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Contents

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SEWERS FOR SMALL CITIES.

By ALFRED E. PHILLIPS, C. E., Ph. D.
Acting Professor of Hydraulic and Bridge Engineering, '95–'96.

During the past few years the matter of proper sanitation and drainage has been attracting the attention of the smaller cities. This is due to the fact that these cities have constructed water works systems and the people are learning that a bountiful supply of pure and wholesome water may be transformed from a blessing into a curse unless an efficient method is provided for carrying it away after contamination.

Many of these small cities have been deterred from constructing an efficient sewer system by a mistaken idea as to the cost of such an undertaking; for the idea is still prevalent that an *efficient* system of sewers must be built of large and expensive mains; and it is a fact that numerous small towns have made the mistake of building sewers that for sanitary purposes are many times too large for the work they have to do and soon become elongated cess-pools that are cleaned occasionally by turning storm water into them or by flushing with a hose from the nearest hydrant. The cost of such a system for a small city, causes a heavy burden upon the taxpayer and its completion necessarily extends over many years. Meanwhile the people of probably the larger portion of the city are compelled to dispose of household wastes, etc., in dry-wells or cess-pools from which the liquid refuse spreads in all directions, finding its way into wells, cellars, etc., spreading disease and death all along its path. In a light porous soil the evidences of this contamination are not so apparent; but in a close, compact soil one has only to dig down a short distance and the sense of smell, if nothing else, will furnish satisfactory evidence. In either case, however, it is only a matter of time until the soil will become thoroughly impregnated with all sorts of disease-bearing filth.

Probably the majority of towns have within their limits one or more open branches; sometimes a dry ditch which flows water only during storms; but more often a constantly flowing creek fed by springs or catching the drainage from the higher levels. In either case the branch follows the lowest contours of the town and becomes the natural outfall for all storm water, house drains, etc. Even while the town is small and only a small amount of sewage is turned into it, such a branch is certain to create a nuisance as the solid matters settle to the bottom, catching on weeds and other obstructions and storm water fails to flush the ditch of its filth. As the population increases and more and more sewage finds its way into the ditch, the nuisance is intensified until it becomes a menace to the public health. Compelled then by public sentiment the authorities try to devise some plan of abating the nuisance. The method usually adopted is as follows: A committee is appointed which constitutes itself a body of consulting engineers. The branch or branches being adjudged the source of evil must, of course, be closed up by the construction of a brick sewer. The problem of its size is soon disposed of upon the basis of the larger, the better. Some sort of plans and specifications are drawn, the contract let and the sewer built. "Out of sight, out of mind" and the committee ends its labors, feeling that the citizens owe them a lasting debt of gratitude for so easily and cheaply solving the problem. Soon, however, a contagious disease makes its appearance, spreads from house to house and carries off its victims in spite of the best efforts of the best physicians. It is not a difficult matter to locate the source of the trouble. An examination of the sewer will disclose the fact that it is so large that not enough water passes through it in dry seasons to keep it properly flushed. The house connections usually consist of drain tile or if of vitrified pipe, are laid with open joints and the polluted air from the sewer readily finds its way into the basements and cellars of the houses. In such a case it would be much better to leave the ditch open as it would then be sure of good ventilation at least, and the gases would not be forced into the dwellings. The source of the difficulty is in the dwellings themselves and the work of improvement must begin there. A system of sewers should be constructed that will rapidly and effectually dispose of all liquid and other wastes and then the authorities should see to it that all house and other connections are made in the proper manner and by a licensed plumber.

The question naturally arises as to what is the best method of providing for a system of sewers for a small town? No iron-clad rule can be laid down for the solution of such a problem, but each case must be decided for itself and on its own merits. There are some general propositions, however, that are applicable to all cases and these should be given due weight in planning a system for any town whether large or small.

The element of cost is the first and most important matter to be considered, especially in the case of a town, small in population but covering considerable territory. A system of sewers should not be designed for such a town that will overburden the taxpayers and delay its construction for an indefinite period. At the same time, the system when complete should be efficient. Excessive cost does not guarantee efficiency and an economical cost of construction does not necessarily imply a lack of efficiency. There are other towns that are quite well populated and yet cover comparatively little territory, so that a complete and efficient system may be planned at a nominal cost to each taxpayer.

Another important proposition and one applicable to all cases is that the outfall for the system should be located at such a point that it will not become a nuisance or be offensive to sight or smell. This would seem to be a self-evident proposition, but there are a great many cities today where evidence may be found that proper attention has not been paid to this matter. In looking over a town preparatory to planning a system of sewers the location of the water works pumping station should be borne in mind and the outfall should be located so that there will be no possible chance for the sewage to find its way back to the public water supply. Its exact location, however, can not be determined upon until after the surveys have been completed.

The kind of system best adapted to a given case, whether separate, combined or double, should be determined upon after all surveys have been completed and an accurate contour map made.

There can be no doubt that the separate system offers an efficient and economical means of relief for very small cities, especially where proper sanitation is of more importance than the relief from surface or storm water. When a large amount of storm and surface water is to be disposed of, it will generally be more economical to construct a double system as it must be borne in mind that storm water can run a considerable distance through the gutters into catch-basins, thus materially reducing the mileage. On the other hand if the combined system is adopted, large and expensive mains must be built over the entire territory covered by the city, and they must be built deeper in order to catch the basements and cellars. There can be no harm in discharging storm water at the nearest available point; but if storm water and sewage are carried in the same mains, the trunk sewer must be built to a proper point of outfall, or at least until a proper point is reached for the construction of an intercepting sewer.

There can be no doubt but that the time will soon come when the legislatures of many of the states will prohibit the use of the waterways for the disposal of crude sewage. This will necessitate treatment either by filtration, irrigation, the chemical, or some other method, and the separate system is particularly adapted to such conditions from the fact that it carries sewage in its most undiluted form and the treatment will be less expensive than when the sewage is diluted with large quantities of storm water.

Having, however, decided upon the system best adapted to a given case, the next step is the preparation of the plans and as the field work comes first, a few hints will be given as to the method of carrying it out.

Field Work.—The field party, as organized for work, should consist of a leveller, rodman and two tapemen. As preliminary to the general survey, a system of bench-marks should be established covering the entire territory to be embraced in the system. Some central, easily identified point should be chosen as the starting point for the system of levels and the datum referred to this point as the "standard" bench-mark. At every opportunity the bench-marks should be checked upon one another and finally back to the "standard". For this purpose a target-rod should be used. We are now ready to begin the field work proper and if two parties are available, one should take the streets or alleys running say north and south and the other those running east and west. If only one party is available, it should first complete the survey of the streets or alleys running in one direction and afterwards take up those at right angles. Such an arrangement will simplify the field work as well as the office work afterwards. An one-hundred foot steel tape will be found most convenient for purposes of measurement and levels should be taken with a self-reading rod at every fifty foot station and at every street and alley intersection. Wherever a ditch crosses a street the level of the bottom should be taken. At every opportunity the levels should be checked upon the bench-marks previously established, and as often as possible additional bench-marks should be established, particularly at street corners. Too many bench-marks cannot be established and their convenience and utility will be fully realized when the time comes for the construction of the system. In keeping the level notes, one set of books should be used for east and west streets and another for the north and south. That is to say, the level notes for an east and west street should not be kept in a north and south book. These matters of detail are of importance as they tend to systematize and simplify the office work later on. If a fairly accurate plat of the town is available, it will be of the utmost service in the survey and the lengths of the streets or alleys as measured in the survey may be checked by it. If any very great discrepancies occur, it may be necessary to check the bearings of the streets with the transit. The field notes should be ample and, as far as possible, cover all contingencies that are likely to arise. Notes should be made of the depth of basements and cellars, particularly in the business districts. A little time and care spent in this matter will save much extra time and worry when the plans are under way in the office. The line of outfall, particularly if of any very great length, should be carefully located with the transit, its bearing noted, and bearings taken of prominent objects in the vicinity. All curves should be run in at once and full notes made. If the sewage is to discharge into a stream, high and low water levels should be taken, and notes made of the direction of flow, the character of the bottom, etc. Information should be gathered at every opportunity as to the character of the soil at various depths, and as to the likelihood of encountering rock or hard-pan in the trenches. Such information may be gotten by the examination of wells in the vicinity, or from parties that have driven deep wells. As far as possible, notes should be made of the location and depth of all water, gas and other mains or conduits, and all private drains or sewers wherever they occur. All these notes should be kept in a thoroughly systematic manner and, wherever necessary, amplified by sketches.

Office Work.—If sufficient assistance is available it will of course be found more satisfactory to keep the office work up with the field work. If this is not the case, however, it is better to put off the office work until the field work is completed, except that during inclement weather when it is impossible to work out of doors, the plat of the city may be begun and carried forward as the opportunity offers. This plat should be made on as large a scale as possible, and for average sized towns a scale of two hundred feet to the inch will be found very satisfactory. If only one plat is to be made it should have the lots platted upon it, showing in which direction the property faces, and later the contour lines can be sketched in and the sewer lines laid down. This plat should be made upon a good quality of paper backed with muslin. Most cities, however, desire several copies of the plat and then it will have to be made upon tracing cloth. I believe it will usually be found better to make two plats, one having the contour lines laid down upon it and the other a plat of the sewer system. It is but very little more trouble to make two tracings and the plats in the end look neater and are much better for reference.

The first work to be done in the office is the preparation of the profiles. "Plate A" will be found most convenient and a horizontal scale of two hundred feet to the inch, with a vertical scale of four feet to the inch will give profiles that are easily handled and at the same time accurate enough for all practical purposes. Elevations should be platted to the nearest tenth of a foot and all street and alley crossings, as well as all ditches, should be noted.

Streets or alleys running in the same direction should be platted upon one piece of profile paper and those at right angles upon another. In addition, the streets or alleys should be platted in the same direction. That is to say, if, for instance, we are platting east and west streets, the left hand end of the profile paper should be the same end of each street, either east or west. Likewise for the north and south streets. The profiles should not be inked in until after they have been thoroughly checked from the note books. After this checking, one person should take the north and south profiles and another the east and west profiles, and the elevations of street intersections should be called off and they should check within two or three tenths of a foot. After this is done and all corrections made, the profiles are ready for inking. This should be done free-hand, and the black lines shaded with a brush, using either moist water color or diluted ink. Brick red will be found to give a very good effect. After the profiles are completed we are ready to take up the contour map. Contour lines should be drawn for at least every five feet difference of elevation and often it will be found desirable to locate them two or three feet apart. Contour points can best be located by reference to the profiles and the starting point should be the low water level. Each street should be taken separately and as one person calls off the stations and elevations, another should by scale apply them to the map, penciling in the elevations. Afterwards the contours can be sketched in, and if a little care is exercised, the results will be sufficiently accurate. Having completed the profiles and contour map, we are now ready to proceed with the actual design of the system. No attempt will be here made to outline the method of determining the quantity of sewage to be disposed of, or the determination of the sizes of mains. Those points are fully covered in many easily accessible works of reference, but the matter of determining grades will be taken up briefly.

Having located the point of outfall, its elevation should be fixed with reference to low water level. From this as a starting point, it may be possible to work back to the higher levels, but it will be necessary usually to lay down several trial lines before the grades for the sewer mains can be definitly fixed. Even then the grade lines should not be inked in on the profiles until the very last thing, as after considerations may make it expedient to make alterations. The lines should at all points be laid deep enough to catch all basements or cellars and to keep out of the way of water and gas pipes and other obstructions. It should also be remembered that the cost of excavation per cubic yard, unless rock or hard-pan is encountered, will not increase until a depth of about ten feet is reached, or until it becomes necessary to rehandle the dirt from the ditch. In laying down the grade lines, it must be remembered that for purposes of ventilation there must be a continual rise along the crown of the sewer. For this reason all changes in size of mains should be made at man-holes and the smaller main, as it reaches the man-hole, should be raised sufficiently to bring its crown on a level at least with the larger or outflowing main. All laterals should be brought together at man-holes and all changes of grade or direction or both, should be made either at man-holes or lamp-holes. To secure proper ventilation, lamp-holes should not be spaced farther apart than two hundred and fifty feet. At the upper ends of the laterals, especially where the grades are flat and only a limited amount of sewage reaches the sewers, flush-tanks should be located. In certain localities roof water may be connected with the sewers for cleansing purposes, but in most cases it is too uncertain a quantity to be depended upon.

All these details should appear upon the plat or profiles and in addition, detail drawings of all man-holes, lamp-holes, bulk-heads or any peculiar construction, should accompany the plans.

A few words in regard to man-holes and lamp-holes: The man-holes should be built of two rings of brick and plastered on the outside with cement, mixed half and half, and washed inside with pure cement. They should have an inside diameter, at the bottom, of not less than four feet. The bottoms should be built of *brick*, and the flow channels should be built in the brickwork as the bottoms are laid and made to conform to the size and shape of the connecting mains. These channels, as well as the entire bottom of the man-hole, should have a coating of pure cement, so as to offer the least possible resistance to the flow. Such a bottom is much better than one in which the channels are formed from split sewer pipe, especially where several lines meet in one manhole. It seems better to have lamp-holes all of one size, rather than to have the lamp-hole of the same size as the pipe in which it is built. An eight inch lamp-hole will afford sufficient ventilation and at the same time is large enough for purposes of inspection.

Specifications.—Specifications should describe fully the character of the work to be done under them, the quality of the materials to be used and, as far as possible, the conditions under which the work is to be executed. They should be full and explicit in every detail; rigid enough and yet permitting a certain amount of pliability. The spirit of the specifications should govern, not the letter. They should be explicit as to how the work is to be measured and how paid for. In a word, they should be so drawn that there can be no doubt as to the evident intention of the author. If the engineer that draws the specifications is the one to carry them out there will usually be no difficulty in the interpretation. Unfortunately, however, this is very often not the case and many men and many minds pass judgment upon them. Unfortunately, too, specifications are often drawn that are impossible of fulfillment, either in the spirit or the letter.

