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DEVELOPMENT OF AIRPORT CONTROL TOWER LIGHTING

By

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DEVELOPMENT OF AIRPORT CONTROL TOWER LIGHTING

SUMMARY

This report describes the development of a method for lighting airport control towers

Earlier experiments with "black" or ultraviolet light were carried on at the Richmond, Virginia, control tower. Instruments and dials were painted with fluorescent paint which made them visible under the ultraviolet light, while allowing the eyes of the tower operators to remain dark-adapted Also included in these experiments was a study of the use of red light for tower lighting. Operations were later transferred to the airport control tower at Weir Cook Airport, Indianapolis, Indiana, where experiments were continued with ultraviolet, red, and white light in various applications The recommendations for the airport control tower lighting plan discussed in this report were made after a study of the results of these experiments

This plan involves the use of ultraviolet, also white and/or red light at the discretion of the tower personnel in order to allow for different psychological reactions among the various people. The tower is divided into seven working areas and specific treatment is recommended for each area

INTRODUCTION

Although the airport control tower is a familiar sight to most people, and is easily recognizable from the outside, there has not yet been full standardization in the interior design Some were constructed by various services of the Federal Government, others by municipalities, and in some cases, private enterprise has provided this facility Regardless of sponsorship, however, these various towers all have the same purpose, the control of airport traffic throughout the day and night, although some airports have decreased activity during the night-time hours For use during periods of darkness adequate lighting is required, and it is the purpose of this report to present a set of lighting recommendations that may be put into effect at any of these towers.

There has long been a need for a satisfactory method of lighting airport control tower interior areas Since the beginning, the operators have been troubled by poor lighting, which frequently is a source of personal discomfort There has never been any difficulty in obtaining sufficient light, but rather in providing a proper degree of darkness For any night visual activity the ideal situation is the complete absence of light, with the eyes of all personnel thoroughly dark-adapted Such a condition, however, is almost impossible to achieve, as there are instruments to be read, regulations to be looked up, notes to be jotted down, flight plans to be recorded, and a variety of other intermittent activities to be carried on, all requiring light

At one time there was also the problem of light from points outside the tower, such as automobile headlights striking the tower windows and reflecting into the operator's eyes This problem was solved several years ago by sloping the windows inward from the top in the now familiar characteristic design. This, however, does not eliminate the possibility of difficulty caused by lights inside the tower reflecting from the glass With the vast increase in night operations at most airports the problem of proper lighting has rapidly become a serious one, as poor lighting is an added source of physical and mental hardship to those who must at all times exercise alertness in the visual control of traffic.

ANALYSIS OF THE PROBLEM

From the foregoing it can be recognized that control towers cannot be lighted in the same manner as can offices, factories or other ordinary working areas The lighting engineer must provide light while maintaining darkness sufficient for dark adaptation, truly a paradoxical problem He must cope with the likes and dislikes of different people, taking into account the various factors in the individual psychological and physical make-up

In order to plan successfully the lighting of control tower areas, it is necessary to study the visual tasks involved so that the proper solution can be applied to each individual "seeing" problem. The functions of the

different control tower areas must be considered, as well as the duties of the operators occupying these areas Following is a description of the functions of each area.

Area I - The local control position desk top, which is mostly occupied by instrument dials, except for a small writing space used by the local control operator when jotting down occasional notes This area gets its greatest use during relatively fair weather when the operator spends most of his working time watching planes on the field, on approach, take-off and circling, while referring to the instruments and relaying information to the pilots, at the same time keeping his rough notes (See Fig 1)

Area II - The top of the ILS monitor on which instruments are mounted Occasional reference to these instruments is necessary (See Fig 2)

Area III - The flight data position desk top, at which all of the clerical work is done by the flight data clerk-operator, who records flight plans, weather, clearances and other information This area is in constant use at a busy airport (See Fig 3)

Area IV - The approach control position desk top which normally contains only a flight progress board for use in instrument weather. Under this condition, the desk becomes the center of activity and is taken over by the approach control operator. (See Fig. 3)

Area V - One to three radio receiver racks which have vertical surfaces with mounted dials These must be referred to infrequently when receivers require tuning (See Fig 4)

Area VI - The general area in front of the three positions where desk drawers containing supplies are pulled out occasionally, and regulations mounted on slide boards sometimes must be read

Area VII - The general area occupied by the recorders. These require infrequent servicing, such as changing of records (See Fig. 5)

Fig 6 shows the locations of these areas in the Indianapolis control tower. It was found after experiment that the lighting of such areas can be accomplished neither by the use of general lighting, nor by a single type of luminaire, as the visual tasks are not consistent with each other and require, for the most part, specific localized treatment

DARK ADAPTATION

It has long been known that seeing in relative darkness can be best accomplished by eyes that are "dark-adapted" by being kept unexposed to light for at least 30 minutes [1] Experiments in connection with "black-out" work during the recent war indicated that the visual acuity suffered little if, instead of being exposed to complete darkness, the eyes were exposed to a very low degree of red light, and further, that visual acuity is much better under a low red than under any other colored light of the same intensity However, a longer time is required for dark-adaptation under red light than under complete darkness

While dark-adaptation of all tower personnel is desirable, it is not entirely necessary As the local control operator does visual work involving the use of the eyes in darkness, it follows that he should have the maximum feasible degree of dark-adaptation It is recognized that many airport ramps are brilliantly flood-lighted, most runways are lighted, the airport beacon frequently sweeps the tower, and many times airplane landing lights happen to be aimed at the tower Under such conditions, which at present are prevalent at most airports, it appears that full dark-adaptation by any tower personnel is unattainable

USE OF WHITE LIGHT

It was recognized from the start that high levels of general lighting with white light would be objectionable, as they caused seriously confusing and objectionable reflections from the windows and from various instrument glass

[1] Mathew Luckiesh and A H Taylor, "A Summary of Researches in Seeing at Low Brightness-Levels," Illuminating Engineering, Vol XXXVIII, 4, April, 1943

