A REVIEW OF AIRCRAFT EXTERNAL LIGHTING ACTIVITIES

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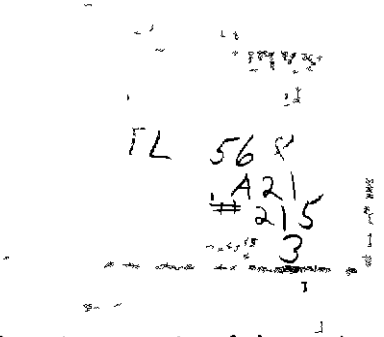

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A REVIEW OF AIRCRAFT EXTERNAL LIGHTING ACTIVITIES

SUMMARY

The initial advent of night flying required external aircraft lights The marine practice was adopted in the form of steady-burning, red and green wing-tip lights and a white taillight However, in the early days, intensities and fixture designs were not uniform These lights became less and less adequate as speeds and traffic densities increased, until, in 1938, growing concern resulted in the expressed need for improvements Since that time, the Technical Development and Evaluation Center of the Civil Aeronautics Administration and its predecessor organizations have collaborated in much of this work

This report reviews the major activities in this field and, in particular, outlines the trends over the past 14 years in thinking and in development Mainly, this has been a highly co-operative activity with private concerns and individuals making major contributions at their own expense Co-ordination of effort is indicated by an orderly process of evolution

The combined opinions and suggestions of all concerned have guided the TDEC in its development and evaluation work

INTRODUCTION

It is not certain that the first airplane to be flown after dark was lighted However, as night flying continued and particularly as night air transportation was established, external lighting became a necessity Designers immediately adopted the marine practice of using red and green port and starboard lights These were located at the wing tips, and a white light was located at the tail The lights were not flashed This system of lighting was soon adopted for all air-transport aircraft and on such personal types of aircraft that were lighted However, there was a lack of uniformity in lamp intensities, fixture design, and other characteristics

These lights proved adequate for many years However, traffic density and speeds were continually increasing with a corresponding reduction in safety In 1938, growing concern in this connection resulted in numerous industry and government conferences at which various remedial measures were discussed, and the need for developing improved external aircraft lighting arrangements was indicated It was then that the predecessor organization[1] of the CAA TDEC first concerned itself with the lighting problem

Since then, it has collaborated directly and indirectly in much of this work The scope of its activities has expanded from the sporadic testing of experimental lighting components to the development of new lighting units and the conduct of flight demonstration seminars on an annual basis

This report presents a brief review of the major activities or events that have highlighted the field of external aircraft lighting from 1938 to 1951, inclusive, as taken from the records of this Center The conclusions or joint recommendations that have climaxed each event are an indication of trends that have guided development efforts in this field These are presented in tabular form in the Appendix of this report

REVIEW OF ACTIVITIES

1 Conference—Air Line Pilots Association
October 1938, Chicago, Illinois

The pilots recommended that the Air Safety Board study the question of developing proper and effective aircraft position lights and, when a method of lighting that has maximum efficiency has been decided on, that all position lights be made uniform It was further recommended that there be two taillights on all interstate aircraft carrying passengers and that both of these lights be of the flashing type

An arrangement of this type had been developed by Mr Charles Adler, Jr , and was made available

2 Conference—Committee of the Illuminating Engineering Society (IES) on Aviation Lighting
April 1939, Washington, D C

The members of this committee were in general agreement that more adequate aircraft lighting signals were needed, and they definitely favored a change in the existing requirements to make possible the approval of units capable of providing such signals They also agreed that there was an urgent need for a lighting arrangement that would indicate not only the presence of an airplane but also its direction of approach

It was further recommended to the CAA that a study be made of more effective methods of tail lighting This study should include an evaluation of the effectiveness of blinking lights, colored lights, and lights of distinctive shapes It was also recommended that a study be conducted to determine what might be done to eliminate the hazard of position-light burnouts during flight, with special attention to the possible use of a two-filament lamp

3 Meeting—Safety Bureau, Civil Aeronautics Board
December 1940, Washington, D C

The Director of the Safety Bureau of the CAB had an informal meeting with representative airline pilots They suggested that

a In addition to the standard white taillight, a flashing taillight should be installed
b The angular limits of the current red and green wing-tip lights should be increased to 180° This would make the aircraft more visible from the rear
c The Civil Air Regulations (CAR) dealing with aircraft lighting should be relaxed enough to permit the installation of the best lighting units available, because lighting units which fully met the regulations were not available

4 Flight Tests—TDEC
June 1941, Indianapolis, Indiana

As air traffic and speeds increased, the need for improved aircraft external lighting became urgent, and considerably more attention was given to this problem The TDEC undertook the flight testing of various position lights which seemed to show promise of increasing the safety of flight The immediate purpose of the tests was to determine the effectiveness of a flashing taillight as compared to a steady light, when viewed from another airplane under various operating conditions

These tests indicated that two taillights were better than one and that flashing taillights were more readily observed than steady lights It also was indicated that the eclipse period per cycle should not be less than 0 15 second and that there should be at least 40 flashes per minute

The experimental flashing mechanism used in these tests consisted of a 12-volt windshield-wiper motor and a mechanically adjustable contact connected to its shaft A rheostat was used to control the speed of the motor

It was concluded that a flashing mechanism satisfactory for airplane installation should be developed Tentative specifications for flashers were to be drawn up and various promising types were to be submitted to the TDEC for laboratory and flight testing

[1] Hereinafter referred to as the Technical Development and Evaluation Center (TDEC)

5 Conference—Aircraft Airworthiness Section of the CAA and TDEC
June 1941, Washington, D C

A development program for the TDEC was discussed at this conference, and the following items were proposed for immediate investigation

a To increase the intensity of the taillight to 32 candlepower (cp)
b To test various flashers for taillight systems
c To determine the advantages, if any, of two taillights of different colors

6 Laboratory Tests—National Bureau of Standards (NBS) and TDEC
June 1941, Washington, D C

Laboratory evaluations were conducted at the NBS on flashers submitted to the CAA, and flight tests were conducted by TDEC It was concluded that the mechanical flashers were superior to thermal flashers because they were less affected by changes in voltage

7 Conference—Aircraft Lighting Committee of the Air Transport Association (ATA), Safety Bureau of the CAB, and Engineering Section of CAA
July 1941, Washington, D C

In order to obtain the reaction of pilots and also of the managerial and engineering staffs of the various air carriers, the Engineering Section of CAA had previously prepared and distributed a questionnaire about position lights The results of this questionnaire were discussed One of the outstanding criticisms of aircraft position lights in current use was that they were not readily identified as belonging to an aircraft

It was decided that the position-light problem might be resolved into three phases

a The immediate development of an improved arrangement of taillights
b The immediate development of improved lighting in the forward direction
c The undertaking of a long-range program involving the entire external lighting problem More specifically, it was suggested that
d Two flashing taillights should be used, that one be white and the other red, and that the red and the white taillights should be flashed alternately at a frequency of flash to be determined by ground tests
e It was believed that the forward-light problem mainly involved the need for much higher intensities or additional light sources The TDEC was to develop an oscillating or sweep-beam type of light which might be located in the nose of the airplane It was suggested that this light incorporate a dual lens arrangement This would show red on one side and green on the opposite, and it was to show white for a few degrees each side of dead center

