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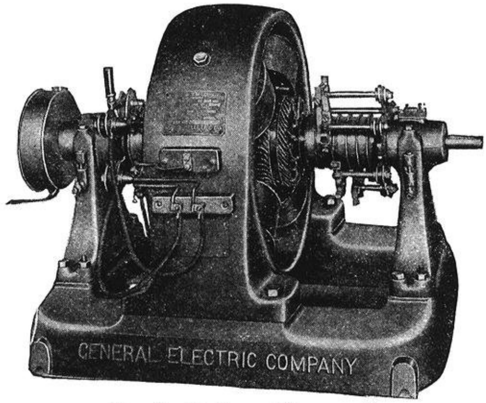
The Wisconsin Engineer

MAY, 1914

Vol. 18 No. 8

Electrical Laboratory Equipment



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The Wisconsin Engineer

VOL. XVIII MAY, 1914 NO. 8

ILLUMINATION OF THE SHOW WINDOW.

By John A. Hoeveler—1911.
Illuminating Engineer—National X-Ray Reflector Co.

It has been said, "The retailer—the man with a store—has no better salesman at his command than his show window. It can display goods and emphasize values in a most alluring manner; and it is ever on the job."

If this is true of a window in the day time, when everyone is passing along the streets hurriedly, how much more valuable is that same window at night, when the multitude moves along more leisurely? We may even go further and say that the most "attention compelling" windows, are the brightest windows—the ones that stand out in contrast to their dimmer surroundings. This emphasizes the need of illuminating a window, and illuminating it brightly.

With the advent of the incandescent electric lamp, show window illumination advanced tremendously, at least insofar as brilliancy was concerned. The popular method of illuminating the window was to outline it with bare lamps. The result was a "much lighted" but hardly a "well lighted" window, since it is a matter of common knowledge how difficult it is to see past such a wall of light. The next step was the use of ornamental lighting fixtures centrally located in the window, and this is still the popular method with many of the small merchants. From the illuminating stand-point it is not particularly good. Deep shadows are cast on the front of the goods, which is close to the plate glass. The glare from the exposed lighting units interferes with clear, comfortable vision. The progressive merchant has discarded the ornamental lighting fixture for window lighting purposes for another reason, which is purely commercial. He is in business to sell his own particular line of goods, not lighting fixtures, and therefore it is folly for him to place his own goods at a distinct disadvantage by crowding his window with highly ornate lighting fixtures. Fig. 1 shows a poorly lighted window. The lighting equipment consists of a long brass rod, supported from two chains, from which the lights are suspended at frequent intervals.

The present day conception of a well lighted window, is the window in which the goods displayed stands out attractively, secures the interest and holds the attention of the observer, without causing a thought to arise in his mind relative to the means by which the lighting is accomplished.

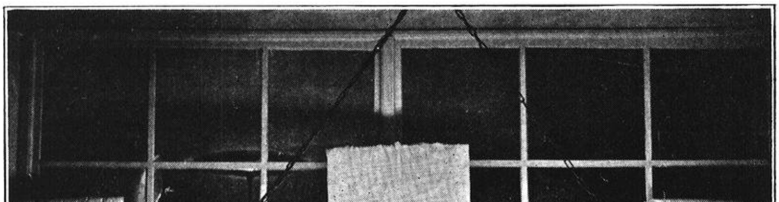


Fig. 1.—*Incorrect window lighting showing the results of glare from exposed lighting units.*

Perhaps it was the commercial aspect, and the prime necessity for attractively and effectively illuminating the show window that first taught us the advantage of concealing the light sources. Certainly we have learned it most thoroughly, and have practised it most consistently in connection with window lighting.

CLASSIFICATION OF SHOW WINDOWS.

In general show windows may be divided into two classes: open-back, and boxed-in.

FIG. 2.—*Cross section of window height equal to depth, high trim.*

Open back windows are typical of the small store—grocery, meat market, etc.—on the outskirts of a city, and in many small towns.

Boxed-in windows, on the contrary, are more common with the higher class stores. Included in this class are all windows which have a solid and opaque background part or all the way to the ceiling. Usually these windows are provided with a false ceiling, and in some cases are arranged in two tiers.

REQUIREMENTS FOR WINDOW LIGHTING.

In citing the requirements for window lighting, the open back window will be left out of consideration, since the lighting of these windows usually is only a continuation of the store lighting. In many instances they have no special lighting, and in practically all cases, where they have special lighting equipment, the illumination of the front of the store also is derived from them.

In order that the boxed-in window may be effectively and pleasingly illuminated, the following requirements must be fulfilled:

1. The lamps must be concealed.
2. The light must be properly directed.
3. The intensity must be ample.
4. The illumination must be uniform.
5. The color of the light must be pleasing.

The importance of directing the light from concealed sources has already been mentioned. A person can easily prove this to

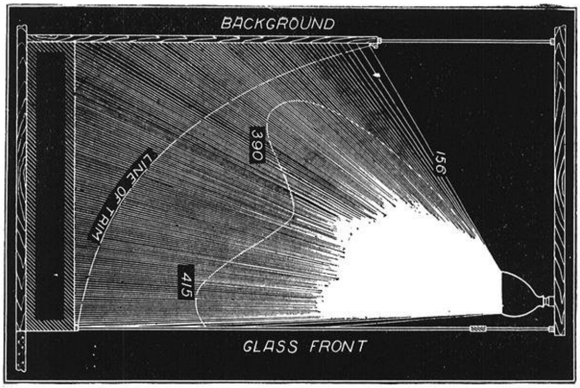


FIG. 3.—*Cross section of window height 1½ times depth, medium trim.*

his own satisfaction by observing the lighting of the windows along a live business street. The windows that attract attention and stand out from their neighbors, invariably are the ones in which this principle is carried out.

The direction of the light is of equal importance to the above consideration. Windows are trimmed in accordance with well defined principles:—the low and flat display at the front, and the high vertical display at the rear. Hence the "line of trim" takes a pretty well defined form as indicated in Figs. 2, 3, 4. The horizontal display at the front requires a high horizontal component of illumination, whereas the vertical display at the rear requires a high vertical component. The simplest manner of securing these results is the use of a properly designed lighting unit placed at the front and top of the window.

The intensity of illumination required on the line of trim depends on numerous conditions: the intensity of the street illumination, the brightness of neighboring windows, the class of goods displayed and the color of the goods and background. In order that a window may attract attention it must be illuminated much more brightly than the street. It will then stand out by contrast. If the window is located on a street, of which the general standard of window lighting is high, the minimum effective intensity

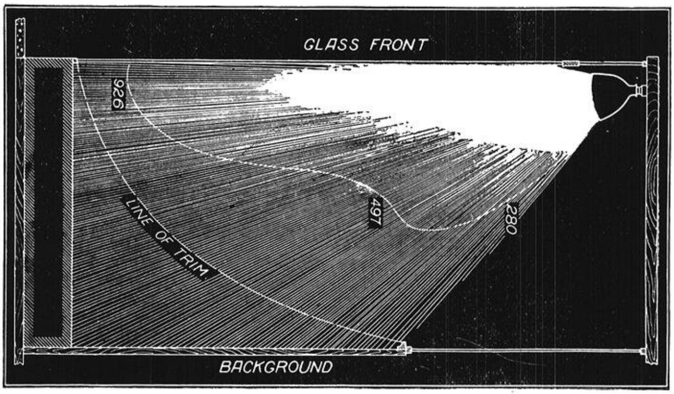


FIG. 4.—*Cross section of window height 2 times depth, medium trim.*

would be that of the neighboring windows. Some classes of goods require extremely high intensity of illumination, others require only moderate intensities. As an example men's furnishings as a rule require only a moderate intensity. Clothing on the contrary requires a high intensity. In general dark goods require much higher intensities than light goods. A light background will always give a window a bright appearance even with comparatively low intensities, whereas the dark back ground tends to produce the opposite effect. Mirrored backgrounds should not be used. One of the chief reasons why merchants desire mirrors, is the fact that they believe the observer will be enabled to see both the front and back of the objects in the window. However the brightness, to which the back of the objects is illuminated, is so low that the results are not very satisfactory. In addition to this, much brighter images of surrounding objects detract rather than add to the effect sought.

The need of uniform illumination in the show window hardly requires any special comment; it is apparant on the face of it. A uniform spacing of lighting units of proper design, along the front of the window, will accomplish this.

The color of the light of the tungsten lamp is most satisfactory for window lighting, and the tungsten lamp has largely displaced the carbon lamp.

FIG. 5.—*Silvered glass window reflector.*

WINDOW LIGHTING EQUIPMENT.

The problem encountered, when designing lighting equipment for show window illumination is of a very special nature. The angle intercepted by the line of trim in the plane perpendicular to the glass varies from 50 to 95 degrees, depending upon the dimensions of the window. This imposes the first condition to be solved. The light flux of the lamp must be confined to an angle of 95 degrees.

Figures 2, 3, 4, are cross sections of three typical windows. The line of trim of the window of Fig. 2, subtends an angle of 95 degrees; in Fig. 3 it subtends an angle of 65 degrees; and in Fig. 4 it subtends an angle of 50 degrees. For each of these windows a different distribution of light is required, as shown in the figures.

A study of the characteristics of reflecting surfaces will at once indicate that only surfaces following the laws of specular or of spread reflection are capable of giving the necessary concentration of light and of these, the specular surfaces are preferable, inasmuch as they permit variation in the light distribution in accordance with the wishes of the designing engineer. A reflect-

FIG. 6.—*Correct window lighting from concealed sources. Equipment—100 watt tungsten lamps equipped with individual X-Ray No.* 780 *reflectors; units spaced on* 18 *inch centers.*

ing surface following the law of diffuse reflection would be incapable of giving the required concentration, and any reflector of this type, designed with this purpose in mind, would be inefficient indeed, due to excessive losses by internal reflections.

