of the panel would require minimal field training by its operator.
7. Controls, other than taxiway and runway standard lighting, would be mounted on the control panel but operations would not be displayed. The lights operated on the display would be the runway edge and associated threshold lighting and, in the case of the taxiway, the display would include the edge and centerline lighting.
8. Maintenance and repair would be minimal.

The contractor developed several mockup units, of which one was acceptable to the airport engineers at the National Aviation Facilities Experimental Center (NAFEC) as well as to the controllers at the NAFEC tower.

SYSTEM DESIGN.

The mimic control system (MCS) has been developed to provide the airport controller with a control panel that presents a visual display of the airport lighting systems that are in operation. The system is easier to operate than the present L-821-type controls. This system will enhance the controller's ability to control and monitor the runway and taxiway lighting, resulting in safer and more efficient use of the airport lighting aids and an associated saving in electrical power consumption.

The MCS has two principal components:

1. The mimic control panel located in the control console of the air traffic control tower cab.

2. The relay control box, located electrically between the mimic control panel and the input to the regulators. Physically, the relay control box can be located either in the control tower or in the regulator vault. The latter location is preferred for ease of maintenance and repairs. Interconnecting cables are also required between the two MCS components and into the control side of the regulators.

The mimic control panel, as shown in figure 2, consists of:

1. A plexiglas panel with a visual display of the airport taxiways, runways, and primary landmarks; hence, the title "mimic panel."

2. Lighted pushbutton switches adjacent to each mimic panel taxiway to operate the regulator for the lights in the corresponding airport taxiway.

3. Light guides, located behind the mimic panel, that illuminate the mimic panel taxiway when the relay sending the control signal to the associated regulator has been closed. For ease of identification, the mimic panel taxiways are illuminated in four colors; red, yellow, blue, and green.

4. Lighted pushbuttons located at the end of each mimic runway. They operate the regulator for the corresponding airport runway lights. The pushbutton is illuminated when the relay sending the control signal to the associated regulator has been closed.

5. Rotary switches which are used to control the brightness level of the airport taxiway and runway lights. One switch controls the intensity of all the taxiway lights; i.e., all taxiway lights will be of the same brightness level. Similarly, one switch controls the intensity of all the runway lights.
FIGURE 2. MIMIC CONTROL PANEL
The mimic panel is mounted on the hinged door of an L-821-type box, thus providing access to the back of the panel for maintenance. Thermostatically controlled fans are mounted in the box to provide cooling if the control tower cab becomes excessively hot. Normally the fans do not run. Rotary and toggle switches are located on the door adjacent to the mimic panel. At NAFEC these switches control the operation of the regulators for:

1. Runway 13/31 centerline lights—25- and 50-foot spacing
2. Runway 13/31 touchdown zone lights
3. Wind indicator
4. Wind indicator blinker
5. Beacon

The relay control box (figure 3) consists of the wiring circuitry, relays, resistors, etc., necessary to control the electrical signal to the regulator. When the pushbutton switch on the mimic panel is operated, the associated relay is actuated, thereby sending an electrical command signal to the regulator. Other contacts on that same relay send a signal back to the mimic panel controlling the light guide and/or the pushbutton light. Thus, the mimic panel display is of the status of the control relays. If it were desired, the mimic panel could be made to monitor the status of regulators or the actual lights.

The rotary switches also operate relays to control the brightness level settings of the regulators. Resistors are used in the circuit to provide specific brightness levels for the so-called "stepless" regulators.

The system is configured to transmit the same input signals to the regulators as are transmitted by the existing L-821-type controls. Therefore, the regulators do not have to be modified for the mimic panel control system conversion.

This system was installed in a newly modernized control console in the NAFEC tower. It was the only means of control that the tower operators had over their lighting systems.

TEST PROCEDURES.

The only tests performed on the system were operational and determinations of the maintainability of the system. Hardware evaluation was not considered a factor since the items used in the design were all off-the-shelf and built to the best commercial standards. No nonstandard or uniquely-developed components or circuits were employed.
FIGURE 3. RELAY CONTROL BOX
TEST RESULTS.

GENERAL. By the time the system, (see figure 4), which presents the controller with a picture of the field's lighting operation, had been in use for 10 months, it had received unanimous acceptance by the tower operators. Other ATC personnel were asked to view the system, either directly or from photographs, and it received no adverse criticism. The operation proved to be almost foolproof and required very minimal ATC training.

The concept of a single brightness control for taxiways and runways proved satisfactory with the exception of cases in which the field had runways of different intensities (high and medium intensity runway lights). In such cases the brightness controls for the various intensities had to be separated, or at least modified.

At NAFEC the five-step brightness associated with high intensity runway lighting was modified so that when the brightness control was on step 1 the medium intensity lighting was on low, when on brightness step 2 the medium intensity lighting was on medium, and when on brightness step 3, 4, or 5, the medium intensity lighting was on high. This modification made it possible to operate two different intensity type runways at the same time, the lighting being compatible. It might be conceivable that the services would rather have separate controls for medium and high intensity runway lights. In this case the medium intensity control would have but three-step brightness.