The long-range program was to take into consideration the reaction time of the pilot to various colored-light arrangements, as interconnected with a pilot's reflexes to aircraft controls, and it was to develop a system of measurements which would give a numerical evaluation to the various position-light arrangements

8 Ground Observation Tests—NBS and TDEC
August 1941, Washington, D C

A program sponsored by the TDEC was undertaken at the NBS Preliminary ground observation tests were made to demonstrate the effectiveness of multicolored flashing taillights including red, white and green combinations

The general conclusions drawn from the tests were

a A flashing white light is more effective than a steady light
b A combination of white and red lights in the sequence of white, red, and a short eclipse was definitely favored
c The sequence of red, white, and a short eclipse was not favored because of a momentary blending of the two colors
d It was suggested that each light be followed by an eclipse, but the equipment used could not provide for this desired cycle
e The combination of red and green taillights was not generally accepted
f The combination of three colors met with no favor

It was planned to modify further the equipment to permit an eclipse between each succeeding light and to conduct flight tests at a later date

9 Flight Demonstrations—American Airlines, Eastern Air Lines, NBS, CAB, and CAA
October 1941, Washington, D C

Flight demonstrations of a two-color flashing taillight were conducted at the Washington National Airport by American Airlines and Eastern Air Lines Personnel of the TDEC participated as observers

The installation included red and white taillights with a switching mechanism which caused the lights to flash alternately at 40 flashes per minute Each cycle consisted of 150° (0 625 second) white, 10 (0 042 second) eclipse, 150° (0 625 second) red, and 50° (0 208 second) eclipse [2] The special taillights, Fig 1, were installed on a DC-3 airplane of the American

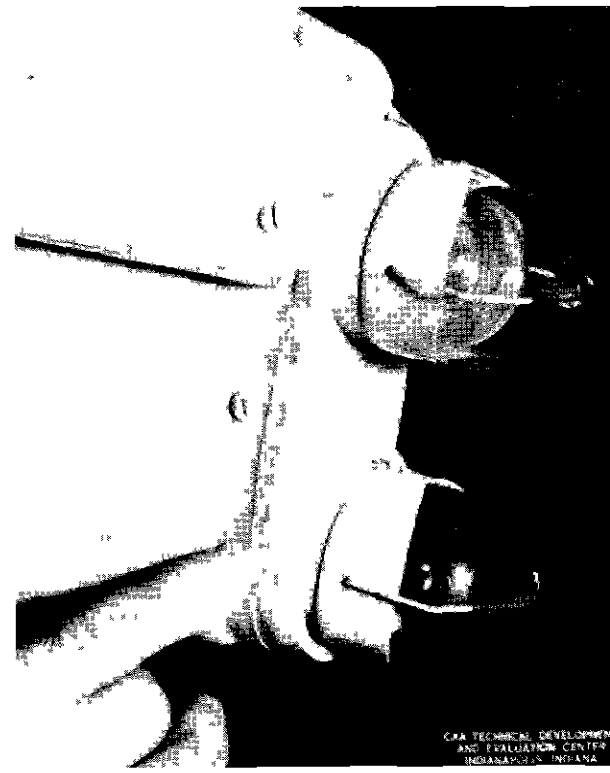


Fig 1 Red and White Flashing Taillight Installation

Airlines The red and the white lights were provided with 32- and 21-cp lamps, respectively, instead of the

[2] The cycle, originally expressed in degrees, referred to the angular rotation of the cam

conventional 15-cp lamps, required for this location Eastern Air Lines provided a DC-3 airplane to carry the observers

It was concluded by the observers that

a The airplane could be singled out readily against a background of city lights when the red and the white flashing taillights were operated

b The steady white light under the same conditions was much inferior to the flashing arrangement

As a result of these and other previous observations, the Engineering Section of CAA submitted to the Regulation Section a number of regulatory revisions which would permit air carriers to install and display this improved type of taillight arrangement

10 Flight Demonstration—American Airlines, NBS, CAA, CAB
January 1942, Washington, D C

A system of position lights that provided for the red flashing taillight to be synchronized with lights on the fuselage and for the white flashing taillight to be synchronized with the red and the green wing-tip lights was installed on an airplane belonging to American Airlines Two fuselage-light arrangements were demonstrated (1) two white lights on either side of the fuselage near the fin, (2) two white lights on the top and the bottom of the fuselage in line with the wing-tip lights This system of lighting was observed during flight at the Washington National Airport

The opinions of the observers were

a The flashing of all the lights is a decided improvement and greatly aids the observer in locating the airplane

b The lights should be flashed at 40 cycles per minute and should be controlled so that the red and the green wing-tip lights and the white taillight would be ON for 0 625 second followed by an eclipse of 0 042 second, and then followed by the white fuselage lights and the red taillight ON for 0 625 second, and last followed by an eclipse of 0 208 second

c The white lights on the right and the left sides of the fuselage near the fin could be eliminated

d The candlepower of the forward white fuselage lights could be increased from 32 to 50 cp

e The cut-offs on the taillights should be changed so that light would be visible for 90° on each side of the longitudinal axis of the airplane instead of for 70°

f A system of flashing lights is necessary, and very little additional work would be required to develop a system of lights which could be considered as a suitable stopgap for the immediate future

g A thorough long-range study of the over-all problem of aircraft external lighting should be undertaken

11 CAR Release No 13
January 1942, Washington, D C

CAR Draft Release No 13 contained proposed amendments to Parts 04, 15, and 60 of the Civil Air Regulations as follows

a Red and white taillights shall be used

b The taillights shall flash alternately

c Steadily burning lights shall be used on personal type of aircraft

d Flashing of the lights on air transports shall be at a rate of 40 cycles per minute

e Each cycle shall be as follows
(1) White taillight ON 0 625 second
(2) Eclipse 0 042 second
(3) Red taillight ON 0 625 second
(4) Eclipse 0 208 second

f Flash-timing tolerance shall be ± 10 per cent

g Both lights shall use 32-cp lamps

h Cut-off angle shall be 140°

i Effective date proposed—July 1, 1942

The above requirements, in the form of Civil Air Regulations, were promulgated on January 1, 1943

12 Flight Demonstration—American Airlines, NBS, CAA, CAB
February 1942, New York, N Y

American Airlines demonstrated position lights to obtain the reaction of the group of observers to various combinations of flashing and steady lights

The following lighting combinations were observed

a Wing-tip lights and taillights flashing, top and bottom forward fuselage lights flashing

b Wing-tip lights and taillights burning steadily, top and bottom forward fuselage lights flashing

c Wing-tip lights and taillights flashing, forward and rear white fuselage lights flashing