The pioneer equipment for concealed lighting of show windows is the familiar trough, constructed of metal and lined with white opal glass, or strips of ripple mirrored glass in which the lamps are placed vertically or horizontally at frequent intervals. While the trough reflector marked a great advance in window lighting methods, and dominated the field for a long time, it has numerous defects. There is a great waste of light due to the lack of control of the end-wise light flux, the interference of light flux of adjacent lamps, and the lack of sufficient variation in design to meet the variable conditions encountered in practice. The distribution of light from the trough is not uniform over the trim. The bulk of the light flux is confined to the upper portion

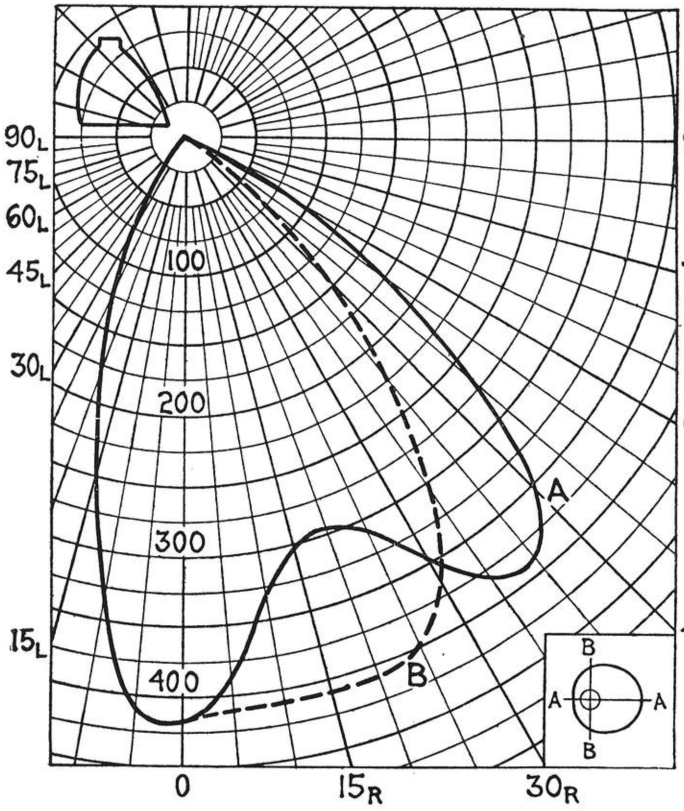


FIG. 7.—*Light distribution X-Ray #780 reflector with 100 watt tungsten lamp.* (1.08 *W. P. C.*)

of the window, with a consequent insufficiency at the front and bottom. However the trough is so far ahead of the old systems of exposed lighting, that it deserves very favorable comment in the history of window lighting.

An individual reflector for each lamp prevents much of the waste of light characteristic of the trough, and makes possible a more even distribution over the line of trim. Such reflectors preferably should be non-symmetrical with a distribution of light that cuts off sharply at the edge of the window and at the top of the trim. Symmetrical reflectors placed at the front of the window in a vertical position are wasteful—practically half of the light escapes through the plate glass onto the sidewalk—and do not give an even distribution of light on the trim. The concentrating type of symmetrical reflector may be used to advantage when tilted at an angle. By a study of the conditions in any particular case, an arrangement of concentrating symmetrical reflectors tilted at a number of different angles may be secured which will give good results. The installation of such equipment, however, entails constructional difficulties, which are entirely overcome by the use of non-symmetrical reflectors in which the lamps hang pendant.

Specially designed silvered glass reflectors (specular reflecting surface) of the type shown in Fig. 5 are meeting with wide application. They are designed in a variety of sizes and shapes, and cover the field in a most complete manner. Their efficiency excells that of all the other commercial reflectors by a handsome margin. Fig. 6 shows a window illuminated by means of 100 watt tungsten lamps equipped with silvered glass reflectors. The light distribution curve of the reflector used is shown in Fig. 7.

A comparison of Figures 1 and 6 will bear out what has been said concerning the need of concealing the light source, of proper direction of the light, and of uniformity of illumination on the trim. In Fig. 1 note the glare due to the lighting units, and the consequent loss of detail on the trim adjacent to the units. Note the front of the two forms in the foreground are in deep shadow, because the lighting units are placed centrally, and the light for these objects is from the rear. The non-uniformity of the illumination is apparent. Now note how all these features have been diminated in the window of Fig. 6.

A DESCRIPTION OF THE REYNOLDS-GIRDER FRAME CORLISS ENGINE.

E. T. ADAMS.

INTRODUCTORY NOTE BY JOHN G. D. MACK.

Some weeks ago Mr. E. T. Adams was in my office and upon seeing this model gave a most interesting account of the design of the Reynolds-Corliss engine as he had heard it from Mr. Reynolds.

I suggested to Mr. Adams that he write out the story for the Wisconsin Engineer, as it would make a valuable contribution to the history of Wisconsin industry, in addition to giving an idea of the methods of design practiced by a man who played so large a part in the development of machine building in this state, —Edwin Reynolds.

Mr. Adams was associated from many years with E. P. Allis & Co. and its successor,—The Allis-Chalmers Company.

In the earlier years he was engineering secretary for Mr. Reynolds, later becoming head of the Steam and Gas Engine Department of the Allis-Chalmers Company.

MARCH 30, 1914.

MY DEAR MR. MACK:

Here is the story of the girder frame as I recall it after many years. I think I have Mr. Reynolds' statement of his problem almost verbatim,—it made a tremendous impression on my mind. It is a volume on Machine Design.

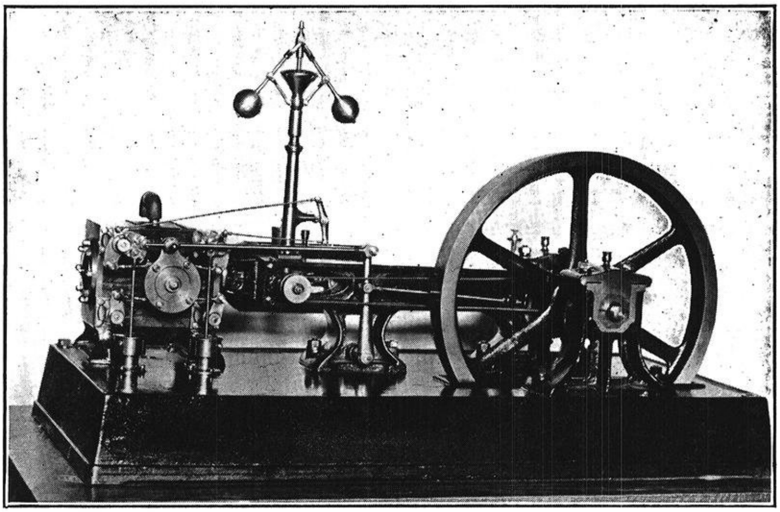
Yours Truly,
E. T. ADAMS.

539 Terrace Ave., Milwaukee, Wis.

The model of the Girder Frame Reynolds-Corliss Engine which you have in your classroom recalls a story of its design as I had it from the designer, Edwin Reynolds. Mr. Reynolds' fame as an Engineer rests chiefly on greater and bolder undertakings, but I know of no work which he did, more characteristic of the man, or which better illustrates the qualities which mark a master.

I think that this design was made during the early seventies. Prior to this date Mr. Reynolds was the superintendent of the Geo. H. Corliss Engine Works at Providence, R. I. Corliss was at this time at the height of his fame and Mr. Reynolds as his superintendent held what was probably the best mechanical position in the country.

At the time of which we speak, Mr. Reynolds visited Milwaukee to meet Mr. E. P. Allis and at about this date concluded an agreement to become the General Superintendent of the E. P. Allis Co. and to build up in the West, a Reynolds-Corliss engine business which was very soon to completely overshadow the work of the Providence plant.



Working model of Reynolds-Corliss engine (1″ x 4″), presented to the College of Engineering by Mr. Louis Allis.

This model was built about twenty-five years ago by the E. P. Allis Company and was exhibited at the Chicago Worlds Fair and other expositions.

The E. P. Allis Co. was at that time very far indeed from being in the prosperous condition to which they grew later, under Mr. Reynolds' superintendency. The shops were most miserably equipped and the company had no money. The machine shop was a light wooden affair, part or all of which had been bought cheap, floated down the Milwaukee river on a scow and re-erected on land which at that day was almost a marsh.

Poor as the machine shop was in tools and equipment of every kind, the foundry was far worse. It was situated at a short distance from the machine shop and in wet weather the space between was a morass, almost impassable. Through this horses floundered as best they could, dragging a "flat" on which castings were transferred from the foundry to the machine shop. A casting lost from the "flat" in transit was lost forever.

The foundry had been equipped as a pipe foundry and a swinging crane arranged to serve the pipe pits was the only mechanical aid in the place. "When I came to look the ground over", said Mr. Reynolds, "the outlook was discouraging, for while the machine shop could handle a fair sized casting, we could not make such a casting in the foundry, neither could we have transported it from the foundry through the morass to the shop and the company had no money with which to provide equipment of any kind.

"The problem then was to design something which could be built with such equipment, in tools and men, as we had, and which could be sold for more than it cost us to build it."

Having decided to establish himself at Milwaukee, Mr. Reynolds returned east to end his connection with the Corliss Works at Providence, and it was during this return journey that he worked out, on the back of old papers taken from his pockets, the design of at least a large portion of the engine of which you have the model.

The frame is made in two pieces on account of the poor foundry equipment and the morass, and also arranged so that either a right-hand or a left-hand engine or one of the longer or shorter stroke could be built from the one set of patterns, a vital consideration where money was lacking.

It is worth while to note the extreme simplicity of the machine and foundry work in this frame, and the ease with which the variations in hand or stroke could be made. There was slight chance for error in the shop, and this also was most important. "The foundry", said Mr. Reynolds, "was especially weak, the men employed there were in no sense moulders. I saw that we must have as few cores as possible, and you will find that there is only one core in the frame, and that one, the jaw for the main bearing, is so formed that the casting would come right no matter how the core is set."

The joint in the frame is most cunningly placed, first to make simple shop operations suited to poor equipment and unskilled mechanics, and second the parts are so placed as to give the greatest stiffness at the points of greatest stress.

The cylinder and valve gear exactly as shown in your model and as copied by almost everybody had manifestly been thoroughly thought out prior to this trip, and very likely it formed part of a more elaborate design which he found it necessary to abandon in order that he "might design something which could be built with such equipment, in tools and men, as we had, and which could be sold for more than it cost us to build it".

FORMULAS FOR ESTIMATING YEARLY EXPENSES OF PROPOSED EXTENSIONS OF DISTRIBUTION SYSTEMS OF PUBLIC UTILITIES WITH SPECIAL REFERENCE TO WISCONSIN UTILITIES.

H. E. PULVER, C. E.

One of the most important problems in connection with public utilities is that of extensions of their distribution systems. While practically all utilities desire more profitable business and are usually willing to extend their distribution systems to secure such business, very few of them have any definite rules or formulas for estimating whether or not a proposed extension will be profitable. In general the distribution system should be extended if the estimated gross yearly revenues from the proposed extension are equal to or greater than the estimated total expenses (including profit) of the extension for one year. In some cases it may be advisable to build an extension which will not be profitable at once, providing that there are good chances to secure additional customers for the extension during the next few years. In making an estimate of the yearly revenues of a proposed extension the smaller utilities do not appear to have found much trouble but they have usually experienced some difficulties in preparing an estimate of the yearly expenses of that extension.

In the following article some formulas are suggested for use in estimating the yearly expenses of proposed extensions of the distribution systems of some public utilities in the state of Wisconsin. In this state all public utilities make annual reports to the Railroad Commission on certain prescribed forms and the information given in these reports is arranged and tabulated and then published by the Railroad Commission as a part of its annual report. Consequently the terms in the following formulas have been chosen and arranged so that direct use may be made of the data contained in these published reports.

In order to facilitate the work of the Commission, the different kinds of public utilities have been divided into classes (the division being usually based on the population of the city in which the utility is located) and all of the utilities of the same kind and class use the same form of annual report. The following table shows the four important kinds of utilities and the classes into which they are divided.

TABLE I.

Classification of Public Utilities in Wisconsin.

