OFFICIAL PUBLICATION OF
IOWA STATE COLLEGE OF AGRICULTURE
AND MECHANIC ARTS

Vol. XVIII OCTOBER 8, 1919 No. 19

LIGHTING FOR COUNTRY HOMES AND VILLAGE COMMUNITIES

BY

WM. KUNERTH

BULLETIN 55
ENGINEERING EXPERIMENT STATION

AMES, IOWA

Published weekly by Iowa State College of Agriculture and Mechanic Arts, Ames, Iowa. Entered as Second-class matter, and accepted for mailing at special rate of postage provided for in section 1103, Act of Oct. 3, 1917, authorized Sept. 3, 1918.

PURPOSE OF THE STATION

THE purpose of the Engineering Experiment Station is to afford a service, through scientific investigations, evolution of new devices and methods, educational technical information, and tests and analyses of materials:

For the manufacturing and other engineering population and industries of Iowa;

For the industries related to agriculture, in the solution of their engineering problems;

For all people of the State in the solution of the engineering problems of urban and rural life.

OFFICIAL PUBLICATION OF
IOWA STATE COLLEGE OF AGRICULTURE
AND MECHANIC ARTS

Vol. XVIII OCTOBER 8, 1919 No. 19

LIGHTING FOR COUNTRY HOMES AND VILLAGE COMMUNITIES

BY

WM. KUNERTH
Associate Professor, Physics

BULLETIN 55
ENGINEERING EXPERIMENT STATION

AMES, IOWA

Published weekly by Iowa State College of Agriculture and Mechanic Arts, Ames, Iowa. Entered as Second-class matter, and accepted for mailing at special rate of postage provided for in section 1103, Act of Oct. 3, 1917, authorized Sept. 23, 1918.

STATE BOARD OF EDUCATION

Members

Hon. D. D. Murphy, President.....Elkader
Hon. Geo. T. Baker.....Davenport
Hon. Chas. R. Brenton.....Dallas Center
Hon. P. K. Holbrook.....Onawa
Hon. Edw. P. Schoentgen.....Council Bluffs
Hon. Frank F. Jones.....Villisca
Hon. Paul Stillman.....Jefferson
Hon. W. C. Stuckslager.....Lisbon
Hon. B. F. Ketcham.....Farmington

Finance Committee

Hon. W. R. Boyd, President.....Cedar Rapids
Hon. Thomas Lambert.....Sabula
Hon. W. H. Gemmill, Secretary.....Des Moines

ENGINEERING EXPERIMENT STATION

Station Council

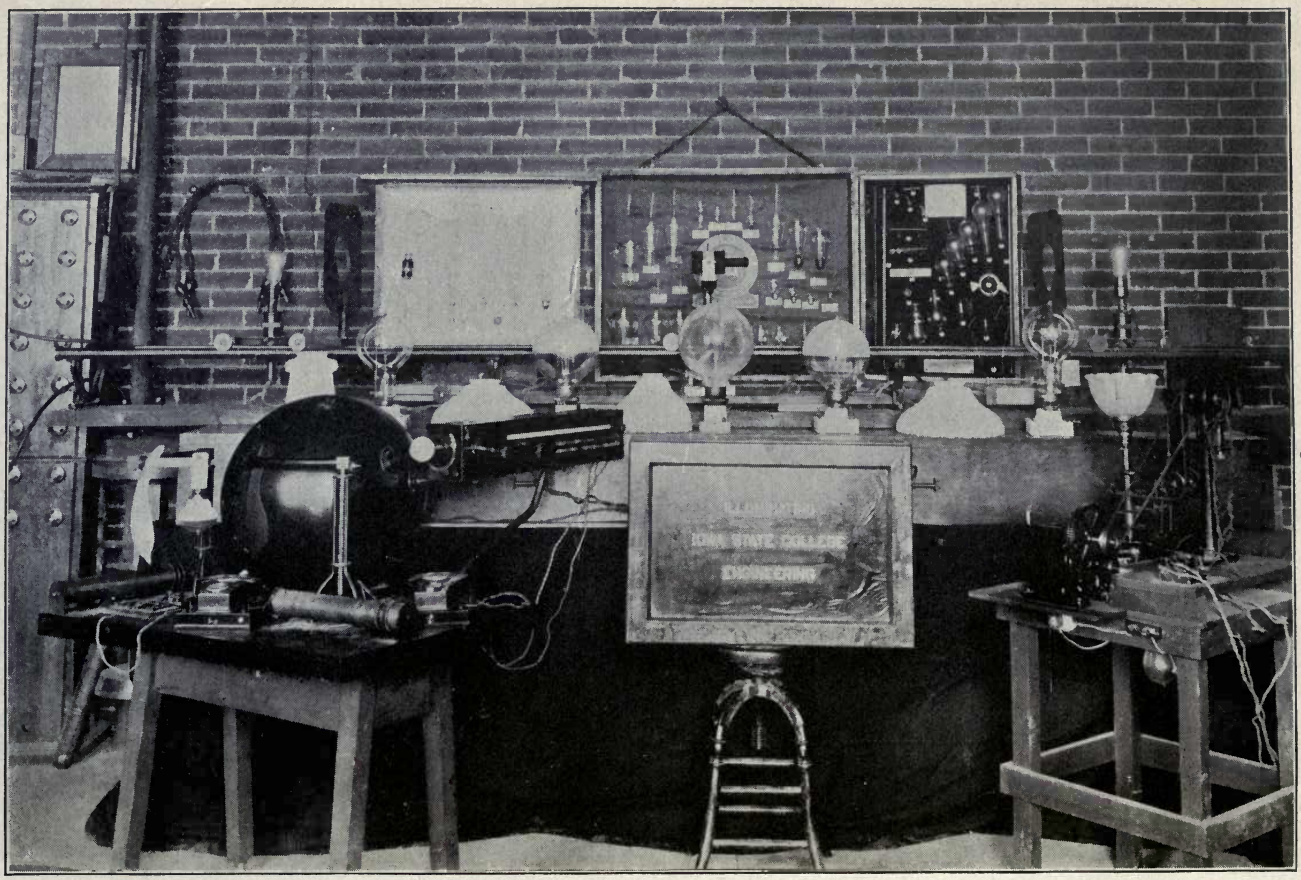
(Appointed by the State Board of Education)

Raymond A. Pearson, LL. D.....President
Anson Marston, C. E.....Professor
Louis Bevier Spinney, B. M. E.....Professor
Warren H. Meeker, M. E.....Professor
Fred Alan Fish, M. E. E. E.....Professor
Allen Holmes Kimball, M. S.....Professor
Fred R. White, B. C. E.....Chief Engineer, Iowa Highway Commission

Station Staff

Raymond A. Pearson, LL. D.....President, Ex-officio
Anson Marston, C. E.....Director and Civil Engineer
Warren H. Meeker, M. E.....Mechanical Engineer
Fred Alan Fish, M. E. E. E.....Electrical Engineer
Allen Holmes Kimball, M. S.....Architectural Engineer
Charles S. Nichols, C. E.....Sanitary Engineer
Louis Bevier Spinney, B. M. E.....Illuminating Engineer and Physicist
William J. Schlick, C. E.....Drainage Engineer
T. R. Agg, C. E.....Highway Engineer
John Edwin Brindley, A. M., Ph. D.....Engineering Economist
Max Levine, S. B.....Bacteriologist
S. L. Galpin, Ph. D.....Geologist
J. H. Griffith, M. Sc.....Structural Materials Engineer
W. J. Whittemore, B. S. in Cer. Eng.....Ceramic Engineer
A. K. Friedrich, E. M.....Mining Engineer
L. G. Williams, B. S. in C. E.....Assistant Engineer
D. V. Moses, B. S. in Chem. Eng.....Assistant Chemist
B. Kamrass.....Assistant Engineer, Road Materials
Clyde Mason, B. S. in E. E.....Assistant Engineer
A. O. Smith.....Mechanician
H. E. Pride, B. S. in C. E.....Bulletin Editor

LIST OF ILLUSTRATIONS


IOWA STATE COLLEGE

LIGHTING FOR COUNTRY HOMES AND VILLAGE COMMUNITIES

In the past decade, a multiplicity of modern improvements has added greatly to the comfort and convenience of farm homes and rural communities. In the last few years the matter of lighting systems has been receiving considerable attention, perhaps because of the more extensive study which has been devoted to all phases of city lighting and to continued improvements in the illuminants themselves.

Illumination is a symbol of intellectual development, for one of the most potent factors in the growing forces of civilization has been the steadily-increasing opportunity for study after dusk.

It is only when one considers the various types of lighting appliances from the torch of the past to the tungsten of the present, and the numerous points to be reckoned with in any lighting system, that one realizes how large is the field of comparison between the various illuminants. This is especially true if such comparison is to be based quite largely upon experimental results. Inasmuch as this work is to deal mainly with the lighting system used in country homes, the available illuminants will naturally be emphasized.

NEED OF BETTER LIGHTING IN COUNTRY HOMES

The New York State Health Department has found that while 21% of country school children have defective vision, only 5% of city school children are so afflicted. One might naturally expect the reverse to be true. The smoky atmosphere, the tall buildings, and the lack of sunlight in many interior rooms in cities often make artificial light necessary during many hours of the day. For all that, investigation has revealed the fact that city school children in general have stronger eyes than do those in the country, probably because of the superior lighting which city school children enjoy in their homes. But poor lighting conditions need not obtain for the rural family. Very good lighting can be secured from practically every kind of illuminant if proper attention is given to the subject. The result will be fewer headaches and stronger eyes.

