DOCUMENT RESUME

ED 021 433 EF 001 896

ILLUMINATING ENGINEERING RESEARCH INSTITUTE ANNUAL REPORT 1965. A REVIEW OF ACTIVITIES DURING THE YEAR, WITH EMPHASIS ON THE RELATIONSHIP BETWEEN COLORS AND LIGHTING.

Illuminating Engineering Research Inst., New York, N.Y.

Pub Date 65

Note- 36p.

EDRS Price MF-$0.25 HC-$1.52

Descriptors- *COLOR PLANNING, *LIGHTING, *PSYCHOLOGICAL DESIGN NEEDS, *PSYCHOLOGICAL STUDIES, *VISUAL STIMULI

Featured in this report is a summary of an extensive and unique study of color combinations and lighting. The summary presents the highlights of a report by Xr. Harry Helson which brings to fulfillment the complex work of this distinguished psychologist who began his inquiries in the late 50's. The report provides a method of forecasting whether a specific object color will be agreeable or disagreeable if used with a specific background color under one of five specific kinds of lighting. (RK)

1965 ANNUAL REPORT

ILLUMINATING ENGINEERING Research Institute

A review of activities during the year, with emphasis on the relationship between
COLORS AND LIGHTING

INDEX

ILLUMINATING ENGINEERING
Research Institute

345 East 47th Street, New York 17, N.Y.

Foreword

September 30, 1966

Featured in this 1965 Annual Report of the Illuminating Engineering Research Institute is a summary of an extensive and unique study of color combinations and lighting. The summary presents the highlights of a report by Dr. Harry Helson which brings to fulfilment the complex work of this distinguished psychologist who began his inquiries in the late 50s.

The Helson Report, in the judgment of the Institute, may well be historic. In organizing more than 156,000 observer reactions into tables with responses ranging from high pleasantness to greatest unpleasantness, the report provides a method of forecasting whether a specific object color will be agreeable or disagreeable if used with a specific background color under one of five specific kinds of lighting.

To do full justice to Dr. Helson's report, we felt that it should be illustrated in color. Since accurate color reproduction is difficult and costly, it was necessary to shop carefully for a satisfactory printer. The printers we decided to use were those in the Netherlands who regularly print the bi-monthly magazine, International Lighting Review, which contains full-color pages in each issue.

Because of the technical complications involved in color printing, and because of the time consumed in trans-Atlantic approval of proofs -- as well as in shipping the completed illustrations which appear on Page 13 -- the actual production and mass distribution of this annual report was delayed from Spring to Fall.

We hope that you will find this report of research progress in 1964 - '65 interesting and informative. We hope, also, that you will be impressed with the potentials suggested in Dr. Helson's work and that the color illustrations will help to dramatize the meaning of his paper. The cover of this annual report, incidentally, uses a combination of green on yellow that commands one of the highest preference ratings among the thousands of combinations that Dr. Helson measured.

Board of Trustees,
John W. Ferree, M.D., M.P.H., Chairman

Color Preference Studies

Pleasantness of Color:
Object, Background and Source

The Illuminating Engineering Research Institute's continuing inquiry into the relationship of color to light, it can be said, was born near New Orleans in 1947 during an annual Technical Conference of the Illuminating Engineering Society.

The colorfulness of the New Orleans Latin Quarter had little to do with it. The studies of light and color came into being quite casually in the course of an informal conversation of three I. E. S. members who are among the leaders in the color world: Miss Dorothy Nickerson, of the U. S. Department of Agriculture; Dr. Deane B. Judd, of the U. S. Bureau of Standards, and Ralph Evans of the Eastman Kodak Company.

This casual conversation -- it took place on a Mississippi River outing near the Queen City -- left a memorable mark on lighting history, resulted in several research projects providing much new technical knowledge, and now, 19 years later, is indirectly responsible for a unique analysis of the psychological and aesthetic effects of combinations of colors under a variety of lighting sources.

"Why not broaden the scope of lighting knowledge by investigating the role of color?" was the innocent question one of the group asked the others in a quiet corner of the S. S. President's lounge. It was an interesting question, all agreed. But there were no answers at that meeting, or that year.

The following year, however, there was an answer. It came as a result of the same question which, this time, was posed at a more formal committee meeting in a basement conference room of the I. E. S. in the New York Life Insurance Company building in New York. Miss Nickerson was authorized there to launch the color investigations -- a computer study to determine how various fluorescent sources would affect the physical appearance of color as seen by a hypothetical international observer adapted to daylight.

This led next to a suggestion that Dr. Harry Helson, then a psychologist teaching at Brooklyn College, make a study of the change in appearance of colors as one goes from daylight to various fluorescent light sources, observations being made after adaptation to each new source.

This idea eventually took shape as IERI Project 11 with Dr. Helson working in conjunction with Dr. Judd. Together they developed a formula to predict color change based on the judgments of a group of observers who described how a spectrum of ten colors changed on passing from daylight to 3500 degrees Kelvin (K), 4500K and 6500K fluorescent lamps.

Stemming from this investigation of color in conjunction with light were other investigations, one of the most significant being another study led by Miss Nickerson. In the new work she and a skilled committee carried the findings of Project 11 a step further to determine how specific colors were rendered by any specific light sources. They confirmed that some sources rendered colors more accurately than did others -- and also that some sources which rendered one color well rendered another relatively poorly. They developed a method of computing a color-rendering index as to the relative effectiveness of a source to truly show a range of colors.

Miss Nickerson's committee made an historic contribution to lighting literature with this work. This report was adopted as a standard of the International Commission on Illumination in 1963.

It is obvious, of course, that the alert illuminating engineer must be deeply interested in the effect of various kinds of electric light on color. This interest is considerably more than academic. In fact, it had become apparent in the 1950s that the future growth of lighting -- the degree of light's ability to become an important factor in architectural design -- depended upon its eventual relationship with color. IERI leadership, the records will show, was quick to recognize a need, to reassure architects and interior designers that the lighting profession was not blindly consecrated to the stark, sterile, white or slightly-off-white atmospheres that accompanied the kind of light that measured up to higher utilization performance. The leadership readily acknowledged the need to refute the charge of color specialists that "lighting engineers would do everything in white".

The questions with which the IERI wrestled was: "How can the lighting engineer maintain the low-brightness ratios he has attained while supplanting the accompanying blandness with the vividness of color? How can he maintain necessary lighting levels and achieve the aesthetic level necessary to play an active role in design?"

In answer to this pair of questions, the IERI decided its first step was to face the basic problem: "What are the facts about the aesthetics of color and color combinations in terms of light?"

If new knowledge on color-in-lighting could be produced, it is expected there would be no difficulty in coordinating it with lighting.