There should be no friction between the engineer and the contractor and the specifications and contract should be so drawn as not to create a hardship for any of the parties concerned. While the contractor should execute faithful and reliable work, he is at the same time entitled to a legitimate profit and should not be robbed of this profit by a hair-splitting interpretation of the specifications.

Proposal.—The blank form of proposal should cover every item likely to occur in the execution of the work and prices should be named therefor. While the specifications should contain a clause providing for extra work, because it is impossible for an engineer to foresee all contingencies that are likely to occur, yet in order to prevent dispute, the possibility for such claims should be reduced to a minimum.

The foregoing clause should not be misunderstood as applying to the construction of the work proper. For instance, many forms of proposal provide a price per foot for each size of pipe; so much for jute; so much for cement; a price for excavation up to seven feet; another between seven and fourteen feet, etc.; a price for rock excavation and so on to the end of the chapter. Such a method involves an endless amount of labor upon the part of the engineer and is unfair to all parties concerned. The better method is to provide for so much per lineal foot of each size of pipe laid in the system, including all jute, cement, excavation and back-filling complete; so much for each man-hole complete; so much for each lamp-hole and flush-tank complete. When the work is completed it is only necessary for the engineer to measure the lengths of the lines, count the number of man-holes, flush-tanks and lamp-holes and the estimate is finished and there is no chance for dispute.

In conclusion, it may be said that the smaller cities are beginning to realize that the construction of an efficient water supply system, involves the construction of an equally efficient sewerage system and there can be no doubt that the Separate system offers a means of relief, entirely within the reach of the smallest municipality.

THE SEPARATION OF THE LOSSES OF THREE-PHASE MOTORS AND A COMPARISON OF THE LOSSES ON BALANCED AND UNBALANCED CIRCUITS.

By ERNEST B. TRUE, B. S., '96.

Seven years ago the three-phase motor was simply an interesting scientific curiosity. It is still a novel sight to see an armature which has no visible connection, in fact no mechanical connection to any motive power, running as if by magic. However, that revolving mass of iron and copper is more wonderful now as it can do work equal to that of an engine larger than itself. In the last five years the three-phase motor has been developed to such an extent that it takes equal practical rank with its older brother, the direct current motor, and promises, with the aid of long distance transmission, to leave it far behind. Such advance has been made in the design and manufacture of this class of motor, that further progress can come only as a result of careful study and painstaking investigation.

The object of this test was the separation of the losses of the machines. As this was done for several loads, it made possible the computation of the efficiency and power factor curves, thus giving a no load efficiency test.

The practical benefit to be derived from this is that it affords a no load test the results of which approach very nearly to those obtained from a brake test. This test does away with the loss of power necessitated by the ordinary commercial test and is also easier to conduct.

At the same time, the separation enables the designer to work to better purpose, as he can see where to make changes to the best advantage. With this end in view, it would be very desirable if a more complete separation of the losses than I have attempted were carried out.

The test is very simple. The iron losses are obtained from readings taken when the machine is running light at normal voltage. Under these circumstances, the total losses consist of the desired iron losses, the field C^2R loss, a negligible armature C^2R loss and the air and bearing friction loss. The motor is run light and the power absorbed, the current in each line, the pressure between the lines and the motor and generator speeds are taken. The resistance of the field windings is measured at the running temperature. The field C^2R loss is computed from the measured currents and resistances. The bearing losses are obtained by taking the speed carefully and then cutting off the power and noting the time it takes the motor to run down. From these readings, the weight of the armature and the measured dimensions of the armature, the moment of inertia, kinetic energy and finally the friction loss are figured. The total loss, as read from the wattmeters, minus the friction and C^2R losses gives the iron loss.

The wattless magnetizing current, which is constant for constant voltages, is also found from these readings by the following formula:

$$C_m = C_c \sin \Phi.$$

C_m is the wattless magnetizing current in one coil, C_c is the current in one coil as measured by the ammeter and sin Φ is the true watts divided by the apparent watts.

The C^2R losses are obtained from readings taken when the motor is blocked and the voltage cut down by resistances placed in the lines. The total watts absorbed, the current in each line and the pressures between the lines are measured for several values of the current. In this case, the total loss is made up of the desired field and armature C^2R losses and the iron losses. The iron losses vary with the one and six-tenths power of the voltage. This is on the assumption that the Steinmetz constant for the relation between the iron losses and the magnetization is correct; and that the magnetization varies directly with the voltage. Both of these assumptions have been proved to be nearly correct. Remembering this fact, the iron losses at the reduced voltages are obtained from the iron loss at the normal voltage already found. The difference between the total loss and the iron loss at that voltage is the C^2R loss for that current.

The actual working current corresponding to any current in a coil is as follows:

$$C_a = (C_c^2 - C_m^2)^{1/2}$$

C_a is the actual working current in one coil. Consequently, the load for any current in one coil is computed acording to the following formula:

$$L = (C_c^2 - C_m^2)^{1/2} lv.$$

In the above formula l is the number of phases, v is the normal voltage in the coil and L is the load in watts.

It will be found convenient to compute the value of the current in one line at full load before making the blocked test. In order to do this, transpose the load formula into the following form:

$$C_c = \left[\frac{L^2}{l^2 v^2} + C_m^2\right]^{1/2}$$

By determining the C^2R loss for this value of C_c and for three or four smaller values and plotting a curve between the values of C_c and the corresponding losses, the C^2R loss for any value of the current in one line is easily found.

The iron and bearing losses are constant for all loads. The C^2R loss for any value of the current in one coil can be read from the C^2R loss curve just mentioned. The efficiency for any value of the current is the total load for the current minus the losses for that value of the current, divided by the total load. The power factor for any load is obtained by dividing that load (true watts) by the corresponding apparent watts ($C_c$vl.)

The power for the tests was taken from the monocyclic dynamo at the Four Lakes light and power station at Madison, Wisconsin. This system does not give balanced currents. An artificial balance was obtained for this test by placing water resistances in the lines. I also carried out an unbalanced test in which the distribution of the current for the blocked readings was kept proportional to that during the light running readings. The resulting C^2R losses found were not satisfactory in both tests for reasons which will be explained later.

Motor number 1 was a 5 H. P. three-phase motor built in 1896. The field windings were delta connected and the motor was designed to run on a 220 volt, 60 frequency current, at a speed of 1,200 revolutions per minute. The power was measured by the "two wattmeter method". In each test three sets of readings were taken at one time and later a check set of two or three more readings was taken. The results were figured from an average of the five or six readings. The line amperes were measured and the coil amperes obtained by multiplying the readings by the square root of three.

The balanced test C^2R loss curve is shown by Fig. I. Table 1 is a summary of the results of the balanced test and Table 2 gives the same summary for the unbalanced test. In Fig. II., curve 1 is the efficiency curve for the balanced test and curve 2 is the one obtained from the unbalancd test. Curve 1′ is the balanced power factor curve and curve 2′ is the unbalanced power factor curve.

Motor number 2 was a 5 H. P. induction motor built in 1893. The fields were star connected and the motor was designed to run on a 100 volt, 50 frequency current, at a speed of 1,500 revolutions per minute. In the test a 60 frequency current was used so it ran at 1,800 revolutions. The power was measured by the "one wattmeter method". Tables 3 and 4 are respectively the summaries of the balanced and unbalanced tests. In Fig. III. curves 1 and 2 are respectively the balanced and unbalanced efficiency curves; and curves 1′ and 2′ are the power factor curves. The unbalanced curves do not check with the brake test curves obtained by Messrs. Perkins and Williams on the same circuit*

* Wis. Engineer, Vol. I, No. 2.

(See curves 3 and 3′). The greater part of this difference is easily accounted for by examining the data of Perkins and Williams's test. This shows that, under ordinary working circumstances, the distribution of the current in the lines becomes nearer balanced as the load increases. The natural consequence is a material decrease in the C^2R loss from what it would have been if the ratio of the currents in the lines had remained as it was at

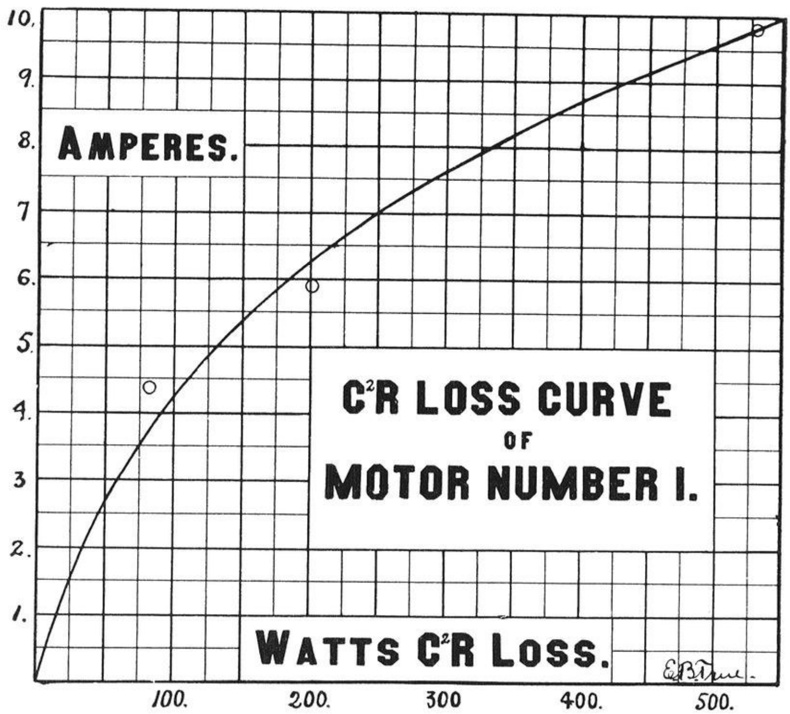


FIG. 1.

no load. In the no load test this ratio was kept nearly constant.

An examination of Table 1 shows that the bearing loss of motor number 1 is about 15 per cent. of the full load loss. The iron loss is 29 per cent. and the C^2R loss is 56 per cent. of the full load loss. Table 2 shows that the varying conditions, caused by the lack of balance, have increased the iron loss about 50 watts or 50 per cent. The C^2R loss is increased 80 watts or nearly 30 per cent.

A similar examination of Table 3 shows the balanced motor number 2 bearing loss to be 10 per cent., the iron loss 20 per cent., and the C^2R loss 70 per cent. of the full load loss. By comparing Tables 3 and 4, it is seen that the unbalanced circuits increased the iron loss 50 per cent. and the C^2R loss about 300 watts or over 50 per cent. of the total full load loss.

Figure II. contains all the available curves of the motor number 1. Curves 1 and 1′ are the balanced computed curves, 2 and

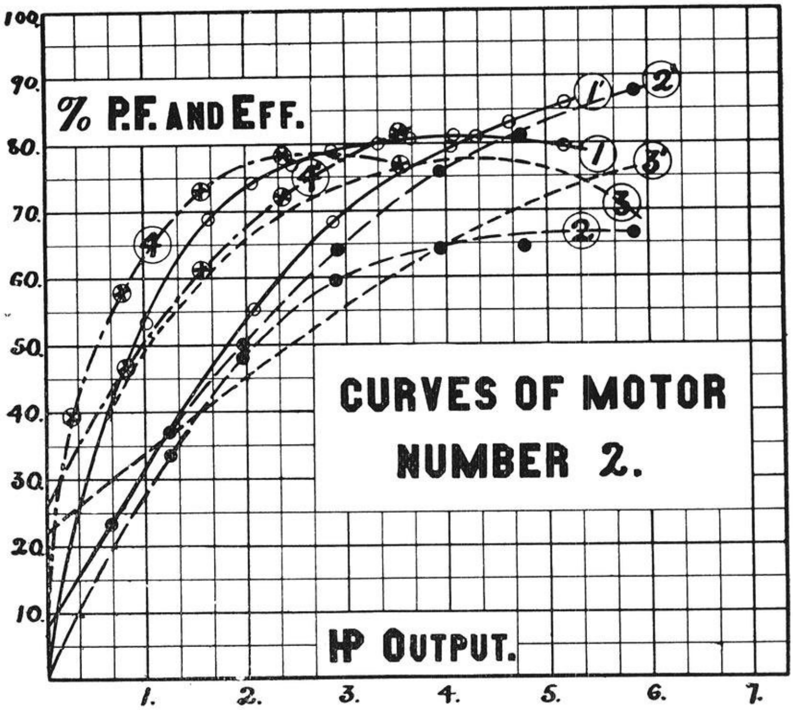


FIG. II.

2′ are the unbalanced computed curves, 3 and 3′ are the curves from the unbalanced brake test of Perkins and Williams. Figure III. is made up of curves of motor number 2. Curves I. and I.′ are from the balanced no load test, 2 and 2′ are from the unbalanced no load test, 3 and 3′ are from Perkins and Williams's unbalanced brake test and 4 and 4′ are from a balanced brake test made by Messrs. Bertrand and Schumann in 1895.

The test shows that, on unbalanced circuits, the iron loss is 50 per cent. higher than under normal circumstances. No dependence can be placed on the C^2R loss increases as given earlier in the paper. The increase in the C^2R loss depends only on the amount that the balance is disturbed. A comparison of the corresponding balanced and unbalanced curves in Figures 2 and 3 shows that the motor efficiencies are from 4 per cent. to 5 per cent. lower when they are run on unbalanced circuits.

The comparative value of this test and the brake test is found by examining Figures II. and III. In Figure II. take curves 2 and 3.