Utility	Class	Remarks
Electric	A	In cities having a population of 10,000 or over.
	B	In cities having a population of from 3,000 to 10,000.
	C	In cities having a population less than 3,000.
Gas	A	In cities having a population of 10,000 or over.
	B	In cities having a population less than 10,000.
	C	Very small utilities operated by gasoline or acetylene processes.
Water	A	In cities having a population of 10,000 or over.
	B	In cities having a population of from 3,000 to 10,000.
	C	In cities having a population less than 3,000.
Telephone (Exchange Systems)	A	In cities having a population of 15,000 or over.
	B	In cities having a population of from 5,000 to 15,000.
	C	All other exchanges except "D".
	D	Exchange systems of 150 telephones or less.
Telephone (Toll Systems)	A	Total operating revenues of $20,000 per year or more.
	B	Total yearly operating revenues of from $5,000 to $20,000.
	C	All other toll systems except "D".
	D	Toll systems operating 150 telephones or less.

In developing the formulas the same general method was followed in each case. The gross yearly revenues, which must be received from the extension to make it pay, were considered as equal to the sum of the different yearly expenses. In each of the formulas the first expense term is called the extension construction term and this is equal to the total first cost of the extension multiplied by the sum of the annual rates of interest, taxes, profit and depreciation. To obtain the other terms in the formulas, the main expense accounts of the utilities (and what is included in these accounts) were carefully considered and units chosen for reducing each of these general expense accounts to a unit cost basis. Then all of the unit expenses, which were based on a certain unit, were summed up and multiplied by the number of those units which would be in the proposed extension. For example, all of the yearly unit expenses, which had been found by dividing certain of the general expenses by the total number of consumers, were added together and then multiplied by the number of prospective consumers on the proposed extension and this term was called the consumer term. In a like manner all of the unit expenses, which were based on another unit, were summed up and multiplied by the number of those units on the extension, thus obtaining another term in the formula. This process was repeated until all of the unit expenses had been included in the formula.

Throughout the formulas capital letters were chosen to represent the units and small letters to represent the unit expenses. Also the letters were so selected as to indicate just what units or unit expenses they were to represent. For instance, "C" represents the number of consumers on the proposed extension, "c" the unit commercial expense, and "g" the unit general expense and so forth.

In order to determine just what is included under each general expense account, reference should be made to the uniform classifications of accounts for the different utilities as prescribed by the Wisconsin Railroad Commission. These classifications are published by the Commission in pamphlet form.

Formula for Distribution System Extensions of Electric Utilities.

$$R=aE+mL+dM+(k+c+g+u)C+(p+t+s+i)fK.$$

REVENUE TERM.

R equals the gross yearly revenues, in dollars, which must be received from the proposed extension to make it pay.

EXTENSION CONSTRUCTION TERM.

aE equals the cost per year due to the construction of the new extension.

E is the total cost of construction (expressed in dollars) of the new extension in place and ready to operate.

a is the sum of the rates of interest, depreciation, profit and taxes charged to the extension and expressed as a decimal.

STREET LIGHT TERM.

mL contains all of the unit expense items which have been determined by prorating on the total number of street lights operated by the utility.

L is the number of street lights on the new extension.

m is the yearly expense per light. This expense is the Municipal Contract Lighting part of the Consumption Expenses and includes such expenses as trimming and inspecting street lamps, street lamp supplies and renewals, miscellaneous lighting supplies and expenses and the maintenance of the street lamps.

MILEAGE OF LINE TERM.

dM contains all of the unit expense items which have been determined by prorating on total mileage of line (pole and conduit) of the utility distribution system.

M is the number of miles of line (pole and conduit) in the extension.

d is the yearly expense per mile of line of the entire distribution system, and includes such expenses as are due to the operation and maintenance of a distribution system. There was not much choice between prorating the distribution system expenses on the line mileage or the number of meters but it was thought that the mileage of line basis would be less in error especially in the residence sections of towns and cities.

CONSUMER TERM.

(k+c+g+u)C contains all of the unit expense items which have been determined by prorating on the total number of consumers of the utility.

C is the number of consumers on the extension.

k is the yearly Commercial Consumption expense of the utility per consumer and includes such expenses as trimming and inspecting commercial lamps, commercial lamp supplies and renewals, miscellaneous commercial consumption supplies and expenses, consumers premises expenses and the maintenance of commercial lamps.

c is the yearly Commercial expense of the utility per consumer and includes the expense due to collections and the promotion of business.

g is the yearly General expense of the utility per consumer and includes such expenses as general office salaries, supplies and expenses, general law expenses, miscellaneous general expenses, R. R. Commission expenses and the maintenance of general office equipment, general office buildings, fixtures and grounds.

u is the yearly Undistributed expense of the utility per consumer and includes the expenses due to injuries and damages, insurance, stationery and printing, operation and maintenance of the stores department and the utility department and their equipments, buildings, fixtures and grounds.

KILOWATT HOUR TERM.

$(p+t+s+i)fK$ contains all of the unit expense items which have been determined by prorating on the total number of kilowatt hours consumed by all of the customers of the utility.

K is the number of kilowatt hours that will be consumed by the extension in one year.

f is one plus the lost and unaccounted for electric current in the extension and expressed as a decimal.

p is the cost of producing one kilowatt hour at the generating station (Power cost) and includes all expenses due to the operation and maintenance of the power plant.

t is the Transmission and Transformation expense per kilowatt hour and includes the expenses of operating and maintaining the transmission system, substations and transformer stations.

s is the expense per kilowatt hour due to the operation and maintenance of storage batteries (Storage expense account).

i is the cost per kilowatt hour due to all other expenses (Depreciation, Taxes and Contingencies Extraordinary) for the whole utility with the exception of the distribution system. See later remarks concerning this term.

Formula for Distribution System Extensions of Gas Utilities.

$$R=aE+mL+(d+c+g+u)C+(p+i)fG.$$

REVENUE TERM.

R equals the gross yearly revenues, in dollars, which must be received from the proposed extension to make it pay.

EXTENSION CONSTRUCTION TERM.

aE equals the cost per year due to the construction of the new extension.

E is the total cost of construction (expressed in dollars) of the new extension in place and ready to operate.

a is the sum of the rates of interest, depreciation, taxes and profit chargeable to the new extension and expressed as a decimal.

MUNICIPAL CONTRACT LIGHTING TERM.

mL contains all of the unit expense items which have been found by prorating on the total number of street lamps operated by the utility.

L is the number of street lamps on the new extension.

m is the yearly Municipal Contract Lighting expense per lamp, and includes all expenses due to the operation and maintenance of the street lamps.

CONSUMER TERM.

(d+c+g+u)C contains all of the unit expense items which have been determined by prorating on the total number of consumers of the utility. These items might have been prorated on the total number of meters instead of the total number of consumers but it was thought that the consumer basis was the more logical one to use.

C is the number of consumers on the new extension.

d is the yearly Distribution expense per consumer and includes such expenses as are due to the operation and maintenance of the distribution system of a gas utility. This expense account was prorated on the consumer basis instead of mileage of main basis because the sum of the parts of this account chargeable to meters and consumers was larger than the sum of those parts chargeable to mains. There are a few gas utilities in Wisconsin which are exceptions to the above statement.

c is the yearly commercial expense of the utility per consumer and includes collection expenses and such expenses as are due to the promotion of business.

g is the yearly General expense of the utility per consumer and includes such accounts as general office salaries, supplies and expenses, law (general) expenses, miscellaneous general expenses, R. R. Commission expenses, and the maintenance of the general office equipment, buildings, fixtures and grounds.

u is the yearly Undistributed expense of the utility per consumer and includes such expenses as injuries and damages, insurance, stationery and printing, operation of the stores and utility departments and the maintenance of the equipment, buildings, fixtures and grounds belonging to these departments.

GAS PRODUCTION TERM.

(p+i)fG contains all of the unit expense items which have been determined by prorating on the total number of thousand cubic feet of gas consumed by all of the customers of the utility.

G is the number of thousand cubic feet of gas that will be consumed by the new extension in a year.

f is one plus the percentage of gas lost and otherwise unaccounted for in the extension and expressed as a decimal.

p is the cost of producing one thousand cubic feet of gas at the production plant (Production expense) and includes all expenses due to the operation and maintenance of the production plant.

i is the cost per one thousand cubic feet of gas due to all other expenses (Depreciation, Taxes and Contingencies Extraordinary) for the whole utility with the exception of the distribution system. See later remarks concerning this term.

Formula for Distribution System Extensions of Water Utilities.

$$R = aE + dM + (c+g+u)C + (p+i)fW.$$

REVENUE TERM.

R equals the gross yearly revenues, in dollars, which must be received from the proposed extension to make it pay.

EXTENSION CONSTRUCTION TERM.

aE equals the cost per year due to the construction of the new extension.

E is the total cost of construction (expressed in dollars) of the new extension in place and ready to operate.

a is the sum of the rates of interest, depreciation, profits and taxes chargeable to the new extension and expressed as a decimal.

MILEAGE OF MAINS TERM.

dM contains all of the unit expense items which have been found by prorating on the total mileage of mains in the distribution system of the utility, regardless of the size of the mains.

M is the total length of mains, in miles, in the new extension.

d is the yearly Distribution expense per mile of mains and includes such expenses as are chargeable to the operation and maintenance of a distribution system of a water utility.

CONSUMER TERM.

(c+g+u)C contains all of the unit expense items which have been determined by prorating on the total number of consumers of the utility.

C is the number of consumers on the new extension.

c is the yearly Commercial expense of the utility per consumer and includes the expenses due to collections and the promotion of business.

g is the yearly general expense of the utility per consumer and includes such accounts as general office salaries, supplies and expenses, general law, R. R. Commission and miscellaneous general expenses, and the maintenance of the general office equipment. buildings, fixtures and grounds.

u is the yearly Undistributed expense of the utility per consumer and includes such expenses as injuries and damages, insurance, stationery and printing, operation of the stores and utility departments and the maintenance of the equipment, buildings, fixtures and grounds belonging to these departments.

WATER TERM.

(p+i)fW contains all of the unit expense items which have been determined by prorating on the total number of thousand gallons of water consumed in a year by all of the customers of the utility.

W is the number of gallons of water, in thousands, which the consumers on the new extension will use in a year.

f is one plus the percentage of water lost and otherwise unaccounted for in the extension and expressed as a decimal.

p is the cost of one thousand gallons of water to the utility when this water is ready to enter the distribution system. This is the Pumping expense and includes such expenses as are chargeable to the operation and maintenance of the pumping plant (including the purification system and the collecting aqueducts, intakes and supply mains and the accompanying buildings).

i is the cost per thousand gallons of water due to all other expenses (Depreciation, Taxes and Contingencies Extraordinary) for the whole utility with the exception of the distribution system. See later remarks regarding this term.

Formula for Distribution System Extensions of Telephone Utilities.

$$R = aE + wM + (o+s+c+g+u+i)P.$$

Revenue Term.

R equals the gross yearly revenues, in dollars, which must be received from the proposed extension to make it pay.

Extension Construction Term.

aE equals the cost per year due to the construction of the new extension.

E is the total cost of construction, in dollars, of the new extension in place and ready to operate.

a is the sum of the rates of interest, depreciation, profits and taxes chargeable to the new extension and expressed as a decimal.