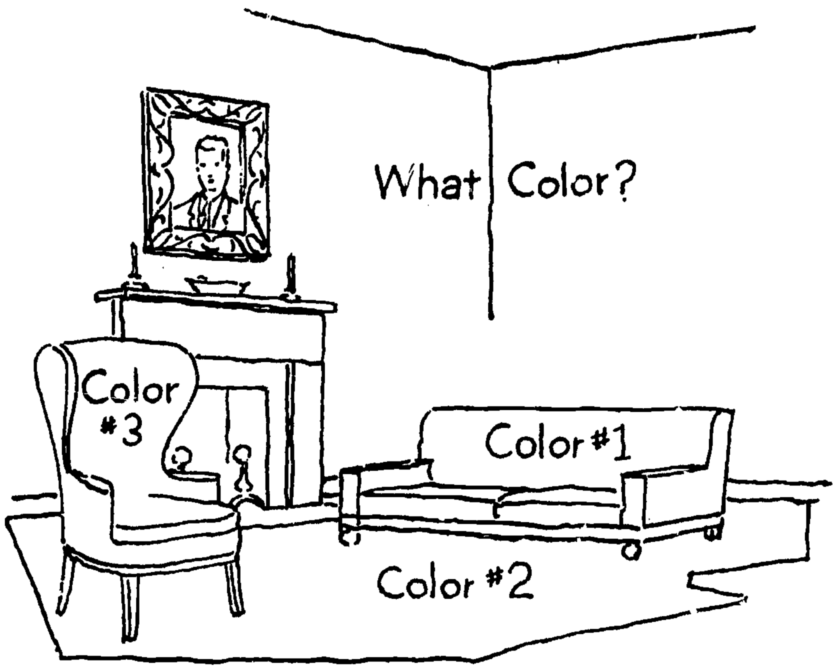
To find this new color knowledge, the IERI again turned to Dr. Helson, then at the University of Texas. He undertook a complex study, with the help of student observers, which was identified as IERI Project 48.

Project 48

In 1960, at the Sheraton Park Hotel in Washington, D. C., to a large audience that braved a blizzard, he described his basic results. These contradicted the cynics who, before his studies began, forecast that the findings would prove the study to have been unnecessary. Nature, they argued, combined all sorts of colors with breathtakingly beautiful results, proving that all colors readily combined.

"Both laymen and certain experts tend to one or another of two fallacious beliefs," Dr. Helson said in his Washington statement which seriously undermined the pessimists' view. "The first is that colors ... can be treated as absolutes which are either pleasant or unpleasant ... as one would either like or dislike oysters or beefsteak." People cannot be this specific about colors, he said, "because colors appear in a context of other colors. What color is," he contended, "depends upon its surround."

The other commonplace fallacy, he said, was denying that it was necessary or even possible to get reliable information about color preferences. He showed that this could be done and insisted that it was necessary to evaluate color preferences in terms of colors against their backgrounds. He also argued that this could be done satisfactorily according to C. I. E. standard specifications of saturation (hue) and brightness (reflectance).



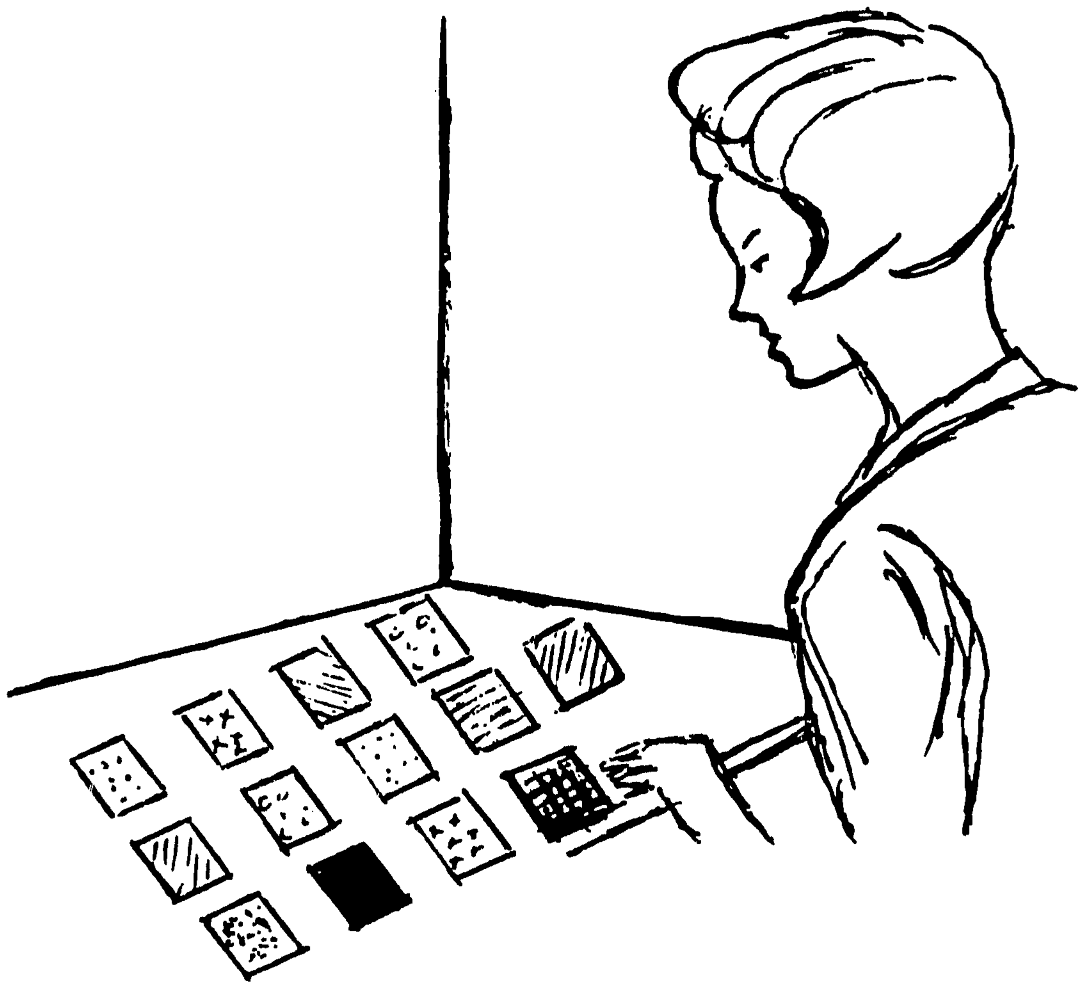
Helson studies, under various light sources, chart color backgrounds that complement groups of foreground colors -- and vice versa

Dr. Helson, since 1960, has analyzed the results he stated in a general way in Washington and presented a final report on Project 48 last Fall. This report will be summarized in the following paragraphs.

Dr. Helson, first of all, dismissed any question of the ability to measure individual aesthetic reactions to color combinations, citing the earlier successes of Guilford and Smith in this area and Guilford alone in measuring aesthetic reaction to pitch and loudness of tone.

Next he established that, since there had been no reliable studies of aesthetic effects of color combinations in terms of lighting -- or pleasantness of the luminous environment -- his inquiry must involve a variety of samplings using a relatively large assortment of observers, sources, object colors and background colors. Further, acknowledging that one source of illumination which might be favorable for one set of colors might not be favorable for another, he accepted a concept of gradations of acceptability. He made clear that, in the end, he was searching for the principles governing aesthetic effects of various color combinations under various sources so as to be able to predict the best combination for a given object color.

He conducted his studies in light-tight booths illuminated by one of five different current lighting sources which turned out to be good, average or poor types of illumination with respect to color rendition -- 4500K fluorescent, 2854K incandescent, 6500K fluorescent (daylight cool white), 3000K fluorescent (standard warm white), and 6500K incandescent.