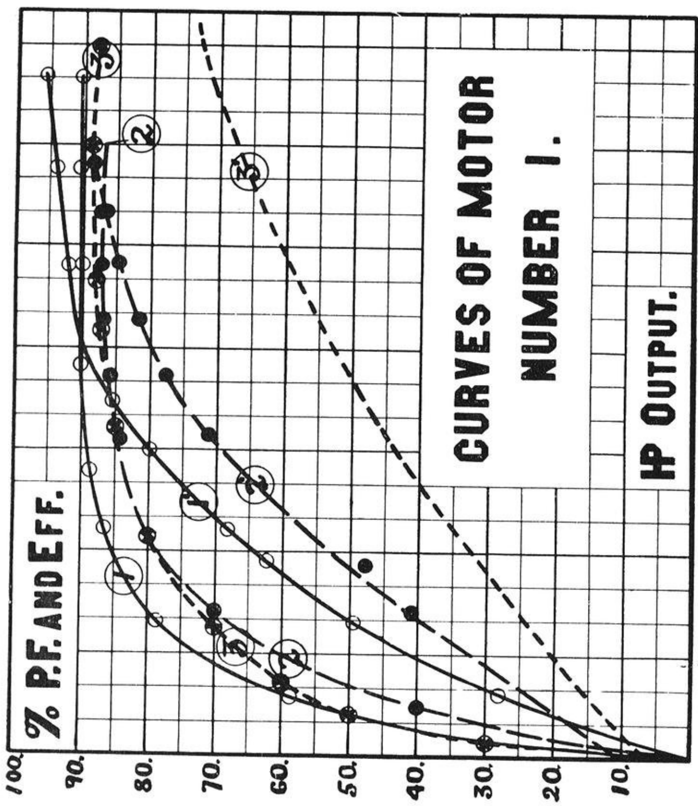


FIG. III.

From 1 1-2 H. P. to 4 1-2 H. P. the calculated curve and the brake curve practically coincide. From there on the brake curve is about 1 per cent. higher than the calculated one. The power factor curves show no similarity. In Figure III. curves 1 and 4 are balanced curves. The computed one rises more slowly but stays up longer than the brake curve. The unbalanced curves (2 and 3) are decidedly unlike for reasons explained before. Although the computed and brake curves of motor number 1 are nearly alike the no load test can not be depended on when unbalanced circuits are used. On balanced circuits it is probably correct within one per cent. The computed power factor curves do not seem to be much related to the brake power factor curves.

In drawing final conclusions as to the value of this method as a practical test, it should be borne in mind that in this case the circuits were not balanced. Even in the so called balanced portion, the pressures were only approximately equal. The water resistances heated so rapidly and unevenly at the higher pressures that it was impossible to obtain exactly balanced readings. To give the test a fair trial a lamp bank, or some other constant resistance, should be used. After the pressures have been balanced, by a constant resistance, or with a generator giving balanced circuits, the pressure could be varied for the blocked readings by changing the excitation.

Motor No. 2 was a good example of the machine of its date and motor No. 1 is a commercial machine of the present design. This enables us to see the advance that has been made in three-phase motor design and manufacture in the last three years. The difference in the highest efficiencies is nearly 10 per cent. The iron loss of motor No. 2 is more than 57 per cent. larger than that of motor No. 1. The improvement in the electrical properties of the iron now used is responsible for much of this gain.

TABLE 1. — *Summary of the results of the balanced test of motor No. 1.*

Coil amperes.	LOSSES.				LOAD.		Eff.	Power factor.
	C^2R.	Iron.	Bearing.	Total.	Watts.	H. P.		
2.5	46	98.5	50.5	195	462	.62	58.3	.281
3.0	60	98.5	50.5	209	988	1.32	78.8	.499
3.5	75	98.5	50.5	224	1,679	2.25	86.9	.682
4.	92	98.5	50.5	241	2,112	2.84	88.5	.831
5.0	135	98.5	50.5	284	2,895	3.88	90.5	.877
6.	187	98.5	50 5	336	3,626	4.86	90.0	.916
7.	250	98.5	50.5	399	4,348	5.80	91.0	.939
8.	335	98.5	50.5	484	5,041	6.75	90.5	.955

TABLE 2—*Summary of the results of the unbalanced test of motor No. 1.*

Amp. in heavy coil.	LOSSES.				LOAD.		Eff.	Power factor.
	C^2 R	Iron.	Bearing.	Total.	Watts.	H. P.		
8	123	148	50.5	231.5	1,080	1.45	70.2	.410
9	145	148	50.5	343.5	1,820	1.90	81.2	.478
10	170	148	50.5	368.5	2,347	3.15	84.2	.712
11	200	148	50.5	398.5	2,807	3.77	85.8	.775
12	23[illegible]	148	50.5	433.5	3,220	4.31	86.6	.814
13	270	148	50.5	468.5	3,621	4.85	87.0	.845
14	312	148	50.5	510.5	4,001	5.37	87.0	.866

TABLE 3.—*Summary of the results of the balanced test of motor No. 2.*

Amp's	LOSSES.				LOAD.		Eff.	Power factor.
	C^2 R.	Iron.	Bearing.	Total.	Watts.	H. P.		
14	124	154	74.6	354.6	761	1.02	53.5	.313
14.5	136	154	74.6	366.6	1,003	1.35	63.4	.398
15	143	154	74.6	373.6	1,205	1.62	69.0	.462
16	165	154	74.6	395.6	1,548	2.08	74.5	.556
17	192	154	74.6	422.6	1,842	2.47	77.0	.623
18	220	154	74.6	450.6	2,124	2.88	78.8	.684
20	285	154	74.6	515.6	2,600	3.48	80.4	.784
22	340	164	74.6	570.6	3,049	4.09	81.3	.797
24	477	154	74.6	707.6	3,475	4.65	79.7	.833
26	560	154	74.6	790.6	3,885	5.21	79.6	.859

TABLE 4.—*Summary of results of the unbalanced test of motor No. 2.*

Amp's	LOSSES.				LOAD.		Eff.	Power factor.
	C^2 R.	Iron.	Bearing.	Total.	Watts.	H. P.		
11.82	112.6	316	74.6	503.2	477	.64	....	.233
14.47	213.0	316	74.6	603.6	920	1.23	34.4	.366
19.38	495.1	316	74.6	885.7	2,192	2.94	59.7	.642
22.20	671.1	316	74.6	1,061.7	2,941	3.95	64.0	.762
25.55	892.2	316	74.6	1,282.8	3,589	4.80	64.5	.811
29.02	1,080.5	316	74.6	1,471.1	4,406	5.90	66.7	.887

INTERNAL COMBUSTION ENGINES.

BY C. W. HART, B. S., '96, AND C. H. PARR, B. S., '96.

II.

OIL AND ITS USE IN THE INTERNAL COMBUSTION ENGINES.

We will now take up that class of motors which is in such extensive use in this country, the oil engine, and more especially the gasoline engine. All the classes of engines which we have described can, with simple attachments, be made to use oil or gasoline.

In America, the part distilled from petroleum between densities 0.636 and 0.75 when redistilled is called gasoline, naptha, and benzine. Oils of density 0.75 to 0.84 are called kerosenes. Both of these products are found on sale in every town and hamlet of the United States.

The kerosenes are used mostly for illumination and in most of the states are subjected to an inspection test by oil experts before being sold. The test consists in determining the flashing point of the oil, and a certain temperature is fixed by law[1] as safe. Oils cannot be sold as illuminating oils unless the temperature of their flashing point is greater than this.

Gasoline is not subject to inspection, it being considered a dangerous oil. However, with the advent of the gasoline stove it has come into quite as extensive use as kerosene, and, though it is feared by some, the number of accidents occurring from its use is very small and what do occur generally result from gross carelessness.

In obtaining fuel for motive power in the internal combustion engine, the conditions imposed are that it be cheap, in condensed form so that it may be conveniently transported, and that no cumbersome complicated devices are required to get it in shape for use. Coal is a cheap fuel fairly easy to transport but lacks the last requirement. In Europe it is extensively used in gas-engines by means of the Dowson gas producers, and, in tests of these power plants extending over several weeks, a consumption of about one pound of coal per H. P. hour was realized. While it would be policy to produce power in this way where enough is used to afford a man for attendance, there are innumerable places and industries which require only a small power and perhaps use it intermittently or portably. In all these cases the fuel which commends itself most favorably is the product of petroleum. It is cheap, convenient to handle, and universally found.

The question now arises which of the products should be used. This of course is settled only by considering the points of safety, convenience, cost, and universality of the product.

The readiness with which oil can be converted into vapor depends largely on its density. The products of density 0.70 and above require the application of heat before they can be sufficiently vaporized to form an explosive mixture. This fact was determined by actual test on an engine. This engine had an attachment for mixing the air and gasoline in a pipe leading to the cylinder. It consisted of a lift valve into the seat of which a hole was drilled, and the gasoline supplied to this hole with slight pressure from an elevated tank. In the gasoline pipe was a valve for regulating the flow of oil. In operation, the valve lifts from the seat by the suction of the engine, when a small quantity of gasoline flows out on the seat and is taken off by the air. It was found that this device worked very well with gasoline of density less than 0.70. The engine was easily started by simply opening the regulating valve, the temperature of the external air being about 70 degrees F. After the engine had been in operation a few minutes, it was noticed that the case surrounding the valve became very cold because of the extraction of heat due to evaporation. Yet when the oil did not exceed 0.70 in density, the engine worked continuously for any length of time. However, when oil of greater density was used, the engine would start easily but would soon stop as the cold was sufficiently intense to prevent evaporation.

This arrangement was tried on both an Otto and a Sintz type of engine. In the Sintz type this valve was the suction valve to the base, and in the Otto type was in the pipe leading to the inlet valve. The same result was obtained by both trials.

It was next arranged to heat the air passing to the valve by drawing it over the head of the cylinder where considerable radiation of heat took place. When the mixing valve was kept at a temperature of about 75 degrees F. no trouble was found in keeping the engine in constant motion and a smaller consumption of gasoline was noted. The reason for this is, no doubt, that when the oil is evaporated at so low a temperature, some of it goes in in the globular form while the air is sufficiently charged with vapor to explode and use the oxygen present. The excess of oil is then wasted through the exhaust. In case all the oil is vaporized, an excess of gasoline immediately produces a noticeable weakening of the force of the explosion. By means of this heating device it was found possible to use oil of considerable greater density than 0.70.

In Europe, the heavy lighting oils are mostly used because the spirit or essence of petroleum, as they term our gasoline, has not found so much favor for other uses as in this country. We shall, however, limit ourselves hereafter to the conditions in this country, and will now describe a few of the attachments used on prominent makes of engines for converting gasoline into vapor.

The attachment used on the Caldwell-Charter engine, and which has given good results in practice, consists of a pipe through which the air is drawn to the engine. Projecting into this pipe is a small tube bent upward at the inner end and connected outside the pipe to a small reservoir holding about a gill of oil. A needle valve serves to regulate the supply of oil passing into the small tube from the reservoir. A pump is operated by the engine which keeps the level of oil in the reservoir at a point a little lower than the inner end of the tube. The tank for oil being placed below and at a distance from the engine, the excess of oil pumped flows back to the tank from an overflow in the reservoir. On the suction stroke of the piston, the air flowing by the mouth of the tube takes up sufficient of the oil as spray to form the explosive mixture. This arrangement, as will be seen, prevents any leakage of oil if the engine stops without the oil being turned off.

In the Charter engine, gravity flow is employed and a valve moved by the governor squirts a charge into the air pipe as the air is drawn to the cylinder. This engine is also so arranged that no oil will flow if the engine stops.

The VanDuzen and several other makes of engines inject a charge into the air pipe by a pump and allow it to drop on to screens through which the air is drawn.

The Sintz engine formerly injected the oil from a pump into the cylinder as the air entered, but now they employ a double seated valve and gravity feed. One seat of the valve is large for air and the other very small for gasoline. This engine also warms the entering air by passing it over the cylinder head.

In many engines the vaporizer consists of a can of oil with a float through which the air is drawn. The float serves to keep the air passing through the same depth of oil.

In the Hornsby-Akroyd engine the cylinder is connected with a compression chamber by a narrow passage. The oil is injected into this compression space which, not being water jacketed, remains red hot. Here the oil is converted into vapor by the heat, and when air is forced through the passage from the cylinder into the compression space, spontaneous ignition takes place. Kerosene may be used in this engine.

In other engines the mixture is sucked through a chamber heated by the exhaust. Thus we see that the most of the engines in this country use cold evaporation of the oil.

The standard scale by which the density of oil in this country is measured is the Baume scale. Some years ago, before the Standard Oil Co. had gained such complete control of the oil industry, the gasoline sold was that of 74 degree Baume scale, and the gasoline engines built were made for that oil. They ran and gave good satisfaction as the density was such that cold evaporation gave good results. Later the oil sold most commonly was lowered according to the Baume scale until today the oil sold as stove gasoline varies between 67 degrees and 70 degrees Baume, and between the densities of 0.70 and 0.71. This density it will be seen is too close to the limit where cold evaporation gives good results. As a consequence many engines which ran well a few years ago give trouble now.

Careful tests were made on three samples of gasoline. One was that commonly sold in Madison by the Standard Oil Co. and was an Ohio product. The other two samples were Pennsylvania products:

	Dersity.	Baume.
Sample 1, Ohio product, gave....................................	0.7106	67°.
Sample 2, Penn. product, gave....................................	0.698	70°.06
Sample 3, Penn. product, gave....................................	0.7065	67°.86

The oil now sold as gasoline is not the pure spirit as formerly but contains much heavy oil. It seems then that if an engine is to use the gasoline sold on our market, heat must be applied for the proper mixing and evaporating of the charge.