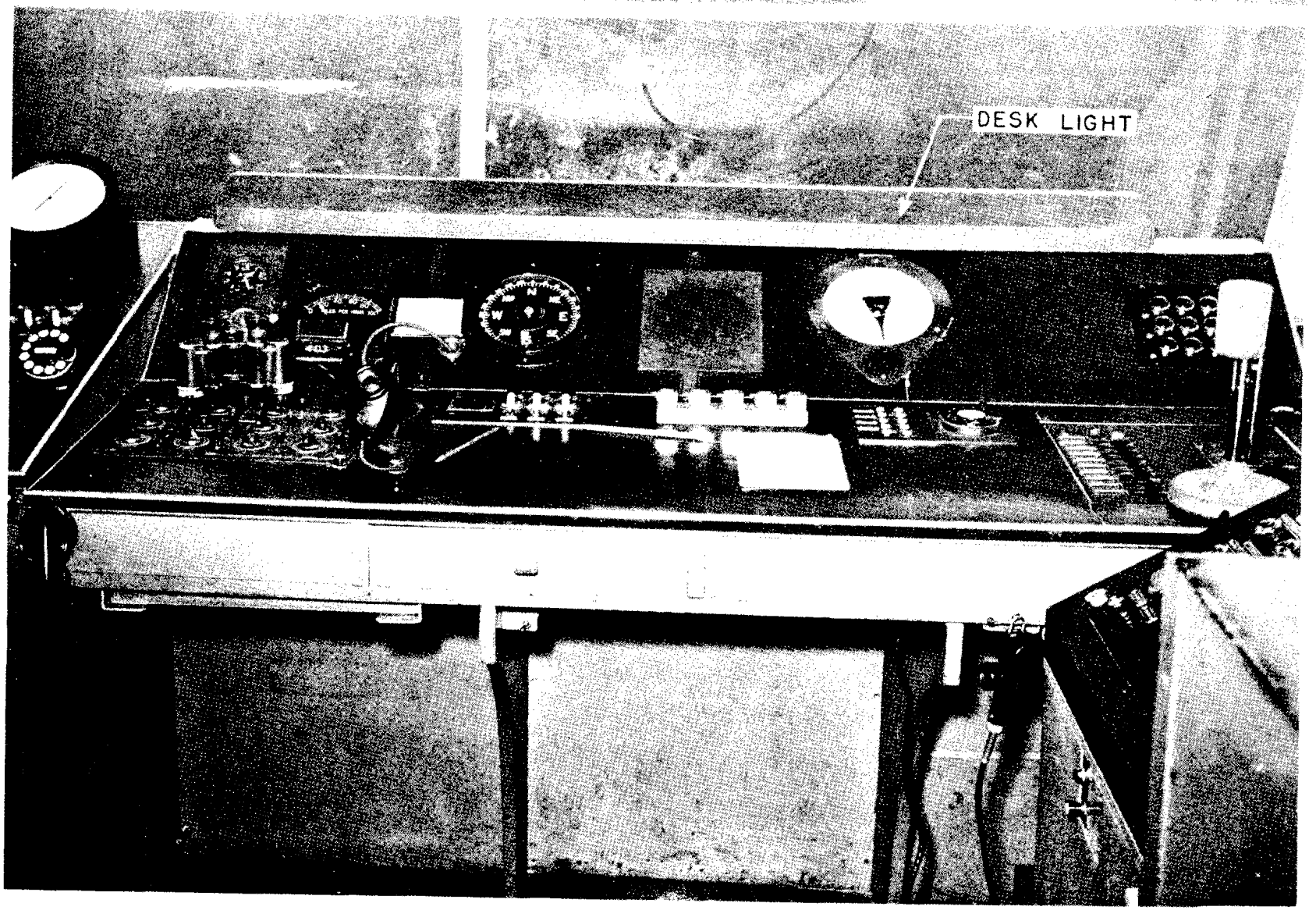


Fig. 1 View of Local Control Position in Weir Cook Airport CAA Control Tower Showing Desk Light