Observer views chips in light-tight booth

He used 122 chips from the Munsell Book of Color and three neutrals (white, gray and black) in his studies. These represented the main regions of hue -- red, orange, yellow, green-yellow, green, blue-green, blue, purple-blue, purple and red-purple. Each hue, in turn, was represented with a low, medium and high value of lightness (value) and saturation (chroma). All 125 colors were exposed against 25 backgrounds, including three neutral backgrounds.

Approximately 12 chips were displayed simultaneously against each background and were observed by five men and five women of diversified interests who rated them on a 9-position scale ranging from "very, very pleasant" to "very, very unpleasant".

Exposing his ten observers to 125 object colors against 25 background colors under five different illuminants, Dr. Helson gathered 156,250 reactions during his tests.

From these reactions he was able to make a series of general observations, as indicated hereafter, each of which, supported by dependable scientific investigation, is important for the illuminating engineer as well as the color expert.

He established at the outset that the source of illumination exerts a significant effect on color preferences. The sources, rated from best to worst in terms of color preference, were 4500K fluorescent, 2854K incandescent, 6500K fluorescent, 3000K fluorescent and 6500K incandescent.

Men and women differ significantly in their color preferences, men tending to cooler object colors (green-yellows, blues and purples), cooler backgrounds, and cooler sources; women tending toward warmer object colors (reds, yellow-reds and yellows) and warmer backgrounds and sources. He also showed that the quality of the light source affects reactions to familiar objects such as foods and complexions. Although there were some minor variations in opinion, results of both men and women were in good agreement. (See chart.)

	COLORS LIKED MOST				COLORS LIKED LEAST			
	Men		Women		Men		Women	
ITEM	2854K Inc.	6500K Fl.	2854K Inc.	4500K Fl.	6500K Inc.	3000K Fl.	6500K Inc.	3000K Fl.
Butter		x		x		x	x	
Beef (raw)	x			x	x		x	
Apples	x			x		x		x
Lettuce	x		x		x		x	
Tomatoes	x		x			x		x
Faces	x		x		x			x

Inc. - Incandescent Fl. - Fluorescent K. - Kelvin degrees

But background, even more than source, affects responses to object colors. Colors are not inherently pleasant; pleasantness depends to a large degree on adjacent colors. Dr. Helson showed this by plotting the results of the exposure of one object color against 25 differently-colored backgrounds under a single lighting source and noting the definitely unfavorable reactions to certain specific backgrounds.

He also established that some background colors could not be used with certain sources. Incandescent light at 2854K has strong yellow components that kill blue surfaces. Similarly, green or greenish backgrounds are unattractive with 6500K fluorescent. Proper choice of background may counteract a bad source, however, and improper choice of background may hurt the effect of a good source.

By averaging across all five lighting sources, he found that the best background colors to enhance the pleasantness of object colors were white, light yellow, light red, light green, dark green, light purple-blue, and black.

Seven of the eight best backgrounds, Dr. Helson emphasized, have low or zero saturation. These, he said, are the best backgrounds to use if the spectral energy of the source is unknown. He also observed that all eight top backgrounds are of medium or low lightness and seven are of medium-to-low chroma. Generalizing from this, he suggests that the best background colors for enhancing object colors are pastels, including neutrals white and black. A background color that enhances an object color is not automatically a good object color against another background, he warned.

With respect to the pleasantness of object colors themselves -- in addition to the effect light sources and backgrounds have upon them -- he cited the importance of lightness and saturation. The best colors -- all effects of source, background lightness and saturation considered -- were, in descending order: blue, blue-green, green, purple-blue, red-purple, and red. Yellow is conspicuously absent. (Observers' twenty lowest ratings were yellow or colors containing yellow.)

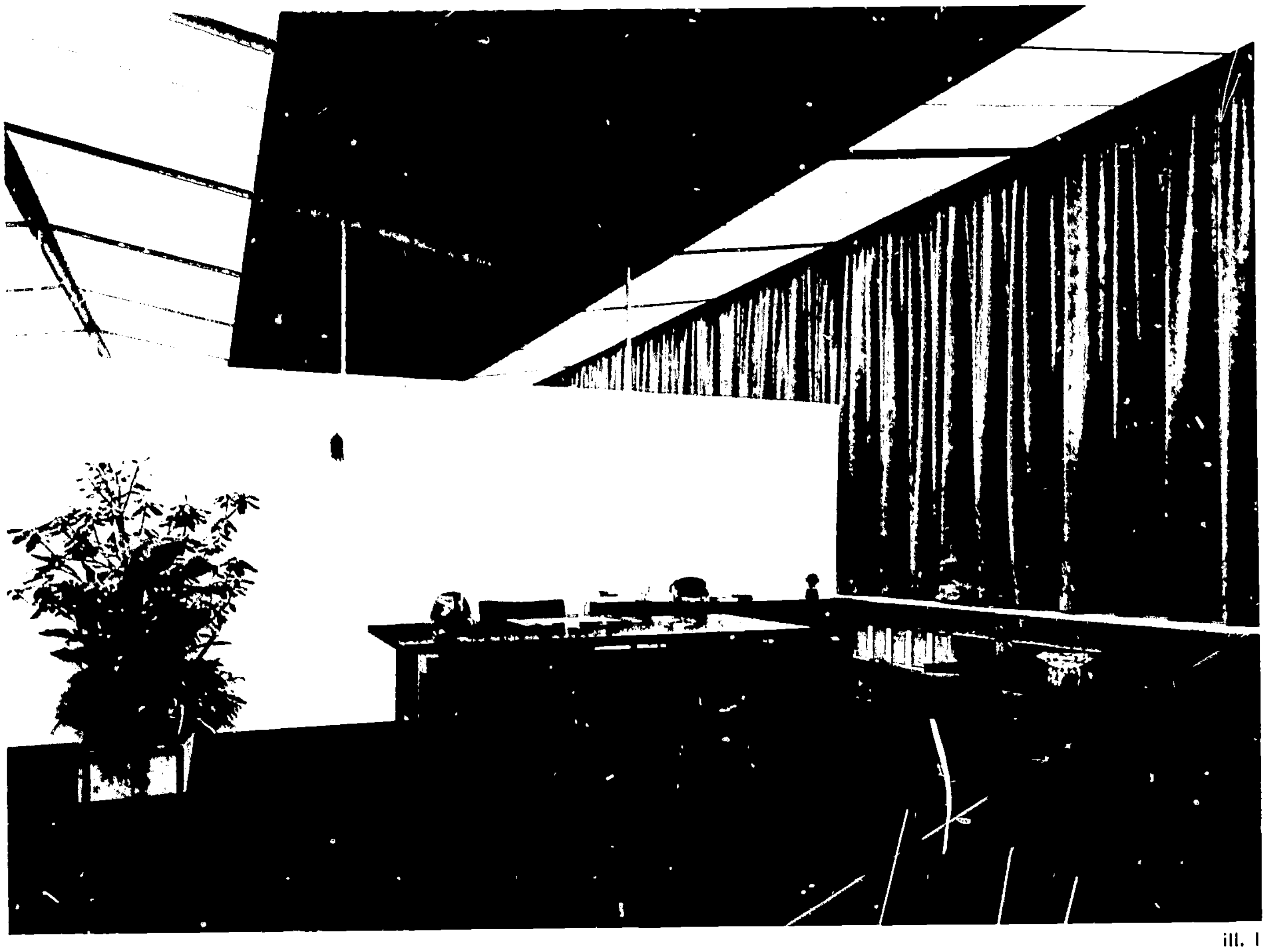
The best object colors, he concluded, are either quite dark or very light, the extremes offering maximal contrast with background colors.