Mileage of Pole Line Term.

wM contains all of the unit expense items which have been determined by prorating on the total mileage of pole (and conduit) line of the utility.

M is the number of miles of pole line in the extension.

w is the yearly Wire Plant (Transmission) expense per mile of pole line and includes all expenses due to the operation and maintenance of the transmission system of a telephone utility.

Phone Term.

$(o+s+c+g+u+i)P$ contains all of the unit expense items which have been determined by prorating on the total number of phones operated by the utility.

P is the number of phones on the new extension.

o is the yearly Central Office (Traffic) expense of the utility per phone and includes all expenses due to the operation and maintenance of a central office.

s is the yearly Substation (Terminal) expense of the utility per phone and includes all expenses due to the operation and maintenance of the phones and other parts of the substation equipment.

c is the yearly Commercial expense of the utility per phone and includes all expenses chargeable to collections, uncollectible accounts and promotion of business.

g is the yearly General expense of the utility per phone and includes such accounts as miscellaneous general, general law and R. R. Commission expenses and also the expenses due to the operation and maintenance of the general office.

u is the yearly Undistributed expense of the utility per phone and includes such expenses as injuries and damages, insurance, stationery and printing, stores department and utility equipment maintenance and operation.

i is the yearly expense per phone due to all other expenses (Depreciation, Taxes and Contingencies Extraordinary) for the whole utility with the exception of the wire plant and substations. See later remarks regarding this term.

The following table gives the various general expense accounts for the four different kinds of utilities and shows what units were chosen in determining the unit expenses and also what small letters were used to represent these unit expenses.

For an example illustrating the use of the formulas, suppose that an extension of the water utility at Neenah, Wis., is being considered and that the following data about this extension has been determined. Length of extension is 700 feet (of 6 inch main) and its total cost will be $650. The extension will serve one fire hydrant, three dwelling houses having six rooms or less, two seven-room dwelling houses and one ten-room dwelling house with water closet and connections for hose for lawn sprinkling. All of the houses will be on flat rates.

The total yearly expenses of the extension will be determined by the formula,

$$R=aE+dM+(c+g+u)C+(p+i)fW.$$

a equals sum of 0.075 (interest and profit), 0.00 (taxes) and 0.01 (depreciation) or 0.085. As this is a municipal company, no taxes are included.

E equals $650, from the data given above.

d equals $796 (Distribution expense) divided by 13.14 (miles of mains), or $60.58.

M is the miles of mains in the extension, or 0.133 miles.

TABLE II.

Summary of the General Expense Accounts, Units and Small Lettters Used in the Preceding Formulas.

Utility.		Account.	Small Letter.	Units chosen for determining Unit Expenses.
Electric	I	Power	p	Kilowatt hour.
	II	Transmission and Transformation	t	Kilowatt hour.
	III	Storage	s	Kilowatt hour.
	IV	Distribution	d	Mile of line.
	V	Consumption (Commercial)	k	Consumer.
	VI	(Municipal Lighting)	m	Street lamp.
		Commercial	c	Consumer.
	VII	General	g	Consumer.
	VIII	Undistributed	u	Consumer.
	IX	All Other	i	Kilowatt hour.
Gas	I	Production	p	1000 cubic feet.
	II	Distribution	d	Consumer.
	III	Municipal ContractLighting	m	Street lamp.
	IV	Commercial	c	Consumer.
	V	General	g	Consumer.
	VI	Undistributed	u	Consumer.
	VII	All Other	i	1000 cubic feet.
Water	I	Pumping	p	1000 gallons.
	II	Distribution	d	Mile of mains.
	III	Commercial	c	Consumer.
	IV	General	g	Consumer.
	V	Undistributed	u	Consumer.
	VI	All Other	i	1000 gallons.
Telephone	I	Central office (Traffic)	o	Phone.
	II	Wire plant (Transmission	w	Mile of pole line.
	III	Substation, (Terminal)	s	Phone.
	IV	Commercial	c	Phone.
	V	General	g	Phone.
	VI	Undistributed	u	Phone.
	VII	All Other	i	Phone.

C equals 6 consumers.

c equals $120 (Commercial expense) divided by 586 (total number of consumers), or $0.205.

g equals $672 (General expense) divided by 586, or $1.147.

u equals $46 (Undistributed expense) divided by 586, or $0.078.

W is the number of thousand gallons that the extension will consume yearly and is estimated as 225 thousand gallons.

f is one plus the percentage lost or otherwise unaccounted for. This percentage is estimated as 8% and is equivalent to 372 gallons per day per mile of pipe which is a fair value for new mains. Then "f" equals 1.08.

p equals $4,862 (Pumping expense) divided by 191,245 (M gallons pumped), or $0.0254.

i equals $4,985 (Depreciation) times 44% (utility minus the distribution system) and divided by 191,245, which is $0.0115. There were no contingencies extraordinary reported.

Substituting in the formula,

$$R=0.085+650\times 60.58\times 0.133+(0.205+1.147+0.78)6+(0.0254+0.0115)1.08\times 225.$$

$$R=55.25+8.06+8.58+8.97=\$80.86.$$

Then the gross yearly revenues which must be received from the proposed extension, if it is to be profitable, must be equal to or be greater than $80.86.

All of the values used in the formula, except those noted as estimated, have been taken from the Fifth Annual Report of the Railroad Commission of Wisconsin, Volume II, Part IV.

The gross yearly revenues from the extension may be estimated from the data given at the beginning of the problem and from the water rates in force on Dec. 1, 1912. The estimate is as follows:

Rental of one fire hydrant	$50.00
Three six-room dwelling houses at $6	18.00
Two seven-room dwelling houses at $6.50	13.00
One ten-room dwelling house including water closet and lawn sprinkling	18.00
Total yearly revenues	$ 99.00

A comparison of the estimated revenues and expenses of this extension shows that it would be profitable and should be built.

The following table shows all of the main expense accounts (expressed as a percentage of the total direct operating expenses) of the four different kinds and classes of public utilities in Wisconsin. The kinds of public utilities included in the table are electric, gas, water, and telephone utilities. Such expenses as depreciation, taxes and contingencies extraordinary are not included.

This table is included so that an idea may be had as to the relative importance of the various direct operating expenses of these different kinds and classes of Wisconsin utilities. These averages should not be used in estimating the expenses of any extension whenever it is possible to obtain the exact amounts chargeable to the different main expense accounts. If it is impossible to obtain such amounts, then the total direct operating expenses of the utility may be apportioned according to the average percentages.

TABLE III.

Per Cent of Total Direct Operating Expenses of Public Utilities of Wisconsin. *Electric Utilities*

Class.	Power.	Transmission and Transformation.	Storage.	Distribution.	Consumption.	Commercial.	General.	Undistributed.
A	57.6	0.8	0.1	8.3	11.4	5.4	12.0	4.4
B	64.1	1.0	0.1	9.3	4.5	2.4	15.4	3.2
C	72.5	0.0	0.0	9.2	5.8	0.7	10.0	1.8

Gas Utilities.

Class.	Production.	Distribution.	Municipal lighting.	Commercial.	General.	Undistributed.
A	69.7	11.2	0.3	9.4	8.2	1.2
B	76.0	5.3	0.5	3.4	13.9	0.9
C	......	No rec.	......	......	......	......

Water Utilities.

Class.	Pumping.	Distribution.	Commercial.	General.	Undistributed.
A	48.1	23.7	11.5	15.0	1.7
B	68.7	9.6	1.2	19.3	1.2
C	69.7	16.6	0.6	11.4	1.7

Telephone Utilities.

Class.	Central Office.	Wire plant.	Substation.	Commercial.	General.	Undistributed.
A and B Bell...........	37.2	9.7	25.2	14.8	9.4	3.7
A and B Independent	43.9	20.4	9.9	7.9	12.7	5.2
A and B Average......	40.55	15.05	17.55	11.35	11.05	4.45
C	42.9	19.1	13.2	3.2	17.2	4.4
D	43.7	20.3	8.3	5.3	15.8	6.6

NOTE.—All data for Classes A and B are averages for two or three years while the data for Classes C and D are for one year only.

All of the information in the table was obtained from the Fifth Annual Report of the Railroad Commission of Wisconsin, Volume II, Part IV.

In each of the suggested formulas there occurs the small letter "i" which represents a yearly unit expense due to depreciation, taxes and contingencies extraordinary for the whole plant minus the distribution system. Now it is doubtful whether or not this term (i) should be included in any of the formulas because, firstly, the old consumers of the utility are already paying these expenses and, secondly, it is probable that, during the next few years, new consumers will be secured for the new extension and thus increase the revenues derived from it. However, if this term is included in any formula it usually will not increase the estimated expenses more than three or four percent.

In applying any formula, it will usually be found that the extension construction term will be the largest and most important term in the formula and, consequently, the estimate of the cost of construction of the proposed extension should be accurate. Such an estimate can be made if a careful and detailed study is made of the particular extension in question.

These formulas are suggested for use in estimating the yearly expenses of distribution system extensions of all classes of public utilities and it is thought that, when properly used, they will give estimates which will be accurate enough for practical purposes. However, in estimating the yearly expenses for distribution system extensions for Class A utilities, it is possible to develope formulas which will give more accurate estimates because the annual reports of this class of utilities will permit of a more detailed analysis of the expense accounts than will the annual reports of the other classes of utilities.

A STUDY OF THE ELIMINATION OF PHANTOM LIGHTS FROM SEMAPHORE ROUNDELS, A REVIEW OF THESIS OF W. K. FITCH AND S. S. GREGORY JR., BOTH M. E. 1913.

JOHN G. D. MACK.

In Vol. 17 No. 3 (December, 1912) of the WISCONSIN ENGINEER the writer presented a general discussion of the electric arc headlight for locomotives, giving a statement of the arguments for and against its use.

In the brief against the arc headlight charge (d) is as follows:

> "The electric arc headlight may indicate a false or phantom light when the light behind the roundel is extinguished, and in some cases a green or other colored phantom has been observed when a light was burning behind a red roundel."

For the reasons given in the article above noted, the writer believes that the danger from these phantom lights is in itself largely a phantom.

However, on account of the rather wide spread belief in the danger of these false indications, an investigation of possible methods of elimination of the phantom lights was proposed, which was taken as a thesis subject by Messrs. W. K. Fitch and S. S. Gregory, Jr., both M. E. 1913. Following is an abstract of this investigation:

Some form of locomotive headlight became necessary as soon as trains were required to be run at night due to the increasing demands of service. The first headlight was in the form of a fire basket, being in front of the engine. This was soon displaced by an oil lamp to which a reflector was added by the Boston and Worcester Railroad in 1840. This form is still in extensive use. The electric arc headlight was applied commercially to locomotives about twenty-five years ago and has been the cause of much controversy, one of the points of discussion, as noted above, being the subject of this investigation.

The principal apparatus employed in the investigation consisted of an arc headlight and turbo-generator loaned by the Pyle National Electric Headlight Co. and a semaphore spectacle casting, roundels, lamps, etc., loaned by the C. & N. W. and C., M. & St. P. Railways.