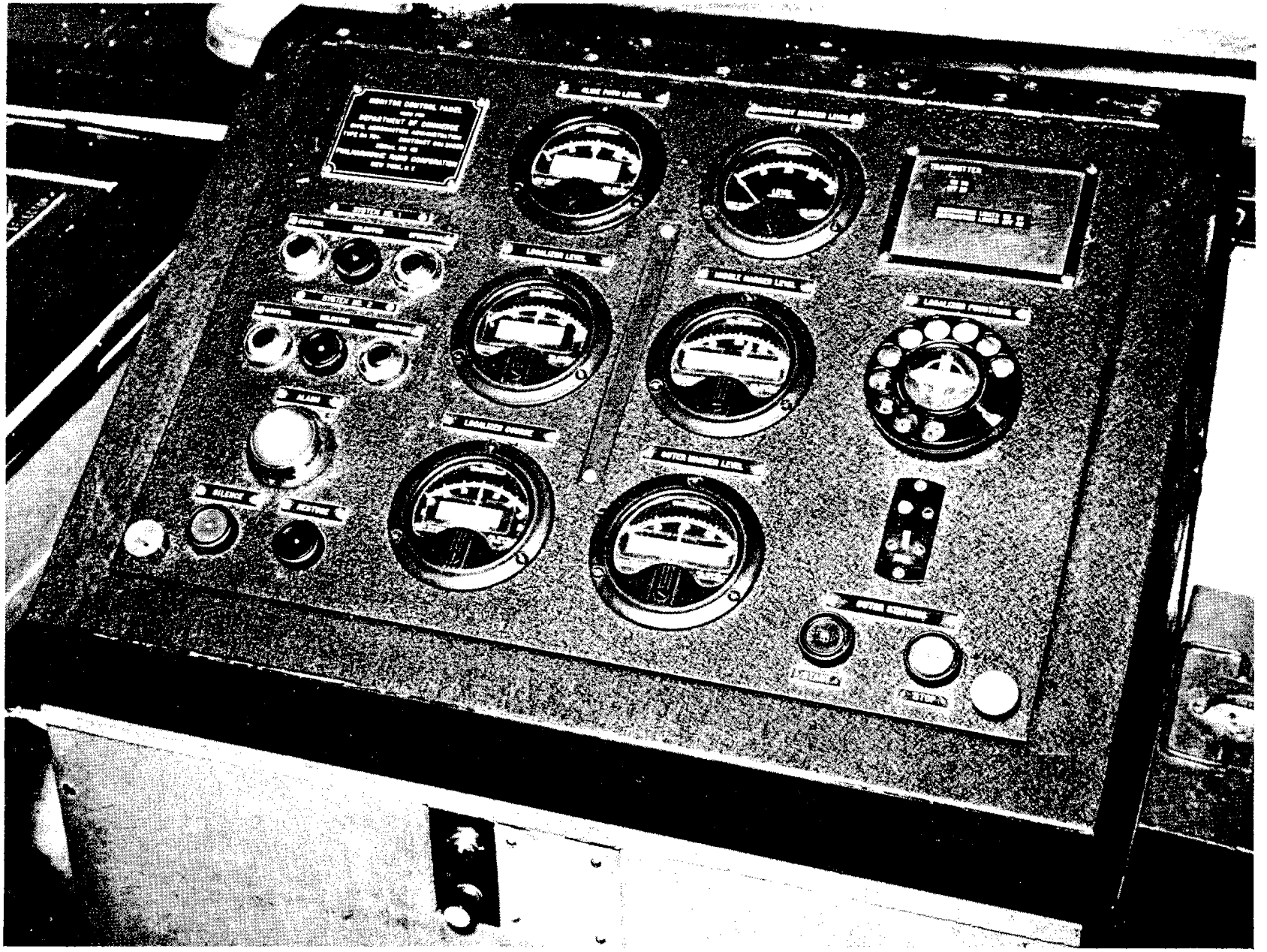


Fig. 2 ILS Monitor

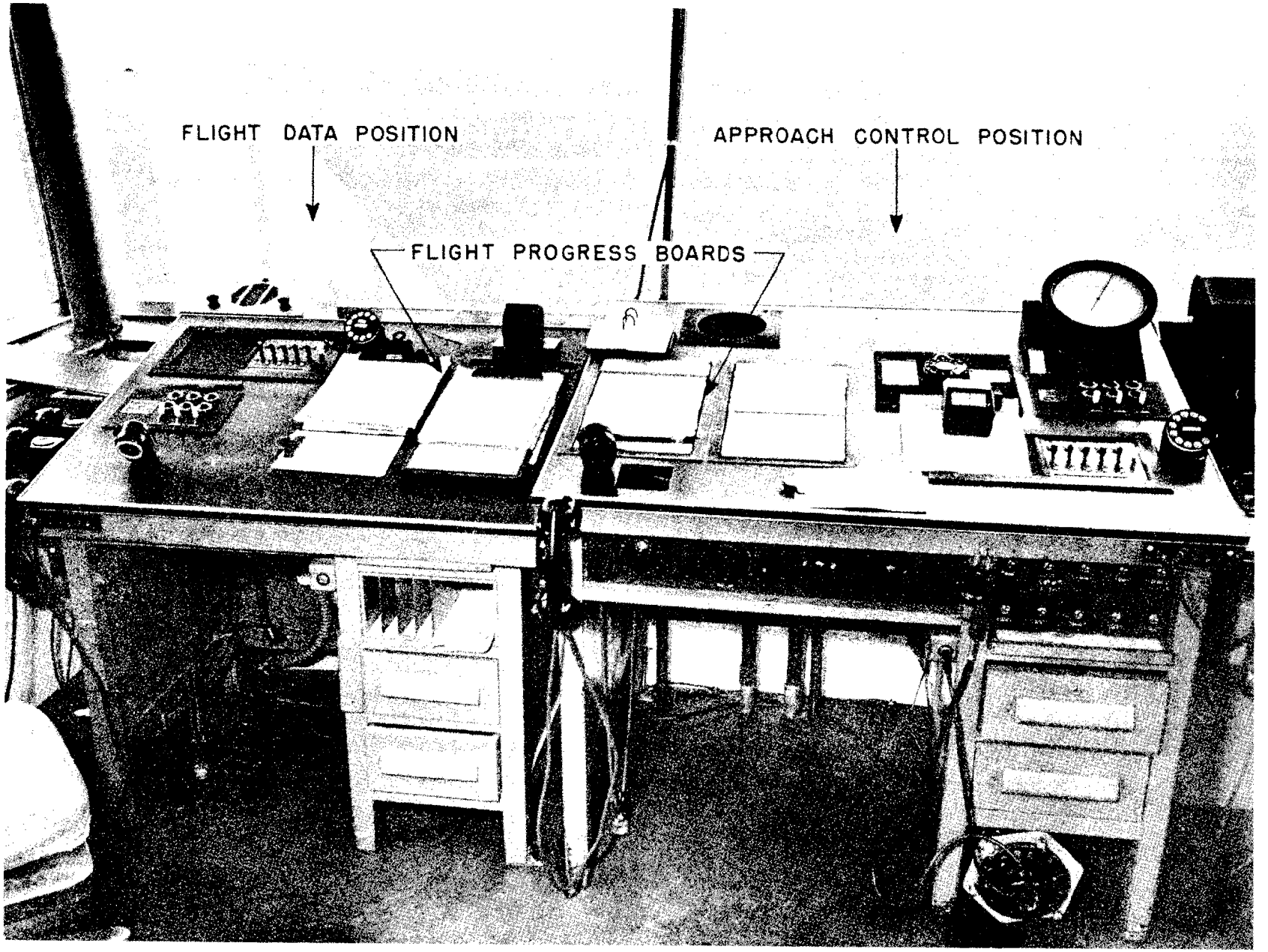


Fig. 3 Flight Data and Approach Control Positions

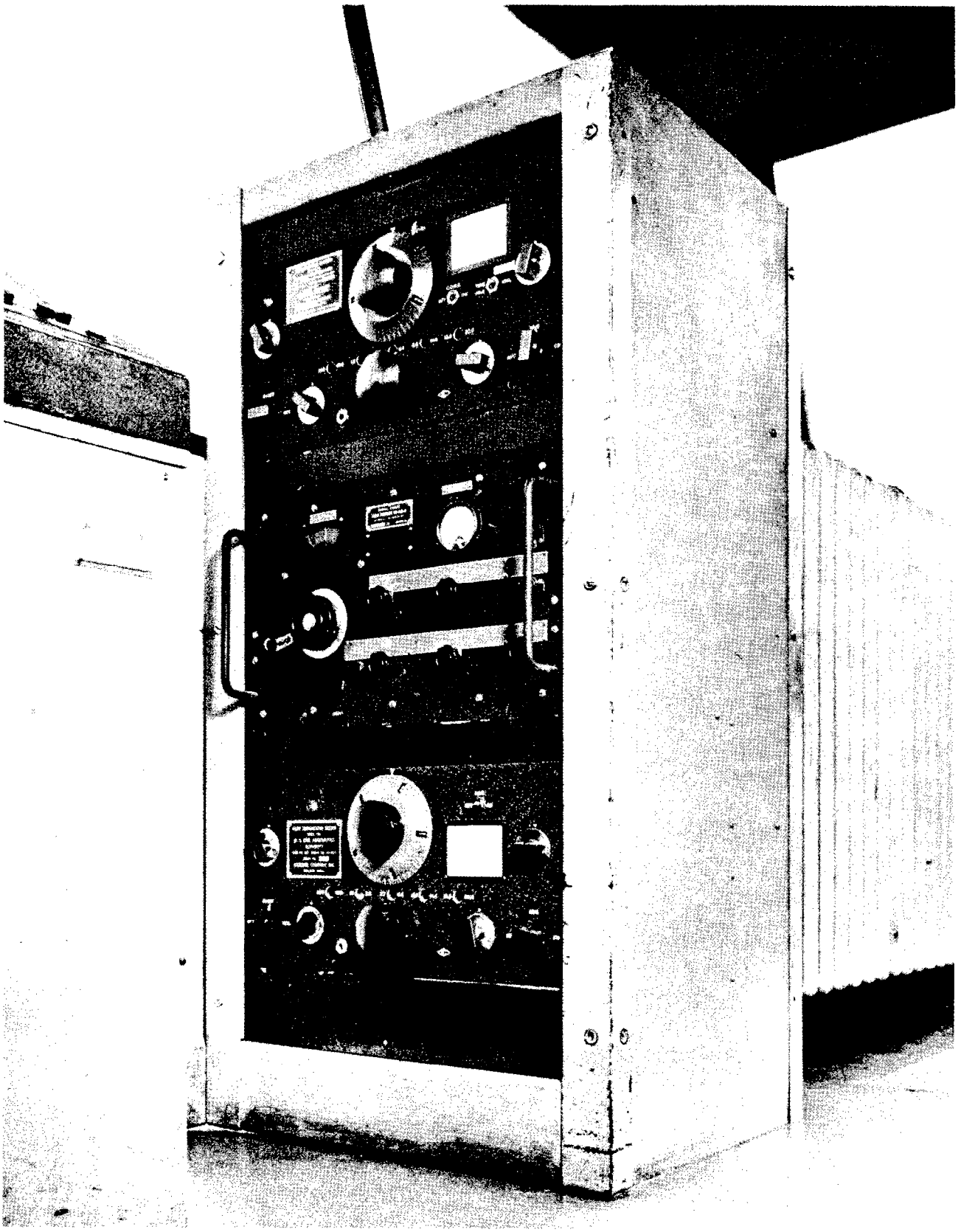


Fig. 4 Radio Receiver Rack

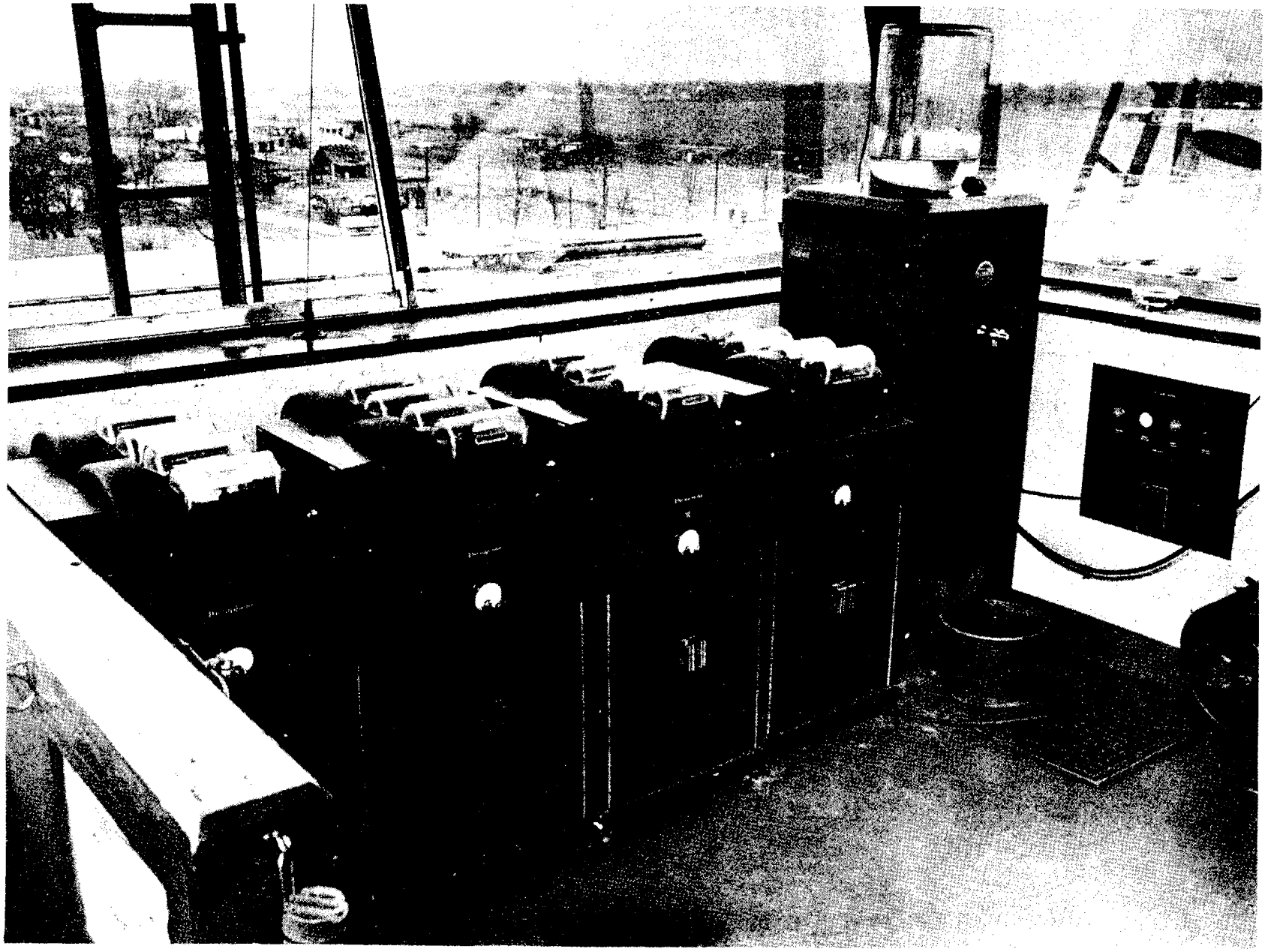
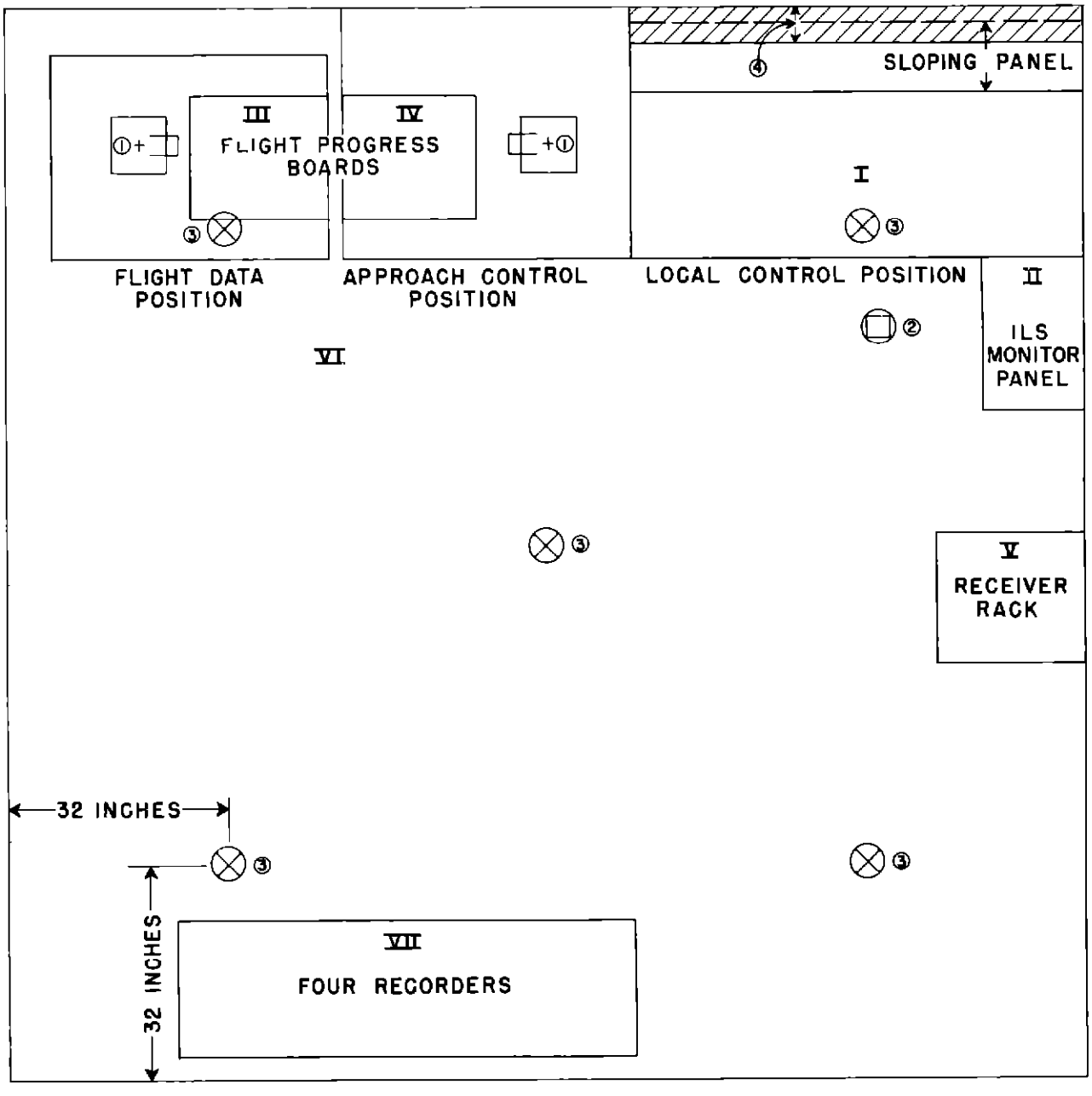


Fig. 5 Recorders in Weir Cook Airport CAA Control Tower



LEGEND

① SPOTLIGHT
② ULTRAVIOLET DOWNLIGHT
③ WHITE DOWNLIGHT
④ ULTRAVIOLET DESK LIGHT

Fig. 6 Plan of Weir Cook Airport CAA Control Tower

covers, and prevented any effective degree of dark-adaptation

USE OF BLACK LIGHT

It was thought at first that possibly all of the lighting could be accomplished by the use of ultraviolet radiation or "black light," as it is commonly known. Accordingly, all instrument dials and pointers and any important references were painted with fluorescent paint, and ultraviolet luminaires were installed to irradiate them. Special fluorescent pencils were obtained and furnished to the operators so that all of the work could be carried on under the "black light," and a degree of dark-adaptation provided for all tower personnel. However, after some usage, various objections began to arise -- a high intensity of general light, preferably white, was required on Areas VI and VII, as it was impossible to find small objects or read ordinary printing under black light unless fluorescent ink is used, some operators objected to the hazy appearance of the atmosphere, a phenomenon caused by fluorescence of the eyeball under ultraviolet radiation,[2] the fluorescent pencils could not be used for normal writing as they were too soft, while the forms and charts required fine writing Then, too, considerable work was required to apply the fluorescent paint to all of the controls and marked references.

USE OF RED LIGHT