Considerable importance must be attached to the tables developed in the course of the Helson study. From them the best and worst combinations of object and background colors readily can be spotted for each of the five types of illuminants tested. Thus, a lighting engineer or interior designer can determine the pleasantness rating of a Munsell color combination by locating it in the chart that most closely approximates the light source and color background to be used. The results of the Helson test thus become not only a valuable addition to lighting knowledge but a valuable practical asset as well.

While it is now possible to determine reactions to colors under specific conditions, as Dr. Helson has shown, it is still difficult and very costly to reproduce color with corresponding accuracy. For this reason, it was decided not to attempt to show Dr. Helson's color combinations in this report.

Instead we are content to present on the opposite page a four-color reproduction of a pleasant and effective combination of hues in an interior setting representative of a good rating from the Helson data. Also shown are lighted booths used in the Helson studies.

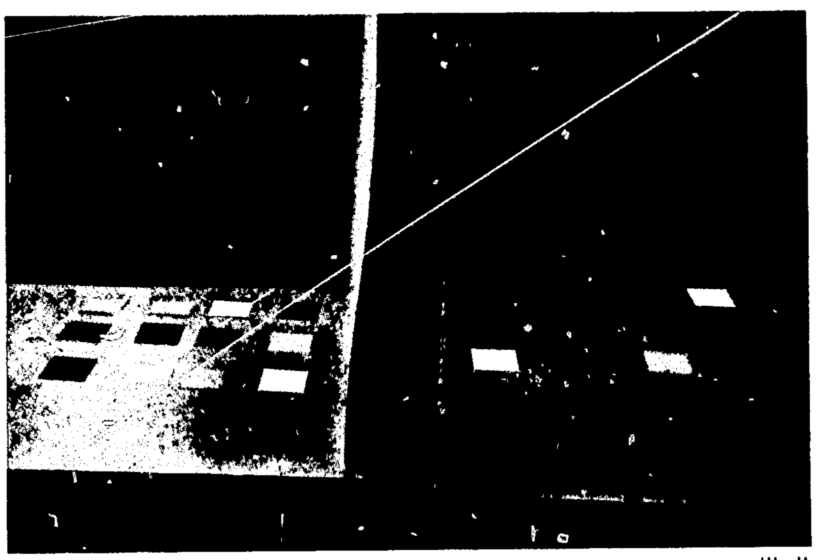
While the tones of the color chips shown in the booths might not be a precise reproduction of those used in the tests, the relative appearances of the colors under various light sources and against differing backgrounds adequately demonstrate the basic findings of the study.



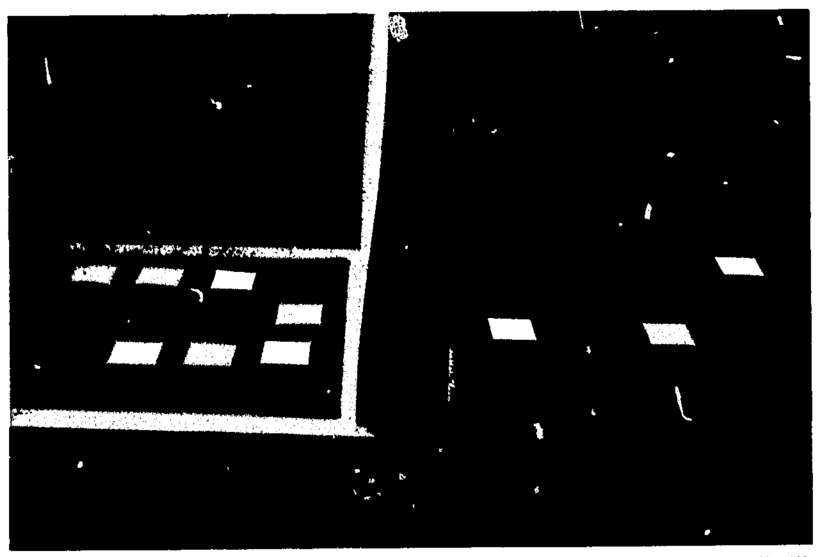
ill. I

Color, Light and Background

A pleasant interior as published in the "International Lighting Review", 1965, III, 109.



Booth 1 Booth 2 ill. II



Booth 1 Booth 2 ill. III

HOW DIFFERENT LIGHT SOURCES AND BACKGROUNDS cause identical objects to appear to be different in color is shown in illustrations II and III. The booths and chips pictured are those used by Dr. Harry Helson in his study of thousands of color combinations. The vertical columns of chips in each illustration are so arranged that those from *right to left* in Booth 2 are identical with those from *left to right* in Booth 1. Color changes in the booths of illustration II are due to the use of two different light sources and two different backgrounds.

Changes in illustration III are caused by changed backgrounds in each booth under sources identical with illustration II.

The color photos on the reverse side of this page were produced by Spin and Zoon Printing Co., Inc., Amsterdam, the Netherlands. The IERI chose this firm in an attempt to profit from the experience of plate-makers who have developed a high degree of special skills with lighted color scenes as a result of printing the International Lighting Review six times each year.

European Symposium

The third international symposium of the Illuminating Engineering Research Institute, providing a means for important exchange of light-and-vision knowledge among researchers in both hemispheres, was held June 14 through 16, 1965, at Soesterberg, the Netherlands. Prof. Dr. M. A. Bouman of the Institute of Perception served as host. The symposium introduced a new pattern of biennial rather than quadrennial meetings.

Major emphasis at the meeting was placed on basic vision, although visual performance, roadway research, disability glare and discomfort glare also were discussed extensively.

The following group of IERI investigators and other American lighting authorities participated in the meeting: Dr. H. Richard Blackwell, director of the Institute of Research in Vision, Ohio State University, Columbus; Dr. Glenn A. Fry, head of the School of Optometry at Ohio State; Dr. Sylvester Guth, manager of the Radiant Energy Laboratory, General Electric Co., Cleveland; Willard Allphin, research lighting engineer at Sylvania Electric Products Inc., Danvers, Mass., and an IERI investigator, and Dr. Robert M. Boynton, director of the Vision Center at University of Rochester.

Dr. Blackwell established his view that contrast was the key element in all vision -- including the ability to see small sizes. Since size has always been a major factor in explaining the ability to see objects, Dr. Blackwell's theorem was the center of considerable debate.

Dr. Guth, chairman of the Discomfort Glare Committee of the International Commission on Illumination, correlated the discomfort glare formulae of several investigators, including his own.

Mr. Allphin explained his proposed practical experiment for evaluating discomfort glare with naive observers from commerce and industry.

Prof. E. M. Strong, of Cornell University, Ithaca, N. Y., reported on the study of luminous ceilings (cf. Project 59-64).

Dr. Fry reported on why Dr. Guth's exponential formula works and also introduced a modification which, he claimed, was even more functional than Dr. Guth's in terms of experimental data.