The flashing rate was 40 flashes per minute for each group of flashing lights, or a total of 80 flashes per minute for both the position and the fuselage lights A special experimental flasher was used to give this flashing rate The observation airplane made approach maneuvers, so that the American Airlines airplane could be observed from all critical angles

From observations, it was recommended that

a The CAA should give consideration to allowing the airlines to use a combination of flashing wing-tip lights, taillights, and white lights located on the top and the bottom of the fuselage in line with the wing-tip lights as follows
(1) White taillight and wing-tip lights ON 0 625 second
(2) Eclipse 0 042 second
(3) Red taillight and forward fuselage lights ON 0 625 second
(4) Eclipse 0 208 second

b Flashing cycles of two or more lights at the rate of 40 per minute should be used in order to provide flashes at the rate of 80 per minute

c No further consideration should be given to the white fuselage lights on either side of the fuselage near the fin

d White lights should use lamps having intensities of 32 cp minimum to 50 cp maximum

e The present regulations, proposed January 1942, covering the flashing white and red taillights should be adopted as soon as possible by all airlines

13 Ground Observation—Kollsman Instrument Division, TDEC
September 1942, Flushing, N Y

The TDEC contracted with the Kollsman Instrument Division of the Square D Company, Woodside, New York, for the development of tubular neon type of lamps Both neon (red) and xenon-mercury (green) lamps were fabricated, tested, and observed These were operated by condenser discharge to provide very short flashes The power supply could be keyed to provide intermittent or steady burning of the lamps

Following laboratory tests, these lamps were mounted on the roof of a building on the south shore of Flushing Bay and were observed from a Coast Guard patrol boat at distances of from one to five miles

It was concluded that

a The neon lights (red) were clearly visible at five miles distance

b The xenon-mercury lights (green) were not visible beyond a distance of three miles

c Condenser-discharge flashing should be evaluated in flight

d Both power supply units were large, heavy, and inefficient in their own power requirements

e The tubular light sources would involve large units for installation on aircraft and did not lend themselves to efficient reflector arrangements

f In general, the use of such lights on aircraft does not appear practical However, it was considered desirable to observe a condenser-discharge flashing light in flight for more complete evaluation

14 Flight Observations—Electronic Laboratories, Incorporated, TDEC
July 1943, Indianapolis, Indiana

The TDEC contracted with Electronic Laboratories, Incorporated, Indianapolis, Indiana, for the development of a condenser-discharge lamp

The lamp was mounted on the fuselage tail of a Boeing 247-D airplane and was flight tested at Indianapolis The airplane in flight was observed from the roof of the hangar The rate of flash was two per second The light was observed for a distance of 25 miles, however, it lacked the ability of other less intense lights to attract attention It was difficult to locate unless the observer knew where and when to look It also gave unsatisfactory indication of the speed or of the direction of flight of the airplane

The condenser-discharge lamp, as tested, was not considered practical for airplane use

15 Ground Tests—NBS and TDEC
March 1944, Washington, D C

Ground observation tests were conducted at the NBS to compare the relative merits of the present flashing schedule of white taillight and wing-tip lights ON 0 625 second and eclipse 0 042 second, red taillight and fuselage lights ON 0 625 second and eclipse 0 208 second with the suggested new flashing schedule of white taillight and wing-tip lights ON 0 542 second, eclipse 0 208 second, red taillight and fuselage lights ON 0 542 second, and eclipse 0 208 second

It was the unanimous opinion of the observers that the present flashing schedule should be abandoned and the new flashing schedule adopted

16 Flight Observations—TDEC
February 1945, Indianapolis, Indiana

Flight observations of an experimental oscillating position light, shown in Fig 2, were conducted by the TDEC The light was mounted on the escape hatch directly over the cockpit of a Boeing 247-D airplane The frequency of the oscillations was varied from 30 to 60 cycles per minute The light was equipped with a 100-cp lamp to provide a maximum beam intensity of some 5,000 cp with a red lens and approximately 25,000 cp with a clear lens The light was observed from another airplane during flight so that observation could be made from all critical angles of approach

The general conclusions drawn from the flight observations were

a The oscillating light with a red lens gives a very distinctive and conspicuous signal differing considerably from any other type of ground or airborne lights

b Use of the 100-cp lamp makes it possible to ascertain the presence and approximate direction of flight of the lighted airplane from at least twice the distance possible with the conventional flashing position lights

c The use of a red light appeared to have definite advantages over the white light since (1) better contrast between stars and other ground or airborne lights is obtained, and (2) there is less illumination of haze in the atmosphere

d A sweeping cycle of approximately 40 excursions of the beam per minute seemed most conspicuous and seemed to have the most ability to attract attention This appears to the observer as 80 flashes per minute

e A nose or underfuselage position on the airplane was suggested as a preferred location for the light With the light located on the hatch of the airplane, the beam of light traveled in front of the pilot and was considered distracting in haze or fog

f It appeared that 60° horizontal beam sweep should be increased to at least 90° and possibly to 180°

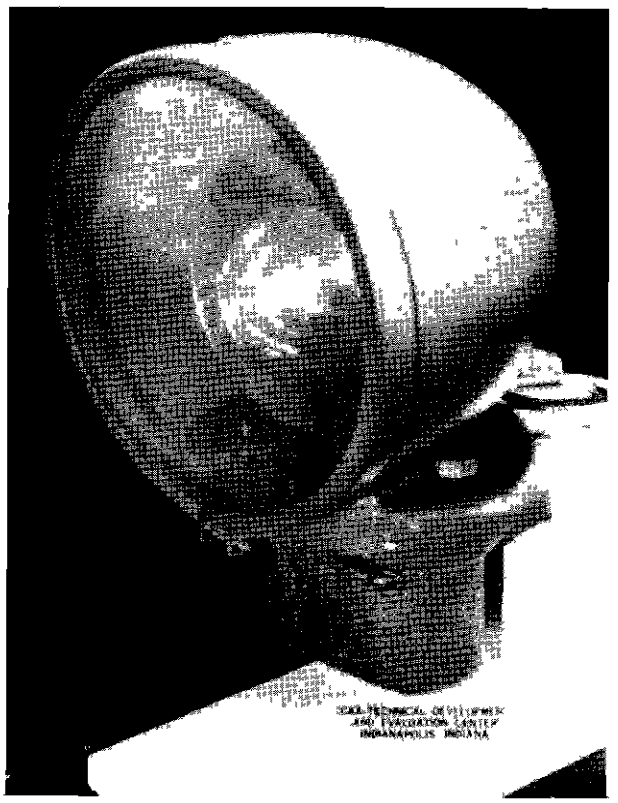


Fig 2 Experimental Sweep-Beam "Fire-Engine" Light

17 Flight Demonstration and Conference at TDEC
July 1949, Indianapolis, Indiana

The primary purpose of the flight demonstration and conference was to obtain the assistance and opinions of all segments of the aircraft industry and to obtain factual information for the United States representatives at future meetings of the International Civil Aviation Organization (ICAO) Observers from the following organizations were present Air Line Pilots Association (ALPA), NBS, Aircraft Owners and Pilots Association (AOPA), IES, Departments of the Navy and of the Air Force, CAB, CAA, lamp manufacturers, lighting assembly manufacturers, and various airlines