In view of the wartime experience in black-outs, it was decided to use general lighting consisting of downlights with red lamps and red filters This found favor with some of the personnel. Unfortunately, however, many of the tower operators objected quite vigorously to the red light for purely psychological reasons, and in many cases would remove the red lamps and filters, replacing them with white lamps

LIGHTING THE LOCAL CONTROL POSITION

In spite of the objections to black light for general illumination, it was found that for local lighting, black light would provide the best results in Areas I and II, and was quite satisfactory for use in Area V

A special desk fixture was designed for mounting above the sloping panel at the local control position. This fixture is four and one-half feet long and is equipped with two T-8 ultraviolet tubular lamps, one 15-watt and one 30-watt, mounted end to end It is provided with a Corning No. 5874 ultraviolet glass filter mounted in a hinged frame, fastened down by means of thumb screws A fixed alzak reflector is installed behind the tubes. A rheostat is provided for dimming the lamps. This lighting fixture is illustrated in Fig. 1. The spectral transmission characteristics of the glass used in the filter are shown in Fig 7. All numerals on instrument dials at the local control position were painted with fluorescent paint, as were the meter-indicating hands, miscellaneous switches, knobs, etc.[3]

With Sylvania "Blacklite" lamps installed in this fixture, the lighting arrangement has been very satisfactory The glass envelope of this type of lamp is made of Corning glass No. 504, which is a mixture of a red-purple cobalt glass with quartz. This is a dark, ultraviolet filter glass with the same transmission characteristics as the No. 5874 filter. The amount of visible light transmitted is held to a minimum, thereby keeping the brightness down to a minimum also. When standard fluorescent ultraviolet (360BL) lamps were used, the dials glowed too brightly because of too much ultraviolet light emission, and use of the rheostat to cut the voltage down for dimming caused the light to go out before it was low enough in brightness.