3d Symposium Hosted by Dutch

AT IERI CONFERENCE were (l. to r.) A. B. de Graf, Dr. S. K. Guth, Prof. Dr. J. F. Schouten, Dr. Ing. G. Soellner, Wendy Collins, John Collins, Miss V. M. Reading, F. Burghout, Prof. E. M. Strong, A. W. Christie, C. L. Crouch, Dr. J. J. Vos, Dr. G. van den Brink, W. J. M. Levelt, Mrs. O. M. Blackwell, Dr. H. Bouma, Dr. H. R. Blackwell, Dr. H. A. Schober (front), W. Allphin (rear), F. L. van Nes, Dr. R. M. Boynton, Dr. L. C. Mead, Dr. M. Aguilar Rico, Dr. P. L. Walraven, P. T. Stone (front) W. H. Edman (rear), Dr. E. Hartmann, Prof. A. Arnulf, Prof. Dr. M. A. Bouman, J. Dourgnan, Dr. G. A. Fry, Dr. W. K. Adrian, Dr. J. van Ierland.

Among the German scientists who spoke were Dr. W. Adrian, of the Lichttechnische Institut für Technische Hochschule, Karlsruhe, who presented data on the variation of visual acuity with wavelengths or colors of the spectrum; Prof. H. A. Schober, head of the Institut für Medizinischeoptik, München, who described his laboratory studies of visibility of radar screens with their inherently poor contrast; Dr. Erwin Hartmann, of the same organization, who spoke on the effect of surrounds on roadway visibility, and Dr. Ing. G. Söllner who described model studies and a simplified discomfort glare criterion for interior use.

French scientists on the program included Dr. E. Baumgart, of the University of Paris, who was chairman of the basic vision section, and Prof. A. Arnulf, of l'Institut d'Optique, Paris, who reported on the quality of images formed by the eye.

The Netherlands' speakers were Dr. Gert van den Brink, of Groningen University, on visual interaction mechanisms; Dr. H. Bouma, of the University of Eindhoven, on pupil size; Dr. J. J. Vos, of the Institute of Perception, on visual performance of older eyes under disability glare -- the work of Dr. M. A. Allen; Dr. Schreuder of Philips, Eindhoven, on computing the overall effectiveness of roadway lighting; Dr. W. J. M. Levelt, also of the Institut at Soesterberg, on binocular brightness averaging; Dr. Pieter Walraven, another Institute spokesman, on the basic relationships of color vision, and J. B. de Boer, chairman of the disability glare and roadway research sections. Prof. Dr. Bouman, host, also reviewed the work being carried on at the Institute.

From England there were John Collins of the Building Research Station, Garston, with the results of a hospital study of adaptation for both young and old; Miss Veronica Reading of the Institute of Ophthalmology, University of London, reporting on disability glare from car headlights in relation to age; P. T. Stone of Loughborough College of Technical Studies, described his work on the physiological basis of discomfort glare, and A. W. Christie of the Department of Scientific and Industrial Research, Hammondswater, told of his studies of roadway lighting and the effects of glare.

Prof. S. Hesselgren of Sistunastiftelsen, Sigtuna, Sweden, argued that perception could not be defined by the "narrow" optical approach but needed a more inclusive "phenomenological" approach.

Year in Review

Following is a concise summary of the activities of IERI researchers during the year 1964 - '65. More detailed explanations of their work during the twelve months being reported will be found on Pages 19 through 28.

Visual Performance and Illumination (Project 30 - 64)

Additional work was done during the year to establish a better-defined mean threshold curve. The 1959 version of the curve was confirmed except that values of illumination for signal lighting were lowered... In this project Dr. Stanley Smith is also studying eye movements and their relationship to complex scanning patterns. He suspects that the greater the complexity, the greater the amount of light required to follow it... Important progress also was made during the year in devising a recording system for eye movements.

Roadway Visual Tasks (Project 47 - 64)

The simulated roadway was lengthened with mirrors and made more like a real-life highway. The studies, using the Pritchard meter, were interrupted at one point so that fog studies could be conducted.

Glare from Large Sources (Project 59 - 64)

William Atkinson at Cornell reports that his continuing glare studies show that different methods of measuring a glare situation will produce different reactions from the same viewers.

Transitional Adaptation (Project 63 - 64)

In his latest transitional adaptation studies, the second part of his project, Dr. Robert M. Boynton examined the effect that a sudden, momentary shift of attention has on adaptation. Small-brightness level changes he found not to be significant. Higher-brightness interruptions made necessary significant size or contrast adjustments.

Micro-Eye Movements (Project 71 - B)

There appears to be a relationship between eye movements and visual performance. Below a critical value of contrast, reduced vision produced less-precise eye movements. It is possible that this might require establishing illumination minima to achieve an optimum level of performance.