The existing U S system and an alternative system of position lights proposed by the United Kingdom, see Table I, were observed in the laboratory and also during flight

The experimental sweep-beam light (Event No 16) was mounted in the nose of a DC-3 Airplane, as shown in Fig 3 It was caused to oscillate at the rate of 40 excursions per minute, and the lamp, which was rated at 100 cp, was overvolted for test purposes so

TABLE I

COMPARISON OF UNITED STATES SYSTEM AND PROPOSED UNITED KINGDOM SYSTEM OF AIRCRAFT POSITION LIGHTS

System	Cycle Segment			
	1	2	3	4
United States	Red and green wing-tip lights with white tail-lights	Eclipse	Upper and lower white fuselage lights with red taillights	Eclipse
	0 54 second	0 21 second	0 54 second	0 21 second
United Kingdom	Red and green wing-tip lights with white tail-lights	Red and green wing-tip lights	Red and green wing-tip lights plus white tail-lights plus upper and lower white fuselage lights	Red and green wing-tip lights
	0 54 second	0 21 second	0 54 second	0 21 second

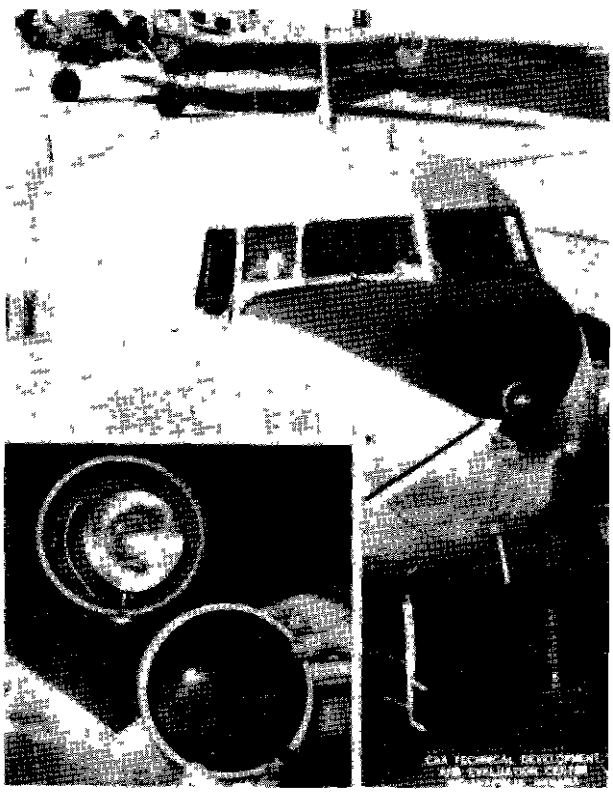


Fig 3 Installation of Experimental Sweep-Beam Light in Nose of DC-3 Airplane

that its intensity was 195 cp The lamp was carefully located with respect to the reflector so that with a red cover glass a maximum beam intensity of 10,000 cp was obtained

During the demonstration, the observers were carried in a second DC-3 airplane that made approaches to the first DC-3 so that the two systems of position lights and the sweep-beam light could be observed from all critical angles of approach The experimental lights were observed with both starlight and city lights as a background The visibility was reported to be 12 miles

The general consensus of those in attendance was

a The U S system of position lights offers better direction and attitude indication than does the system of the United Kingdom, however, neither system by itself was considered adequate for present-day conditions

b The red taillight of the U S system was easily confused with the red light on the wing tip

c A dual taillight was preferred to one light

d An amber light was suggested to replace the present red taillight

e The intensities of the flashing taillights and wing-tip lights should be increased as much as the present fixtures will permit

f Their flashing rate should be increased beyond 40 cycles per minute for greater effectiveness

g The sweep-beam light could be readily seen from an approaching airplane for a distance of 20 miles Two or three minutes of time elapsed before the other lights of the airplane were detected

h A more desirable location for the sweep-beam light would be the wing tips In the fuselage-nose position, the light beam produced disturbing reflections when the aircraft was flying through a hazy atmosphere

i A committee that represents the aircraft and the air transport industries should be appointed to consider the suggestions that were made for improvements in aircraft position lights The worthwhile suggestions were to be utilized in a later demonstration

18 Conference—Committee of Representatives From Aircraft and Air Transport Industries (Paragraph 17i)
September 1949, Washington, D C

As recommended (Event No 17), a committee met with Mr H F Tanke of the CAA as Chairman to consider the suggestions for improving aircraft position lights and to decide the nature of future evaluation and tests

It was determined that the next flight demonstration should include

a A variety of flashing rates
b Fuselage lights having 50 cp
c An array of taillights including white, red, amber (yellow), and lunar white

19 Flight Demonstration and Conference at TDEC
August 1950, Indianapolis, Indiana

This demonstration was the result of suggestions made by the committee described in the foregoing paragraph It was conducted at the TDEC under the auspices of the CAA with Mr W A Collins as Chairman The members who were present were representatives of the aircraft and air-transport industries, ALPA, Departments of the Navy and of the Air Force, CAB, NBS, Great Britain, Guggenheim Aviation Safety Center, lamp and lamp-fixture manufacturers, and the CAA

A Department of the Air Force H5H helicopter, a United Air Lines DC-3 airplane, and DC-3 and Boeing 247-D airplanes belonging to the TDEC were flown in the demonstration

Fig 4 Rotating-Prism Light

The Sikorsky helicopter was equipped with a lighting unit mounted on top of the cabin just ahead of the pylon The unit consisted of two high-intensity, sealed-beam units located back to back, rotating at 50 revolutions per minute (rpm) in a horizontal plane inside a red glass dome, and giving 100 flashes per minute The light was developed at the Naval Air Test Center at Patuxent River, Maryland, with the cooperation of Federal Enterprises, Inc , of Chicago, Illinois

The United Air Lines DC-3 airplane was equipped with a lighting unit developed by their engineers and mounted on top of the fin The unit included a single sealed-beam lamp which rotated in a horizontal plane inside a red plastic dome while it oscillated slowly in a vertical plane through about 70° The DC-3 airplane belonging to the TDEC had an experimental high-intensity light installed in the nose This was developed by Luminator Inc , of Chicago, Illinois, and consisted of a fixed sealed-beam unit in front of which rotated two clear plastic discs Each disc was formed as a row of parallel prisms, and the speed and direction of rotation of each disc could be adjusted to cause the resulting beam to follow a variety of patterns A similar light, embodying the use of a rotating prism, is shown in Fig 4 A red plastic cover was mounted in front of the discs During the demonstration, the beam was caused to sweep from side to side