There is a growing realization of the fact that good illumination is as much a necessity as are pure water, fresh air, and proper sanitation and that the effect of poor lighting, whether natural or artificial, reacts strongly on the health. Poor light makes for neglect of cleanliness, for what is not clearly seen will not be thoroly cleansed. Poor light increases the strain from forms of work that tax the eyes and thus makes the work more difficult. Nor can we ignore the effect of nervous depression upon even normally healthy persons when working for long hours amid gloomy surroundings. They become morose and their health eventually suffers. In the treatment given in the best modern sanatoria, great stress is laid upon the value of abundant sunlight.

The country home should be well lighted not only because light safeguards the eyes, but because a well-lighted home is attractive and fosters a cheerful disposition. Proper attention paid to the lighting of a home

may help solve the problem of keeping young men and women on the farm. Just as a moth is attracted by the light of a candle, so young people are drawn by good lighting. Abundant light in their own homes where they may read in comfort, or play games, will contribute largely to their staying at home evenings. The depressing atmosphere of many a dimly-lighted country home has no doubt been a substantial factor in driving its young people to seek residence in the brightly-lighted towns and cities.

With his greatest interest concentrated on his stock, machinery, and crops, the farm husband has frequently neglected in the past to give the proper attention to his home. But the day is now rapidly approaching—in fact, it is already here—when farm women are coming into their own and the improvement of the farm home is receiving proper attention.

COLOR OF LIGHT

As the variety of illuminants increases from year to year, the question of the color of light becomes more interesting and more important. There are no two illuminants which produce light of exactly the same color; only the light from a clear north sky is truly white. Tho the approach to whiteness is no index of their acceptability, lights are usually arranged in tables according to their whiteness. This plan has been followed in the table below, which places the illuminants in the order of whiteness with white at the end of the list:

Torch.
Candle.
Fish tail burner (luminous gas burner).
Kerosene bare flame.
Carbon 32 CP.
Carbon 16 CP.
Mazda B 60-watt (vacuum).
Acetylene bare flame.
Kerosene mantle.
Mazda B 32-volt (vacuum).
Mazda C (gas filled).
Blau gas mantle.
Acetylene mantle.
Gasoline mantle.
Illuminating gas mantle.
Mazda C_2 (daylight lamp).
Sunlight.
North sky light.

The above order of the illuminants was determined by the writer at the University of Chicago, by the use of a spectrophotometer.

INTRINSIC BRILLIANCY OF THE LIGHT SOURCE

While the introduction of high intensity light sources in recent years has had certain advantages, it has also brought with it a great strain on the eyes. The eye should never be exposed to a brightness of more than three candles per square inch. The table below shows that the eye must suffer greatly when exposed to some of the modern illuminants, which should therefore be placed out of the range of vision or should be surrounded by shades or globes. The more common light sources and their brilliancies are given herewith:

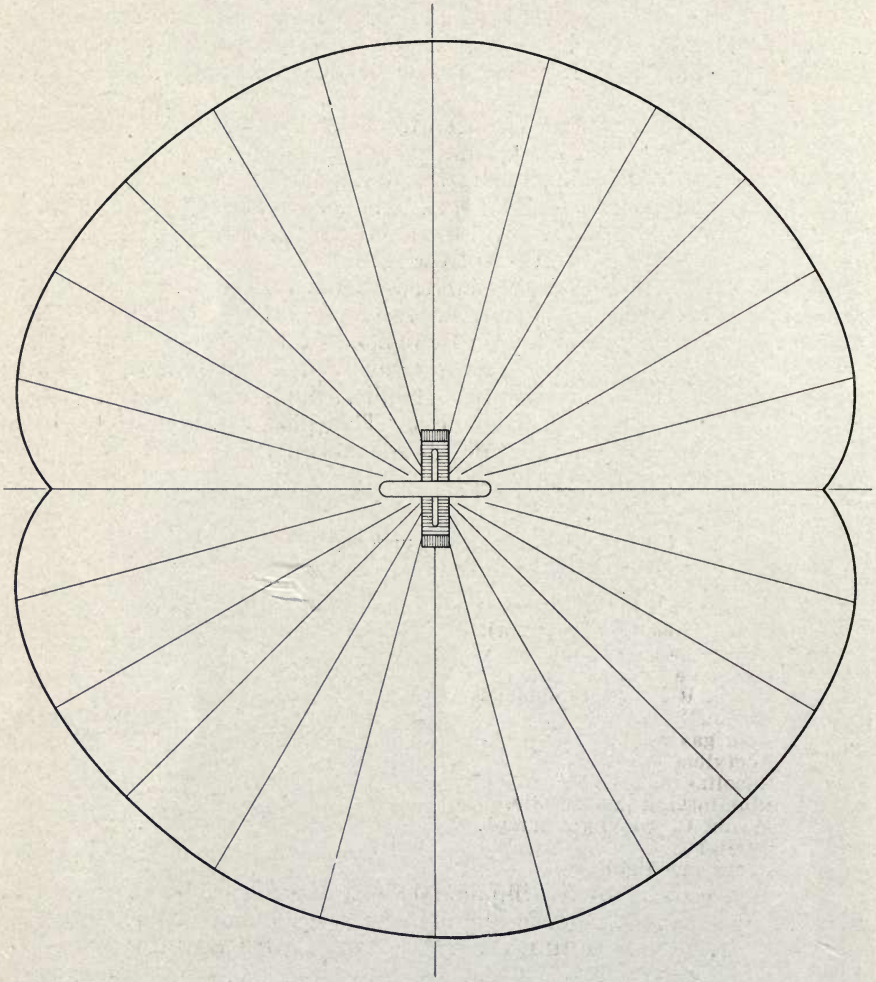


Fig. 2 ←——= 5 Candlepower

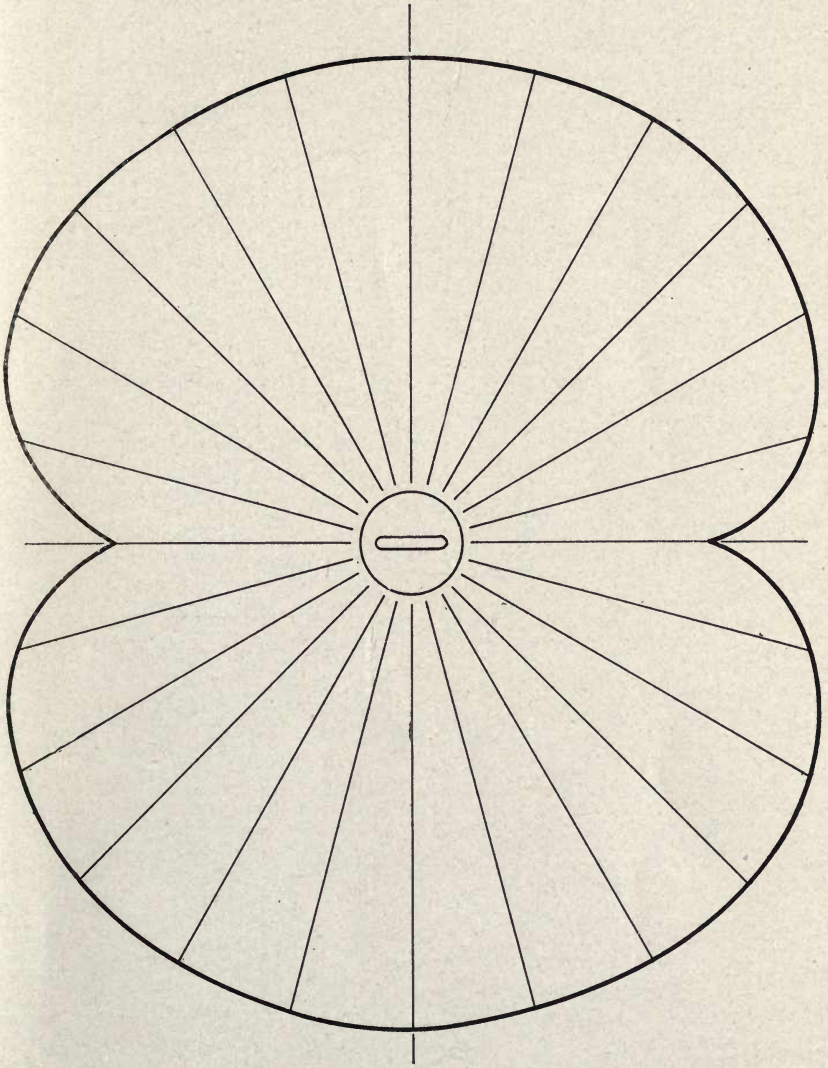


Fig. 3

← = 2 Candlepower

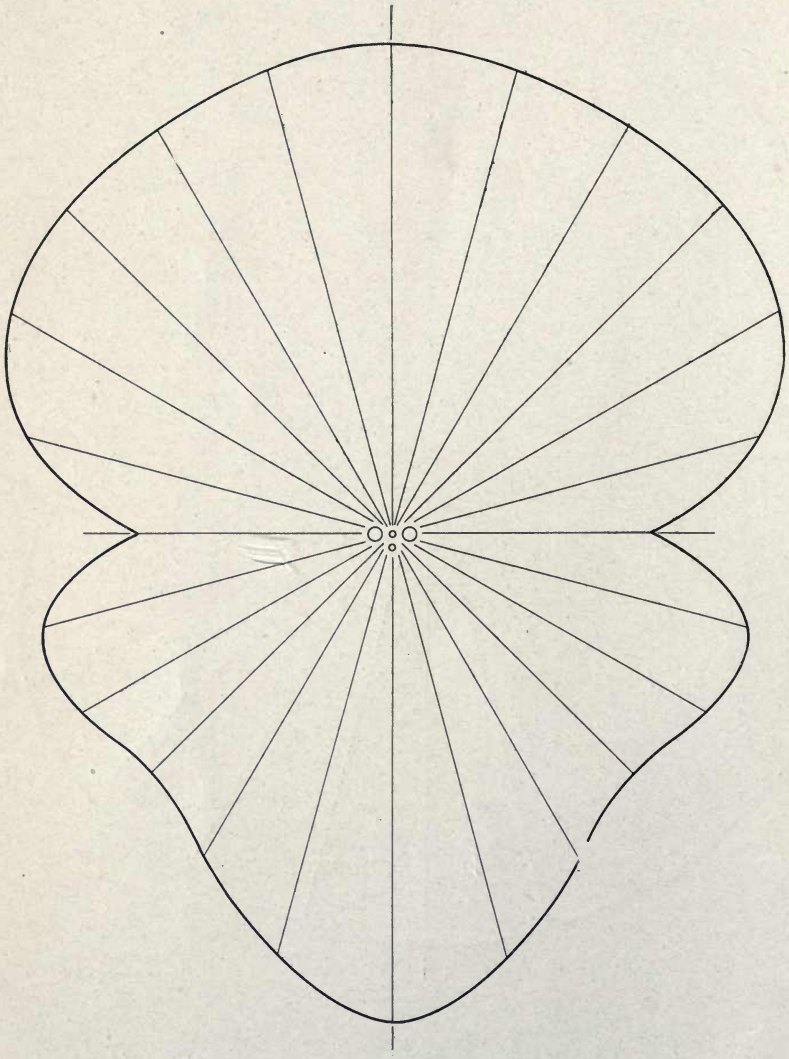


Fig 4 ⟵ = 20 Candlepower

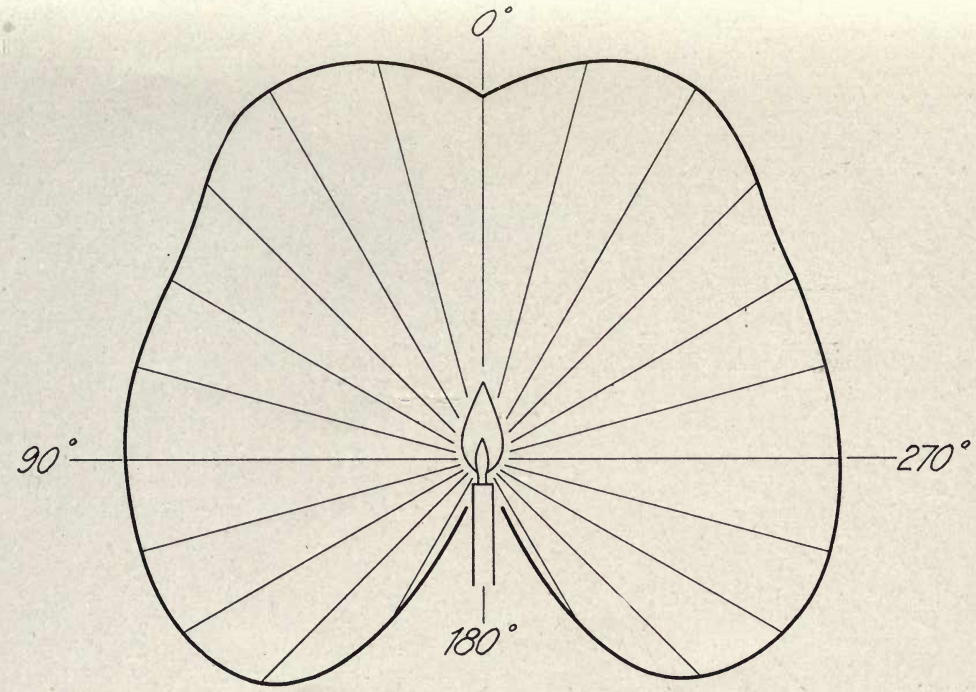


Fig. 5

← = 0.4 Candlepower