The practice of injecting oil into the cylinder with a pump is open to the objection that it is difficult to construct a pump which shall deal out such minute quantities with sufficient accuracy and remain constant in its operation.'

The practice of sucking the air through the oil has the fault of taking the lighter hydrocarbons off first. In these engines generally only a portion of the air is drawn through the oil; the remainder is sucked through another opening covered by an adjustable valve. When the tank is freshly filled, the air passing through the oil is too rich for ignition and must be diluted by opening the adjustable air valve mentioned. As the lighter vapors pass off, the air valve must be partly closed and more of the air drawn through the oil in order to make the charge sufficiently rich. This goes on until the air valve is completely closed and all the air for the engine comes through the oil. Here we have a dangerous condition of things. The tank and pipes leading to it from the engine are filled with the same explosive mixture as is used in the engine, and if the explosion passes back through the valves as we have seen it do in other types of engines, the result must be disastrous. In many cases also a heavy residue remains in the tank which cannot be used.

Our first attempts at constructing a device for mixing the air and gasoline were with a pump injecting the oil on screens through which the air passed. It worked fairly well but we soon saw that it would be a source of trouble in practice as a leak in the packing or a little lost motion would so change the amount injected that the engine would not work.

Our next efforts were with the suction of air through gasoline, but for the above named objections we gave up this method, and in all our later experiments have used the attachment first described; the lift valve with the gasoline entering through a hole in the valve seat. This can be used with an elevated tank and if the valve is properly ground in no leakage will take place when the engine stops, even though the gasoline valve be left open. As an extra safeguard, however, the elevated tank can be made small and a pump used to draw gasoline from the source of supply and keep this elevated tank full to a certain level. The excess of oil pumped can flow back to the supply. Thus only a small quantity of oil need be kept in the building with the engine and while a pump is used, it can be several times too large for the quantity of gasoline required so that it is not a delicate affair likely to get out of order.

The mixing valve supplied with warm air gives a very uniform mixture as is shown by taking a number of indicator cards superposed upon each other. The load being constant, the explosions were so nearly uniform that only one line appeared on the card.

We also used this mixing valve cold and then passed the mixture through a heated chamber before it entered the cylinder. This arrangement worked quite as well as the first order.

Our experience has shown that in many cases where electric ignition is used and thought to be faulty, the real fault lies in improper or irregular mixtures. In one case we ran an engine with a weak battery which allowed it to miss explosions now and then. It ran with increasing irregularity and finally stopped. We took off the cylinder head and found a coating of soot in the compression space and the igniter points badly coated. We cleaned only these points and then applied a strong battery and after a short run again took off the cylinder head. We found the interior bright and clean, showing that with proper and complete combustion the cylinders of these engines will not become fouled.

At first thought it may seem an easy task to construct a mixing device, as little trouble is found in the internal combustion engine using gas; but when we consider that the gas and air there used are both in the same state and each of considerable volume, and that in this case we have oil in one state and air in another and the amount of oil per charge perhaps the most minute quantity; and that the variation allowable is extremely small, we begin to see the difficulty imposed.

(To be Continued.)

NOTES ON THE USE AND TESTING OF HYDRAULIC CEMENTS.

By H. P. BOARDMAN, B. S., '94.

I.

The following scattering notes are the result of nearly two years' experience in the cement testing laboratory of the Sanitary District of Chicago.

The testing of hydraulic cements used in various classes of engineering work is becoming more common than formerly and yet many engineers still fail to realize the full scope of such work.

Hydraulic cement mortar is now largely used in many classes of engineering structures where formerly, common lime mortar was used. Probably nearly all cements on the market to any extent, give a stronger mortar than lime, so some at once conclude that anything answering to the name of cement is good enough for all classes of work.

Others recognize the distinction between natural and Portland cements and are apt to think natural cements fit only for comparatively unimportant work but that anything called Portland cement is suitable for the highest class of work.

Still others think that, whenever the importance of the work seems to demand Portland cement, an imported Portland should be used, some preferring German, others English, others Belgian, etc., etc., and some being satisfied with nearly anything so long as it is Portland cement from across the water.

There seems to be a strong prejudice in the minds of many engineers against American Portland cements and it is not altogether without reason, though it becomes unreasonable and unjust especially if it leads to the condemnation of *all* American cements without a fair trial.

Probably the best proof of the quality of a cement is its manner of behavior in work after years of exposure to the agents which tend to disintegrate it. Where the behavior of any one brand of cement under various conditions of exposure, in work for which it is suited, is always good, the inference naturally is that it is a good brand of cement to use. But that, in the writer's opinion, should never lead to an unqualified acceptance of that brand of cement, without the precaution of any tests or checks on the uniformity of the product. Instances will be cited later in this paper showing why this opinion is held.

On the other hand, occasional apparent failures of a certain brand of cement are not conclusive proof of bad quality, for the best of cements may be spoiled in the manipulation.

Again if there is any method of inspection by which we can, with reasonable certainty tell in advance of its actual use, what the quality of a cement is, we may be comparatively safe, in many classes of work, in using a cement which while usually good, may vary somewhat in quality.

It should be borne in mind that different classes of work require different kinds of cement. Oftentimes a higher grade of cement is specified than is necessary for the work in hand, thus increasing the cost materially. It often happens that Portland cement is specified where a good brand of natural cement would answer every demand. In concrete work, mortar for laying wall, foundation work, etc., when great strength or extreme hardness of exposed surface is not necessary, natural cement is often good enough, especially when the difference in cost is considered.

It is true that larger proportions of sand can be used with a Portland cement than with a natural cement, for a given strength of mortar or concrete. This somewhat mitigates the evil of excessive cost of the Portland cement, but it introduces another evil, since it is much more difficult to get a sufficiently uniform mixture of cement and sand when the proportion of sand is large. In the rush of ordinary contract work, it requires very close inspection to insure a homogeneous mortar of four or five sand to one cement.

There has been considerable said of late about standard specifications for Portland cement. Undoubtedly a properly drawn up set of specifications would be very useful in the line of suggestion to be followed more or less closely. But as there are so many brands of cement differing widely in composition and in behavior as respects minor details and since the uses to which cement is put are so varied, it seems to the writer inconsistent with good practice to rigidly follow the same specifications in all cases or even to attempt to formulate specifications covering all possible tests for any particular case. It would seem better practice in general to so frame specifications that the particular requirements as to testing of cements should be left largely to the discretion of the engineer in charge of work; where limits are assigned making them broad enough to include any cement that would be suitable for the work in hand and inserting a clause to the effect that the engineer be privileged to require any further tests that seem to him necessary.

If narrow limits are assigned for all kinds of tests there will be difficulty in finding a brand coming within those limits in *all* particulars, unless the person framing the specifications had in mind a certain brand at the time, in which case that brand would be favored above others.

In some cases if the cost is not too much increased thereby, it is undoubtedly better to specify that one of several brands, pretty certain to be satisfactory, be used, but even then tests should be made continually.

SOME HINTS ABOUT TESTING.

The testing of cement can vary more or less in its details according to the purpose in view.

If the principal object aimed at is a comparison with tests made in various places, uniform methods of manipulation should be adhered to if such rules can be universally adopted.

Very useful experiments could be made in this country as are being made in France by the "Commission de Methodes D'Essais Materiaux de Construction" and in Germany by a similar organization, for purposes of information along these lines.

In the writer's opinion tests made of the actual cement used in work, by the parties in charge of such work, are the most useful and if properly conducted on an extensive scale are very instructive.

In such tests it is not necessary that a standard form of specification be followed absolutely in order to insure beneficial and instructive results. Instances of details in which such deviations may and often must be tolerated are: In the choice of a sand used in making mortar briquettes, whether "standard" or commercial; in the proportion of water used in mixing; in the kind of breaking machine used.

TESTS BY THE SANITARY DISTRICT OF CHICAGO.

The old saying "Necessity is the mother of invention" is typified in some of our experiences in the cement testing laboratory of the sanitary district and the process of evolution of some of the methods used may be more interesting and perhaps more instructive than the mere enumeration of conclusions.

Our first busy season opened in the spring of 1895. During the season of 1895 no work calling for the use of Portland cement was undertaken so the tests of that season were largely confined to natural cement, though some special tests of Portland cements were made, and some had also been made the previous winter.

The desire from the beginning has been to make a thorough test of every carload of cement submitted for use on the work. The usual test of natural cement was a tension test of thirty neat briquettes per carload made from samples taken from thirty sacks, all broken at the age of seven days. One idea of the test being to catch irregularities, the samples were kept separate throughout the test, instead of being mixed in lots of five or more as is often the practice.

MACHINE MIXING.

In order to facilitate the making of briquettes, experiments were made which finally led to the adoption of an Imperial Milk Shake machine for mixing cement and water for briquettes. The motion which causes the mixing is a vertical piston motion. The work being found too severe for glasses, brass cups for holding the ingredients were constructed. The cups which seem to work best are of about the following inside dimensions: Cylinder 2 1-2 inches in diameter and 2 inches long with hemispherical ends (one of them a cover) of same diameter, giving a total depth of 4 1-2 inches. The cups were designed for mixing only one briquette at a time though they would hold material enough for two.

At first it seemed best or at least easier, in mixing with the milk shake, to use more water per briquette than had been customary in mixing by hand with a trowel on the slab. When these first tests were broken at the age of seven days, they were found to be much lower than usual and, doubting so radical a change in the strength of the cement, we cast about for some other explanation. It was finally decided that the excess of water used in mixing was responsible for most of the loss of strength. Retests of most of the carloads of cement involved, showed them to be about normal.

EFFECT OF VARYING PROPORTIONS OF WATER.

This question about the amount of water to be used in mixing the briquettes led to quite extensive tests, made during that summer and the following winter, of the effect of varying proportions of water. These tests were made with various kinds of cements both neat and mortar and for ages ranging from one day to one year. The tabulated results of some of these tests are given in a "Topical Discussion on Hydraulic Cement," by Mr. Thos. T. Johnston, published in the Journal of the Western Society of Engineers Vol. 1, No. 1, January, 1896. The universal testimony of these tests is that for neat briquettes the best results are obtained with a medium proportion of water, usually about that which will give a consistency permitting easy manipulation and causing moisture to show readily on the surface when finishing. In the case of mortar briquettes the best consistency is, for some cements, about the same as indicated above for the neats, while others seem to do best much wetter than that, or about the consistency of mortar used in actual work.

This would not be true of tests where the cement was pounded into the moulds. In such tests undoubtedly a drier mixture would give the best results.

After a little experience it was found that briquettes could be mixed with about the same amount of water in the milk shake as by hand.

COMPARISONS OF MILK SHAKE AND HAND MIXING.

The use of the machine was continued throughout the season, part of each set being mixed by hand and part by milk shake.

This comparison extended through the tests of about 350 carloads and the average results from the milk shake briquettes were about 6 per cent. higher than from the hand mixed briquettes.

During the busy season of 1896 the milk shake method of mixing was used almost exclusively for neat briquettes of all natural and Portland cement submitted for use on the canal. This practice was the outcome of the above mentioned comparison made in 1895 which seemed to warrant such a course.

But occasional comparative tests made with Portland cements this season (1896) seem to indicate that with some brands slightly better results are obtained by hand mixing when the cement and water are thoroughly worked over and over by pressure with a trowel or by similar careful method. These tests however have not yet been carried on to a sufficiently extensive degree to be conclusive.

The milk shake method of mixing was tried for Portland mortar samples but it was found difficult to obtain a uniform mixture of sand and cement throughout the sample so that method was abandoned and the one finally adopted where it was not necessary to preserve the identity of the individual samples was to mix mortar for five or ten briquettes at the same time in an iron trough, using a small hoe for mixing.

COMPARISON OF BRIQUETTE MAKERS.

During the busy season of 1895 there were three men engaged in making briquettes nearly all the time. Two were transferred to another department after the work of the season was about two-thirds completed and they were replaced by two others, so that five different briquette makers were engaged in the tests of that season.

In compiling the following data for comparison of makers the comparatively few sets of briquettes that averaged below 100 pounds were discarded. This comparison is restricted to the regular 7 days' neat tests of natural cements and in table I. each number given in the columns "Average Breaking Strength" is the average of the averages of the number of "sets" given just to the left, in the other column. Each "set" represents the test of a carload and in the table only the sets and portions of sets mixed by hand have been included. The averages given for the different makers, in the same horizontal line, correspond as to the period of time and it will be seen that the combinations of averages as given, though taking into account the different weights of the averages according to the number of sets included, do not tell the whole story.

Table I.

I.		II.		III.		IV.		V.	
No.	Average breaking strength.	No.	Average breaking strength.	No.	Average breaking strength.	No.	Average breaking strength.	No.	Average breaking strength.
22	130.5	9	125.8	4	133.6	......	....	......	....
9	131.7	16	132.4	11	144.6	......	....	......	....
2	120.0	2	141.1	2	134.5	......	....	......	....
14	138.9	15	138.7	13	143.2	......	....	......	....
19	141.5	18	139.2	17	138.5	......	....	......	....
11	151.4	19	137.9	14	138.5	......	....	......	....
8	161.8	25	166.4	23	163.6	......	....	......	....
85	139.9	104	142.9	84	146.6	......	....	......	....
......	....	15	147.9	......	....	16	155.0	24	158.4
......	....	13	141.9	......	....	18	145.7	17	132.8
......	....	8	125.9	......	....	3	147.9	11	126.6
......	....	36	140.8	......	....	37	149.9	52	143.3

The different makers are designated by Roman numerals.

Likewise in 1896 four different men made briquettes for nearly all the tests, no more than three being so engaged at the same time. Helpers were utilized to operate the milk shake machines to facilitate the work. During this season the briquettes were mixed slightly wetter than formerly when mixed by hand. The tests of the natural cements for some reason or other ran much higher in general than those of the same cements did in 1895. Just how much (if any) of this difference in strength was due to the slightly higher per cent. of water used in mixing, it is difficult to state for there certainly must have been a change in the cements themselves, from one season to the next, from some cause or a complication of causes.