The investigation was carried out on a level shore stretch along Lake Mendota on the University grounds. The headlight was placed on a platform in the rear of the hydraulic laboratory and the spectacle casting set on a pole at a distance of 345.5 feet from the headlight, the axis of the spectacle casting being 21 feet above the axis of the headlight.

A window of the hydraulic laboratory served as an upper observation station, giving a vertical range of view more or less than 20 feet above the axis of the headlight.

In these tests the principle of "maximum conditions" was adhered to, that is the apparatus was adjusted to produce the brightest possible phantom, so that if the phantom were exorcised under these conditions, it would certainly disappear under less favorable conditions for its existence.

First run: Green roundel set in vertical plane, no lamp behind it. Result—dim white phantom from lower station (beside headlight) brilliant white phantom from upper station. On moving the upper edge of the roundel ⅛ inch toward the headlight a brilliant white phantom was observed from the lower station, thus giving condition for maximum phantom, that is, direct reflection. The same tests with like results were made with red roundel.

With roundels set for maximum phantom the result was substantially the same when the lamp was burning behind the roundel.

Second run: Experiments of first run repeated and checked. Red and green roundels, each of which had one surface sand blasted were then tried. The rough surface was tried facing, and away from the headlight.

The sand blasted surface when toward the headlight absolutely dispelled the phantom, but when the roundel was reversed, the phantom appeared in full intensity indicating the principal reflection is from the front surface. The sand blasting reduced the intensity of light from the lamp behind it, an amount estimated at fifty percent. No experiments were made however, on the distance of visibility of the light thru the sand blasted surface.

With the rough surface of the roundel toward the headlight, it was found that wetting this surface caused the phantom to appear in full brilliancy.

Third run: In this run a determination was made, with the materials available, of the limiting degree of fineness in the roughing or corrugations of the roundel which would allow the phantom to be restored by wetting the surface.

The glasses used were as follows:

No. 1. "Imperial Plate Ornamental Glass", one smooth surface, one surface in small pyramids about 1/8″ square and 1/32″ deep.

No. 2. "Luxifer Glass", one smooth surface, one surface corrugated to form equilateral triangles 3/16″ altitude.

No. 3. Same as No. 2 except triangles about one third size of those on No. 2. These glasses were dyed red and green on one side with "Standard Glass Stain".

No. 1 with colored rough side to headlight showed no phantom wet or dry, but a rather poor red light with semaphore lamp lighted behind it. The light had an orange tinge, due possibly to the coloring being rubbed off slightly on the vertices of the pyramids.

The same glass colored green on smooth side gave no indication of phantom wet or dry, the rough side being toward headlight.

Glass No. 2 gave similar results but No. 3 showed a weak phantom when dry and a brilliant reflection when wet showing that the corrugations of No. 3 were too fine.

An 8-inch chemical "watch glass" was tried as a roundel with the convex side toward the headlight which gave a bright phantom of small diameter.

Conclusions.—The sand blasting of the front surface is not effective in removing the phantom as wetting of the surface causes its reappearance.

The size of corrugations to prevent a phantom when the surface is wet lies between 1/32 and 3/16 inch.

The various roughened surfaces tested reduced the intensity about 50 per cent, but it is suggested that this defect may be largely removed by a special roundel containing concentric corrugations on the front surface so formed as to concentrate the beam.

In making the observations five observers were used on each experiment in order to obtain average values and to eliminate possible eye defects of a single observer.

The thesis gives a record of the data taken by each observer, sketch of the arrangement of the apparatus and photographs of the various parts.

Additional note by reviewer. In the past year developments in headlight work have been proceeding quite rapidly along two lines.

1. The use of high power metal filament lamps in place of the arc. A few months ago an extensive series of experiments was carried on with these lights and arc lights by the Railroad Commission of Nevada under direction of Professor J. G. Scrugham, Professor of Mechanical Engineering, University of Nevada, who informs me that incandescent lights were highly successful both as to penetration and reduction of the "dazzling" characteristics of the arc.

2. The use of a yellow color screen of "No Glare" glass in front of the head-light as described to me recently by Dr. Nelson M. Black of Milwaukee. This screen reduces the total illumination as compared with ordinary clear glass only about 15 per cent. It absorbs all the ultra violet beyond the visible spectrum, all the violet of the visible spectrum and a large portion of the blue. These rays are the glare producing factors in an illuminant and also interfere with distant vision when refracted, diffracted and diffused by the various media in the atmosphere.

The remaining colors, green, yellow, orange and red, are transmitted with slight reduction in intensity.

LENGTH.

4	3	2	1	0	Sum of End Areas – Fractional Part. .0	.1	.2	.3	.4	.5	.6	.7	.8	.9
					CUBIC YARDS 1–100									
216	162	108	54	0	0.0	0.2	0.4	0.6	0.7	0.9	1.1	1.3	1.5	1.7
217	163	109	55	1	1.9	2.0	2.2	2.4	2.6	2.8	3.0	3.1	3.3	3.5
218	164	110	56	2	3.7	3.9	4.1	4.3	4.4	4.6	4.8	5.0	5.2	5.4
219	165	111	57	3	5.6	5.7	5.9	6.1	6.3	6.5	6.7	6.9	7.0	7.2
220	166	112	58	4	7.4	7.6	7.8	8.0	8.1	8.3	8.5	8.7	8.9	9.1
221	167	113	59	5	9.3	9.4	9.6	9.8	10.0	10.2	10.4	10.6	10.8	10.9
222	168	114	60	6	11.1	11.3	11.5	11.7	11.9	12.0	12.2	12.4	12.6	12.8
223	169	115	61	7	13.0	13.1	13.3	13.5	13.7	13.9	14.1	14.3	14.4	14.6
224	170	116	62	8	14.8	15.0	15.2	15.4	15.6	15.7	15.9	16.1	16.3	16.5
225	171	117	63	9	16.7	16.9	17.0	17.2	17.4	17.6	17.8	18.0	18.1	18.3
226	172	118	64	10	18.5	18.7	18.9	19.1	19.3	19.4	19.6	19.8	20.0	20.2
227	173	119	65	11	20.4	20.6	20.8	20.9	21.1	21.3	21.5	21.7	21.9	22.0
228	174	120	66	12	22.2	22.4	22.6	22.8	23.0	23.1	23.3	23.5	23.7	23.9
229	175	121	67	13	24.1	24.3	24.4	24.6	24.8	25.0	25.2	25.4	25.6	25.7
230	176	122	68	14	25.9	261	26.3	26.5	267	269	27.0	27.2	27.4	27.6
231	177	123	69	15	27.8	28.0	281	28.3	28.5	28.7	28.9	29.1	29.3	29.4
232	178	124	70	16	29.6	29.8	30.0	30.2	30.4	30.6	30.7	30.9	31.1	31.3
233	179	125	71	17	31.5	31.7	31.9	32.0	32.2	32.4	32.6	32.8	33.0	33.1
234	180	126	72	18	33.3	33.5	33.7	33.9	341	34.3	34.4	34.6	34.8	35.0
235	181	127	73	19	35.2	35.4	35.6	35.7	35.9	36.1	36.3	36.5	36.7	36.9
236	182	128	74	20	37.0	37.2	37.4	37.6	37.8	38.0	38.1	38.3	38.5	38.7
237	183	129	75	21	38.9	391	39.3	39.4	39.6	39.8	40.0	40.2	40.4	40.6
238	184	130	76	22	40.7	40.9	41.1	41.3	41.5	41.7	41.9	42.0	42.2	42.4
239	185	131	77	23	42.6	42.8	43.0	43.2	43.3	43.5	43.7	43.9	44.1	44.3
240	186	132	78	24	44.4	44.6	44.8	45.0	45.2	45.4	45.6	45.7	45.9	46.1
241	187	133	79	25	46.3	46.5	46.7	46.9	47.0	47.2	47.4	47.6	47.8	48.0
242	188	134	80	26	48.1	48.3	48.5	48.7	48.9	49.1	49.3	49.4	49.6	49.8
243	189	135	81	27	50.0	50.2	50.4	50.6	50.7	50.9	51.1	51.3	51.5	51.7
244	190	136	82	28	51.9	52.0	52.2	52.4	52.6	52.8	53.0	53.1	53.3	53.5
245	191	137	83	29	53.7	53.9	54.1	54.3	54.4	54.6	54.8	55.0	55.2	55.4
246	192	138	84	30	55.6	55.7	55.9	56.1	56.3	56.5	56.7	56.9	57.0	57.2
247	193	139	85	31	57.4	57.6	57.8	58.0	58.1	58.3	58.5	58.7	58.9	59.1
248	194	140	86	32	59.3	59.4	59.6	59.8	60.0	60.2	60.4	60.6	60.7	60.9
249	195	141	87	33	61.1	61.3	61.5	61.7	61.9	62.0	62.2	62.4	62.6	62.8
250	196	142	88	34	63.0	63.1	63.3	63.5	63.7	63.9	64.1	64.3	64.5	64.6
251	197	143	89	35	64.8	65.0	65.2	65.4	65.6	65.7	65.9	66.1	66.3	66.5
252	198	144	90	36	66.7	66.9	67.0	67.2	67.4	67.6	67.8	68.0	68.1	68.3
253	199	145	91	37	68.5	68.7	68.9	69.1	69.3	69.4	69.6	69.8	70.0	70.2
254	200	146	92	38	70.4	70.6	70.7	70.9	71.1	71.3	71.5	71.7	71.9	72.0
255	201	147	93	39	72.2	72.4	72.6	72.8	73.0	73.1	73.3	73.5	73.7	73.9
256	202	148	94	40	741	74.3	74.4	74.6	74.8	75.0	75.2	75.4	75.6	75.7
257	203	149	95	41	75.9	76.1	76.3	76.5	76.7	76.8	77.0	77.2	77.4	77.6
258	204	150	96	42	77.8	78.0	78.1	78.3	78.5	78.7	78.9	79.1	79.3	79.5
259	205	151	97	43	79.6	79.8	80.0	80.2	80.4	80.6	80.7	80.9	81.1	81.3
260	206	152	98	44	81.5	81.7	81.9	82.0	82.0	82.4	82.6	82.8	83.0	83.1
261	207	153	99	45	83.3	83.5	83.7	83.9	84.1	84.3	84.4	84.6	84.8	85.0
262	208	154	100	46	85.2	85.4	85.6	85.7	85.9	86.1	86.3	86.5	86.7	86.9
263	209	155	101	47	87.0	87.2	87.4	87.6	87.8	88.0	88.1	88.3	88.5	88.7
264	210	156	102	48	88.9	89.1	89.3	89.4	89.6	89.8	90.0	90.2	90.4	90.6
265	211	157	103	49	90.7	90.9	91.1	91.3	91.5	91.7	91.9	92.0	92.2	92.4
266	212	158	104	50	92.6	92.8	93.0	93.1	93.3	93.5	93.7	93.9	94.1	94.3
267	213	159	105	51	94.4	94.6	94.8	95.0	95.2	95.4	95.6	95.7	95.9	96.1
268	214	160	106	52	96.3	96.5	96.7	96.9	97.0	97.2	97.4	97.6	97.8	98.0
269	215	161	107	53	98.1	98.3	98.5	98.7	98.9	99.1	99.3	99.4	99.6	99.8
4	3	2	1	0	.0	.1	.2	.3	.4	.5	.6	.7	8	.9

THE IMPROVEMENT OF EARTH ROADS.