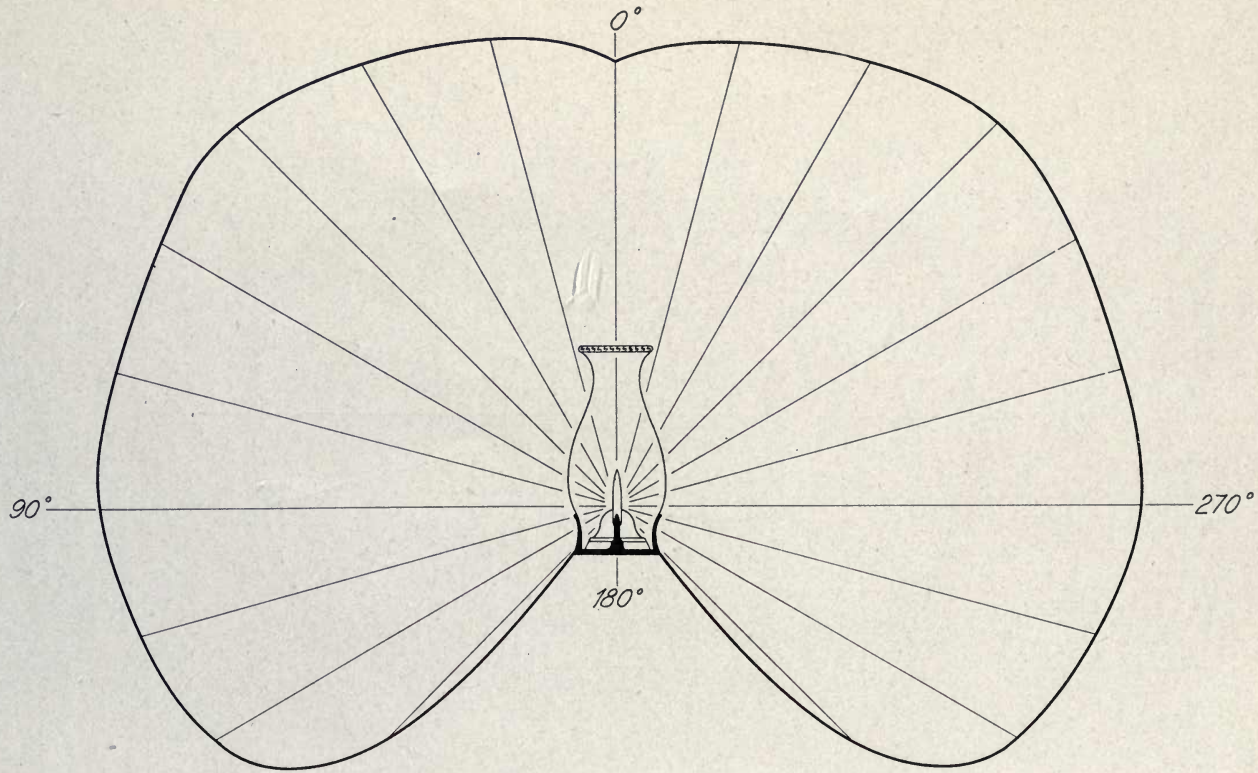


Fig. 6 ← = 2 Candlepower

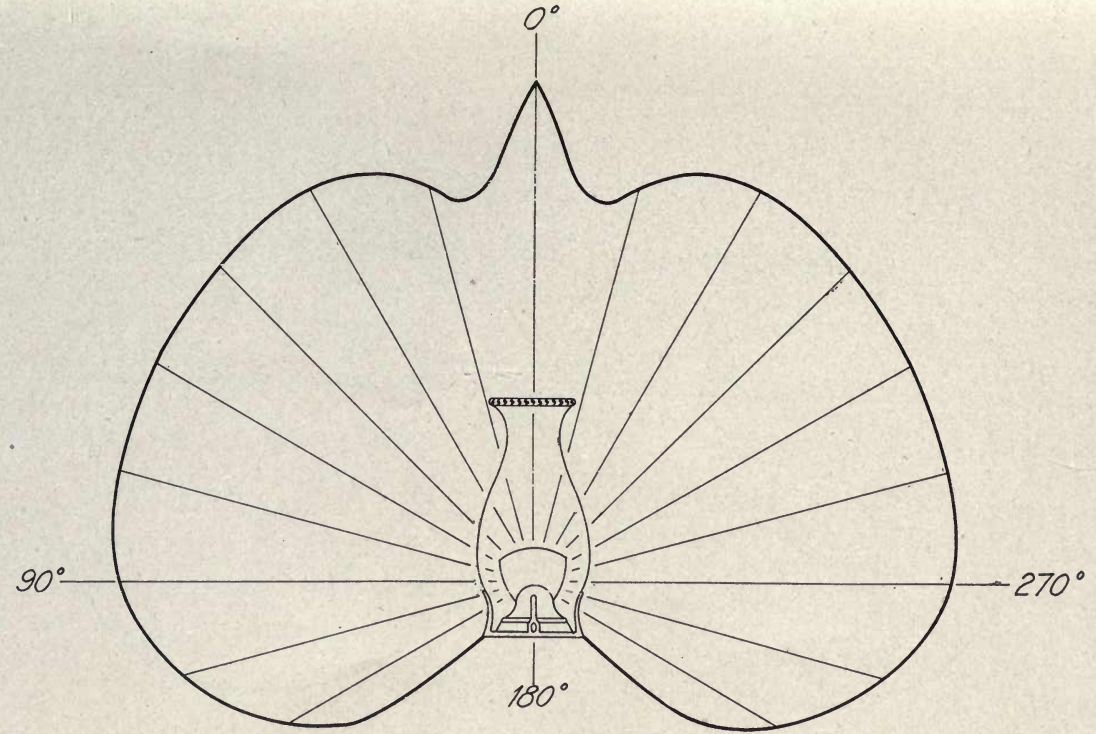


Fig. 7

← = 2 Candlepower

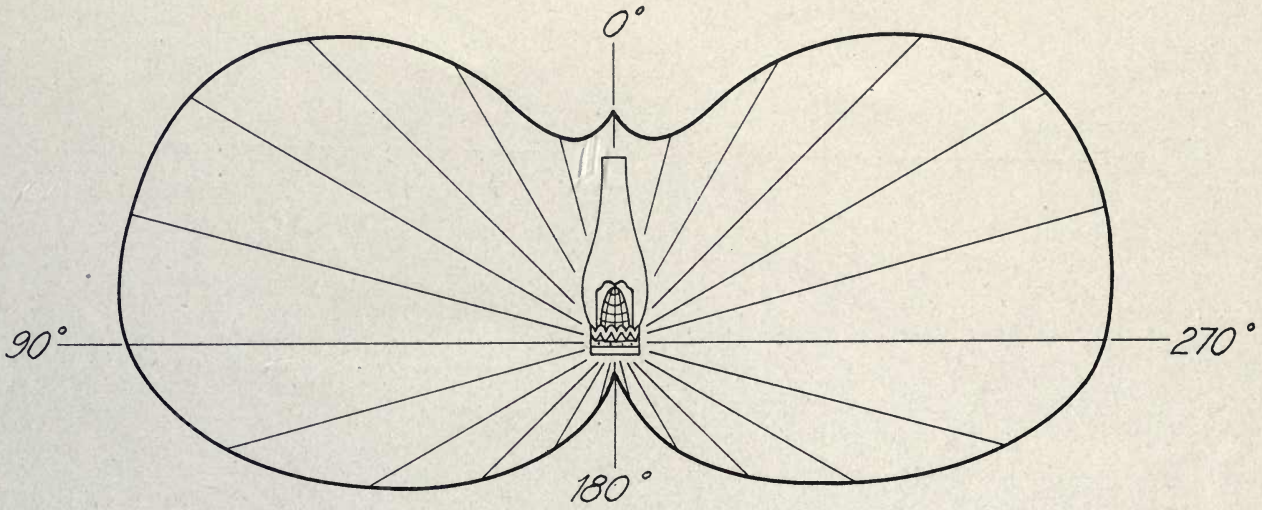


Fig. 8

← = 20 Candlepower

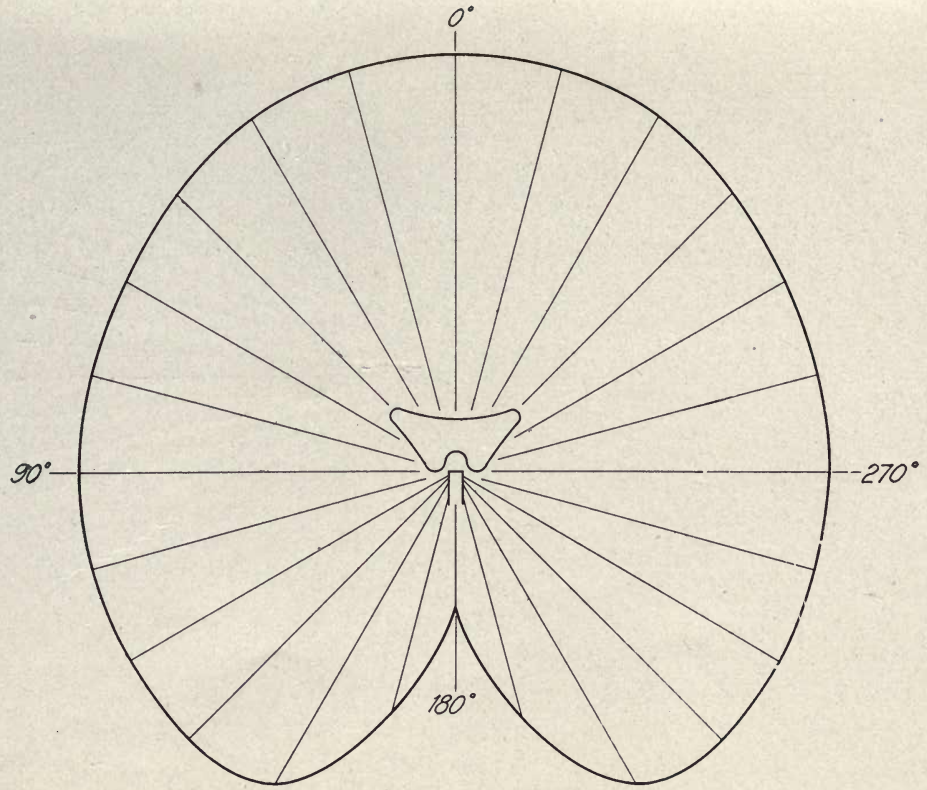


Fig. 9

← = 4 Candlepower.