There is no apparent difficulty with stroboscopic effects, as the fluorescent paint

[2]Operators who wear glasses are not troubled by this phenomenon, as ordinary glass is substantially opaque to ultraviolet radiation.

[3]Fluorescent paint and pencils were purchased from Switzer Bros of Cleveland, Ohio.

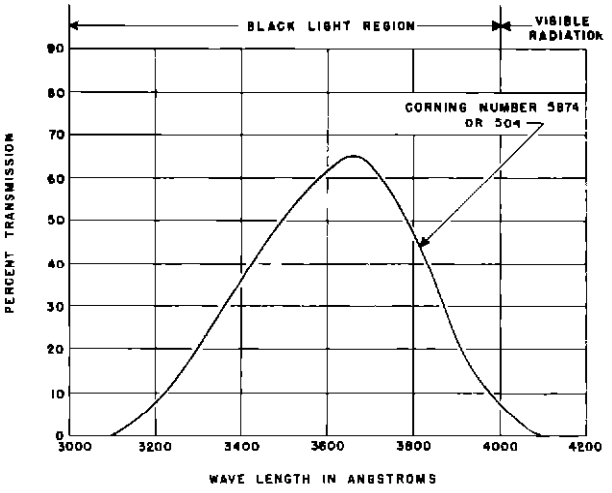


Fig. 7 Spectral Transmission Characteristics of Glass Used in Black Light Filter

continues to glow, while the lamp flickers due to its current passing through zero value during each cycle The light is turned on and properly adjusted at dusk, after which it is operated all night without further attention With this lighting the local controller has no difficulty jotting down rough notes for his own use with a fluorescent pencil His eyes are sufficiently dark-adapted to enable him to do his job satisfactorily and in comfort

LIGHTING THE ILS MONITOR PANEL

Area II, the ILS monitor panel, was lighted by means of a special surface type, ceiling-mounted downlight, complete with baffles and using a 100-watt Type EH-4 ultraviolet spotlight lamp. The various instrument dials were painted with fluorescent paint as in the case of Area I The lamp was provided with a brightness adjustment to give the operator proper control, see Fig 8.

LIGHTING THE FLIGHT DATA AND APPROACH CONTROL POSITIONS (FLIGHT PROGRESS BOARDS)

Some time ago the use of a pair of special spot or projection lighting units was advocated by Mr. Russell L Biermann, Chief Controller at the Tulsa, Oklahoma, Control Tower. These lights were to be mounted above Areas III and IV, the flight data and approach control positions, to light the flight progress boards. They were to be located, one to the left and one to the right of the board, as shown in Figs. 9 and 10, and were designed so as to project sharp overlapping rectangular beams of light on the flight progress board. Thus there would be a minimum of light spilled about the room and the light source would not constitute an unpleasant bright spot. There still would be some secondary light reflected from the flight progress board, but this probably could be held to a minimum Mr Biermann advocated a light without lenses and submitted a design Such a light requires a point source lamp for sharpest cutoff of beams and elimination of spill light After attempts to modify Mr Biermann's design, to obtain a unit that would not overheat and yet provide enough brightness for use with a red filter, it was decided that a unit with a lens system would be more practical

The combination of Areas III and IV required a rectangular spot of light approximately 18 by 40 inches to give proper coverage Accordingly, several inexpensive commercial units of this type were purchased and installed in the Indianapolis tower, as illustrated in Fig 9 These units are equipped with a triple lens objective system and red color filter They use a standard 400-watt or 250-watt G30-120 volt spotlight lamp. Operated through a variac, they may be used at lower-than-rated voltage so as to prolong the lamp life and to provide lower brightness, as needed After their installation the operators removed the red filters and are now getting satisfactory results with the lights dimmed to produce illumination on the order of 0 8 to 1 0 foot-candle of white light on the flight progress boards At midnight when it is customary to check the records to make a traffic count, these lights are brightened to produce approximately 4.0 foot-candles on the flight boards for a period of 15 to 20 minutes The arrangement produces no sharp shadows, and provides sufficient illumination for Areas III and IV At some locations, such as the Chicago tower, where larger flight progress boards are employed, it may be necessary to use two pairs of spotlights Although the unit illustrated in Fig 9 is a flush type adapted to surface mounting, a surface type appears to be more practical, and is recommended for existing