Comparisons of the different briquette makers for 1896 show no greater variation than the table given for 1895 when the tests are properly correlated as to the time of making. A very short time, not more than a week or so, spent in preliminary practice seemed to suffice to render a new man proficient enough to make about as strong briquettes as the more experienced makers. However more difference was observed on the start in the evenness and smoothness with which briquettes were filled out on the corners and finished off by the different men. But this finishing has little to do with the strength of the briquette.

Two natural cements, Louisville and Utica, are involved in these comparisons but as there was no assignment of their brand to any particular maker it is likely that they were pretty evenly distributed among the different ones and the difference in strength between the two cements is not great.

(To be continued)

A CASE OF FAULTY TERMINOLOGY.

By EDWARD R. MAURER, B. C. E., '90.
Assistant Professor of Pure and Applied Mechanics.

I. STRESS AND STRAIN.

The forces R and Q induced in a bar, Fig. 2, by pulls at its ends are called by some engineers and writers stresses and by others strains. This difference of usage is further confused by a use of the word strain among engineers to denote, among other things, the stretch, s, of the bar due to the pulls at its ends. This non-uniformity of usage is mainly due to the acceptance by some and the rejection by others of Professor Rankine's definitions of these two terms. In the 50's he endeavored to restrict a loose use of the words by defining them precisely. According to him, R and Q are stresses and s is a strain.

The nonconformists as a rule object especially to this definition of the term strain. They* argue that strain and stress are from the same root, "the Latin *stringere*, and have the same elemental English significance of a stretching or deforming force or pressure"; that this "inherent meaning" has been "bred in the bone of European races thousands of years" and "scientists may struggle to all eternity to establish" this new meaning of the word strain "in the consciousness of the students but they will never do so".

The opinion expressed in the last part of the previous sentence

*As represented by Engineering News. See its issues of June 2, 9 and 23, 1892.

the writer believes to be erroneous. Students readily adopt the Rankine term strain and, after a short treatment of their "bones" in the class room their ill-defined previous use of the word is dropped. Students abandon less completely the popular meanings of the word power, for example, for the technical meaning of the same word. The thing in terminology that bothers the average student is the multiplicity of so-called technical terms for a single quantity and the use of a single term to designate a multiplicity of different quantities. The statement of fact in the above mentioned sentence is probably correct and that fact ought probably to have deterred Prof. Rankine from attempting to change so radically the meaning of the word strain. But, to ask, at this late day, many authors and engineers to discard a word which they use synonomously with distortion, because its Latin root means force is unreasonable.

In order to get the usage on the words stress and strain and other allied terms, "straw vote" manner, the writer sent the following circular letter to 125 representative engineers in this country:

Madison, Wis., ——, 1896.

Dear Sir:—I am trying to ascertain what the usage of the words *stress* and *strain* is among practicing engineers. Will you kindly jot down the name or names which you give to each of the following quantities and return this sheet at once in the enclosed stamped envelope?

P ....

R .... (Sign your name here.)

$\frac{R}{A}$ ....

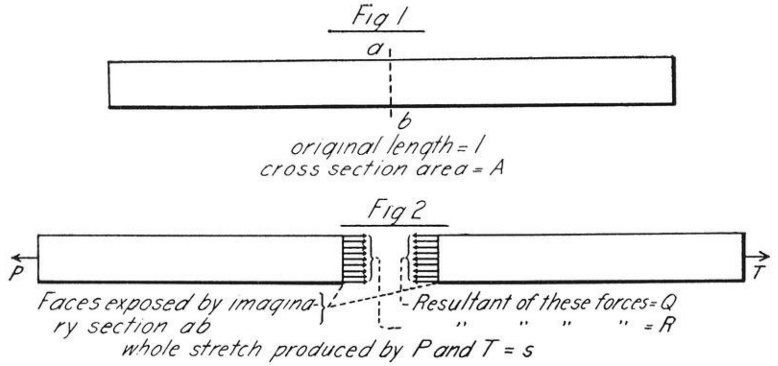
s ....

$\frac{s}{l}$ ....

	R	s	R ÷ A	s ÷ l	P
1	Stress	Strain	Intensity of stress	Strain per unit length	Load.
2	Stress	Strain	Intensity of stress	Unit strain	External force.
3	Stress	Strain	Stress per unit area	Strain per unit length	Straining force.
4	Stress	Strain	Stress per unit area, unit stress		Stress.
5	Stress	Strain	Unit stress	Unit strain	Load.
6	Stress	Strain			
7	Stress	Strain			
8	Stress	Strain, stretch	Unit stress	Unit strain, unit stretch	Force, pull.
9	Stress	Elongation	Intensity, unit stress		Force.
10	Stress	Elongation	Stress per unit area	Elongation per unit length	Force.
11	Stress	Elongation	Unit stress	Elongation per u. length, u. elong.	Force.
12	Stress	Elongation	Unit stress, modulus of stress		Force.
13	Stress	Elongation	Fibre stress		Load.
14	Stress	Elongation	Stress per unit area	Relative elongation	Force, stress.
15	Stress	Elongation			Strain.
16	Stress	Stretch	Stress per unit area, unit stress	Stretch per unit length, u. stretch	Strain.
17	Stress	Deformation	Stress per unit area	Unit deformation	External force.
18	Stress	Extension	Strain	Elongation	Pull, tension.
19	Stress		Unit stress		Strain.
20	Stress, strain	Elongation, stretch	Stress or strain per unit area	Unit elong., elong. per unit length	Load, stress, strain.
21	Stress, strain	Stretch	Unit strain	Unit stretch	External stress or strain.
22	Stress, strain	Elongation	Unit stress, unit strain	Elongation per unit length	Stress, strain.

	R	s	R ÷ A	s ÷ l	P
23	Strain	Elongation	Strain per unit area	Elongation per unit length	Stress.
24	Strain	Elongation	Strain per unit area	....	Stress.
25	Strain	Elongation	Strain per unit area	....	Strain, force.
26	Strain	Elongation	Strain per unit area	....	Strain.
27	Strain	Elongation	Strain per unit area	....	Stress, load.
28	Strain	Elongation	Unit strain	Unit elongation	
29	Strain	Elongation	Unit strain	Unit elongation	Strain.
30	Strain	Elongation	Unit stress	Linear elongation	Strain.
31	Strain	Stretch, extension, deformation.	Strain per unit area	....	Strain.
32	Strain	Elongation, stretch	Unit strain	Elongation per unit length	Strain.
33	Strain	Stretch	Unit strain	....	Stress.
34	Strain	Extension	Unit strain	Unit extension	Force.
35	Strain	Stress	Strain per unit area	Stress per unit length	Strain.
36	Resistance	Strain	Resist. unit, stress unit	Strain per unit length, strain unit	
37	Breaking stress	Elongation	Ultimate strength	Per cent. of elongation	Breaking stress.
38	Resist., strain.	Elongation.	....	Elongation per unit length	Force, tension, stress.
39	Strain	Distortion	Resistance per unit area	....	Stress.
40	Resistance	Stretch	Resistance per unit area	Stretch per unit length	Force.
41	Internal force.	Strain	Unit stress	Coefficient of strain	External force.
42	Force of rupt.	Stretch, elongation	Rupture strain per unit area	Per cent. of elongation	Force.
43	Resisting force	Stretch, elongation	Stress, specific force	Specific elongation or stretch, per unit length	External force.
44	....	Elongation	....	Per cent. of elongation	Strain.

The figures below explain the symbols:



Yours truly, etc.,

———.

The answers are tabulated on pages 354 and 355.

Even though there are comparatively few engineers represented in the above table, it will be safe to say that Rankine's definitions, especially that of stress, have been adopted by many engineers; and, when it is remembered that all physicists and the "professors (of engineering) almost as one man" follow Rankine; it will be safe to say also that Rankine's definitions are well established.

The terminological mess exhibited in the table ought to appeal to every engineer's sense of exactness and precision and make him willing to adopt any reasonable nomenclature for the universal adoption of which there is hope. Such a nomenclature is Rankine's. The engineering societies could do much toward remedying this matter by endorsing Rankine's terms and encouraging the general adoption of the same.

II. UNIT STRESS, UNIT STRAIN, UNIT ELONGATION, ETC.

The writer proposes to show in the following that the much used terms unit stress and unit strain to designate the quantity $\frac{R}{A}$ and unit strain, unit elongation, etc., to designate the quantity $\frac{s}{l}$ are, scientifically, incorrect.

Stress per unit area is called unit stress; strain per unit area is called unit strain; stretch per unit length is called unit stretch; strain per unit length is called unit strain; elongation per unit length is called unit elongation, etc.

By analogy, if the above are correct, force per unit area should be called unit force; distance traversed per unit time should be called unit distance; load per unit length should be called unit load; weight of a body per unit volume should be called unit weight; work done per unit time should be called unit work, etc.

But the names demanded by the analogy are incorrect, as every one must admit, as a unit weight, for example, must mean that quantity by which weights are measured, and it can not mean anything else so long as the present and accepted meaning of the word unit stands. Likewise the term unit stress means that quantity by which stresses are measured, as the pound, the ton, etc., and it ought not to mean anything else. It is true that high authorities follow the usage which the writer is criticising but notice how illogical the explanation of these terms is by one of them: "Stress is measured in pounds or tons the same as (the external) forces." And may not the reader of the explanation add to himself that the unit stress therefore is one pound or one ton? But he reads next that stress per unit area is called unit stress! Surely such terminology is unscientific and being so it ought to be abandoned.

The terms stress per unit area, elongation per unit length, etc., are, of course, correct but their length is objectionable. The terms stress intensity and relative elongation are in limited use and are fairly good. Better terms could be adopted probably and perhaps, after all this fault finding, the writer might be expected to suggest such better terms but he leaves this for authoritative writers and societies, to whom this matter may commend itself, to do.

NOTES ON ELECTRIC RAILWAY POWER STATIONS.

BY HENRY A. LARDNER, '93; E. E., '95.

The principal points to be considered in the design of power stations for railway work are, the amount of power required per car, the size and number of the units and the arrangement and coupling of the engines and dynamos. Incidentally the kind of engine that will best meet the conditions will be considered.

As the conditions vary in such a marked degree with the size of the station, three divisions will be made in the following notes; and stations operating five, twenty-five and one hundred cars respectively will be considered. This method of procedure is due to Messrs. Crosby & Bell but their cases being worked out on equipment and speeds in vogue several years ago, it is the intention of these notes to bring the subject into harmony with present practice.

The largest element of uncertainty that enters into the problem will be the determination of the amount of power required. The factors that govern this are the weight of the cars, the speed at which they are run and the grades and curves on the line. In small roads with a few cars the grades must be considered very seriously but on roads with a large number of cars the distribution will be so even that a car coming down by gravity and taking no current will in a measure compensate for the extra current of a car going up. Curves of the kind found on street railways take a great deal of power and a road having many of them must have its station designed accordingly. The weights of cars of various dimensions are given in Table 1.

Table 1.

16	feet	body,		Seats	22,	Weight	empty	14,000	Loaded	23,000
18	"	"		"	24,	"	"	15,000	"	27,000
20	"	"		"	28,	"	"	16,000	"	32,500
*21	"	"		"	32,	"	"	16,500	"	32,500
*†25	"	"		"	36,	"	"	23,000	"	42,000
†26	"	"		"	36,	"	"	23,000	"	42,000
*23½	"	"	summer	car	35,	"	"	13,500	"	28,500
*26	"	"	"	"	40,	"	"	14,000	"	31,000
*28½	"	"	"	"	45,	"	"	15,000	"	34,000

The above table is approximately correct and includes the weight of the motors.

The first three cars will have a 2-25 H. P. motor equipment.

The use of various constants determined from the study of existing stations, is here, as in many other engineering problems our best guide in deciding upon the power required per car. But in many cases where the grades are exceptionally severe, the speed high or other conditions remote from existing practice it is necessary to make some calculations.

* These cars have cross seats and others longitudnal.

† These cars will probably have an equipment of two thirty-five horse power motors, and if used for high speed inter-urban service the first two marked with a dagger should have two fifty H. P. motors or four of twenty-five H. P. motors.

Assume the following conditions for a five car road. Track, girder rails. Weight of cars with average load, 20,000 lbs. Equipment, two twenty-five H. P. motors. There are a number of five per cent. grades on the line. Speed desired on the level, 14 miles per hour. Speed on grades, 6 miles per hour.

Upon laying out an approximate schedule for the road we find that it is possible for the following conditions to exist: Two cars running on the level, two working up grades and one starting. The average working conditions may be nothing like as severe as this, but we can see the possibilities of the above conditions and must design our station accordingly.

The power required at the axeles must now be determined for each car. Reliable data for the coefficient of traction is rather hard to obtain and it is harder still to choose a value for a given road and equipment without having first made some tests. As this is out of the question in a new road the best we can do is to choose a value from some existing data which most nearly corresponds to our conditions. Table 2 gives the coefficients as found by different observers, at various speeds and are given in lbs. per ton of 2,000 lbs.

Table 2.

Miles per hour.	5	10	15	20	30	40	50	60
No. 1	9.15	9.6	10.5	11.4	14.6	19	24	31.5
No. 2	15	17.5	20	23	30			
No. 3	15	15.7	16.4	17.6				
No. 4	6.25	6.95	8.1	9.8	14.5	21	29.6	40
No. 5	4.2	4.77	5.7	7.1	10.9	16.3	23.2	31.7
No. 6	3.5	4.5	5.75	7.	9.5	12.	14.5	17.
No. 7		10.						