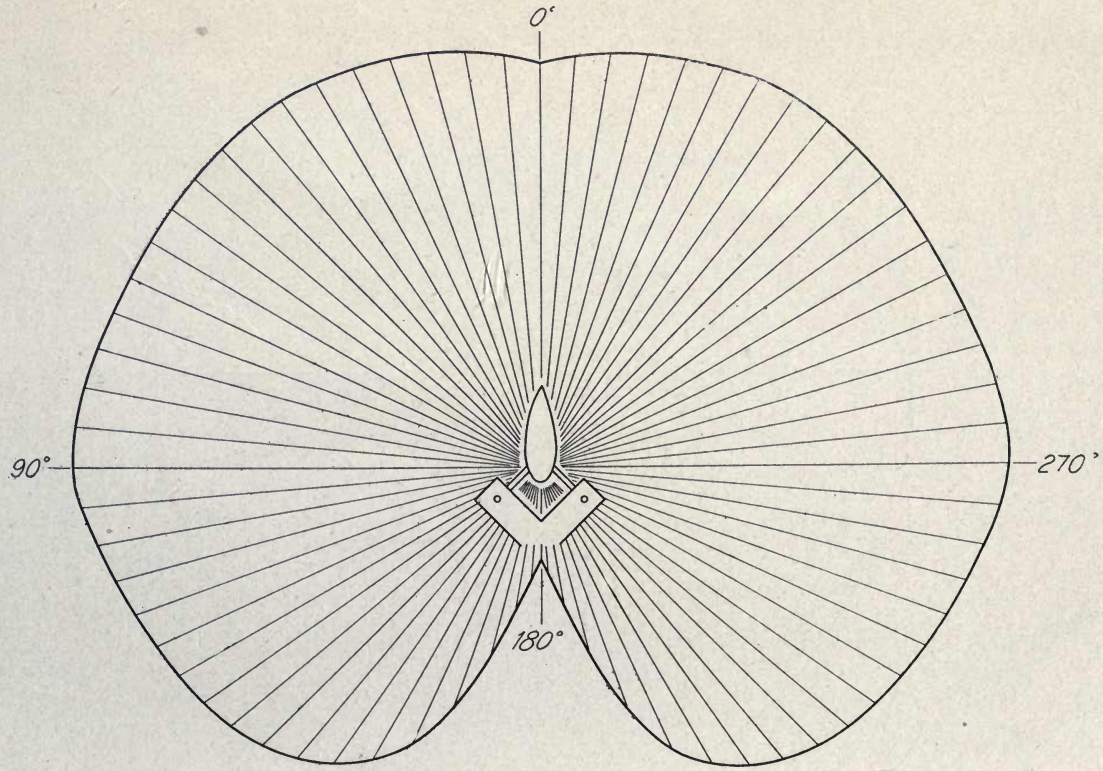


Fig 10

← = 4 Candlepower

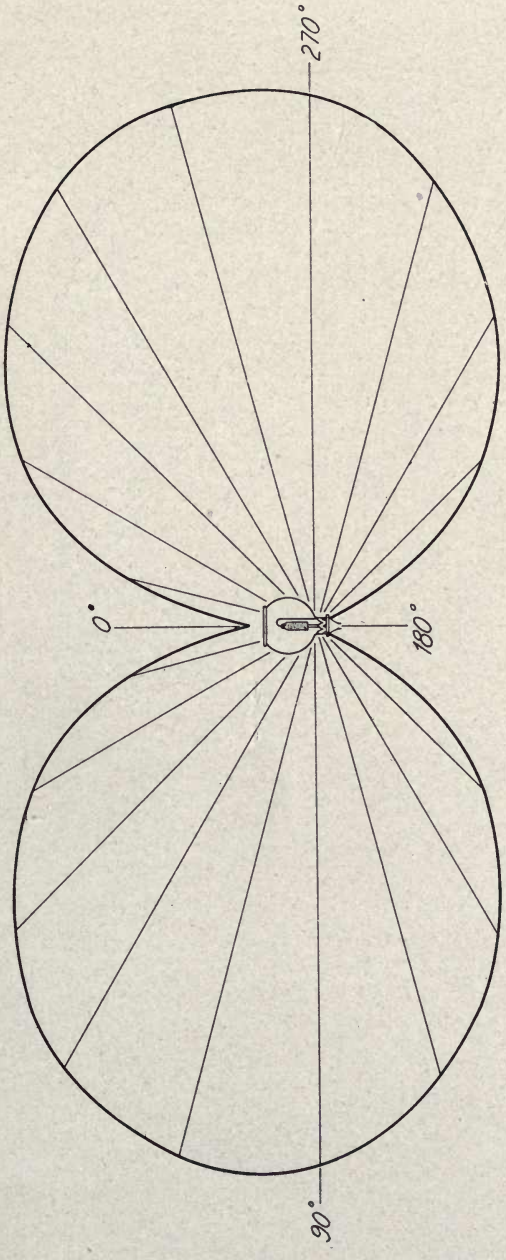


Fig 11

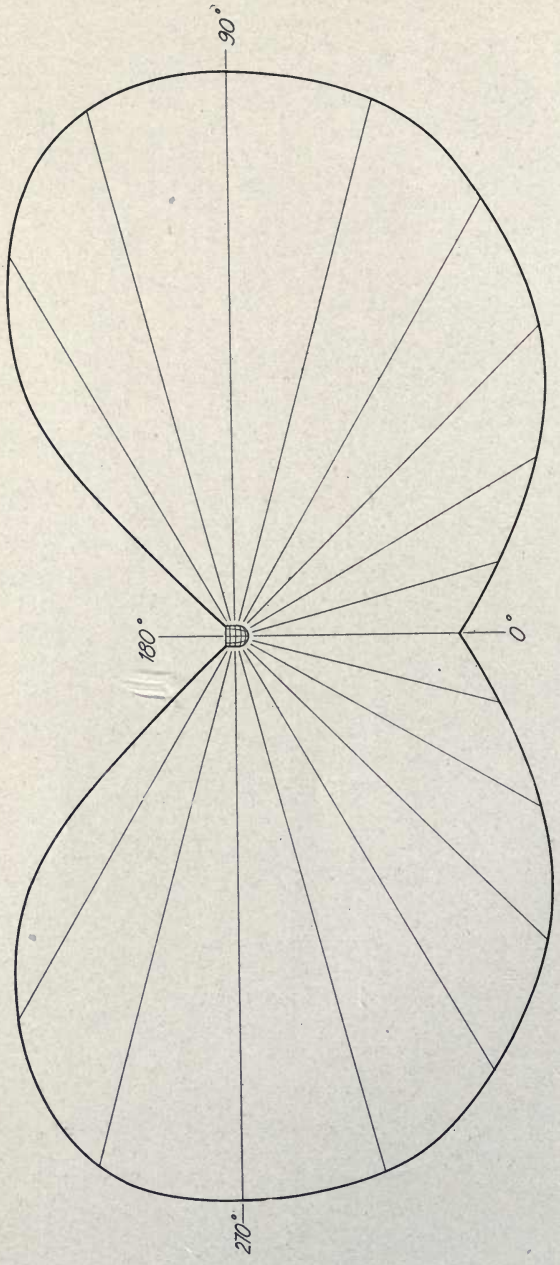


Fig 12

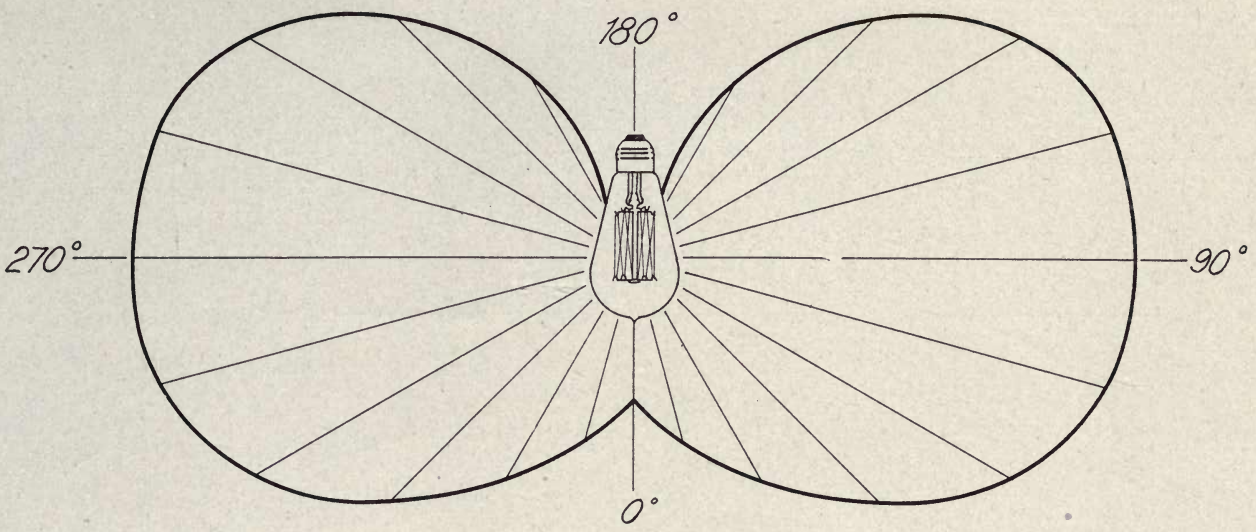


Fig 13

← = 10 Candlepower

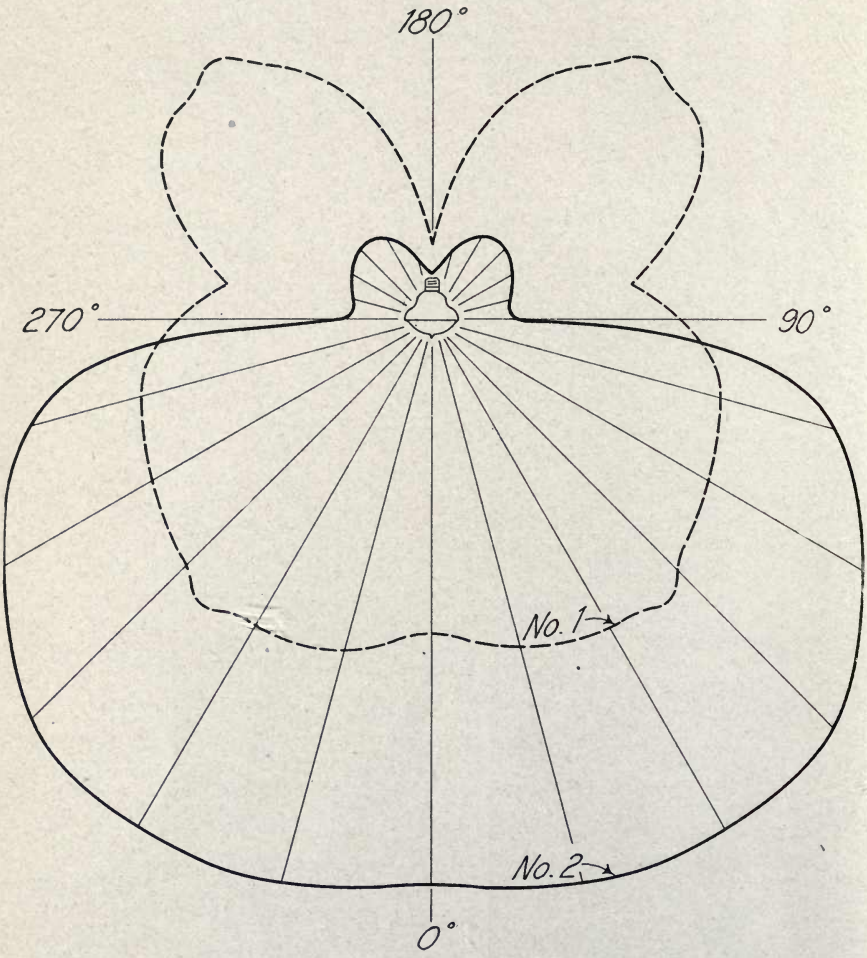


Fig. 14 ← = 10 Candlepower

No 1- Without Shade

No 2- With Shade

RELATIVE BRILLIANCIES OF LIGHT SOURCES

Illuminant	Brightness in candles per sq. in.
Candle	3
Kerosene bare flame	6
Acetylene bare flame	20
Carbon incandescent lamp	580
Incandescent mantle	30-100
Mazda vacuum lamp	1,000
Mazda gas-filled lamp	4,000
Sun at noon	600,000

INTENSITY OF THE SOURCE

Everyone knows that for some kinds of work much more light is required than for others. To get the right amount of light for each, it is necessary either to vary the distance between work and lamp or to use an illuminant that lends itself to a great range of intensity. Intensity change may be secured either by varying the size of the lamp, or by regulating the illuminant by turning the light up or down as in flame lamps and mantle lamps. For purposes of comparison the table below shows the ranges in candle-power over which the units in any one system have been found to extend.

CANDLE POWER INTENSITIES OF LIGHT SOURCES

Candle	Up to	3 C.P
Kerosene bare flame (flat wick)	Up to	20 C.P.
Kerosene mantle	Up to	60 C.P.
Kerosene pressure lamp	Up to	120 C.P.
Acetylene bare flame	Up to	30 C.P.
Acetylene mantles	Up to	60 C.P.
Illuminating gas	Up to	120 C.P.
Gasoline mantle	Up to	170 C.P.
Blau gas	Up to	140 C.P.
Incandescent lamps	Up to	1,000 C.P.

DISTRIBUTION OF LIGHT AROUND A SOURCE

Inasmuch as the total amount of light obtained from any source depends largely upon how it is distributed around the source, it is well to consider how illuminants vary in this respect. In some instances the distribution of light around the source in a horizontal plane is very unsymmetrical. It is well to know how to place a lamp, to get the most light where most is wanted. The curves presented herewith show the distribution of light in a horizontal plane around the lamp. The illuminants whose curves are not given have practically a uniform distribution in the horizontal plane, except that the fish tail gas burner has a distribution almost identical with the kerosene flat flame.

When an incandescent lamp is placed with its long axis vertical, more light is sent out in a horizontal than in a vertical direction. Some illuminants can be placed in only one position. In such a case the use of a shade or reflector is usually necessary to get the light where it is wanted. Even though the light source can be placed in one of many different

positions, the use of a shade is still highly desirable as will be shown later. By this means the light is redirected so as to be more useful. However the application of a shade or reflector can never increase the total amount of light. It can only decrease it. The curves shown herewith give the distribution of light in a vertical plane around the light source. The kerosene angle lamp whose distribution curve is not shown is known to throw much more light downward in a useful direction than does the ordinary erect flame.