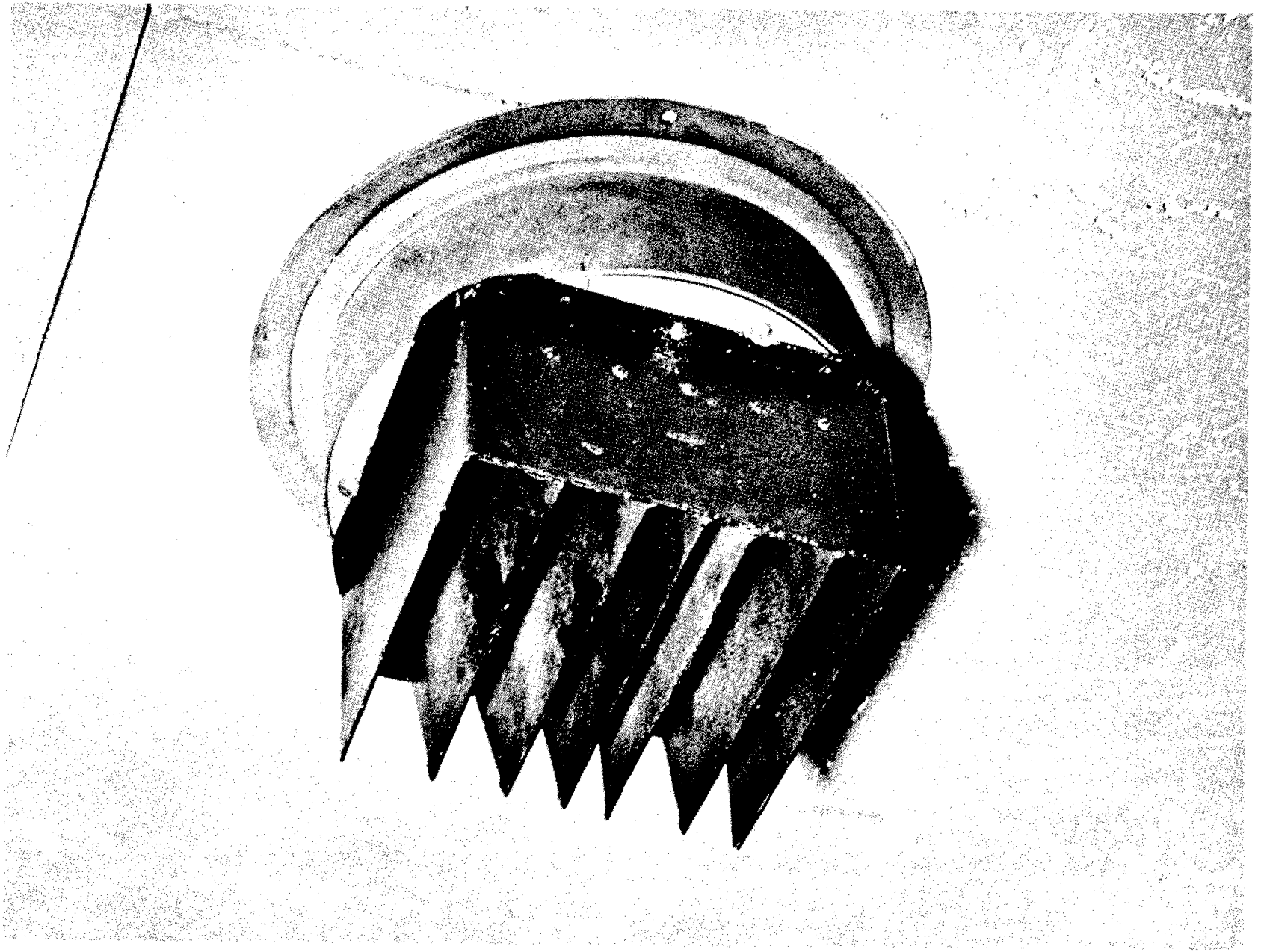


Fig. 8 Ceiling Mounted Ultraviolet Downlight

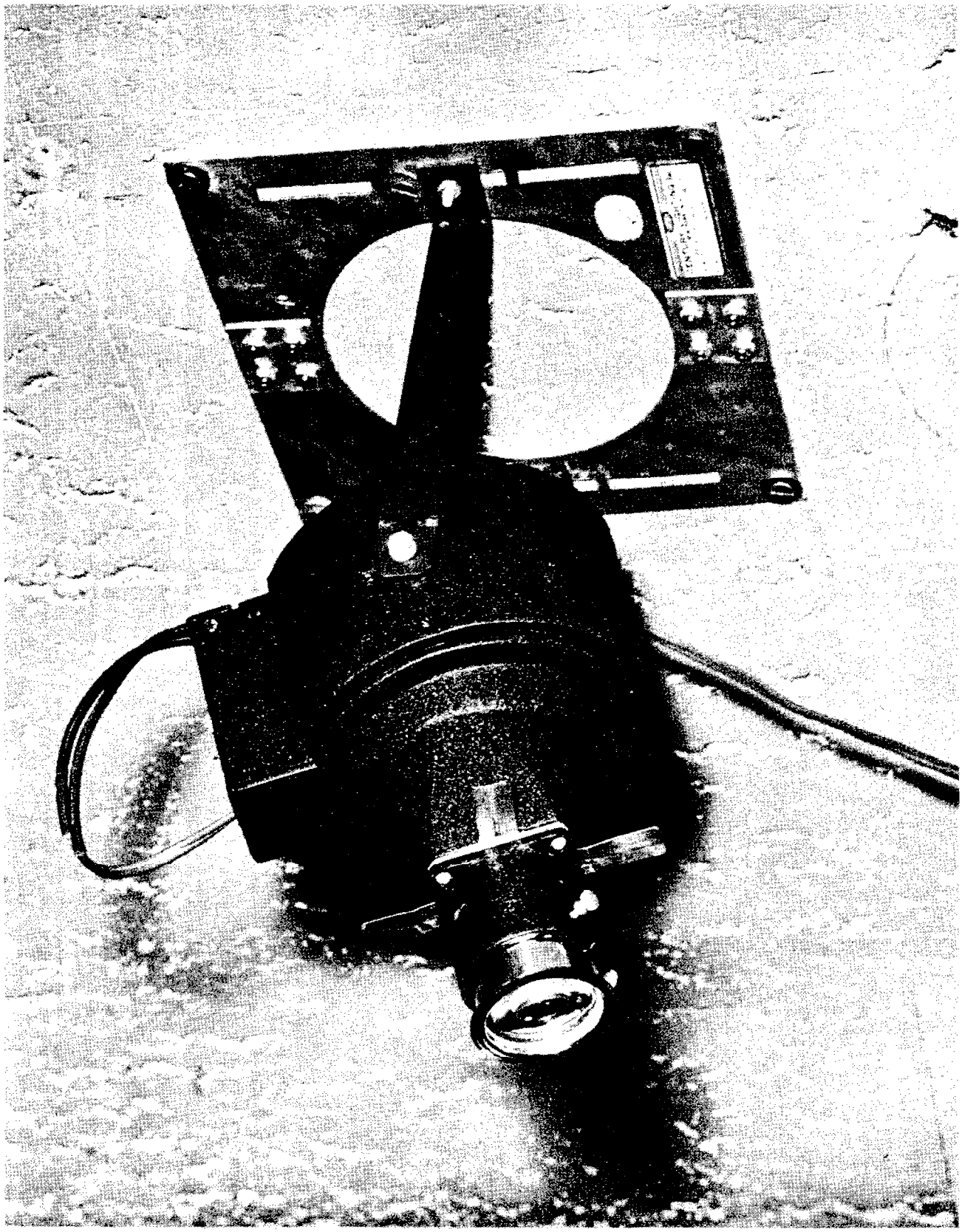


Fig. 9 Ceiling Mounted Spotlight for Lighting Flight Progress Boards

towers While flush-mounted spotlights are desirable, Underwriters' Laboratories approved types were not obtainable at the time of these tests Because of fire hazard due to excessive heat this is an important consideration.

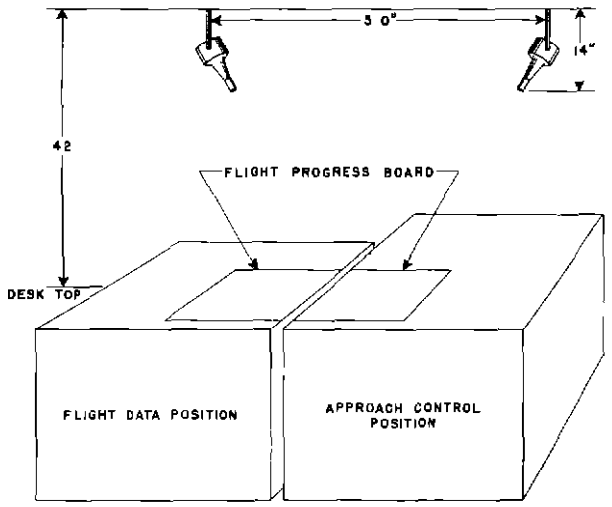


Fig 10 Perspective View of Spotlight Positions

Some slight objection to the yellowish color of the light was registered by controllers when the lamps operated at low voltage However, this is not considered to be serious enough to disqualify this type of lighting

It may seem surprising that under such levels of illumination clerical work can be done in comfort, especially when recognized general office lighting requirements are in the range of 30 to 50 foot-candles It must be remembered, however, that in this case the eyes have become accustomed to surroundings that are in complete darkness so that the effect of a very low degree of illumination on this area is comparable to a higher degree of illumination on another area with surroundings that are light but yet lower in brightness than the working area itself Even though the illumination levels required are low, in making installations of these lights care must be exercised to avoid causing unpleasant glare through improper placement of the units In order to reduce glare at Indianapolis, it was found necessary to move the lights away from the windows and slightly toward the operator, after they had been operated a short time

LIGHTING THE RECEIVER RACK

Area V, the vertical surface of the receiver rack, is lighted by spilled light from the unit that lights Area II. At Indianapolis this rack does not stand directly below the light, but is offset approximately three feet horizontally which puts the light at a convenient angle. At other airports it may not be possible to light both Areas II and V with only one luminaire, in which case it will be necessary to provide separate units. Where more than one rack is used, and they are installed in a row, one light source frequently will serve the group. The various dials and knobs, of course, must, be treated with fluorescent paint in the same manner as in the other ultraviolet light applications

Several other methods for illuminating the receivers have been suggested by Mr John H Hilton, Chief Airport Traffic Controller at Indianapolis One method involves the use of internally-lighted dials These are now provided on the BC 639A receiver Another method makes use of small, hooded, white lights on the faces of receivers, with individual switches on each to permit momentary use of a light while adjustments are being made This is the method that was used in some GCA trailers Still another solution to the problem is to employ general white incandescent light of an intensity so low that there will be no serious interference with dark adaptation on the part of tower personnel