The values given in No. 1 are by D. K. Clark and are for a "T" rail track. They include such wind resistance as an ordinary car is liable to meet with. No. 2 is based upon Mr. Clark's statement that for tramways where girder rails are used the requirement is from 15 to 30 lbs. per ton. Assuming that 30 miles is the highest speed considered, the values for girder rails will be about double what they are for T rails.

This seems natural as there is apt to be a good deal of friction on the flanges of the wheel on this kind of track. No. 3 is taken from values given in a trade hand-book and probably came from Molesworth. It is for girder rail construction. No. 4 is given by Wellington who deduces a number of empirical formulae for different kinds of rolling stock. The one most nearly suited to street railway work and which is given in No. 4

$$\text{is } \frac{v^2}{106} + 6 = R$$

R is the coefficient, V is speed in miles per hour.

For such equipment as coaches on steam tracks of the best companies the formula is given as

$$\frac{v^2}{130} + 4 = R$$

and the results are given in No. 5. Mr. Wellington does not vouch for these formulae above thirty miles per hour. His data is for T rail practice and includes air and oscillatory friction. (See Wellington's Economic Railway Location.) No. 6 is from Engineering News, March 8th, 1894, and is given the most reliance by Mr. Kent in his hand-book. The formula is

$$\frac{v}{4} + 2 = R$$

No. 7 is from some tests on T rails in Baltimore by Mr. Herman Hering. The track and equipment tested by Mr. Hering were good and the track had its own right of way and was therefore not surrounded by pavement.

Partly from the foregoing data and the remarks which accompany them, and partly from statements of other authorities Table 3 is made up for use in street railway work.

Table 3.

Miles per hour.	5	10	15	20	30	40
1..................	7.5	9	11.5	15	25	39
2..................	9	11	13.75	18.75	31	49
3..................	14.5	16.5	19.5	24.	36	54
4..................	18.	20.6	24.2	30	45	67

This table presumes the usual street railway equipment in good order. No. 1 is for the best T rail track on its own right of way. No. 2 is for T rails laid in the pavement or public road. No. 3 is for girder rail in good condition. No. 4

is for dusty girder rail track. This table is believed to cover most of the conditions existing in practice. If the head of a girder rail becomes worn down enough for the wheel to rub on the flange, the coefficient becomes very much greater than any values given. The resistance of curves at the speeds common to street practice will be about one-half pound per degree per ton. The radius of a curve is approximately 5730 feet divided by the degree of curvature. Thus a curve with a radius of one hundred feet is a 57 degree and 18 minute curve and the resistance would be about twenty-eight and a half lbs. per ton. For every degree of grade the traction coefficient must be increased by 20 and thus the formula for H. P. required by a car is

$$\frac{8 \times W \times S\ [K + (20 \times \text{per cent. grade}) + \frac{1}{2} C]}{3000}$$

where K is the coefficient given in the table, W the weight of the car in tons, S the speed in miles per hour, C the degree of curve.

To return to our five car road. With two cars running on the level each will require seven and one-tenth horse power. This value was arrived at by assuming 19 lbs. per ton as the coefficient. With a gear efficiency of 90 per cent. and an average motor efficiency of 85 per cent., we must have about 9.3 H. P. per car from the line or for these two cars 18.6 H. P.

The cars working up the grades will require 25 H. P. apiece cr 50 H. P. for the two cars on 5 per cent. grades. We have assumed one car as starting, and the amount of power required is not easily calculated during its acceleration. It is a matter of observation however that cars of the size assumed and equipped in a similar manner will take from 80 to 120 amperes while the car is getting up to speed. Cars of different weights and equipments may be assumed to take a corresponding amount of power. Assuming that the starting car takes 100 amperes at 475 volts we require for it about 65 H. P.

The rating of motors is generally placed at the figure that they will run at continuously without serious heating but it must be understood that for short periods of time this rating can be exceeded without inflicting damage. The calculations now show that we need 135 H. P. from the line. The line loss is usually between 15 per cent. and 25 per cent. and assuming 25 per cent. for this item we must supply 180 H. P. from the dynamo. If two cars should be starting, one on the grade and two running on the level, the dynamos would be required to furnish 225 H. P. for short intervals. This gives a constant of 45 H. P. per car. No fixed constant can be advanced for such small roads and each one should be calculated in some such way as indicated.

From the table given by Mr. W. H. Williams in the Wisconsin Engineer of June, 1896, we may conclude that the average load on a station will not exceed 70 H. P. and we have seen what the maximum may be.

Allowing 80 per cent. for the efficiency of the dynamo, engine and belting, the average indicated H. P. will be 87 1-2 and the maximum 265 H. P. Considering the character of the load the only satisfactory engine for this case is a simple high-speed, with a rating at 1-4 cut off of 150 H. P. If the range of cut off is wide, as is usually the case in this class of engines, the load will be at all times within the power of the equipment. In stations of this size it is not generally possible to provide for a duplicate equipment and two engines of one-half this size might suggest themselves as avoiding the danger of a total breakdown. However the use of such small units would be uneconomical and neither one would carry much of the load if left to work alone. Absolute reliability is generally not required in a road of this size. The dynamos should be two in number of about 125 H. P. or 100 K. W. capacity each. Either one of these machines would carry the greater part of the load for some time as most of the modern railway generators are wound to carry a 50 per cent. overload for several hours. They are also designed so that they reach a point of good efficiency at about 1-3 load; so that no great loss is sustained in running them on so low a load as the average.

The dynamos are to be belted from the engine as shown in Fig. 1, and placed so that the engineer will have the commutators in view while he is attending to his engine or switch board. If extension is to be provided for, the switch board may be placed or moved to the dotted position and another engine and generator added as shown by the dotted outline. The switch board

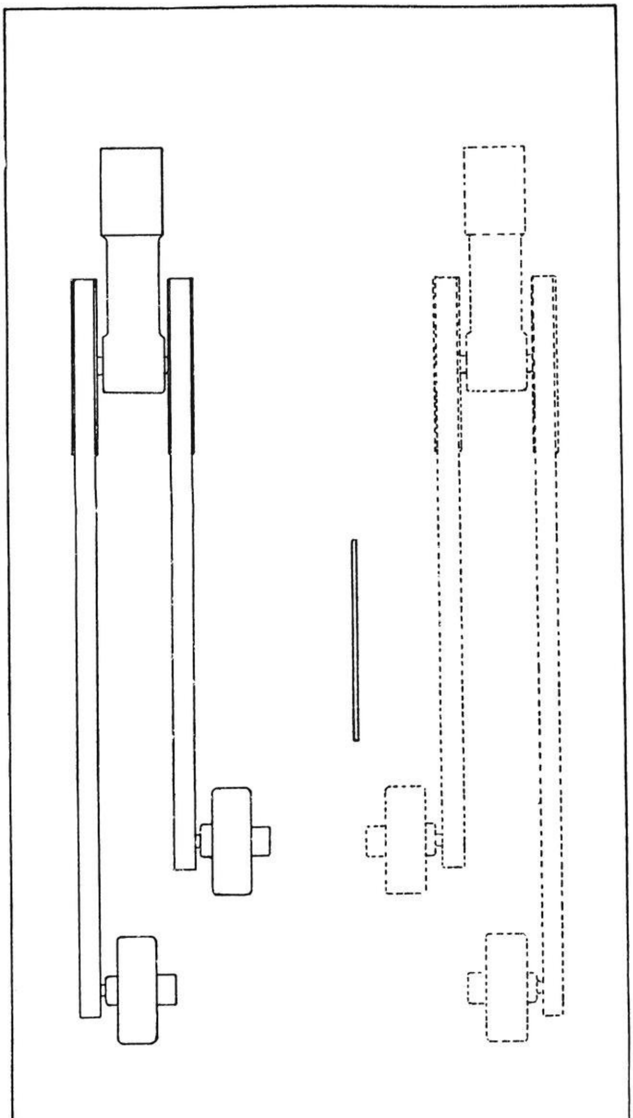


FIG. I,

should consist of two generator panels and at least two feeder panels. Each of the feeder panels should be provided with a switch and circuit breaker, the usual feeder ammeter being omitted if desirable. The object in having at least two circuit breakers on the feeders is that if anything happens on the line it will throw only the breaker feeding that half and the total load will not be thrown off the generators, as is the case in many small stations, where the machine circuit breakers are the only protection and the feeders are made up solid to the bus bars. A summation ammeter may be mounted above the center of the board, and the voltmeter for throwing in the machines at one end on a bracket extending out at right angles. It can thus be seen by the attendant while adjusting the rheostats.

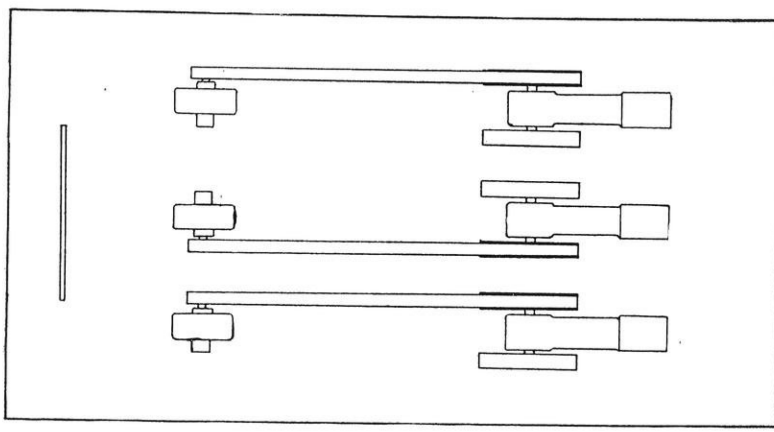


FIG. 2.

The main ammeter and voltmeter may be placed on a separate panel if desired.

An arrangment of the station which will have reliability for its strong point would be to install three engines of about 80 H. P. apiece at one fourth cut off, each belted to a generator of about 60 K. W. capacity. Any two units would carry the load and the third would be in reserve. This arrangement would be especially desirable in the case of an all night load of one or two cars and only one unit need be run. The arrangement is shown in Fig. 2. It will be noticed that the machines are so placed that the commutators are in all cases away from the belts.

For any road having under fifteen cars the load upon the station will be rather irregular and the effects of steep grades and curves will enter in a way that is hard to estimate and the safest way is to work the problem out in the manner indicated. It is probable that the lowest figure that could be taken for any road with less than 20 cars is 30 H. P. per car as a maximum demand, but if speeds are slow and grades light it might be possible to reduce this somewhat.

In considering the class of roads of from 25 to 50 cars with the equipment of two 25 H. P. motors per car the results may be arrived at most easily by consulting the data of existing stations. In this class there are enough cars on the line to make the load fairly constant and starting cars and cars climbing grades will not have such a noticeable effect. Twenty to twenty-five H. P. per car in the dynamos will be required in this size station provided the speed of twenty miles per hour in the suburbs is not exceeded, the usual speeds in the city maintained and the grades light. There are some inter-urban roads of this size making high speeds that are using 30 H. P. per car in the generator. Taking 25 H. P. per car, the 25 car station should have 625 H. P. in the generators and about 750 H. P. maximum in the engines and a probable average load of 600 indicated H. P. in the engines. In a station of this size a breakdown would be intolerable and therefore a spare unit must be provided.

For economy in first cost of running expenses we desire to keep the units as large as possible and yet not have too large a spare set lying idle. Consulting modern practice again we find that the best favored plan would be to install four 200 H. P. engines. These engines will be used three at a time in regular rotation and as the load will be fairly constant they may be chosen from the Corliss or other high grade types and of such size as to give 200 H. P. at the most economical point of cut off. They may be compounded if condensing water can be obtained. As Corliss engines are now built with a wide range of cut off for railway work two of these machines will carry the load in an emergency. The dynamos, four in number, should be belted, one to each engine and as we have provided for a spare in this station there is no reason for making them more than 200 H. P. or 150 K. W. apiece, especially as standard makes will carry 50 per cent. overload for some little time. The arrangement of the station is merely an extension of Fig. 2 to four units, space being left for an additional unit. If there is a strong probability of an increase in power being demanded within a short time the installation should be three units of 300 H. P. each, thus keeping the final equipment down to four units. Standard sizes of generators should alone be used to obviate the trouble in getting supplies; and having the machines all of a size will reduce the spare parts to be kept on hand to a minimum. It may be stated as the best practice in stations of any considerable size that the size and number of units may be decided upon by dividing the total H. P. required by three for the size of the unit and adding one more of the same size as spare. Thus in most of the best modern stations four units are found and where extension is certain to be required three units form the equipment. Unless crowded for room it is not advisable to direct connect engines and dynamos until the size of the generator reaches 400 or 500 K. W. Beyond this the belts get cumbersome and the generators are not built beyond 500 K. W. for direct driving. Below 500 K. W. the cost of the slower speed direct connected units is against their use. The belt driven 500 K. W. machine of one of the standard companies run at 320 revolutions and weighs 45,000 lbs., while the direct connected unit of the same size runs at 110 revolutions and weighs 98,000 lbs. It is needless to say that their cost is not the same.

Connecting by means of a countershaft has one advantage, that of complete flexibility in connecting engines and dynamos, but it is so expensive and wasteful of energy that it is now seldom seen. Another reason for the falling into disuse is the continually increasing reliability of station machinery.

A few remarks only will be needed concerning the 100 car road. Fifteen H. P. per car in the generators will in general be sufficient. Some of the level lines in Philadelphia report as low as 12 and one or two roads having 200 or more cars from one station as low as 10 H. P. per car.

A figure as low as the last should not be recommended without great care. For high speed inter-urban traffic as much as

20 H. P. per car is provided in some of the stations near Boston that are running over 100 cars.

In roads having over 100 cars the constant does not fall in any marked degree with the increase of load and is governed more by grades and speed than by the addition of extra cars.