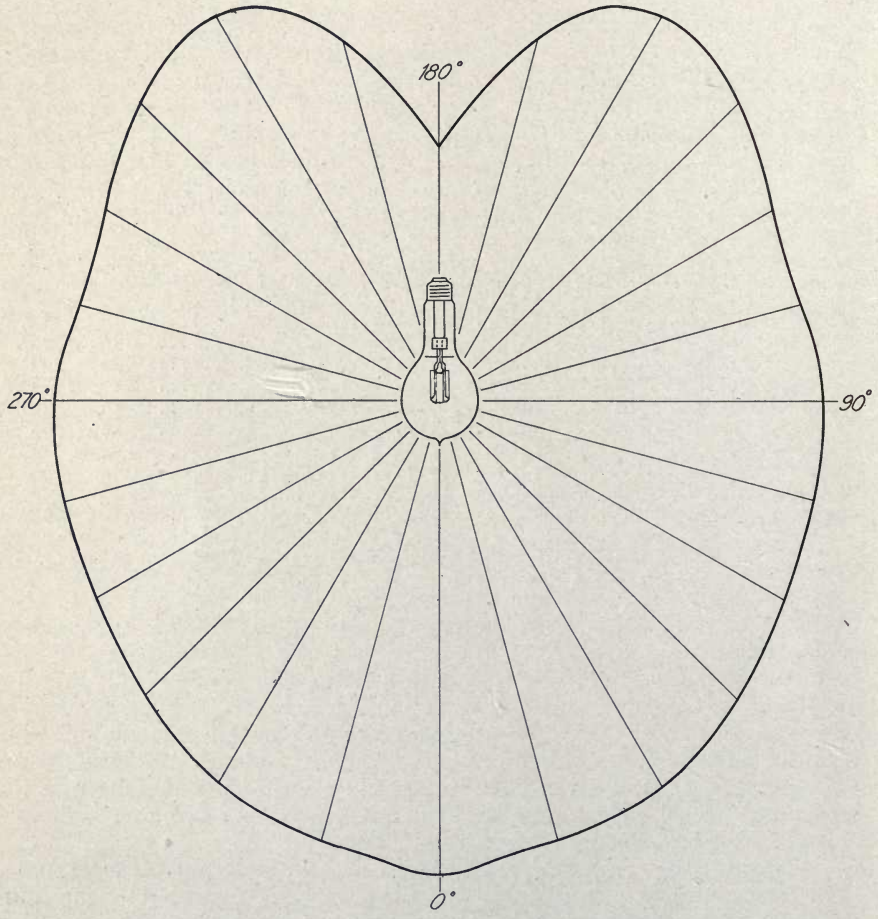


Fig 15

USES OF SHADES

The function of a shade, globe, or reflector is fourfold:

To redirect the light.
To soften the shadow.
To protect the eyes from excessive brilliancy.
To serve as a decoration.

Which of these functions is the most important in any case depends upon varying conditions. When the distribution curve of the lamp shows that most of the light is thrown outward and upward, the redirection of the light will probably be the chief function. For the direct lighting system, especially where walls and ceiling are of a dull color, the softening of the shadow is of importance. In regard to most of our modern incandescent lamps, whether mantle or filament, there is need of protecting the eyes from excessive brilliancy. Because of the intense brightness of the tungsten filament in a gas-filled bulb, the clear glass shades are no longer in favor and are being displaced by the opalescent glassware.

Emphasis should be placed upon cleaning the glassware, whatever the system used. Experiments show that under average office conditions the efficiency of lighting decreases about ten per cent per month because of the accumulation of dust on the glassware. It is easily worth while, therefore, whatever the system, to keep the glassware and reflecting surfaces clean.

While the use of glassware of any kind always reduces the efficiency of an illuminant, it is nevertheless highly desirable to use shades in almost all cases. A shade can never increase the total amount of light, but it may redirect the light in such a way that much better use can be made of it than without a shade. Even tho it is decidedly advantageous to use a shade, one should not, on the other hand, put the "light under a bushel."

CONVENIENCE OF LIGHTING

Without a doubt the most convenient lighting appliance is some form of the electric system. Almost all other appliances require the use of matches, and in some instances the gas must first be generated. Several devices have been patented whereby a gas can be ignited conveniently without the use of a match; but most of these methods do not measure up to the electric system. The most common system in use today is that which employs a small "pilot light" which burns constantly and ignites the main flame or mantle whenever it is turned on.

Neither the lamps nor the lighting systems should attract attention to themselves but should show up prominently the objects that are to be illuminated. This holds good for the other senses as well. A lighting system that draws attention to itself by the odor it produces or by the noise it makes when in operation, is not as desirable, other things being equal, as one that is not characterized by these disadvantages.

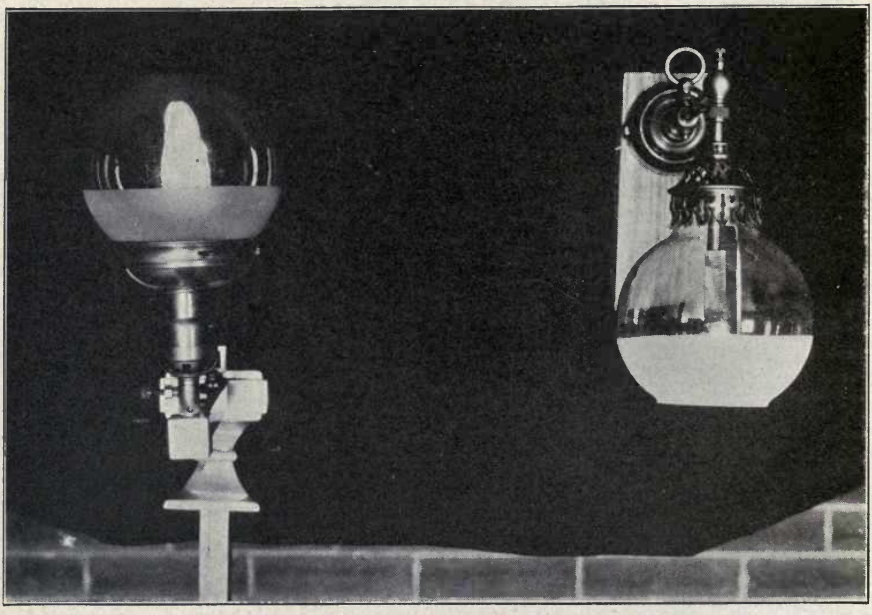


Fig. 16 Fig. 17

EASE OF OPERATION

Closely allied to convenience in lighting is another point which may be designated as ease of manipulation or operation. In all the systems that consume fuel there is a task of replenishing, the difficulty of which varies with the kind of system and even with the different types of any one system. In the private electric systems there must be considered the items of recharging and refilling the batteries. But over against this must be set the attention required by other systems; acetylene plants are to be recharged; oil lamps are to be filled and trimmed; a Blau-gas tank is to be replenished, and so on.

PORTABILITY OF LAMPS

At present we cannot have sufficient light everywhere. There are many dark corners at best. A portable lamp is very convenient as it can be used at any place at any time, and hence give sufficient illumination at that place and time. Most of the illuminants, however, are definitely fixed in position, except as they are used in individual reading lamps, which, of course, are portable or semi-portable. In a few systems the illuminants only are portable.

The present tendency is to have installed one of the large, more or less complex generating plants of one type or another. These do not permit much portability in the individual lamp.

The portable acetylene reading lamp which was used in these experiments is shown in Fig. 18. It requires neither chimney nor wick. Gasoline, or acetylene using mantles, is in many ways much better; but the mantle problem then presents itself. For the kerosene lamp the reader is referred to Bulletin No. 37 on "Illuminating Power of Kerosenes," by the writer, and published for distribution by the Engineering Experiment Station. The kerosene mantle lamp is shown in Fig. 19.

Among the illuminants used for barn, granary, and other outbuildings, the kerosene lantern has in the past, been practically the only portable lamp used. At present there can also be had a gasoline lantern, a cut of which is shown herewith (Fig. 20). If such a lantern is suspended in the proper place it will at a very small expense light the entire barnyard and the approach thereto. It has all the advantages and disadvantages of the regular gasoline reading lamp which is shown in Fig. 21. The battery flashlight is also being used, but it is not practical for continuous service.

NEED OF SIMPLICITY

Two systems using the same fuel may be so different in construction that the one is much harder to manipulate than the other. With this complexity there usually goes an increased element of danger. If a system is very complex it is not desirable; there are not only more parts to be worn out but there is also more skill required to attend to it without increasing danger.

STEADINESS OF LIGHT

That a light be steady is much more important than is usually assumed by the average user. If a light flickers or varies over an appreciable range it necessarily injures the eyes. The rapid accommodation required of the eye by a flickering light soon brings fatigue and weakness. A person may not realize at first that his eyes suffer, but sooner or later, under these conditions, they will give way under the excess strain. Aside from physiological considerations, it is not human nature to value highly anything that is vacillating or in any way unsteady.

RELIABILITY OF SERVICE

When a person turns on a light he expects it to serve him until he is thru using it. Practically all the systems now in use are reliable as a source of continuous light. If the owner has provided himself with sufficient fuel for the system he uses he can be reasonably sure that he will have continuous light. However, the transmission line from a central power plant, which is gaining in favor rapidly, is not as yet thus dependable, altho it has other important advantages. It may be put out of commission by lightning, by the blowing down of the wires in a storm, or by one of the numerous accidents that may happen at the central plant. If the farmer has a private plant of some sort he is not at the mercy of the maintenance department of a transmission company for continuous service.