Research Activities

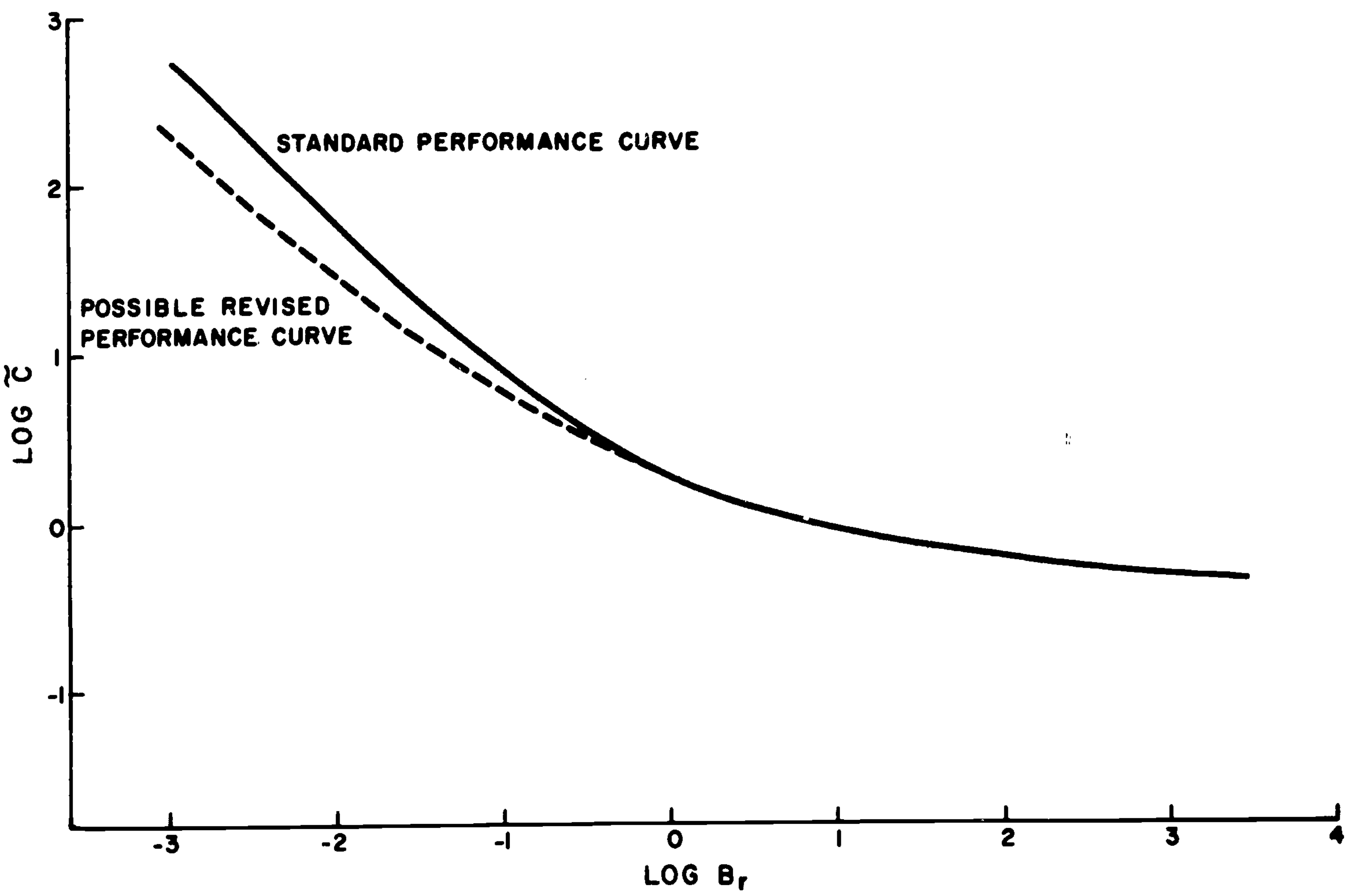
Visual Performance and Illumination

Project 30-64

During the past year, work was extended to determine thresholds for the 4-minute circular disc target under varying exposure times and varying levels of background brightness. In previous reports, data had been given from three observers. The additional work included the collection of data from ten more observers, and the establishment of a new, better-defined "mean threshold curve". The curve relates threshold contrast and background luminance for young adults whose vision showed no deficiencies and was therefore labeled "normal".

In the new studies, the target was exposed for 1/5th of a second, and 14 different background levels were used, ranging from .001 foot-lamberts to 1700 ft.-L.

This curve confirms the 1959 version for most applications, but at the lower end lowers the values of illumination for signal-lighting.



Under the guidance of Dr. Stanley W. Smith at the Institute for Research in Vision, a new set of studies was carried on to determine how variations in the viewing positions of the Field Task Simulator might affect results. Ordinarily the observer rests his head against a padded bar which makes it possible to turn the head without materially changing the distance to the discs. In the new experiments, three other viewing conditions were compared with the normal position. One of the variations used the "bite bar" to prevent head movements. The second was the "free head" condition which allows the observer to get as far as he desires from the test discs. The third was the "restricted field" condition which used the normal headrest but restricted the field of view to one disc at a time, thus limiting the amount of time spent on any single disc.

Tentatively, the tests showed that viewing conditions do not have a large effect on results.

* * *

One of the newer activities at the Institute for Research in Vision is a study of eye movements. Science has found that the eye, in waking hours, is practically always moving, searching out and scanning the objects that must be seen. The complexity of scanning patterns differ. Some are more complex than others.

The object of this work is to determine the amount of light required for the various patterns. In general, the greater the complexity of the pattern the greater the amount of light required. Also it has been found that the higher the lighting level the less precise the eye needs to be in coming to a fixation in its scanning. It has been reported that the eye, under high levels of lighting, can take in detail while off the line of sight by as much as two degrees.

This would suggest that, through additional lighting knowledge, the process of seeing might be considerably speeded

In order to examine the patterns of eye movements, and to gain more knowledge of their actions under various conditions of lighting,

TO STUDY EYE MOVEMENTS, researchers at Institute for Research in Vision develop elaborate electronic equipment involving a match-box-size "eye-position recorder" mounted on a mask worn by researcher.

an eye-movement camera and "eye-position-marker" has been developed. The camera records eye movement patterns so that they can be reproduced in the laboratory under controlled conditions which will make possible establishing a predictable relationship between fixed viewing and specific eye-movement patterns.

Considerable progress was reported at Columbus during the latter part of the '64-'65 fiscal year in the development of the eye-position recording camera, particularly in determining the requirements of the optical system and certain TV circuiting involved in the equipment design. The researchers have reported receiving valuable help from Dr. J. L. N. Besseling of the University of Cape Town, South Africa, in completing feasibility studies.

Roadway Visual Tasks

Project 47-64

In order to increase the fidelity of simulation, the road was lengthened through the use of a mirror on the end wall. Additionally several artificial horizons were incorporated to simulate conditions one might encounter in real life. Also, provisions were made to interchange pavement samples to simulate different roadway surfaces.

Studies have gone forward with the mannikin as well as the block test object.

In an effort to correlate brightness measurements of the roadway and the test objects with VTE measurements, the Pritchard meter has been employed. When the 3-degree observation angle was made more oblique, it was found that the Pritchard meter was not sufficiently sensitive. This was corrected and improvements also were made on the VTE for viewing under simulator conditions.

Tests are now being made along three significant paths of the roadway.

At one point in the studies, the clear-roadway conditions were interrupted so that additional studies under fog conditions could be carried on.

TWO INSTRUMENTS--the Visual Task Evaluator and the Pritchard brightness meter, shown here determining visibility of aerial photographic targets -- are used in searching for data on roadway lighting along simulated highway.

Glare from Large Sources
Project 59'-64

William Atkinson at Cornell University is conducting studies of discomfort glare from large area sources in association with Prof. Ralph Hopkinson, now at University College, London. Among the sources being studied are windows, luminous ceiling areas and luminaire areas for lighting to the higher levels -- 100 to 200 foot-candles.