D. P. DALE, C. E.

How to improve our earth roads is a great and pressing problem, and one with which we will have to deal for many years to come. More than eighty percent of all the highways in this country are unsurfaced dirt roads, improved very slightly or not at all. A realization of the great usefulness of a system of first-class rural roads has begun to dawn upon us, and the work of development is bound to follow. This article undertakes to set forth some of the principles which should govern, and to describe a method whereby the engineering work incident to such improvement can be expeditiously done.

There are in the United States some 2,200,000 miles of public highways; of these about 300,000 miles are hard-surfaced. It is probably safe to say that not five percent of the remaining 1,900,000 miles of earth roads are in satisfactory condition. When we consider the fact that almost the entire output of farm and forest must first be transported over country roads, their importance becomes evident.

The problem is receiving more attention from engineers and publicists. The road congresses are discussing it; the State highway departments exist almost entirely for the sake of the rural roads; the advocates of interstate and transcontinental road systems are assigning as main reasons for their projects the fact that such systems are bound to be powerfully suggestive of a comprehensive scheme of good rural roads the country over.

With the solution of the roads problem there is necessarily involved a more or less complete solution of other difficult problems; rural education, the hardships of country life, the high cost of living. That the cost of transportation forms a considerable part of the total cost of commodities, and that the opportunities for social intercourse among the people depend largely upon the efficiency of the highways, were facts probably clear in the mind of Secretary Houston when he made the following statement at the Detroit Roads Congress regarding Federal aid: "The primary undertaking should be to improve those community roads which are essential for the marketing of products, and for the betterment of the physical, intellectual, and social side of rural life.''

The present condition of American rural roads can in truth be called hardly less than barbarous. It is asserted that in hardly any European country does the quality of hard pavements average better than in America; it is also probably true that in no European country does the quality of rural roads average so low as in America. An estimate shows that it costs more to haul a bale of cotton over twelve miles of ordinary southern rural road than to transport it by steamship from New York to Liverpool.

Since earth roads form a large and very useful part of our system of highways, we all suffer on account of their present backward condition, whether we realize the fact or not. Since their value is now but slightly developed, and in the future will probably be highly developed, the services of a considerable number of engineers will be required. For these reasons we are interested in the question.

Earth roads are a problem in maintenance rather than construction. A brick or asphalt pavement well designed and built will last several years under heavy traffic with very occasional maintenance, but a new earth road will go to pieces in a year unless maintained. It is a commonplace to say that an earth road is never built but always building, and requires constant and conscientious care to be made to operate efficiently. Nevertheless, these roads must sometimes be built or rebuilt; in the process surveys must be made, and volumes of earthwork measured. The method herein later described has been found well adapted to the purpose where it was evolved and used, in northern Mississippi.

The improvement of the road is the final object and the sole object for which the surveys are made. Let us consider the desired finished condition of the improvement, and note what the characteristics of a good earth road are.

The purpose of a highway is to afford rapid and easy travel. The slopes should be not too steep nor too many; bends should be few and gradual; the surface should be even, hard, and smooth. Good grades, good alignment, and good surface, are the fundamental requirements of a good earth road. Our aim, then, is to replace the existing inferior ways by a system of highways satisfactory in these respects, and that at the least possible cost.

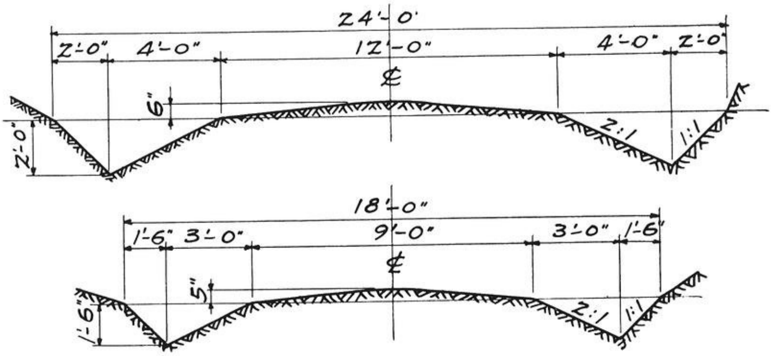
A factory-made article should be correct in design, material, workmanship, and finish. Good design for roads involves the proper placing of the center line on the ground, the selection of the appropriate cross-sections for the various conditions, the determination of economical grades, and the designation of the necessary drainage and other structures. Good workmanship requires the rejection of inferior material and the best use of the available materials, the careful location and construction of the structures, and skill in the observance of good design throughout. Debris having been removed, a sufficiently pleasing appearance will be secured when these requirements are fulfilled.

Road-building is a science. Certain principles must be observed if success is to follow. It is also an art, and presents many opportunities for the exercise of individual judgment.

The "economic theory of location" applies also to earth roads. Many of the existing thoroughfares were located by the haphazard method; they grew from old Indian trails, were improvised for army transportation, were located arbitrarily on section or other land lines, or were otherwise badly placed. Sometimes it is possible, by relocating a stretch of road, to effect a considerable saving of distance between important points, to better serve the mass of population, to eliminate bad hills, to reduce the number of bridges and culverts necessary, or to plan a road less expensive to build and maintain. It is the business of the engineer to decide in each particular case whether sufficient advantages accrue from a relocation to justify it.

When the roads in a given area are to be improved, the relative importance of each should be determined with more or less exactness. A map giving a general view of the area served and traversed is very useful. Account should be taken of the amount, character, and direction of traffic; the distribution of population and of taxable values; cooperation with neighboring or larger systems; relative topographic and geologic conditions; and custom.

Reduction of grades is an important object, since it reduces the heights to which loads must be raised in passing over the road, and therefore lessens the wear and tear on harness, animals, vehicles, and men. A maximum grade of five percent on first-class roads, and of seven percent on second class, are common. These limits must sometimes be exceeded, however, as on long steep hills. In such cases, by using a narrower section at the top of the hill, an increased reduction in grade without an increase in yardage, can be accomplished. Usually it does not pay to reduce grades already as low as four or five percent; on the other hand, it is sometimes desirable to increase a very flat slope, since a level roadway will not drain as well as one with some longitudinal fall.



Typical sections for first and second class roads on sandy clay soil. The crown is formed by two straight lines joined by a short arc.

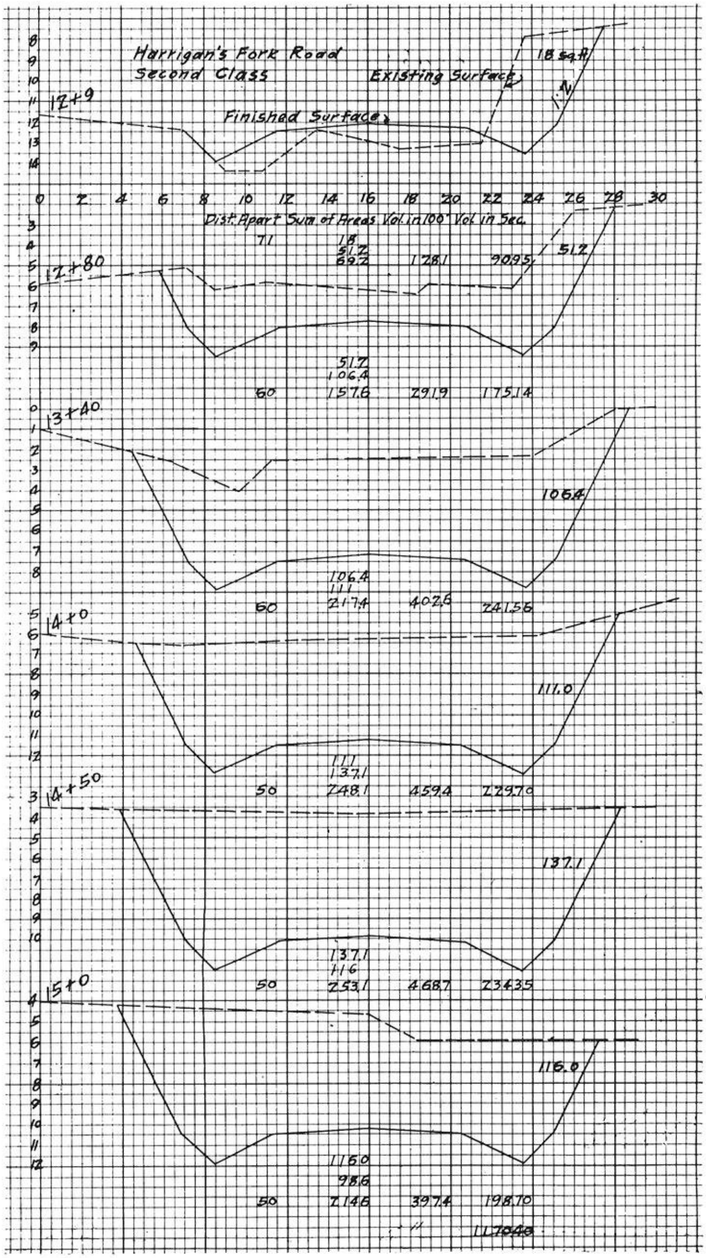
Alignment is a much simpler matter than on railroad work. It is neither necessary nor desirable to record the exact lengths of curves and tangents, mark the points of intersection, or compute the grades. The tendency is to go into these points in too great detail; the accuracy which is necessary and proper in railroad work, if practiced here, would entail a disproportionate or prohibitive cost; it is therefore not permissible. Accuracy in the measurement of earthwork volumes is of course just as necessary here as elsewhere.

The cross-section to be used depends upon the road material, rainfall conditions, the legal width of right-of-way, the longitudinal grade, and the amount of the appropriation. A drawing showing a number of model sections, each adapted to a given set of conditions, and showing all details as to crown, ditches, shoulders, etc., is a useful means of educating the contractor as to the purposes of the engineer. The contractor can learn more about a section which he has never seen from a scale drawing than from ever so clear a specification. Each section, if designated by a symbol, can be called for on the profile.

Drainage is by far the most important consideration in the management of roads, at every step from location to maintenance. In nearly all cases of bad roads, the cause is defective drainage. No road can long remain good if water stands upon or near it; on the other hand, almost any soil, if dry and compact, makes an excellent road surface. In support of the latter statement, the fact may be cited that during favorable seasons, some of the splendid stone roads of New York State are abandoned by the traffic in favor of parallel earth drives. There are three systems to be provided; surface, subsoil, and cross drainage.