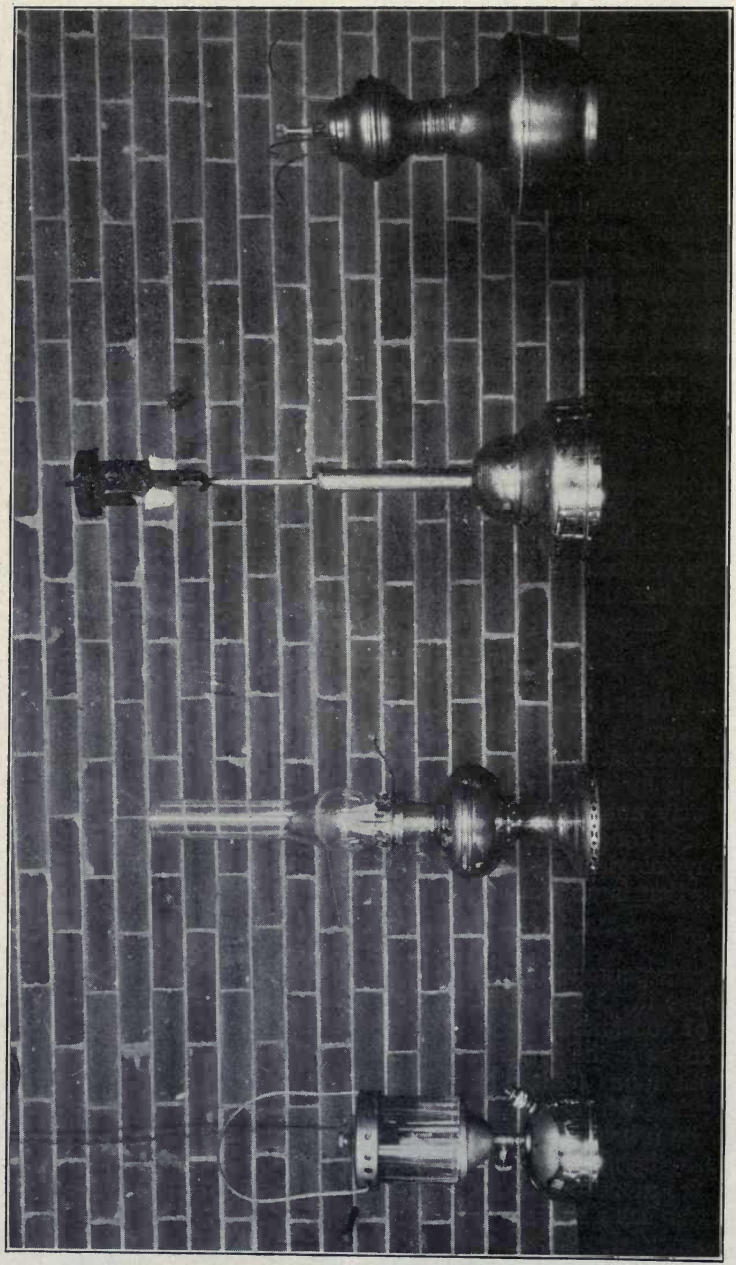


Fig. 18 Fig. 21 Fig. 19 Fig. 20

ADAPTABILITY OF LIGHTING SYSTEMS

The success of a farm lighting system depends no more upon its mechanical excellence than upon its adaptation to farm conditions and upon the resourcefulness and habits of those who must run it. So the problem of providing light for the farm or village community resolves itself into an analysis of the peculiar requirements and limitations of the inhabitants and of the necessary lighting equipment for any one system.

In a level, thinly-wooded country near a large commercial center, the electric system from transmission lines would probably be most satisfactory. This system, however, would hardly be as successful in very rough country or at a long distance from a power plant.

The success of any lighting plant depends upon the skill and care devoted to it. In the hands of those who do not understand mechanical or electrical manipulation, who think that lighting systems are too complicated for them to comprehend, or who are careless in the maintenance of their apparatus, a system which would otherwise prove successful will soon run down.

BY-PRODUCTS

In all flame or mantle lamps, carbon dioxide (CO_2) and moisture are by-products. The CO_2 is produced by the combustion of carbon, which is one of the chief constituents of fuel, and the moisture is produced by the oxidation of hydrogen. It has been demonstrated by experiments* that the amount of gas thus produced is altogether too small to have very much effect on the air in the room. Furthermore, it should be noted that such carbon dioxide gas is in itself not injurious to a person breathing it, but is thrown out by the lungs just as it is inhaled. It is only the carbon dioxide produced by our lungs that is injurious because it is mixed with organic impurities.

The moisture produced by the oxidation of hydrogen is a desirable factor, for in almost every home the humidity is lower than it should be. The flame or mantle lamps also produce considerable heat. This is also in their favor, for hot air currents aid in ventilation.

Acetylene (C_2H_2) is made by combining water (H_2O) with calcium carbide (CaC_2) in accordance with this expression:

$$CaC_2 + 2\,H_2O = Ca\,(OH)_2 + C_2H_2.$$

The by-product here is slacked lime $Ca\,(OH)_2$ and may be, and is, used in white washing fences and the interiors of farm buildings.

COST OF LIGHTING

Of all the different illuminants available for country homes, those of the lowest initial cost are more likely to be introduced first. In the past the only available illuminants have been low priced. As farmers grow more prosperous they are more inclined to consider some higher-priced system. In a few instances the cost of installation may appear high, but it should be remembered that some of these systems serve a double purpose. Thus, for example, where illuminating gas, natural gas, or Blau

*American Gas Light Journal, Vol. 104, pp. 18 and 321.

Fig. 24 Fig. 25 Fig. 22 Fig. 23

gas can be obtained, the system when once installed will lend itself to both heating and lighting at a moderate cost. Where natural gas is available the heating may be the primary object—even the heating of the house. In the electric system of lighting the apparatus also lends itself to other uses such as power, when it can be conveyed thru circuits taking small current. When the 110-volt system is available, either thru private installment on the part of the farmer or from the tapping of a transmission line, many uses can then be found for electricity on the farm, while the lights will be practically as effective as in the city.

At the present time, farm tenancy in Iowa, tho already very nearly 40%, is still on the increase. It is reasonable to suppose that farm owners will be less inclined to purchase and install an expensive lighting system for a tenant than when they themselves live on their farms. It is apparent then that in a community where there are many tenants the high-priced lighting systems are at a disadvantage in proportion to their merits.

One of the items which every user of light is anxious about and which very few if any have definite knowledge of, is the item of running expense. Even with a record of the outlay each year, there still remains the question of the amount of light received. While the use of the mantle results in quadrupling the amount of light for the same fuel consumed, the extra expense due to breakage of mantles is not to be overlooked. Again there is to be considered the expense for wicks, chimneys, shades, and bulbs. This varies considerably with the amount of care that is taken. The average life of a 110-volt Mazda B (vacuum) lamp is now about 1,800 hours, that of a 32-volt Mazda B (vacuum) lamp is about 2,300 hours. The latter has the longer life because it has a thicker filament due to its larger current-carrying capacity. The average life of a ramie fibre Welsbach mantle under proper care is about 200 hours, and as much as 5,000 hours for mantles made of silk fibre. The ramie fibre mantle mentioned is the one in common use.

The following table gives the amount of light obtained for one cent of fuel or energy when bought at the rate specified:

AMOUNT OF LIGHT OBTAINED FOR ONE CENT OF FUEL OR ENERGY

Name of Illuminant	Relative lighting capacity	Cost of fuel or energy
Candle	60	15c per lb.
Illuminating gas (bare flame)	200	$1.00 per 1,000 cu. ft.
Kerosene (flat flame)	550	15c per gal.
Kerosene (circular flame)	400	15c per gal.
Kerosene (mantle)	1,500	15c per gal.
Kerosene pressure lamp	1,950	15c per gal.
Acetylene (bare flame)	300	3.5c per lb.
Acetylene (mantle)	1,000	3.5c per lb.
Gasoline (mantle)	2,000	20c per gal.
Carbon (incandescent)	300	10c per kw. h.
Gas (mantle)	1,200	$1.00 per 1,000 cu. ft.
Mazda B (vacuum)	900	10c per kw. h.
Mazda C (gas filled)	1,300	10c per kw. h.
Blau-gas (mantle)	335	10c per lb.