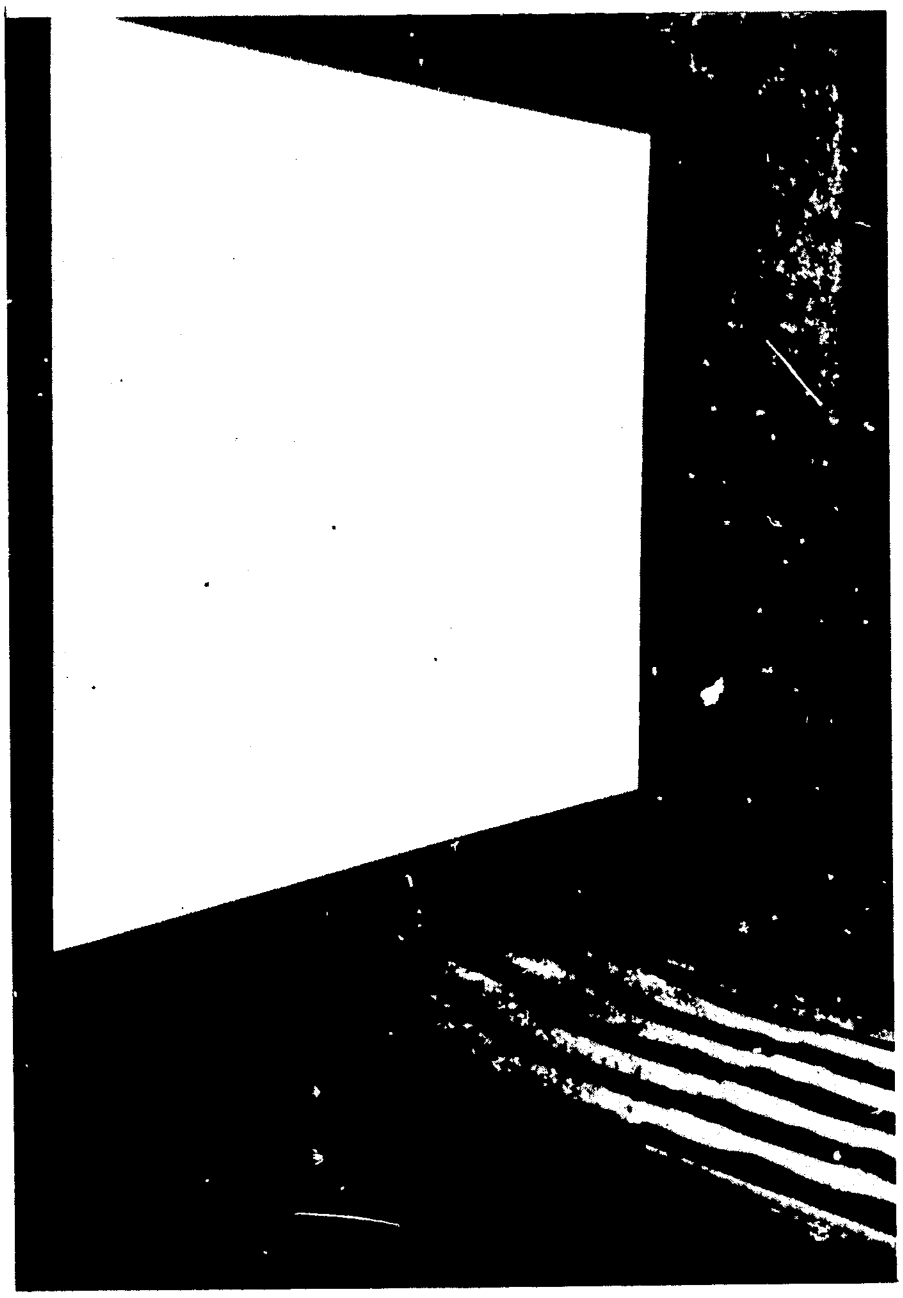
Prof. Hopkinson's findings show that large area sources should never exceed 300 footlamberts and preferably should be in the neighborhood of 150 footlamberts.

On the basis of tests on his observers, however, Mr. Atkinson believes that glare judgments are relative rather than absolute. He has found that, with different methods of glare measurements, different results have been obtained from observers. He has also found that observers are reacting in direct relationship to their adaptations. The observer's discomfort judgment, he believes, is usually the next convenient step higher than the level being observed, whether high brightness or low brightness.

Mr. Atkinson's observations on reactions are being weighed and discussed by members of the IERI Technical Advisory Committee.

Atkinson also attempted to establish the borderline between comfort and discomfort (BCD) for luminous ceilings of various sizes.

Using the lighting source created for the entire study -- a vertical wall of brightness-controlled light -- his observers lay on their backs at right angles to the source. In this position it was possible to make the upright wall serve as a luminous ceiling and, by controlling bright-nesses, to simulate effects that would be produced by ceilings 100, 50, 25 and 12-1/2 feet on a side, six feet above the observers' heads.



WITH OBSERVER lying on cot at right angles to upright source, a wall becomes a ceiling for purposes of brightness test.

These tests were conducted specifically for the Direct-Glare Sub-committee of the RQQ Committee of the Illuminating Engineering Society. Results have been submitted to the subcommittee for study.

Transitional Adaptation

Project 63-64

Laboratory work on the second portion of Dr. Robert M. Boynton's transitional adaptation studies at the University of Rochester was completed during the past year. Analysis of his data is now going on.

In the first portion of the study, covered in the IERI's 1964 annual report, transitional adaptation was defined as the adjustment of the eye to sudden changes in brightness, up or down.

The initial studies considered the effect on the ability to see when the subject looked away from a well-lighted task, on which he had been working, to another viewing task of a higher or lower level of brightness. It was found that serious adaptation problems were created by sudden changes.

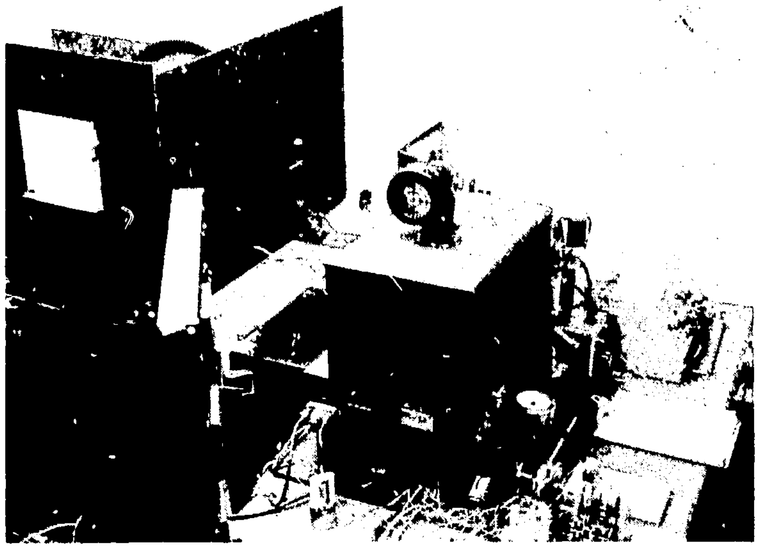
A 10-to-1 change in either direction, it was reported, required up to 150 percent increase in size or contrast to compensate. As a result of this study, it is now thought that brightness changes should not exceed 5-to-1 -- preferably should not exceed 3-to-1.

In the second portion of the study, Dr. Boynton was concerned with the adaptation problem created by a brief glance away from the task to another brightness level -- a sudden and momentary transfer of visual attention which does not involve another seeing task.

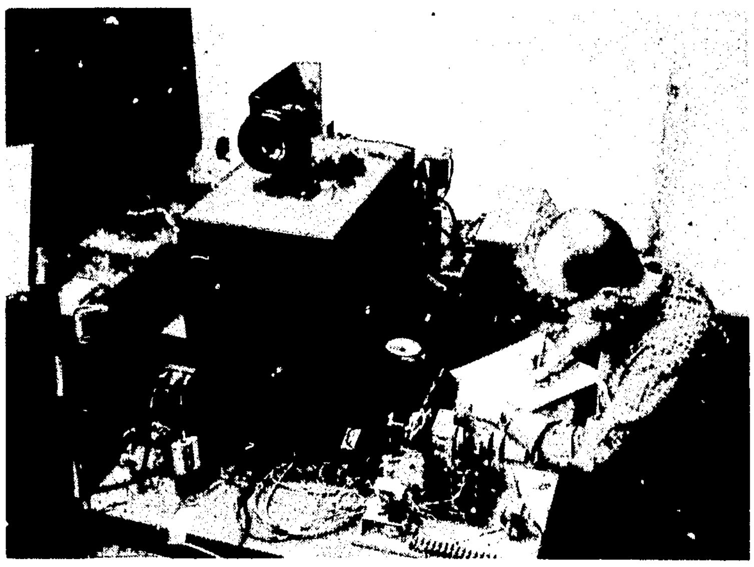
In these studies Dr. Boynton subjected a viewer, working under fixed brightness, to a sudden change to another brightness. Four levels of brightness were used in the test. In each instance the test involved glancing away from the fixed brightness to the new brightness, and looking back after short intervals. The intervals also varied -- from .04 to 10 seconds. The measure of performance occurred 3/10ths of a second after the observer looked back at the original task.