Surface drainage is accomplished by having the crown of the road act as a roof, whereby the rainwater is shed freely and quickly to the side ditches; and by having the side ditches of proper capacity, slope, and outfall, to get final rid of the water as expeditiously as possible. The purpose of subsoil drainage is to keep the foundation dry; it is effected by having the side ditches of sufficient depth; by tile drains laid below and parallel to the side ditches; and by stone or tile outlets laid transversely to the center line at proper intervals. In seepy ground, or where there is a spring in the road, a few tile properly laid, will, by preventing access of water to the foundation, remedy the trouble more effectively than any amount of top dressing. Ordinarily, however, the level of saturation in the foundation soil can be adequately lowered by maintaining the side ditches at the proper depth. On long hills, especially steep ones, outlets should be provided for the side ditches at intervals of 200 feet or so, otherwise the accumulating volume of water will soon make a bad gully at the bottom of the hill.

Highway bridges and culverts are a study by themselves. Experience has shown that the more permanent these structures are, the cheaper they are in the long run. Culverts should always have sufficient area for the passage of the ordinary maximum stream flow, and should be strong enough to withstand safely the loads to which they will be subjected. The stream should be straight for some distance above the point where it en-



Harrigan's Fork Road
Second Class
Existing Surface
Finished Surface
18 sq.ft.
12+9
12+80
13+40
14+0
14+50
15+0
Dist. Apart Sum of Areas Vol. in 100' Vol. in Sec.
51.2
106.4
111.0
137.1
116.0

ters the culvert, and should leave without washing the foundations.

The surveys should enable the engineer to issue instructions for putting the road in the desired condition, in as efficient a manner as possible; they should also provide an accurate measure of the earthwork moved, in order that the contractor may be paid on a legal and equitable basis. Under the scheme here described, three surveys are necessary; thy may be called the reconnaissance, the location, and the final.

The Reconnaissance. First of all an inspection of the territory served and traversed by the road or system of roads should be made by the engineer as a part of his study of general conditions. There are to be noted the main features concerning drainage, topography, soil, and special conditions. This survey may well be done on horseback, in company with the local road official and perhaps interested property owners. They can supply facts which it is very useful to know—facts regarding places troublesome in rainy seasons, the location of road materials, the topography of neighboring territory, the distribution of population, traffic conditions, etc. To supply such facts is the most important service which these people can render to the engineering party, although some of them are not so aware. This survey and a study of the general map should determine the relative importance of the various roads, and should enable a classification to be made; it should decide what major relocations if any are necessary.

The Location. The purpose of this survey is to take data which will enable a rational plan to be worked out in the office. Levels for profile and cross sections are taken; stakes are set which indicate only the stationing. Notes are taken in detail as to the size and direction of flow of streams, existing and recommended drainage structures, soil, and special difficulties. The data thus secured forms the basis of the instructions issued to the contractor for his guidance; these instructions should be sufficient for his guidance.

The Final Survey. The profile is rerun, and sections are taken at the same points as previously. Note is made of the state of the work; if not complete or poorly done, a percentage is estimated. An inspection is made of all culverts and small bridges. If there is anything to prevent final acceptance of the contractor's work, an entry is made describing what and where it is. With this data the contractor's monthly estimate, based on unit prices, can be made out.

The principal difficulty, in the writer's experience, was to work out the problems incident to the location. In these surveys, the necessity for rapidity is extraordinary. In the first place the quantities run lower than on railroad work, since the requirements as to grade and alignment are much less exacting. The cost of a survey is not materially reduced by a reduction of the quantities; it costs appreciably no less to measure a cut one foot deep than one two feet deep. The permissible cost of engineering can hardly run above four or five percent of the total cost of the improvement. The handicap of small quantities is obvious.

Second, the measurement is more difficult than on railroad surveys. On account of the greater complexity of the transverse contour both before and after the work is done, many more readings have to be taken. Three points will ordinarily describe the surface of the ground on railroad location; seven are necessary in the simple case on a highway survey, one at the center, one at each shoulder, and one each at the bottom and the outside edge of each ditch. On some roads, eleven-point sections are frequently necessary; and owing to the greater irregularity, sections must be taken at shorter intervals. Conditions in this regard are probably more favorable however over the country generally than in the South, where the annual rainfall is 50 inches or more, and where the roads are very old and deep.

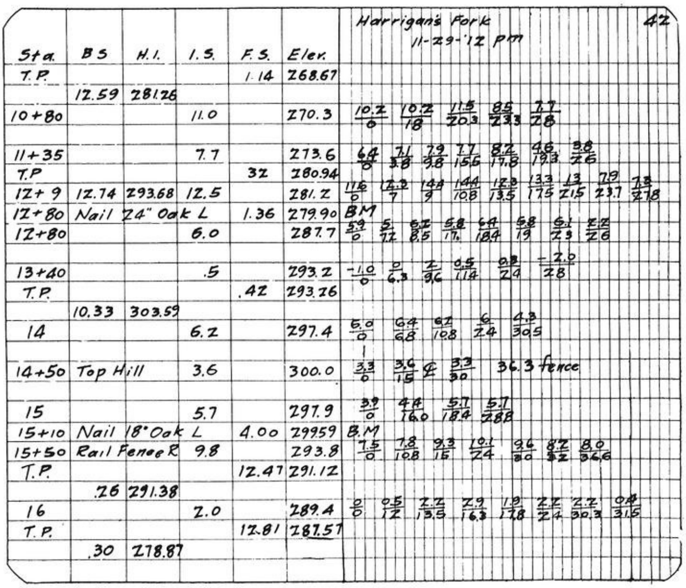
The special problem then is to provide a rapid and accurate measure of the earthwork, where the sections are very irregular, generally of small area, and short distances apart.

In general, three sets of drawings are necessary to outline the complete plan for a highway improvement; a map, a longitudinal profile, and transverse profiles. Of these, the last-named are by far the most important. On low-grade improvements, the map can be entirely dispensed with; even the longitudinal profile need not always be provided. After the contractor becomes accustomed to the methods of the engineer, it can be drawn to a smaller scale, and provided only for the hilly regions. What is necessary is a set of accurate cross sections, of proper and known distance apart, and of easy reference to the physical road. To get these is the main purpose of the location survey; its organization to that end will now be described.

The instruments to be used are:

1 Engineer's level	2 Plumb bobs
1 Level rod	12 Chaining pins
1 Turning point	1 Light ax
1 100′ steel tape	120 Stakes per mile
1 50′ steel tape	Kiel, 10-d nails

The party consists of three men: one who acts as levelman and head chainman, in charge; one who serves as rodman and



Sta.	B S	H. I.	I. S.	F. S.	Elev.
T.P.				1.14	268.67
	12.59	281.26			
10+80			11.0		270.3
11+35			7.7		273.6
T.P				32	280.94
12+9	12.74	293.68	12.5		281.2
12+80	Nail 24" Oak L			1.36	279.90
12+80			6.0		287.7
13+40			.5		293.2
T.P.				.42	293.26
	10.33	303.59			
14			6.2		297.4
14+50	Top Hill		3.6		300.0
15			5.7		297.9
15+10	Nail 18" Oak L			4.00	299.59
15+50	Rail Fence R		9.8		293.8
T.P.				12.47	291.12
	.26	291.38			
16			2.0		289.4
T.P.				12.81	287.57
	.30	278.87			

stakeman; a third who acts as rear chainman and teamster. It is necessary to have a horse and wagon to carry the stakes, the instruments, the lunch, extra clothing, etc., and to provide transportation to and from work. It pays to use good stakes. Pine slabs 3/4 inch x 1 1/2 inch x 16 inch are about right.

Procedure is as follows: First, a distance of one or two thousand feet is chained off, station stakes being set on the left-hand side of the road at the points selected by the head chainman. Ordinarily these are at 100′ intervals, but they are also necessary wherever there is an appreciable change in the slope of the center line, or a variation in the nature of the cross-section. The head chainman sticks a pin at the initial point of the run, and taking the zero end of the tape goes forward, applying it successively, and sticking his pins by the usual method at station points. He also carries the stakes, and marks them. The stakeman, after receiving a stake, drives it somewhere on a line at right angles to the center line of the road, well out of the way, preferably at the fence. It is his duty to have the stake properly driven and be on hand by the time the next stake is marked. The rear chainman is responsible for correct reading of the plus; he also checks the stationing as recorded on the driven stakes.

At the end of a run, the last pin is left stuck to mark a new starting point. The tape is then swung aside out of the way of passing vehicles, and the party returns to the zero of the run.

The position of stakeman is more important than that of rear chainman. Reading the tape and collecting and counting the pins are routine duties; it requires more discrimination to set stakes properly under all the conditions which occur. The duties of the stakeman also involve more physical activity than those of the tapeman. Experience has shown that, other things being equal, a job requiring more physical energy requires also more nervous energy, and that the man of higher intelligence shows more speed and endurance. It is good policy therefore to appoint the more competent of the two assistants as stakeman.

Ten stations can thus be marked off in ten minutes ordinarily. The next step is to take data for a cross-section at each point where a stake has been set.

While the chief of party is setting up the level in position to command a full transverse view of the road at as many points as possible, the rodman, (formerly stakeman) drives the wagon ahead. Meantime the tapeman prepares a bag of "rough" stakes, and accouters himself with the light ax, the 50′ steel tape, nails, and the extra chaining pin, which he thrusts through the ring in the end of the tape. A bench mark established, teamwork begins.

The tapeman drives his pin in the ground at the station stake, and stretches the tape normally across the road, maintaining it horizontal as nearly as practicable. Before leaving, he drives a rough stake, or chips the bark of a tree, on line, to establish a second point on the trace of the section. As a legal precaution, this is always done. The rodman meantime, starting at the stake, gives a rod reading at determining points in the section, calling out at each observation the corresponding tape reading. The rodman has considerable opportunity for the exercise of judgment in the selection of these points; as in the case of the longitudinal profile, they should be taken at the points where the slope changes, so that a series of straight lines joining them will represent pretty accurately the contour. Data is taken over a section wider than the existing road, in order to provide for a possible shifting of the center line. At each observation the rodman is released by signal as soon as the reading is taken; the levelman records the two readings while he moves to the next point. When the rodman gives a reading at the center of the road or at the point he selects as representing the typical elevation of the road at that station, he makes a special signal, in order that the levelman can designate and use this reading as one point on the longitudinal profile. The rodman also has a distinctive signal to indicate when the last reading on a section is taken; when this is given, the levelman employs his time computing elevations, checking foresights against backsights, or taking notes, while the other two are winding up, moving on, and getting set at the next point.

When the range of one setup is covered, a turn is taken in the ordinary way. Time will be saved by making the setups so that rod readings can be had on the full cross-section at every stake up to and for some distance ahead of the instrument.

Bench-marks are set about 500′ apart. A nail driven horizontally into a tree or substantial post about a foot above the ground, opposite a stake, makes a mark easily set, easily described, easily found, easily sighted, stable, and not apt to be destroyed.

Forty-five minutes will usually suffice to take the levels over a thousand feet. Under favorable conditions and after some practice the field work for two miles can be done in one day, and an average of one and one-half miles per day be maintained.

In the level book, notes are kept on the left-hand page as in ordinary profile leveling. In the right-hand page are kept miscellaneous notes and data of sections. The rod reading is recorded first, and in each case is written above the corresponding tape reading. The center-line reading, if a point is on the transverse profile, is sometime transferred to the "IS" column on the opposite page. The illustrations show a sample page of notes and a portion of the profile, and some sections made from the data there shown.