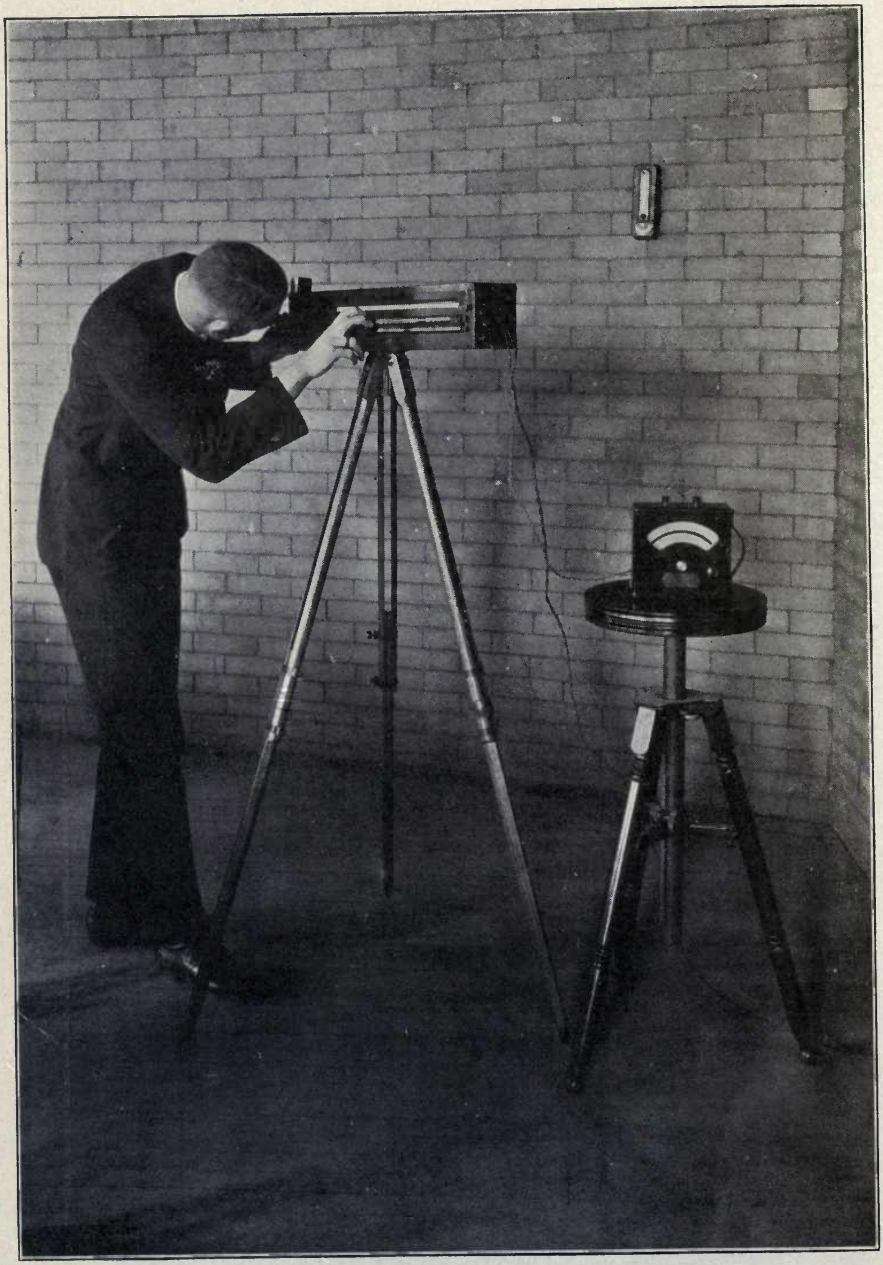


Fig. 26

The relative lighting capacity is given in lumens-hours for one cent. A lumen-hour may be explained thus; if the light from a standard candle falls normally upon a screen, which has an area of one square foot, placed one foot from the candle, the amount of light received by the screen is designated as one lumen. If this amount of light continues to fall upon the screen for one hour the amount of light thus received by the screen is one lumen-hour.

In the preceding table no attempt is made to take account of plant depreciation, interest on money invested, cost of labor for refilling, cleaning, trimming, and recharging, cost of mantles and wicks, bulbs, matches, chimneys, cost of repair, taxes and insurance.

In the table below all these factors are considered, and it gives the total cost of lighting an eight-room farm house for one year.

TOTAL ANNUAL COST OF LIGHTING AN EIGHT-ROOM FARM HOUSE

Lighting System	Annual cost
Candle	$114.00
Kerosene flat flame	40.00
Kerosene circular flame	46.00
Kerosene mantle	31.00
Kerosene pressure lamp	31.00
Gasoline reading lamp	31.00
Gasoline system	37.00
Acetylene reading lamp	54.00
Acetylene plant (bare flame)	96.00
Acetylene plant (mantle)	70.00
Blau-gas	56.00
Public service, electric (carbon)	74.00
Public service, electric (Mazda B)	56.00
Public service, electric (Mazda C)	56.00
High voltage private (carbon)	173.00
High voltage private (Mazda B)	131.00
High voltage private (Mazda C)	129.00
Low voltage private (Carbon)	139.00
Low voltage private (Mazda B)	97.00
Low voltage private (Mazda C)	95.00

The low-voltage system as compared with the 110-volt circuit has the advantage of being an independent plant, unless the latter is also a 110-volt private plant run either by batteries or by dynamo direct. The attention a battery requires is roughly proportional to the number of cells. In such a case there is no interference by storms nor any other hindrance that is comparable to damage on a line. The disadvantage of low voltage, however, lies in part in the greater amount of copper required to carry the extra heavy current made necessary by the low voltage. Also, the heavy current transmitted will produce a heavy line loss, for when the current is doubled the loss, other things being equal, is quadrupled. Both of these items will increase directly with distance. With a 110-volt circuit one can run machinery with practically equal ease near the central power plant or miles from such a plant. With the low-voltage system such is not the case. If one wants his system to last and to be efficient he must be careful not to overtax it by running heavy machinery with it.

DANGER

For several years past the slogan, "Safety First," has attracted considerable attention. At first, having only an industrial application, it has now invaded every realm of human endeavor. That there is some danger connected with each kind of lighting system no one can deny. The different systems, however, are well enough understood in the main that with proper care each one is practically free of danger. Each system has its own exponents among those who have successfully operated it; and each system again has its unfavorable critics among those who either have not used it at all or have used it carelessly.

Fire marshals who have made out reports on this problem, seem to differ so widely that very few, if any, definite conclusions can be derived therefrom. It seems certain, however, that almost all the danger arising from any system is due either to ignorance or to carelessness.

SIMPLE RULES OF LIGHTING

1. The light belongs on the work, not in the eyes.
2. Light should come over the left shoulder.
3. Make sure that lamps are in the right position.
4. Provided the illumination is sufficient, the farther the light source is from your work the better.
5. Good lighting means:
   (a) Reduction of accidents.
   (b) Greater accuracy in workmanship.
   (c) Less eye strain.
   (d) Sufficient light well distributed.
   (e) Better working and living conditions.
   (f) Greater contentment and cheerfulness.
   (g) More order and neatness in the home.

BULLETINS OF THE ENGINEERING EXPERIMENT STATION

*No. 1. The Iowa State College Sewage Disposal Plant Investigations.
*No. 2. Bacteriological Investigations of the Iowa State College Sewage.
*No. 3. Data of Iowa Sewage and Sewage Disposal.
*No. 4. Bacteriological Investigations of the Iowa State College Sewage Disposal Plant.
*No. 5. The Chemical Composition of the Sewage of the Iowa State College Sewage Disposal Plant.
*No. 6. Tests of Iowa Common Brick.
*No. 7. Sewage Disposal in Iowa.
*No. 8. Tests of Dry Press Brick Used in Iowa.
*No. 9. Notes on Steam Generation with Iowa Coal.
*No. 10. Dredging by the Hydraulic Method.
*No. 11. An Investigation of Some Iowa Sewage Disposal Systems.
*Vol. II, No. 6. The Good Roads Problem in Iowa.
*Vol. III, No. 1. Tests of Cement.
*Vol. III, No. 2. State Railroad Taxation.
*Vol. III, No. 3, Steam Generation with Iowa Coals.
Vol. III, No. 4. Incandescent Lamp Testing.
*Vol. III, No. 5. Steam Pipe Covering Tests.
*Vol. III, No. 6. The Assessment of Drainage Districts.
Vol. IV, No. 1. Tests of Iowa Limes.
Vol. IV, No. 2. Holding Power of Nails in Single Shear.
Vol. IV, No. 3. Miracle Contest Papers for 1908. (Theses on Cement and Concrete.)
Vol. IV, No. 4. Miracle Prize Papers for 1909. (Theses on Cement and Concrete.)
Vol. IV, No. 5. Sanitary Examination of Water Supplies.
Vol. IV, No. 6. Sewage Disposal Plants for Private Houses.
Bulletin No. 25. Electric Power on the Farm.
Bulletin No. 26. The Production of Excessive Hydrogen Sulfid in Sewage Disposal Plants and Consequent Disintegration of the Concrete.
Bulletin No. 27. A Study of Iowa Population as Related to Industrial Conditions.
Bulletin No. 28. History of Road Legislation in Iowa.
Bulletin No. 29. Costs of Producing Power with Iowa Coals.
Bulletin No. 30. The Determination of Internal Temperature Range in Concrete Arch Bridges.
Bulletin No. 31. The Theory of Loads on Pipes in Ditches, and Tests of Cement and Clay Drain Tile and Sewer Pipe.
Bulletin No. 32. A Topographical Survey of the Spirit and Okoboji Lakes Region.
Bulletin No. 33. House Heating Fuel Tests.
Bulletin No. 34. The Use of Iowa Gravel for Concrete.
Bulletin No. 35. The Iowa Engineering Experiment Station and Its Service to the Industries of the State.
Bulletin No. 36. Report of the Investigations on Drain Tile of Committee C-6, American Society for Testing Materials.
Bulletin No. 37. Illuminating Power of Kerosenes.
Bulletin No. 38. Electric Central Station Operation in Iowa.
Bulletin No. 39. Good Roads and Community Life.
*Bulletin No. 40. An Investigation of Iowa Fire Clays.
Bulletin No. 41. Sewage Disposal for Village and Rural Homes.
Bulletin No. 42. A Study of Oil Engines in Iowa Power Plants.
Bulletin No. 43. Practical Handling of Iowa Clays.
Bulletin No. 44. Locomotive Tests with Iowa and Illinois Coals.
Bulletin No. 45. Investigations of Gravel for Road Surfacing.
Bulletin No. 46. Electric Pumping, with Results of Tests and Operating Records.
Bulletin No. 47. The Supporting Strength of Sewer Pipe in Ditches, and Methods of Testing Sewer Pipe in Laboratories to Determine Their Ordinary Supporting Strength.
Bulletin No. 48. The Early Purchase and Storage of Iowa Coal.
Bulletin No. 49. An Investigation of Tests of Iowa Shale Drain Tile.
Bulletin No. 50. The Theory of Underdrainage.
Bulletin No. 51. Recommendations for Farm Drainage.
Bulletin No. 52. The Spacing and Depth of Laterals in Iowa Underdrainage Systems and the Rate of Runoff from Them.
Bulletin No. 53. Load Concentrations on Steel Floor-Joists of Wood-Floor Highway Bridges.
Bulletin No. 54. An Investigation of the Protective Values of Structural Steel Paints.
Bulletin No. 55. Lighting for Country Homes and Village Communities.

*Out of print.

Bulletins not out of print may be obtained free of charge upon request addressed to The Director, Engineering Experiment Station, Sta. A, Ames, Iowa.

The Iowa Sta
ducts work alo

The Gradua
tion in all the

Four, five a
ent divisions
in agriculture
sions include
courses are c

Extension
the state.

Research v
ing Experim
atory.

Special an
are supplied,
tins will be