Dr. Boynton then recorded how much increase in size or contrast the subject required for correct letter recognition. Fourteen observers were used.

The effect of small brightness-level changes was not significant, Dr. Boynton reported. But changes at the higher levels made necessary significant size or contrast adjustments to compensate for transitional adaptation time.



OBSERVER (above) peers into sphere at uniformly-lighted field, brightness of which can be increased or decreased suddenly. After appropriate interval, test letter is flashed into view. When he is able to see test item, observer presses a button, reaction to which is registered on equipment (top right). Researcher at right records the responses.



Micro-Eye Movements

Project 71-B

Dr. Blackwell employed the Visual Task Evaluator to assist Dr. Frederick W. Hebbard in making measurements of his test objects with different contrasts.

It was shown that, below a critical value of contrast, reduced vision produced less precise eye movements. This suggested a rational relationship between eye movements and visual performance. It is expected that such an analysis at different illumination levels should prove revealing.

Administrative Report

During the 1964-65 period the following personnel administered the activities of the Institute:

Board of Trustees

John W. Ferree, M.D., Chairman
A.F. Wakefield, Treasurer
C.L. Amick
E.O. George
J.D. Mitchell
E.M. Strong
Henry L. Wright

Research Executive Committee

Leonard C. Mead, Chairman
H.F. Davidson
Warren H. Edman
Glenn A. Fry
Charles D. Gibson
W.P. Lowell, Jr.
R.M. Zabel

In addition, the Technical Advisory Committee on Light and Vision rendered its continuing recommendations and counsel to the Research Executive Committee and Trustees in reviewing progress reports on each project and proposals for continuing and new research. The personnel of this Committee was as follows:

Dr. Glenn A. Fry, Chairman
Mr. Willard Allphin
Dr. H.R. Blackwell
Dr. Charles J. Campbell, M.D.
Dr. S.K. Guth
Mr. J.J. Neidhart
Prof. Eric Pawley
Prof. E.M. Strong

The Research Executive Committee and the Technical Advisory Committee on Light and Vision each held two meetings, one of which was a joint meeting to review progress; the others were concerned with consideration of proposals and recommendations to the Trustees.

During the year a new Technical Advisory Committee on Light and Heat was authorized in connection with proposed research in this area.

The Research Executive Committee appointed a Nominating Committee on Personnel for Committees. This Committee met and made plans for orderly succession and strengthening of the technical advisory committees.

The Finance Committee, consisting of representatives from IERI and IES, met to review progress, the objectives of research financing and the feasibility of reaching these objectives.

In June the Institute sponsored the 3rd international vision research symposium at the Institute for Perception, Soesterberg, the Netherlands, details of which are given earlier in this report.

Mr. R.G. MacDonald, President of the West Penn Power Company, was appointed as the new Chairman of the IERI Development Committee to replace the retiring chairman, Mr. Walter H. Sammis. The Committee held its third joint meeting with the Board of Trustees to review the status of lighting research, the impact of the IERI research program in the field, and what needs to be done in the near future.

The Board of Trustees reviewed the summary reports on the four research projects, approved proposals on each for continuation, and contracts were processed as follows:

Project #30-65 - "Studies of Visual Performance," Ohio State University

Project #47-65 - "Studies of Illumination Requirements for Roadway Visual Tasks," Ohio State University

Project #59-65 - "Discomfort Glare from Large Area Sources," Cornell University

Project #63-65 - "Transitional Adaptation," University of Rochester

During the year, four IERI Newsletters were distributed to a mailing list of over 1200 on: the Institute's part in the Better Light - Better Sight Study Lamp Program; the 3rd IERI international vision research symposium in Soesterberg, the Netherlands; reporting on European research; the Development Committee meeting at Cornell University.

As Secretary of the Institute, Mr. C. L. Crouch was invited to present to the Dutch Illuminating Engineering Society the American illumination and visual research activities. Since he was in Holland, Mr. Crouch was able to visit a series of laboratories abroad and to learn first-hand of their visual research, namely:

Laboratory	Research in Progress
Technische Hochschule Karlsruhe, Germany	light sources and application, including discomfort glare in roadway lighting
Philips Laboratories Aachen, Germany	discomfort glare in rooms
Eindhoven, the Netherlands	all of the elements contributing to visibility of roadways under night-time illumination
University of Groningen Groningen, the Netherlands	basic studies on the effect of stimulation and interplay of retinal elements not related to the particular detail being seen
Institute of Hygiene & Physiology, Technische Hochschule, Zurich, Switzerland	investigating the possible effects of flicker of light sources on the well-being of workers
University of Munich Munich, Germany	many researches in light and vision including applications for roadway visibility

Laboratory	Research in Progress
Roadway Research Laboratories Slough, England	series of studies on roadway lighting, particularly disability glare, including the effect of age
Building Research Station, Dept. of Scientific & Industrial Research, Watford, Herts., Eng.	studies of discomfort glare from large sources and hospital lighting

FINANCIAL STATEMENT
(As of September 30, 1965)

Balance on hand as of 9/30/64		$ 18,347.49
Receipts - Illuminating Engineering Society		60,000.00*
		$ 78,347.49
Disbursements -		
Projects - 1964-65**		
#30-64 Smith - Visual Performance	12,061.	
#59-64 Atkinson - Discomfort Glare	9,260.	
#63-64 Boynton - Transit. Adaptation	5,440.	
1965-66***		
#30-65 Smith - Visual Performance	11,910.	
#47-65 Birkhoff - Roadway Lighting	1,680.	
#59-65 Atkinson - Discomfort Glare	-	
#63-65 Boynton - Transit. Adaptation	-	
	40,351.	
Accessory Services, Etc. (including Proj. #59AS-1 for analysis of direct discomfort glare, #70AS-2 for veiling reflections test object, #70AS-3 for purchase of potentiometer)	1,301.70	
Non-Project Expenses: Travel - Research Exec. and Tech. Adv. Committees and European Symposium	4,427.67	
Administrative Expenses (including Public Information, Secretary's travel, auditing, stationery, photos, slides, charts, etc.)	6,702.78	
		52,783.15
Balance on hand as of 9/30/65		$ 25,564.34

*This does not include the approximate estimate of $ 10,000 in services.

**$22,021 was paid prior to October 1, 1964 on these projects, including Proj. #47-64.

***Projects approved by Res. Exec. & TA Committees & Trustees during 1964-65.

NOTE: Auditor's report dated December 2, 1965 shows cash receipts $60,000; cash disbursements, $52,783.15; cash balance on 9/30/65, $25,564.34.

ALLOCATIONS - 1965-66

Projects -	#30-65 Smith - Visual Performance	11,910.)	
	#59-65 Atkinson - Discomfort Glare	16,320.)	40,266.
	#63-65 Boynton - Transitional Adaptation	12,036.)	
Proposed 1965-66 Budget Items	Administrative expenses	8,116.)	
	Travel - Res. Exec. & TA Comms.	2,000.)	12,116.
	Accessory Services	2,000.)	$ 52,382.