Ordinarily no slope stakes are set for the contractor; all necessary information is given him on paper. In the office the longitudinal profile is plotted on a roll of paper ten inches wide, to a scale of 1″=200′ longitudinally, and 1″=15′ vertically. By this, taken in connection with other data, the engineer works out his disposition of material, taking care to provide for only one handling, and shows the proposed grade line. Here are also shown the size and location of new culverts, bridges, and drains, instructions as to the direction of haul, and general notes.

All cuts, but not all fills, are shown. The reason for this practice is as follows: specifications almost uniformly read that earthwork is to be measured and paid for in excavation only, except, perhaps, where borrowed. It is interesting and instructive to measure the volume of a fill for the sake of comparing it with the volume of the cut from which the material was excavated, but to do so is not necessary. Our chief concern with the fills is to know that they have merely a satisfactory height, grade, and transverse contour, that they are built of sound material, and have ample berms. Owing to the nature of the cross-sections, extremely irregular and constantly changing, it would be an interminable task to determine the finished surface of the fills resulting from the cuts. The contractor has no special difficulty in making the fills at the proper places. In cases where the desired disposition of material is not the easiest or most obvious way, specific directions are given on the profile.

In balancing cut and fill quantities, the appearance of the profile is often deceptive, the areas above and below the grade line bearing no necessary mutual relation. On most of the work there is neither waste nor borrow; allowing for growth and shrinkage, the volume of excavation will then be equal to the volume of embankment. Now the cuts are at the tops of the hills, where the roadway is usually narrow, and has high steep banks. A considerable portion of the material excavated comes from cutting back these banks. Where such material is used to make a fill, the area below the grade line will be in excess of that above. The opposite condition occurs where the width of the road on the hill is nearly standard, and there is an adjacent gully to fill. The engineer has to determine by trial the cut necessary to effect a given grade reduction, provide material for a fill across an adjacent valley, or plug a washout. The cross-sectional data is of use for this purpose.

A considerable yardage may be involved however without any effect on the profile, as for example where the road is narrow and nearly level, and has a high bank on one side and the brink of a gully on the other. The usual remedy is to shift the center line toward the bank, cut back the wall, and throw the material over the precipice until the requisite width is attained. The phenomenon of the road being a ten-foot ledge on the side of a gulch twenty feet deep and fifty feet wide, is not uncommon in many parts of the South.

The transverse profiles are plotted on squared paper to a scale of ¼″=1′–0″. The section can be most easily shown by taking the origin of coordinates in the upper left-hand corner and plotting rod readings down from the HI, instead of elevations up from the datum. The engineer has templates representing the model sections; he selects in each case the appropriate one, and draws in proper position the profile of his proposed finished section. By means of a planimeter the included area is quickly obtained, and a check can be made. A print is made, and furnished to the contractor; by it he can tell what cut or fill to make in every point in the section. With paper ruled in ⅛″ squares, the problem of reading the drawing is simple; he can tell when he has the section in the required condition, and he learns to make the road quite acceptably.

When an examination shows that the road is built as called for, or when the section as built is drawn on and the new area found, it remains to compute the yardage. With the areas at each end of the prism given, the quantities can be easily taken from a table, or be computed.

The appended table has been found very useful for this purpose. It is used as follows: Take the sum of the end areas of a prism 100′ long, expressed in square feet to the nearest tenth; find the integral part of this number in the main body of the table in some column on the left; read the cubic yards in hundreds at the top of that column. Take the column on the right headed by the fractional part of the sum of the end areas, follow it down until in the same line as where the integral part is; there will be found the remaining part of the required quantity. Add the two to get the yardage in the prism.

For example, suppose the sum of the end areas is 128.3 square feet, for a prism 100′ long. 128 is found in the column headed by 2; there are therefore 200 and some yards in the prism. On the same level, in the column headed by .3, is found the number 37.6; the total volume is therefore 237.6 cubic yards, as can be shown:

$$\frac{128.3 \text{ x } 100}{2\text{x}27} = 237.6$$

This table necessarily neglects the prismoidal correction. It gives the same result whatever be the difference in end areas.

Good roads are bound to come. Not having them, we are nevertheless paying for them, several times over each year as some say, in the increased cost of transportation and the loss of tremendous social and economic advantages. It is in the hope that the discussion here presented will contribute toward an accomplishment of the great possibilities of good earth roads that this article is written.

The Wisconsin Engineer.

EDITORIALS.

With this issue, another milestone in the life of the WISCONSIN ENGINEER will be passed. This fact leads us to reflect on the statement made by a sister publication concerning the non-necessity of a student technical journal. We know that the ENGINEER is edited by men who are not experts, and whose hair is not tinged with the gray of two score and ten years; yet we feel that the ENGINEER is a factor which holds the engineering student body together, and also keeps the alumni in touch with their alma mater. The men that run the magazine have the interest of the engineering college at heart, and hence feel that if their work on this journal will in any way aid Wisconsin, their effort has been well expended.

In writing this last editorial, we realize that we are saying farewell to the many friends that knew us only through the medium of this publication. To the loyal alumni who have the interest of their college so much at heart, we surely extend a hand of most cordial appreciation. You, Alumni, are the men who have helped Wisconsin in many ways. You are the men who have made good, and because of your success our college is stamped as an excellent school; you are the men whose paths we have endeavored to follow, whose qualities we have tried to emulate, and whose fellow workers we hope soon to be. As we leave this University and follow you on the road of active life, we trust that our actions may not be such that will make you ashamed; but that our success, like yours, will add honor to our Alma Mater.

For those who have opposed our policies we hold the greatest respect. We feel that you also cherished the same ideals but hoped to accomplish them by a different method. Our hope is that no matter what method be used, the ideal may be attained.

To the underclassmen we extend our heartiest good wishes. You have met us in the rush and on the athletic field, and will soon crowd into the places which we held as seniors. We hope we have given you a comaradie that was not only pleasant, but constructive, and that you will find that your association with us has done you good.

A few days more, fellow classmen, and we will be separated—many of us never to visit the old haunts together again. How we will occasionally long for the familiar voices that so heartily cussed the heavy lessons some good old "prof" handed out. How we will miss the association with those men on the faculty whom we first feared and then learned to respect so much. We will soon see what a power they have been in moulding our perspective, and how often we will long for a word of kindly advice. We have had our scraps, we have cussed our "lab" partners, we have hissed at the "Laws"; but as we leave, the only feeling that goes with us will be one of affection for the dear old school that has done us so much good. We may have to "rough it" on the mountain side, run levels through a desert, or drive dagos in the ditch; but the thought of the fellowship of our college days will have a mellowing influence upon us, and we will endeavor to act as men that have cultivated a large part of their possibilities. We will be better able to appreciate the lovely, even though our technical occupation requires us to work among unlovely surroundings; and while we may have to work amid the unbeautiful, the fact that we have once had a glimpse of intellectual beauty, will make us add beauty to our work. As we leave each other, we go out with high hopes, trusting that our endeavor will be of such quality that we may have much joy and few regrets.

At the end of this semester Alexander Graham Christie, Associate Professor of Mechanical Engineering, leaves this university to take a similar position in the newly established College of Engineering at Johns Hopkins University. Prof. Christie is a graduate of the University of Toronto, and after teaching at Cornell for a short time, he came to Wisconsin in 1909, where he has been engaged in the Steam & Gas Department. It is with great regret, indeed, that the students of this department hear of his departure. As a recognition of the excellent work that Prof. Christie has done for Wisconsin, the Tau Beta Pi Chapter of this University elected him an honorary member this spring.

Prof. Christie expects that his work at Johns Hopkins for the first part of the year will consist largely in the organization of the laboratory and in the supervision of the apparatus installation. While the equipment may not be as large at first, as at other schools; it has been planned to get those of the most modern design and typical of best engineering practice. We add the sincere hope that Prof. Christie will meet with success and happiness in his new position.

EDITORAL NOTE.

Owing to an oversight the following proof-sheet corrections were not made in the article on *"Bazin's Investigations of the Flow of Water Over Submerged, Sharp-crested Weirs"* of the April issue.

P. 321, ll. 14–15:—downstream head, h_1, to the upstream head, h, . .

P. 321, ll. 19-21 . . . . work . . . . is . . . .

P. 322, ll. 32–33:—, m increasing slowly with h so long as the downstream water-level did not fall below $h_1 = -0.05\,p$

P. 324, l. 3:— $\frac{P_o}{h}$

" l. 4:— $\frac{p}{h}$

" l. 25:— . . . . dial float gages . . . .

P. 325, formula (3):—$m = 1.05\,m' \left[1 + \frac{1}{5}\left(\frac{h_1}{p}\right)\right] \sqrt[3]{\frac{z}{h}}$

P. 325, l. 27:— . . . . data do not . . . .

P. 326, l. 1:— $N^{\frac{3}{2}}$

P. 327, l. 5:— . . . . have been collected . . . .

P. 327, l. 7:— . . . . navigation or flood flow purposes . . . .

The translation of Bazin's material on submerged weirs referred to in this article will be of especial interest to engineers who are connected with flood prevention or turbine testing where head cannot be sacrificed as well as to investigators in this field.

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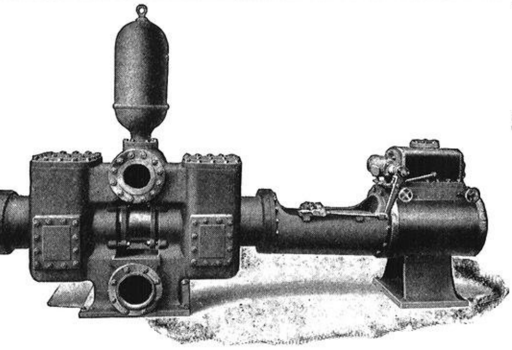

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Transacts a general banking business. Issues letters of credit and travelers' checks, good in all parts of the world.

NOTICE

We carry a complete line of high-grade **Machinists' Supplies** and all classes of **Mechanical Tools.**

NO SPECIAL SALES

We sell at retail any article in our store at **Wholesale Prices.**

Western Iron Stores Co.

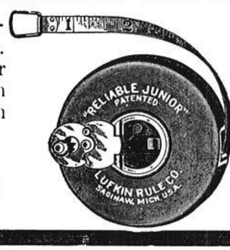
Phone Grand 1246

135 Second Street = = = Milwaukee, Wis.

THE RELIABLE JUNIOR LUFKIN STEEL MEASURING TAPE

FINEST CONSTRUCTED—MOST CONVENIENT—NEATEST VEST POCKET LONG STEEL TAPE ON THE MARKET

Quarter inch steel tape with **Instantaneous Readings;** in 25 ft. to 100 ft. length. Hard leather case with double folding flush handle, opened by pressing on opposite side.



25 ft. weighs only 3 ounces
50 ft. only 5 ounces comp.

Length	Diameter of Case
25 ft.	2¼ in.
50 ft.	2¾ in.

Marked feet, inches and sixteenths or marked feet, 10ths and 100ths accurate and durable

THE LUFKIN RULE CO.

Saginaw, Mich. New York