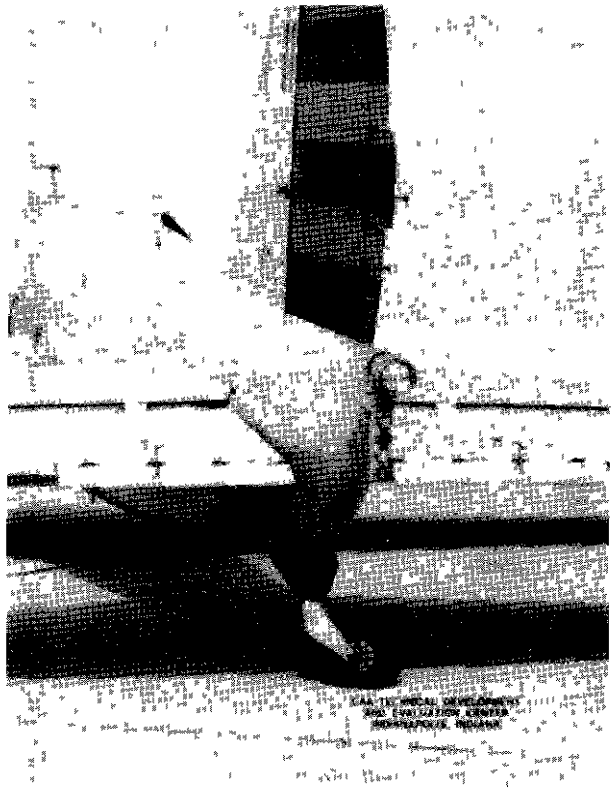


Fig 5 Standard-Thomson Aircraft Sweep-Beam Light and an Array of Experimental Flashing Lights on Tail of Boeing 247-D Airplane

In addition to its standard wing-tip and fuselage lights, the Boeing airplane carried

a Five taillights in a vertical row with red, aviation-yellow or amber, lunar-white, and clear cover glasses See Fig 5
b Six Fuselage lights just aft of the cabin, with two on the center line and four at 45° from the vertical See Fig 6

c Three aircraft type of sweep-beam, high-intensity lights with two in the leading edge of each wing tip, as previously recommended (Event No 17), and one in the tail of the fuselage See Figs 5, 7, and 8

Each of the taillights contained a 21-cp lamp and was equipped with special studded reflectors manufactured by The Grimes Manufacturing Company, Urbana, Ohio The five taillights were spaced 2½ inches between centers With this combination, the effect of close spacing (2½ inches) and of wide spacing (7½ inches) were observed The switching arrangement permitted showing the lighting combinations of amber with clear, red with clear, and amber with lunar white at a variable flashing schedule of 40, 80, and 120 cycles per minute

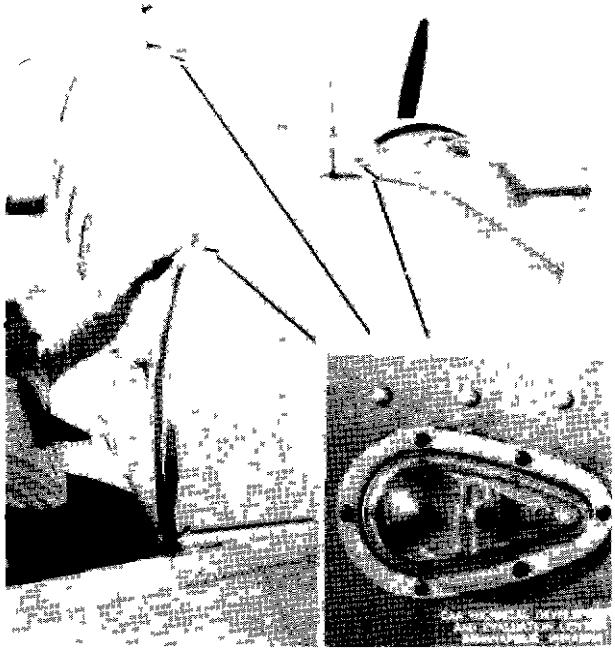
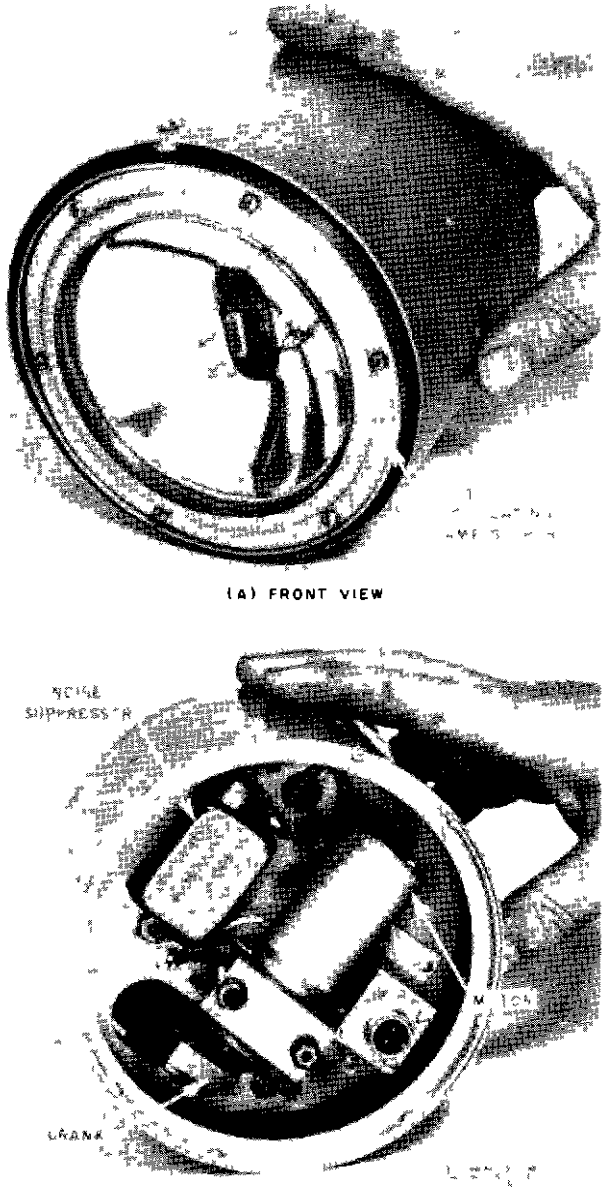


Fig 6 Experimental Arrangements of Flashing Fuselage Lights on DC-3 Airplane

The switching arrangement and flasher mechanism permitted the upper and the lower forward, the upper and the lower aft, and the 45° aft fuselage lights to be shown separately or in combination with the conventional position lights

The sweep-beam lights were an outgrowth of a TDEC development in which the design requirements were determined through the modification and testing of the experimental light. The Standard-Thomson Corporation, Dayton, Ohio, undertook the design of the aircraft type of light in accordance with those design requirements and supplied three such lights to the TDEC The light is 5⅝ inches in diameter, 4 inches long, weight 2¼ pounds, and uses 78 watts of electrical power It includes a 4½-inch diameter, PAR-36, sealed-beam lamp which is caused to oscillate from side to side through an angle of 60° at 40 excursions per minute, thus producing 80 flashes per minute Special lamps were supplied by both the General Electric Company and the Westinghouse Electric Corporation They have a maximum beam intensity of approximately 50,000 cp However, where red or green plastic covers are used, the intensity of the resulting beam is reduced to approximately 10,000 cp