LIGHTING THE GENERAL AREAS

Areas VI and VII originally were lighted by special downlights, equipped with baffles, 40-watt red lamps, and red glass filters, as shown in Fig 11 When the red light proved objectionable the filters were removed and inside frosted white lamps were substituted for the red lamps These lamps are wired on individual switches with brightness control and are turned on for intermittent use only, such as for general cleaning of the floor, search for dropped objects, servicing of the recorders, reading of regulations, etc. For this use illumination on the order of 3.5 to 4.0 foot-candles is required Three or four of these units may be placed about the tower at strategic positions, provided with individual switch and brightness controls Small

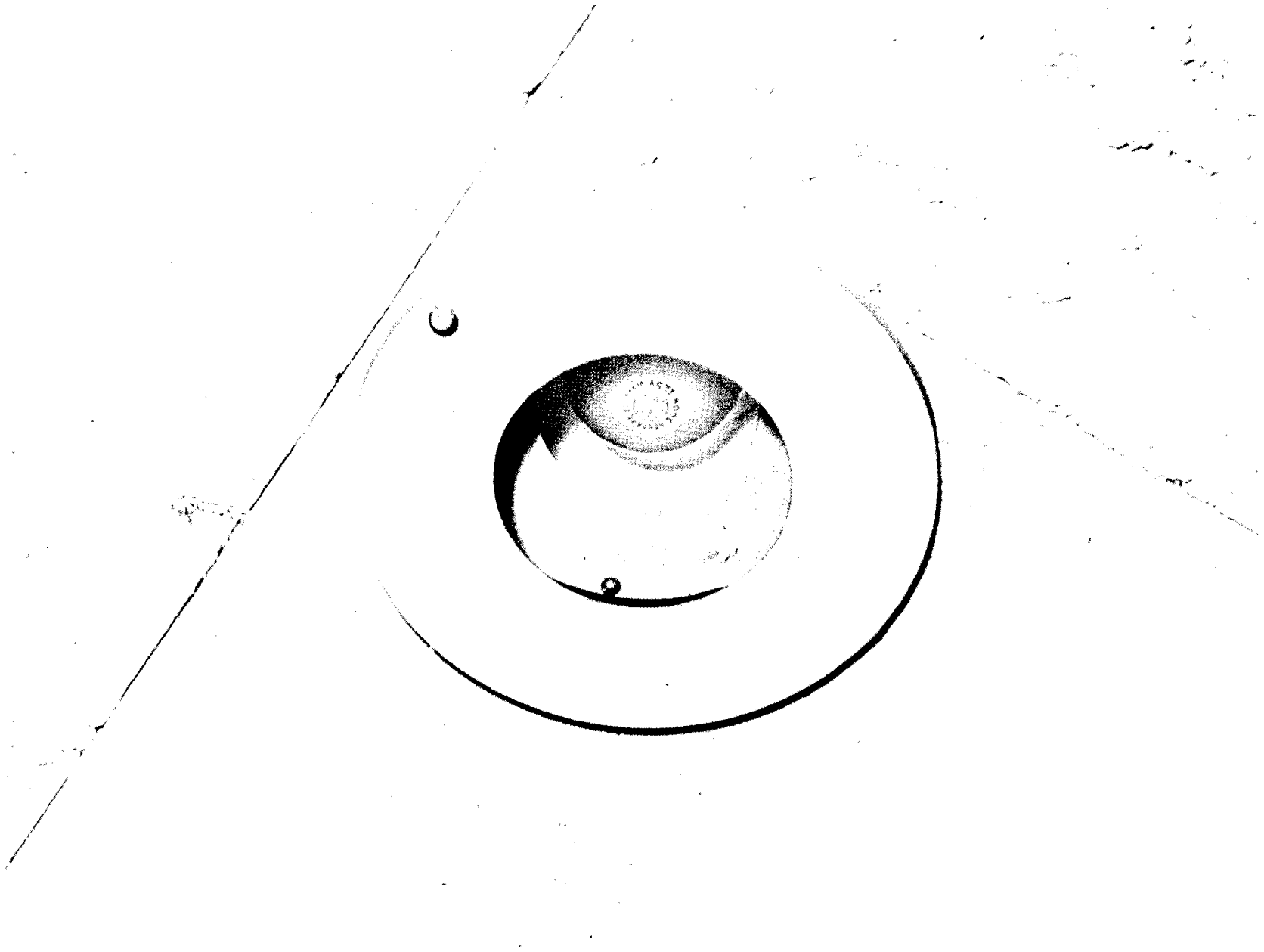


Fig. 11 Flush Mounted Downlight for General Lighting

hooded auxiliary lights on flexible mountings also can be used to advantage for lighting the recorder servicing operations

Table I outlines the various lighting recommendations.

Figs 12, 13, 14 and 15 are drawings of the various types of experimental lighting units employed at Indianapolis These fixtures

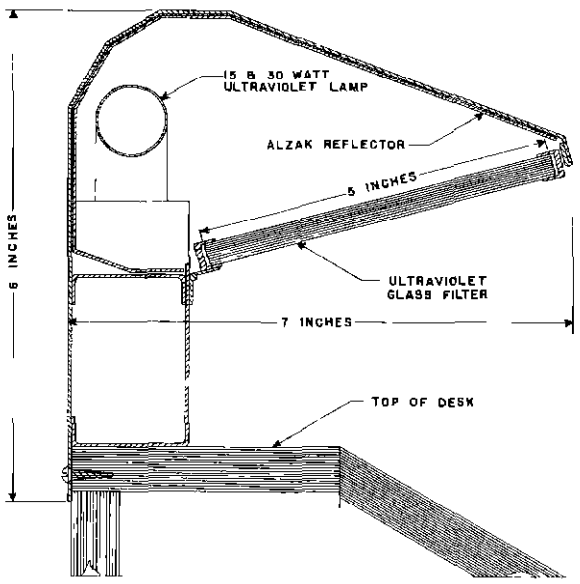


Fig. 12 Ultraviolet Desk Light

can be improved by modifications in design, placing special emphasis upon ease of maintenance

CONCLUSIONS

Experience to date, as evidenced by the favorable reception of the lighting by tower personnel at Indianapolis, indicates that the recommendations presented in this report offer a satisfactory solution to the problem of lighting control towers. Many minor variations of the general system are possible. Regardless of the type of fixture used, particular attention should be given by the engineer to the problem of glare in order to prevent undesired eyestrain and other discomfort to operating personnel. Wherever possible, white light fixtures should be designed to permit use of red filters at the option of the operators