The size and number of units in stations of 100 cars or more can be readily determined by the rules suggested and in general will be direct connected generators driven by compound condensing engines of the most efficient types.

Cross compound engines with the dynamo in the middle of the main shaft are among the most favored types and some twin tandem compounds are used in the same manner. Triple expansion engines are not well suited to railway work, as, even in the largest station, it cannot always be arranged to have a full load on each engine. Vertical engines are not recommended where space will permit the horizontal type, the former being more expensive and harder to inspect and repair.

Where equipment other than two twenty-five H. P. motors per car is considered necessary, a proportional amount of the values given for the H. P. per car should be used.

SOME NOTES ON ELECTRIC STREET RAILWAY TRACK.

By W. M. CAMP, B. S.
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The object of this paper is to point out present tendencies in street railway track construction as regards the types of materials used, the manner of putting them together in the track, and methods of ballasting the track and the materials used therein.

In streets where no paving has been used or contemplated the common practice has been to spike the rails directly to the ties and fill the track with dirt or ballast even with the rail top; for this a rail of ordinary height has answered. But where paving has been used it has, until late years, been customary, in order that a rail of ordinary height—say four or five inches—might be used with paving blocks of 6 or 8 inches or of ordinary thickness, to support the rail a sufficient height above the ties to bring its top even with the top surface of the paving blocks. One manner of supporting the rail very widely practiced was with cast or wrought iron chairs spiked to the ties. However this method was never satisfactory, as it placed the rail too far from its real support—the ties—the consequence being that most generally the rails, sooner or later, spread or tilted badly. In certain instances care was taken to electrically weld the rails and chairs together. Another method was to lay the rails on 6x8″ or 5x7″ stringers which were placed upon the ties and held against being spread by spiking cast angle braces against both sides on each tie. This added some stiffness to the track vertically and the spacing between the ties was on this acount increased to 3 feet in many instances. As it was difficult to properly tamp the ties, directly under the stringers, and also because fewer ties were used, track in most cases did not hold up as well as where stringers were not used; and, in spite of the stringers being braced, the rails were spread upon them, inasmuch as the stringers were frequently split by the driving of the spikes. Then as soon as the stringers began to decay the rails would become badly tilted. The result of this experience has been that both chair supports and stringer supports for the rail have been abandoned in recent work and the older, simpler, and surer method of spiking the rails directly to the ties has been taken up again as the only substantial and satisfactory one.

In order to simplify the construction of track in paving, rails are now made deep enough to reach the ties without supports. The sections are made comparatively narrow at the base (usually about 5 inches) and with a web thin in proportion to the height. The gauge is maintained by means of tie rods placed between the rails at intervals. The latest forms which have come into largest use are the "Shanghai" and the "Philadelphia" types. The Shanghai type is in cross section a "T" rail about 7 inches in height, rolled in weights from 70 to 85 lbs. per yard, according to the proportions given to the head, web and flange in the different sections. The Philadelphia type is a girder rail, rolled in sections from 7 to 9 inches in height, weighing from 80 to 95 lbs. per yard, the name having been taken from the city where it was first introduced. Sections up to 10 1-2 inches in height have been proposed but it is not known that any such have as yet come into use. These two types, spiked directly to ties distributed about 17 in number to the 30 ft. rail, may be taken to represent the latest and best practice of the present day. They should be connected together above the middle line of the web every 6 feet by 3-8x1 1-2″ flat tie rods having round ends, each end provided with two nuts to facilitate adjustment.

The use of tie rods with rails of high section is to provide against their being tilted and spread by heavy teaming which is much more severe on track than street car traffic. On streets where vehicular traffic is light, tie rods are not needed; and on curves they are not needed, in any event, on account of the stiffness of the curved rail, it not being possible to tilt a rail so sharply curved as rails in street curves generally are, without throwing its ends up or down. Rail braces are sometimes used in street car track but they are not needed. In paved streets the paving takes the place of a brace and in unpaved streets wagon wheels will cut down beside the rail and bend or knock out the braces.

Such depth of rail gives great stiffness for the weight, the thinness of the web having as yet developed no failures. The difficulty in rolling rails of such sections so as not to have undue strains developed in certain parts of the metal, while cooling, is now thought to be largely overcome. Track laid with such rails, if properly supported above solid ground, ought to hold to good surface until the rails are worn out.

Unlike steam road practice, rails laid in track covered up in the street should be butted together, if laid at average temperature, no space being left at the joints to provide for expansion due to heat.

If the rails are laid when the temperature is below its medium, leave a small space at each joint such that the rail at average temperature will expand to just close the joint. There are several reasons for this. In the first place, the rail being in contact with the ground or pavement, except on its top surface, will not be subject to such wide variations of temperature throughout the day as a rail open to the air over the whole extent of its surface, inasmuch as its heat will be given up to or taken from the earth whose temperature does not change so rapidly as that of the air. But not to take into consideration this fact at all, the track is so firmly held by its covering that there is no danger of its being thrown into kinks or out of line by high temperature, as is the case with steam road track. It has been thought that nothing could resist the expansion or contraction of metals by change of temperature; but experience teaches that closely laid rails in streets cannot and do not expand and that the strains which in open track would cause either expansion or buckling, are here taken up in the rails themselves. It is found that the strains are less than the strength of the metal below the elastic limit. The advantage of small space at the joints on street railways is greater than with steam roads, owing to the smaller diameter of the wheels on the former and the consequent greater drop of the wheel into the open space.

If it is thought that longer rails for steam roads are an improvement, there is every reason why rails longer than 30 feet should be an even greater improvement to tracks in streets, because the greater joint space made necessary by increase of rail length with the former does not become an objection in the latter case where no joint space is required. Besides the decreased number of joints, there is, with the electric railway, the decreased cost of bonding, and very certainly an increase in the conductivity of the rails, taking bonding at its best. Rails for tracks in streets should, then, be the longest possible which can be had. At present they can be had in 60 ft. lengths, but it would be better to use longer ones and no doubt the time will soon come when they can be had 100 feet long or even longer. Any additional expense which might be incurred in the handling of such long rails, as compared with the expense of handling 30 ft. lengths, would be many times repaid by the advantages to be had by their use. As rails in street tracks are seldom taken up before they are worn out there could not be urged the slight objection, sometimes offered in the case of steam roads, that longer rails might at times require larger section crews.

Girder rails usually come from the rolls all turned in the same way. With respect to one side of the track, half must, of course, be turned oppositely from the other half. If possible, such long rails of the girder type should be sent from the point of shipment turned end for end half and half; otherwise half of them should be turned when unloading from the car, as turning them when they are about to be laid takes time and in narrow streets there might not be sufficient room to do it conveniently. Another arrangement which would accomplish the same purpose would be to get the railroad company which hauls the rails to take half the cars in each shipment to a turntable or "Y" and turn them. A portable derrick furnishes the cheapest and most convenient means for unloading rails from cars to wagons.

Rails in street tracks should be laid broken jointed; that is, a joint on one side of the track should come opposite the middle or intermediate portion of the rail on the other side of the track. Especially where cars with single trucks or wheel bases are used, low joints or rough places in the surface, when directly opposite, as in square jointed track, cause a violent teetering of the car body which, from its long overhang and spring support, gains momentum enough to keep it vibrating long after the bad spot has been passed.

Splices.—Much attention should be given to splices at the joints, if anything, more so than on openly built track, on account of their inaccessibility. Either fish plates or channel plates have been the splices most used but there is no reason why heavy angle bars should not be used for girder types, as well as for the T rail. The splice should be long, provided with six 1-inch bolts, and where rails of the deeper types above referred to are used there should be twelve 7-8 inch bolts in two rows of six each, staggered; the splice in either case should be fully 48 inches long. Where there are double rows of bolts, each splice bar is usually rolled with a rib running lengthwise along its middle between the two rows of bolt holes. The nuts should fit the bolts snugly, so that they will not work loose.

As splices always work to a better fit after the track has been used for some time, the bolts should be tightened, and this cannot be conveniently done where the splice is closely packed about with pavement. An excellent, though somewhat expensive, arrangement has been to provide a removable covering for each splice in the shape of a casting called a "joint box". This box is placed with its open side against the outside of the rail so as to cover the splice and is spiked to the ties, the paving then being laid up to and around the box. The upper side of the box is provided with a removable corrugated cover which can be taken up at any time when it is desired to get at the bolts. When no contrivance of this kind is used, some form of positive nut lock might be used and the bolts should be tightened all they will stand the last thing before putting down the paving, driving both bolts and splice bars to a tight fit by striking with a heavy hammer. Unlike steam road practice, the splices for rails in streets cannot be made too tight; and it ought, therefore, to be possible with long heavy splices tightly bolted to secure a much stronger rail at the joint than we could expect to get on the steam road.

Ties.—The standard length for cross ties in street railway track of standard gauge is 7 feet. The length is made shorter than with ties in open track in order that less tearing up of pavement and less excavating outside the track be necessary when getting at the ties for repairs. Ties laid in street tracks should be spaced the same as ties laid in open or steam road tracks; that is, laid with an interval between of just sufficient width to allow a shovel to be used conveniently; this will require about 17 pole ties of 6 to 8 inch face per 30 feet of track. It is wrong to specify that pole ties be laid any certain distance apart centre to centre, unless such is intended to mean an average distance or spacing, because pole ties are never all of the same width of face; nevertheless the largest practice, apparently, calls for ties laid "two feet centres".

Cedar ties with tie plates are undoubtedly the best for street use. The durability of ties in covered tracks is, on the average, about the same as in open track; for while there are some conditions, probably, that tend to lengthen the life of a buried tie, the drainage for track in streets is usually so poor that any conditions favorable to increased life are offset by it. Inasmuch as the cost of renewing ties in paved streets is heavy, it would seem that some of the tie preserving methods practised by steam roads ought to be a more paying investment for street roads than with steam roads even, and it is certainly worth careful consideration.

Unless the ties are of the softest woods the use of tie plates is not to be recommended. Ordinarily street track has very little curve in proportion to its whole length; the curves are used mainly for turning corners and are necessarily short. There is no tendency for the traffic of the railway to spread rails or spikes on straight line and the pavement assists much to hold the rail in place, besides when tie rods are used with high rails there can be no spreading caused by heavy teaming traffic. As the use of tie plates on steam roads with any kind of timber, except the softest, is a question open to debate; there can be far less reason why they should be used in street track to protect ties from being cut into by the rail; because the number of wheels passing a given point per day on steam road is far greater than the number passing a given point on street track (comparing, say, roads of each kind doing average business) while the wheel loads for steam roads are several times those of street car wheel loads and they also move at a much higher average speed.

Steel ties are to be recommended, where the track is ballasted with concrete. A light flat or corrugated tie is perhaps sufficient because the tie is not needed so much to *support* the rail as *to hold it to gauge*, the concrete itself serving as a support. The tie ought to be dipped into and heavily coated with coal tar while it (the tie) is hot from the rolls.

Ballast.—In order to get sufficient depth for ballast considerable excavation must usually be made, where the top of the rail is placed at street grade, as it usually is. A hard road or a macadam pavement is most cheaply broken up for excavation by doubling teams on a special form of narrow plow called by some a "rooter". It consists essentially of a straight plate of steel about 7-8 inch thick attached to a beam and held in a vertical position while it is being drawn through the ground, the bottom front corner of which plate is drawn out into a point so lining as to draw downward slightly. A common mouldboard plow encounters too much resistance and cannot, therefore, reach deeply enough to do good work.

Owing to the difficulty, and often the impracticability, of properly draining track roadbed in streets, the matter of ballasting the same is surrounded by some conditions and difficulties not met with in open track; but unless something in the way of ballast is provided, the track might, during wet weather, be well regarded as a large churn dasher for stirring up the mud. For track laid in unpaved streets, gravel ballast will answer quite well and is often the best that can be afforded. Cinders are much better on account of being a better absorbent of moisture and should be used, where they can be had. Where the ground underneath is of such nature that rainfall passes away with average rapidity, a depth of 6 inches of gravel ballast, or even 4 inches, under the ties will usually hold track to fair surface, so that the expense of raising and tamping it occasionally does not become burdensome. And where the ground under the street does not take up water so readily, a greater depth of gravel than 6 inches will not usually accomplish any better results because the excavation for the track will catch and hold water and will churn up and down in the ballast. The best thing to do in such case is to turnpike the street, make the track its crowning point, and keep the ditches open on both sides. Little trenches should then be made between the track excavation and the ditch at frequent intervals and be filled with gravel. Where the street is not already made crowning so as to shed water, the trouble of making it so when laying the track is not great, for the track can be placed at the proper grade with less excavation and the material thrown out of the ditches can be used to build up the sides of the street to conform to the track.

But when track is laid in paved streets, conditions are still more changed and the expense of tearing up pavement in order to repair rough track becomes such a considrable item that more money must be expended in the ballasting, so far as repairs can be reasonably reduced. In the first place, the bed of the excavation for the track, if not very firm ground, should be well rolled down with a 15 ton steam roller before ballast of any kind is placed upon it. Keep rolling as long as the ground continues to settle. Places inaccessible to the roller should be rammed by hand and all soft places where trenches have been dug for sewers or water pipe should be well "puddled" or flooded with water and allowed time to settle. The ballast should then be thrown on and spread and well rolled down evenly before the track is laid, so that it (the track) will not thereafter require raising more than an inch or so to place it to grade. If there is time to turn on water and flood the gravel and then to dry it out before the rolling is done, all the better. Conditions are here different from those of the steam road type of track, where the bed is compacted by the settlement under trains, it being the cheaper method on account of its accessibility to repairs at all times. After the track is laid the tamping should be done with tamping bars, or with tamping picks if broken stone is used in place of gravel.