As installed in the Boeing, red and green plastic covers were used on the wing-tip installations, and a clear plastic cover was used on the fuselage-tail installation The forward beams covered a horizontal angle from straight ahead to 60° outboard, or a total of 120° The tail unit swept through a total angle of 60° The vertical spread of the high-intensity portion of the beam was 14° These lights were visible at 20 to 30 miles distance on a clear night, with 15 miles visibility reported by the U S Weather Bureau at the airport, and appeared as a steady light punctuated by very intense flashes at the rate of 80 flashes per minute



(A) FRONT VIEW

(B) REAR VIEW

Fig 7 Standard-Thomson Sweep-Beam Light, Original Model

The conference group arrived at the following points of agreement based on the demonstrated lighting configurations and on ensuing discussions

a General

(1) The intensity of the flashing taillights, the wing-tip lights, and the fuselage lights is inadequate and should be increased as much as possible

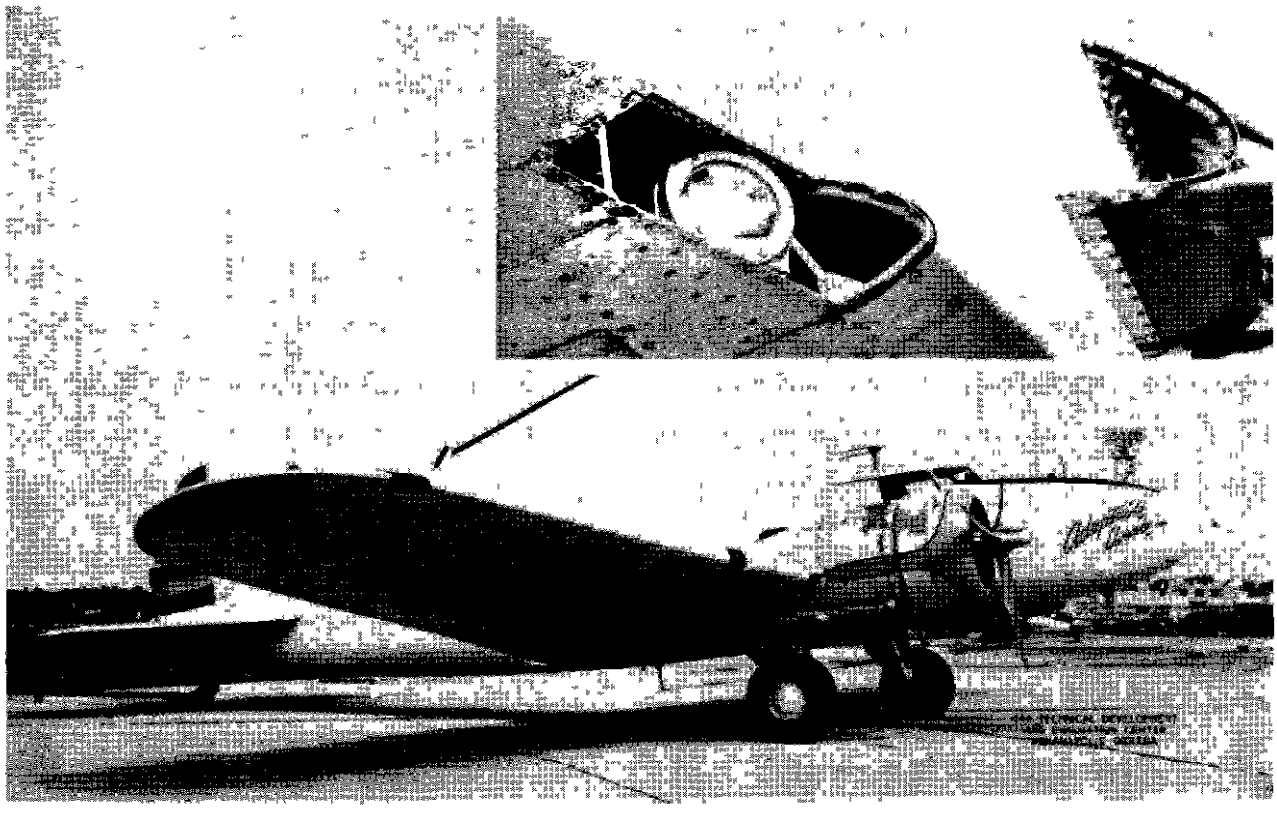


Fig 8 Installation of Standard-Thomson Sweep-Beam Light in Wing Tip of Boeing 247-D Airplane

(2) All aircraft, including personal type of air planes, should be equipped with flashing lights

b Flashing Sequence

(1) A definite improvement in the present flashing arrangement might be obtained by changing to the following sequence
  (a) Both wing-tip lights, upper and lower fuselage lights, and white taillight ON
  (b) Eclipse
  (c) Both wing-tip lights, upper and lower forward fuselage light, and red taillight ON
  (d) Eclipse

(2) The entire sequence should be repeated at the rate of 30 to 40 cycles per minute

c Taillight Color Combination

(1) The red and white taillight combination was superior to the others demonstrated The aviation-yellow light did not provide a distinct color, and the lunar-white light was inconspicuous even at a relatively short distance of 4,000 feet

(2) The taillights should be separated as much as possible, since wide spacing gave a jumping effect that added to the over-all conspicuousness However, this separation distance should be standardized

d Fuselage-Light Configurations

(1) The fuselage lights that were located in line with the wing-tip lights were superior to the other configurations presented

e Very-High-Intensity Lights

(1) Rotating-beam, high-intensity lights
The light which tilted as it rotated did not provide adequate hemispheric coverage The idea was considered desirable in principle, and further development of this light was recommended

(2) Sweep-beam lights, wing-tip location
  (a) These were effective in the sector swept by the beam, but the sectors should be expanded to obtain increased coverage
  (b) If the lights are installed in the tail of the fuselage, the intensities should be reduced in order not to blind the pilot of a closely following aircraft This could be particularly undesirable during take-off or landing operations
  (c) Since the beams did not sweep so that they would cross in front of the airplane, the effect of any possible halation was minimized

(3) High-intensity lights should be located either outboard of the propellor discs or as far back on the fuselage as possible The fuselage-nose location was considered undesirable

(4) Service testing of new high-intensity lights on airline aircraft was recommended

f Helicopter Lighting

The rotating helicopter light was effective as a warning light but lacked distinctiveness

20 Flight Demonstration and Conference — TDEC, CAA, and ALPA
September 1950, Chicago, Illinois

The question of how the wing-tip, fuselage, and taillights should be flashed with respect to each other was not resolved at the August 1950 conference at Indianapolis (Event No 19) In order to obtain a consensus in that connection, the TDEC and the ALPA arranged for a demonstration at Chicago The ALPA invited a representative group of airline pilots to observe these flight tests