No lighting program should be under-

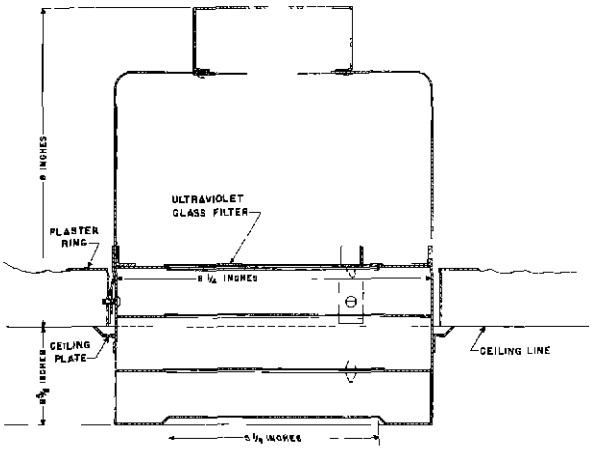


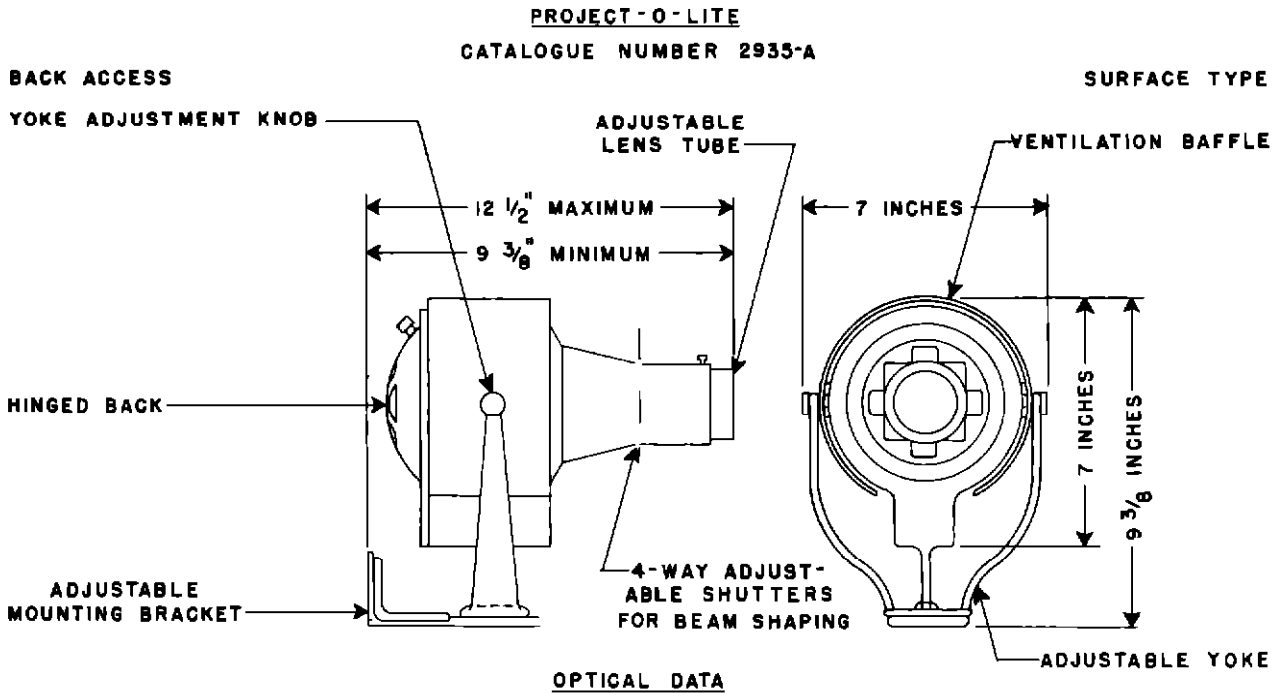
Fig. 13 Ultraviolet Downlight

taken without full consideration of the color scheme. Use of black on relay racks and panels is to be avoided On the other hand the ceiling should not be too light The subject of painting is covered in detail elsewhere.[4]

ACKNOWLEDGMENT

Acknowledgment is made to the personnel of the Indianapolis Control Tower for their assistance in testing the lighting system.

[4]M. S Gilbert and H J. Cory Pearson, "Development of Interior Painting and Lighting for CAA Facilities," Technical Development Report No. 76, December 1947.



OPTICAL DATA

OBJECTIVE LENS SYSTEM	MAXIMUM CIRCULAR BEAM SPREAD	MAXIMUM SPREAD AT ONE FOOT	AVERAGE CANDLEPOWER	
			400 WATTS SPOT LAMP	250 WATTS SPOT LAMP
TRIPLE	50°	0 93 FEET	600	300

Fig. 14 Surface Type Spotlight

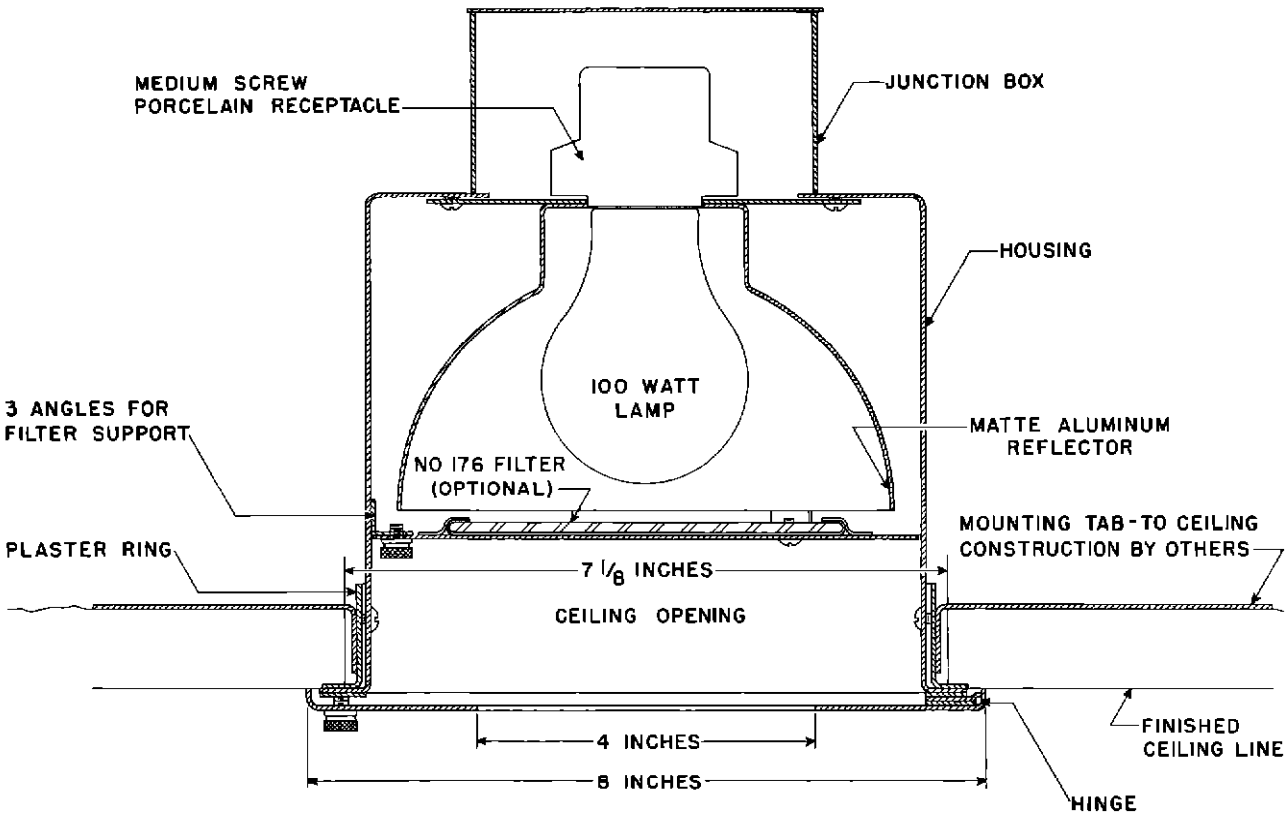


Fig. 15 Downlight for General Lighting

TABLE I

LIGHTING RECOMMENDATIONS FOR AIRPORT CONTROL TOWERS

AREA	DESCRIPTION	LIGHT	LUMINAIRES	FOOT-CANDLES	LAMPS
I	Local Control Position	Ultraviolet	Special Desk Type		1-15 Watt and 1-30 Watt T8 Sylvania Red Purple "Blacklite"
II	ILS Monitor	Ultraviolet	Special Ceiling Mounted Downlight with Baffles		1-100 Watt EH-4
III IV	Flight Data Position Approach Control Position	Red or Low Intensity White	Ceiling Mounted Surface Type Spotlight with Triple Lens Objective to Produce Rectangular Beam of Light	0.8 to 1.0 F. C Normally, and 4 0 F. C. During Traffic Count	400 Watt 120V-G30 Spotlight or 250 Watt 120V-G30 Spotlight
V	Radio Receiver Rack	Ultraviolet	Special Ceiling Mounted Downlight with Baffles		1-100 Watt EH-4
VI VII	General Areas in Front of Positions General Areas Around Recorders	Red or White	Downlights	3.5 to 4.0	100 Watt Standard Inside Frost Lamp

Note All dials, instrument pointers and important references must be outlined in fluorescent paint wherever the ultraviolet light is used

The spotlights over Areas III and IV will require 400-Watt lamps if the red filters are used, or 250-Watt without the red filters.

Each light should have both individual switching and brightness control