MAINTENANCE. During the test period a lamp on the mimic panel failed and was easily replaced. It should be noted that to assure maximum lamp life all lamps were operated below their normal operating voltage. Since the installation, no other maintenance or repairs have been required. Since the system operates on movable switches and relays, and avoids the trap of solid state switching, it is felt that minimal maintenance procedures training is required. The contractor met all requirements as to maintenance and operations without exception. The complete design plans are available at NAFEC upon request.

The very modular design of the system tends to make it extremely simple to maintain. Switches and control relays operate the regulators and feed information back to the display in the form of an electrical signal to indicate operation. Any interruption of the signal in the system may readily be detected by the failure of a relay to operate and of a light display to indicate. The mimic panel is plugged into the cabling through Cannon plugs and therefore may be easily removed for maintenance and/or repairs.

ECONOMICS. The direct cost for installation, design, and development at NAFEC was approximately $30,000. This cannot be considered excessive due to the fact that it incorporated the construction, installation, and development costs. It is not likely that this type of unit will ever be inexpensive to build and install or will compare in price with the FAA specification L-821. The cost estimate for a mimic system must be five to ten times the cost of the present L-821. This estimate would depend upon the number of light guides on the mimic
FIGURE 4. VIEW OF MIMIC CONTROL PANEL INSTALLED IN ATC CONSOLE
panel that would require interfacing with regulators. The number would vary from the dozen regulators at NAFEC to the many more such devices found at airports such as Kennedy, in New York, or Logan, in Boston. The primary costs would be in the mimic panel and secondly in the interface equipment necessary in the lighting vault. The cost of cabling, field construction, and installation would be no greater than that of a system using a standard L-821 unit. It is anticipated that the annual electrical costs would be less, and prorated over a period of five years it is possible that the costs of the standard L-821 system and the mimic panel would be similar. The reason for this cost similarity is that the controller would not have to translate control position with field lighting because the picture would be before him on the mimic display. Thus he would know at a glance which runways and taxiways were illuminated and could readily turn them OFF and ON as required for optimum field operation, enabling a savings on electric power.

Another consideration is the cost of future expansion. Any additional runways, taxiways, or changes in taxiway segments would require the refitting of the mimic control panel systems with both modified or new light guides and a new display face to indicate any additions or modifications. These refitting costs, in the $2,000 to $3,000 range, are not considered excessive when the entire cost of changing runways or taxiways is considered. In such cases the cost of modifying the mimic panel would be a small percentage of the total cost. The interface equipment cost would be minimal. The power control panel would have built-in spare relays (plug-in) and thus it would be a simple task to connect the mimic panel to the power control unit and to the individual switches or relays. Cabling would not be a problem if sufficient spare wires were designed into the installation to prepare for future expansion. Since this installation would normally use 52 pairs or 26 pair cabling, no problem exists because most installations would require less than 20 or 35 pair of wires, thus leaving many spare wire pairs. The cost of modifying circuits that are controlled by the mimic control panel but not displayed on the mimic display panel would be no greater than the costs of a present L-821 installation.

OPERATIONAL. Presently the system supplies the needs of the ATC operator and, due to its inherent design, in the future it could readily interface with automated systems. This should be considered as a requirement of any lighting control system since at most large hub airports the possibility of automation is a real factor. In the case of this system design, the automated control signals would be superimposed upon the control relays and would therefore operate the regulators, which would then feedback to the panel and indicate to the ATC operator the basic runway and taxiway operations. For the evaluation at NAFEC visual approach slope indicator (VASI), touch down zone (TDZ), and centerline (CL) lighting operations were not a part of the display, although it is apparent that they could easily fit into the mimic display. The display is limited only to the miniaturization of lighting guides and control switches. During the installation at NAFEC only the most simplistic and readily available components were considered. No attempt was made to demonstrate all the functions nor was an attempt made to subminiaturize the system. Subminiaturization could easily be performed on any operational unit where space is an important criterion.
CONCLUSIONS

It is concluded that the mimic control and display panel is an excellent means of operating airport lighting, for the following reasons:

1. The system enables the controller to see at a glance which circuits are energized. Thus only those circuits required for field operation are used.

2. The use of only those circuits necessary for field operation provides for a substantial electrical power savings.

3. The use of the equipment requires minimal training for the air traffic controller and exhibits great ease in operation.

4. The system has an inherent safety factor in that the controller knows at a glance which taxiways and runways he has in or out of use.

The panel's disadvantage is its initial cost of design and installation and the cost of expanding the display when taxiways, runways, or other lighting systems are added to it.

RECOMMENDATION

After a further review by FAA Air Traffic Service headquarters and field personnel to determine criteria on a nationwide basis, it is recommended that the mimic control and display panel be used on any field where multiple runway and taxiway paths exist. It is further recommended that a study be initiated to ascertain the most economical means of system design and installation, so as to reduce the initial economic impact.