The Boeing 247-D airplane belonging to the TDEC was flown to Chicago, and various flashing arrangements were shown It was the opinion of the group that-

TABLE II

SUGGESTED FLASHING SCHEDULE

Cycle Segment			
1	2	3	4
Red and green wing-tip lights plus white fuselage lights plus white taillights	Eclipse	Red and green wing-tip lights plus white fuselage lights plus red taillights	Eclipse
ON 0 54 second	0 21 second	ON 0 54 second	0 21 second

a The flashing schedule shown in Table II should be adopted by the airlines immediately as an interim measure

b The present flasher system could be easily modified to provide the suggested flashing schedule

c A long-range study program should be planned concerning external lighting for aircraft

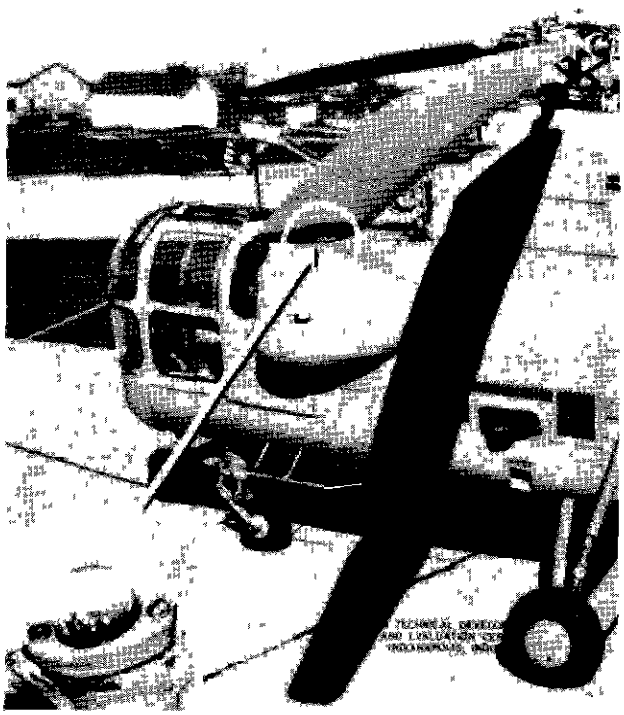


Fig 9 Installation of Low-Intensity Helicopter Rotor-Tip Lighting

21 Flight Demonstration by TDEC of Helicopter Rotor-Tip-Lighting—for the Departments of the Navy and Air Force, lamp manufacturers, and CAA
October 1950, Indianapolis, Indiana

This flight demonstration was part of a navy program in which the Department of the Air Force and the TDEC co-operated The purpose of this demonstration and conference were to

a Effect improved co-ordination of the activities of the Departments of the Navy and of the Air Force, the CAA, and the aircraft industry concerning the development of external lighting for helicopters

b Evaluate recent developments in this field

c Plan for continued developments of external lighting arrangements for helicopters

For demonstration purposes, a Sikorsky H5H helicopter was supplied by the Department of the Air Force from the Wright-Patterson Air Force Base, Ohio A set of three wood and fabric blades designed for this helicopter was supplied by the Naval Air Test Center, Patuxent River, Maryland Each one of these was equipped with a 3-cp lamp in the tip See Fig 9 Arrangements were provided for steady or flashing operation of either 68 or 80 flashes per minute

The helicopter was flown in the vicinity of the Weir Cook Municipal Airport, Indianapolis, Indiana Observers were carried in the Boeing 247-D airplane belonging to TDEC The airplane circled the helicopter, so that the lighting could be observed with a dark background and with the city and airport lights as a background

It was the consensus of the conference that followed that

a Rotor-tip lighting, as demonstrated, is very distinctive and conspicuous but is should be further developed to obtain greater intensity The light, as installed, was visible at a distance of not more than one mile when viewed against the background of airport and city lights Positive visibility for a distance of five miles was considered desirable

b Flashing rotor-tip lights were less effective than steady lights

c Rotor-tip lighting provided considerable assistance in landing and in determining the clearance between rotor tips and other objects

d Rotor-tip lighting was not disturbing to the pilot

e A complete rotor-tip lighting system should not require more than 300 watts of electrical power

A program for continuing the development of rotor-tip lighting was proposed

RESULTS

The keynote of activities concerning external aircraft lighting for the past 14 years has been cooperation Individuals, manufacturers, the airlines, and other private organizations, at their own expense have made many important contributions in this field Both government and private organizations have coordinated their efforts so that an orderly evolutionary process has resulted and duplication of effort has been minimized

The combined opinions and suggestions of all concerned have guided the TDEC in its planning for continued activities in this field, which activities include

a Conducting studies and laboratory and flight tests looking toward the establishment of minimum basic design criteria for external lighting units and associated equipment

b Conducting studies and laboratory and flight tests looking toward the establishment of minimum basic standards covering the installation of external aircraft lighting units and associated equipment

c The evaluation of new external aircraft lighting units, associated equipment, and external lighting installations in aircraft as they become available

APPENDIX

RÉSUMÉ OF RECOMMENDATIONS RESULTING FROM CONFERENCES AND TESTING

Event No	Date and Place	Event	Organization	Recommendations or Conclusions (Repetitions are marked with an *)
1	October 1938 Chicago, Ill	Conference	ALPA	Adopt uniform lighting arrangement * Adopt use of two flashing taillights *
2	April 1939 Washington, D C	Conference	IES Committee on Aviation Lighting, NBS, CAA	Provide approach direction indication Adopt standards * Conduct study to evaluate a, Flashing b Color c Various configurations Use two-filament lamps for reliability
3	December 1940 CAB Washington, D C	Conference	Safety Bureau, CAB, ALPA	Relax CAR to permit use of available units Adopt use of flashing taillight * Increase wing-tip light cut-offs to 180°
4	June 1941 TDEC Indianapolis, Ind	Tests	TDEC	Flashing light is better than steady light * Two taillights are better than one * Eclipse of not less than 0 15 second At least 40 flashes per minute Development of flashing mechanism necessary * TDEC should evaluate available flashers
5	June 1941 Washington, D C	Conference	CAA Aircraft Airworthiness Section and TDEC	TDEC should conduct program to a Effect taillight intensity increase to 32 cp b Evaluate existing flasher mechanisms * c Evaluate two different-colored taillights
6	June 1941 Washington, D C	Laboratory Evaluation Flight Tests	NBS, CAA	Mechanical flashers superior to thermal flashers

RÉSUMÉ OF RECOMMENDATIONS RESULTING FROM CONFERENCES AND TESTING (Continued)

Event No	Date and Place	Event	Organization	Recommendations or Conclusions (Repetitions are marked with an *)
7	July 1941 CAB, Washington, D C , Mr Lederer's Office	Conference	CAB, CAA, ATA, Armed Forces, United Air Lines	TDEC should conduct program to a Develop very-high-intensity forward light b Develop a sweeping-beam VHI light c Provide red at left, green at right, white at center d Develop red and white flashing taillights * e Develop flashing mechanism * TDEC should conduct study to develop basic requirements for lighting *
8	August 1941 NBS, Washington, D C	Ground Tests	NBS sponsored by TDEC	Flashing red and white lights better than steady lights * Definite eclipse between flashes is essential Use of red and green taillights is undesirable A flashing light is better than a steady light *
9	October 1941 Washington National Airport	Flight Demonstration	American Airlines, Eastern Air Lines, CAA, CAB, NBS	Flashing taillights and wing-tip lights very effective * Intensities of 32-cp red and 21-cp white effective Steady white taillight inferior to flashing lights * Rate of forty cycles per minute effective Flash duration of 0 625 second effective Eclipse durations of 0 042 second and 0 208 second effective NOTE 0 625 + 0 042 + 0 625 + 0 208 = 1 5 second, or 40 cycles per minute
10	January 1942 Washington National Airport	Flight Demonstration	American Airlines, NBS, CAA, CAB	All lights should be flashed (transport) * Forty flashing cycles per minute as follows a White taillight and wing-tip lights on 0 625 second * b Eclipse 0 042 second * c Red taillight and white fuselage lights on 0 625 second * d Eclipse 0 208 second * Do not use white lights at rear of fuselage * Forward white fuselage lights should be 50 cp * Cut-off for taillights 90° each side Flashing system is an effective stopgap * Long-range study necessary *

RÉSUMÉ OF RECOMMENDATIONS RESULTING FROM CONFERENCES AND TESTING (Continued)

Event No	Date and Place	Event	Organization	Recommendations or Conclusions (Repetitions are marked with an *)
11	January 1942 Washington, D C	CAR Release No 13	CAA	Red and white taillights shall be used * Taillights shall flash alternately Steady taillights for personal aircraft Flashing shall be at 40 cycles per minute * Cycle shall be as follows a White taillight on 0 625 second (150° of arc on flasher commutator) * b Eclipse 0 042 second (10°) * c Red taillight on 0 625 second (150°) * d Eclipse 0 208 second (50°) * Flash-timing tolerance ± 10 per cent Both lights fitted with 32-cp lamps Dihedral angle – 140°
12	February 1942 New York, N Y	Flight Demonstration	American Airlines, NBS, CAA, CAB	Use red and white taillights * Use top and bottom white fuselage lights Locate fuselage lights just aft of cockpit Use 40 cycles per minute (80 flashes per minute) * Lamps not less than 32 cp nor more than 50 cp Promulgate regulations (reference No 11) as soon as possible Flashing schedule to be as follows * a White taillight and wing-tip lights ON 0 625 second * b Eclipse 0 042 second * c Red taillight and fuselage light ON 0 625 second * d Eclipse 0 208 second *
13	September 1942 Flushing, N Y	Field Test	Kollsman Instrument Division, CAA TDEC	Incandescent neon lamp a Was reasonably effective b Required associate equipment that was heavy and bulky c Associated equipment absorbed excessive power
14	July 1943 Indianapolis, Ind	Flight Test	Electronic Laboratories, Inc , TDEC	Condenser-discharge lamp a Required large, bulky associated equipment b Gave little indication of speed or direction of flight c Could be seen 25 miles d Had little conspicuousness e Was not distinctive f Was considered inadequate and impractical

RÉSUMÉ OF RECOMMENDATIONS RESULTING FROM CONFERENCES AND TESTING (Continued)

Event No	Date and Place	Event	Organization	Recommendations or Conclusions (Repetitions are marked with an *)
15	March 1944 NBS, Washington, D C	Ground Tests	NBS, TDEC	Abandon previous flashing schedule Adopt new flashing schedule as follows a White taillight and wing-tip lights on 0 542 second (130°) b Eclipse 0 208 second (50°) c Red taillight and fuselage lights on 0 542 second (130°) d Eclipse 0 208 second (50°)
16	February 1945 Indianapolis, Ind	Flight Tests	CAA, TDEC	Oscillating light with red lens gives a Very distinctive light b Very conspicuous signal c 20-mile visibility on clear night Forty cycles per minute seemed most conspicuous and attention-attracting * Red light gave less illumination of haze Over-cockpit location unsatisfactory Nose location recommended 90° sweep-angle recommended
17	July 1949 TDEC Indianapolis, Ind	Flight Demonstration and Conference	ALPA, NBS, AOPA, IES, CAB, TDEC, Departments of the Navy and of the Air Force, Lamp and lamp fixture manufacturers, Airlines	U S system of position lights preferred over United Kingdom system Neither system alone adequate Red taillight easily confused with red light on wing Try amber (yellow) as a taillight * Increase intensity of flashing lights * Increase rate of flashing * 20-mile visibility of sweep-beam (clear night) Locate sweep-beam lights on wing tip Appoint committee to screen above suggestions
18	September 1949 Washington, D C	Conference Screening Committee	ALPA, CAB, CAA, Department of the Navy, Lamp and lamp fixture manufacturers	Conduct test on present light configuration, but with a Increased flashing rates * b Increased intensity of fuselage lights * c Amber (yellow) and white taillights *

RÉSUMÉ OF RECOMMENDATIONS RESULTING FROM CONFERENCES AND TESTING (Continued)

Event No	Date and Place	Event	Organization	Recommendations or Conclusions (Repetitions are marked with an *)
19	August 1950 TDEC Indianapolis, Ind	Flight Demonstration and Conference Transport aircraft and Helicopter	ALPA, ATA, CAA, CAB, NBS, TDEC, Departments of the Navy and of the Air Force, British Embassy, Airlines, Light manufacturers	Increase intensity of flashing lights * Use flashing lights on personal type of aircraft Suggested flashing schedule as interim measure a Fuselage and wing-tip lights, 80 flashes per minute b Red and white taillights flash alternately Flashing rate should ultimately be increased * Red and white best for taillights * Locate fuselage lights just aft of cockpit * Use standard separation for taillights Sweep-beam lights effective a Should provide wider coverage b Tail sweep-beam light too intense c Wing-tip installation is undesirable Rotating type of light requires more development Helicopter lighting a Rotating-dome light effective as warning b Development of more distinctive lighting arrangements Request another flight demonstration to evaluate flashing schedule outlined in Item 3
20	September 1950 Chicago, Ill	Flight Demonstration and Conference	ALPA, CAA, TDEC, Light manufacturers	Schedule outline in Reference 19 is very good United Air Lines will modify flashers to effect this schedule
21	October 1950 TDEC Indianapolis, Ind	Flight Demonstration and Conference	Departments of the Navy and of the Air Force, Lamp manufacturers, TDEC	Rotor-tip lighting with 3-cp lamps a Very effective within range of 3-cp lamps b Should have higher intensity c Should be steady d Provides considerable assistance to pilot in landing e Did not disturb pilot during flight Continue development program for rotor-tip lighting Special lamps to be developed