Six inches of broken stone ballast ought to be afforded track laid in paved streets. The stone should be broken or crushed to pass through a ring of 2 inches internal diameter and just enough sand should be mixed with it to fill the interstices, so that the ground underneath cannot work up through and cause settlement. The best method of doing this is to throw sand over the ballast after it is in place and wash it in with water from a hose, a process familiarly known as "puddling". It should then be well rolled down and such a depth should be used that the track will require raising about 2 inches to get it to grade. Then as fast as the track is ballasted, either with this or any other kind of ballast, a car loaded as heavily as possible should be kept moving back and forth over it so that all slight settlement can be picked up before the pavement is put down. Track carefully put up or ballasted in this manner ought to hold very well and it is, perhaps, the wisest construction for any except the best paying roads. Where necessary, the draining of the excavation should be looked after. Space between the ties should be filled in with the same material that is placed underneath them, with a shallow coating of sand over the top as a bedding for the pavement.

The best thing, if it can be afforded, is where the bed underneath the ties is made a mass of concrete, 6 or more inches thick. The advantages gained by the use of concrete are that the pressure from above is distributed evenly over the ground and no churning of ties can take place even if the whole structure be permeated with water. The use of concrete, however, could not be recommended where the ground has been but recently made or is for any other reason of a yielding nature or where there is probability of excavation being made under or near the track by city or other authority. The ground should be thoroughly rolled and concrete should be laid evenly so that the amount of sand ballast necessary to give the ties an even bearing upon it shall be as shallow as possible. Sufficient water should be thrown upon the concrete to enable it to set properly and it should be protected against disturbance until it has set. The spaces between ties and slightly above them are sometimes filled with concrete in order that the paving may have an even bearing over the whole surface, between the ties as well as on top of them; but where wooden ties are used this plan can hardly be approved of, as the necessary breaking up of the concrete when the ties have to be removed would spoil the whole bed. The spaces between the ties should be filled in with broken stone, rammed and afterward puddled with sand. But where steel ties are used it would be better to make all filling with concrete.

The concrete should be thoroughly mixed upon a platform. The sand and cement should first be thoroughly mixed in the dry state, when water enough should be added to form a good mortar. The stone should be wetted before being added and the whole well mixed together by turning over and over with shovels. The proportion, by measure, for Portland cement would be about 1 part cement to 3 of sand and 7 of stone; for Rosendale, 1 of cement, 2 of sand and 5 of stone.

Another and later method of construction is the use of a concrete foundation without tie supports of any kind, the rails being held by tie rods and set in and supported by the concrete. This plan has been adopted in Montreal and Toronto, Canada, where the severity of the winters ought to test it well, if anywhere, where block paving is used the concrete is brought to a height even with the base of the rail, except where the filling is made around each rail to hold it in place. Where asphaltum paving is used the track is filled in with concrete to about half the height of the rail. It would seem, however, that steel ties laid in concrete offer a more desirable way of holding the rail to place than that of embedding it in concrete, owing to the necessity for breaking up the concrete in event of renewing rails therein.

EDITORIAL NOTES.

The success of the last number of the ENGINEER appears to have been even more marked than that of the first issue. With the aid of our alumni in supplying articles we have been able to take a place in the front rank of college technical publications. The immense amount of work required in its publication, (especially in preparing the index), has been cheerfully performed by the students. But we have found greater difficulties, in meeting the expenses required in its publication, the amount of which must be apparent to all. The majority of the engineering students subscribe, but as their number is limited,

Wisconsin Engineer Index

To Current Engineering Periodicals.

Explanation:—W, words, M. Jan., W. Jan. 4, or E. Jan. 6, at the end of the reference, indicates that a description or digest of the article may be found in the index of the Engineering Magazine of January, in The Electrical World digest of January 4, or in the Electrical Engineer digest for January 6th.

List of periodicals from which articles are indexed:

Age of Steel, The. *w.* $3. St. Louis.
American Architect, The. *w.* $6. Boston.
American Electrician. *m.* $1. New York.
Am. Engineer and Railroad Jour. *m.* $2. New York.
Am. Chemical Journal. *b-m.* $4. Baltimore.
Am. Gas Light Journal. *m.* $3. New York.
American Geologist. *m.* $3.50. Minneapolis.
Am. Journal of Science. *m.* $6. New Haven.
American Machinist. *w.* $3. New York.
Am. Manufacturer and Iron World. *w.* $4. Pittsburgh.
American Miller. *m.* $2. Chicago.
American Shipbuilder. *w.* $2. New York.
Am. Soc of Irrigation Engineers. *qr.* $4. Denver.
Annual Report of Illinois Society of Engineers and Surveyors. New York.
Architect, The. *w.* 26s. London.
Architectural Record. *qr.* $1. New York.
Architectural Review. *qr.* $5. Boston.
Architecture and Building. *w.* $6. New York.
Australian Mining Standard. *w.* 30s. Sidney.
Boston Journal of Commerce. *w.* $3. Boston.
Brick. *m.* $1. Chicago.
Brick Builder, The. *m.* $2.50. Boston.
British Architect, The. *w.* 23s. 8d. London.
Builder, The. *w.* 26s London.
Bulletin Am. Iron and Steel Assn. *w.* $4. Phila.
Bulletin of Univ. of Wisconsin. Madison.
California Architect. *m.* $3. San Francisco.
Canadian Architect. *m.* $2. Toronto.
Canadian Electrical News. *m.* $1. Toronto.
Canadian Engineer. *m.* $1. Montreal.
Canadian Mining Review. *m* $1.50. Ottawa.
Cassier's Magazine. *m.* $3. New York.
Clay Records. *m.* $1. Chicago.
Colliery Engineer. *m.* $2. Scranton.
Colliery Guardian. *w.* 27s. 6d. London.
Compressed Air. *m.* $1. New York.
Domestic Engineering. *m.* $2. Chicago.
Electric Railway Gazette. *w.* $3. New York.
Electrical Age. *w.* $3. New York.
Electrical Engineer. *w.* 19s. 6d. London.
Electrical Engineer. *w.* $3. New York.
Electrical Engineering. *m.* $1. Chicago.
Electrical Industries. *m.* $1. Chicago.
Electrical Journal. *s-m.* $2. Chicago.
Electrical Plant. *m.* 6s. London.
Electrical Review. *w.* 21s. 8d. London.
Electrical Review. *w.* $3. New York.
Electrical World. *w.* $3. New York.
Electrician (Electn.) *w.* 24s. London.
Electricity, (Elec. Lond.) *w.* 7s. 6d. London.
Electricity (Elec.) *w.* $2.50. New York.
Electrochemische Zeitschrift. *m.* 18.40 marks. Berlin.
Elektrotechnicker Anzeiger. *s-w.* 10 marks. Berlin.
Electrotechnische Zeitschrift. *w.* 25 marks. Berlin.
Engineer, The (Eng.) *s-m.* $2. New York.
Engineer, The (Eng. Lond.) *w.* 36s. London.
Engineer and Contractor. *w.* $1. San Francisco.
Engineer's Gazette. *m.* 8s. London.
Engineering (Engng.) *w.* 36s. London.
Engineering and Mining Jour. *w.* $5. N. Y.
Engineering Magazine. *m.* $3. New York.
Engineering-Mechanics. *m.* $2. Phila.
Engineering News. *w.* $5. New York.
Engineering Record. *w.* $5. New York.
Engineering Review. *m.* 7s. London.
Eng. Soc. of the School of Prac. Sci. Toronto.
Eng. Soc. of Western Pennsylvania. *m.* $7. Pittsburgh.
Fire and Water. *w.* $3. New York.
Foundry, The. *m.* $1. Detroit.
Garden and Forest. *w.* $4. New York.
Gas Engineers' Magazine. *m.* 6s. 6d. Birmingham.
Gas World, The. *w.* 13s. London.
Heating and Ventilation. *m.* $1. New York.
Ill. Carpenter and Builder. *w.* 8s. 8d. London.
India Rubber World. *m.* $3. New York.
Indian and Eastern Engineer. *w.* 20 Rs. Calcutta.
Indian Engineer. *w.* 18 Rs. Calcutta.
Industries and Iron. *w.* £1. London.
Inland Architect. *m.* $5. Chicago.
Inventive Age. *s-m.* $1. Washington.
Iron Age. *w.* $4.50. New York.
Iron and Coal Trade Review. *w.* 30s. 4d. London.
Iron and Steel Trades Jour. *w.* 25s. London.
Iron Industries Gazette. *m.* $1.50. Buffalo.
Iron Trade Review. *w.* $3. Cleveland.
Jour. Am. Soc. Naval Engineers. *qr.* $5. Washington.
Jour. Assn. Eng. Societies. *m.* $3. St. Louis.
Journal of Electricity, The. *m.* $1. San Francisco.
Jour Franklin Institute. *m.* $5. Phila.
Journal of Gas Lighting. *w.* London.
Journ. of Inst. of Elect. Engineers. London.
Jour. New England Waterw. Assn. *qr.* $2. New London.
Jour. of Royal Inst. of British Arch. *s-qr.* 6s. London.
Journal of Society of Arts. *w.* London.
Journal of the Western Society of Engineers. *b-m.* $2. Chicago.
La Nature. *w.* 24.50 francs. Paris.
L'Eclairage Electrique. *w.* 60 fr. Paris.
L'Electricien. *w.* 25 fr. Paris.
L'Energie Electrique. Paris.
L'Industrie Electrique. *b-m.*
Locomotive Engineering. *m.* $2. New York.
Machinery. *m.* $1. New York.
Machinery (Mach. Lond.) *m.* 9s. London.
Manufacturer and Builder. *m.* $1.50. New York.
Manufacturer's Record. *w.* $4. Baltimore.
Marine Engineer. *m.* 7s. 6d. London.
Master Steam Fitter. *m.* $1. Chicago.
Mechanical World. *w.* 8s. 8d. London.
Metal Worker. *w.* $2. New York.
Mining and Sci. Press. *w.* $3. San Francisco.
Mining Industry and Review. *w.* $3. Denver.
Mining Journal, The. *w.* £1, 8s. London.
Mining World, The. *w.* 21s. London.
Municipal Engineering. *m.* $2. Indianapolis.
National Builder. *m.* $3. Chicago.
Nature. *w.* $7. London.

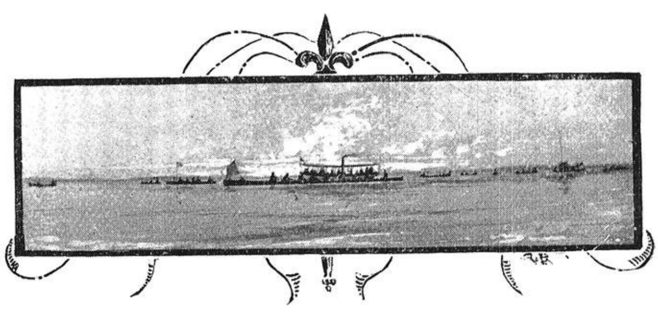
and as advertising is difficult to obtain at the present time, we must rely to a considerable extent upon the hearty support of our alumni. Although many have sent in their subscriptions we know there are many more who should give us their aid. Besides getting good value for their money, our alumni should feel that by subscribing they are aiding us in publishing a magazine that is helping to make a name in engineering circles for "Old Wisconsin".

Our Field of Work.—Some of the students have objected to our practice of publishing theses and of reviewing the engineering bulletins. Their argument is that they can and do read these productions in the original; consequently do not care to read the abstracts given in the WISCONSIN ENGINEER. When these same men get to writing theses, they will no doubt think differently but, laying personal feeling of this kind aside, we appreciate their sentiment. Our subscribers, however, include a large body of alumni and other engineers as well as numerous libraries, and the investigations carried on in our own labaratories are of great interest to them. We are therefore compelled to proportion the class of reading matter according to the demands of these two classes of subscribers. These considerations should waive all further objections.

Engineering Lectures.—The engineering department is to be congratulated in securing such prominent and able men on its staff of lecturers as have appeared, and others yet to appear, during the present series. We have had with us some of the most prominent engineers in the country and to hear from them their experiences in the engineering world is an advantage readily appreciated by the student body. If attendance and interest is any criterion the popularity and success of the course is established and if the standard, as at present set, is maintained, which it no doubt will as will be seen if the appended list is looked over, the future success is assured and the object sought for attained.

A short sketch of the different lectures already delivered is here given. Also a short sketch of the lecturers,

New Science Review, The. *qr.* $2. New York.
Physical Review. *b-m.*
Plumber and Decorator. *m.* 6s 6d. London.
Popular Science Monthly. *m.* $5. New York.
Power. *m.* $1. New York.
Practical Engineer. *w.* 10s. London.
Proceedings Engineers' Club. *qr.* $2. Philadelphia.
Progressive Age. *s-m.* $3. New York.
Railroad Car Journal, The. *m.* $1. New York.
Railroad Gazette. *w.* $4.00. New York.
Railway Age. *w.* $4. Chicago.
Railway Master Mechanic. *m.* $1. Chicago.
Railway Press, The. *m.* 7s. London.
Railway Review. *w.* $4. Chicago.
Railway World. *m.* 5s. London.
Safety Valve. *m.* $1. New York.
Sanitarian. *m.* $4. Brooklyn.
Sanitary Plumber. *s-m.* $2. New York.
Sanitary Record. *m.* 10s. London.
School of Mines Quarterly. $2. New York.
Science. *w.* $5. Lancaster, Pa.
Scientific American. *w* $3. New York.
Scientific Am. Supplement. *w.* $5. New York.
Scientific Machinist. *s-m.* $1.50. Cleveland.
Seaboard. *w.* $2. New York.
Sibley Jour. of Engineering. *m.* $2. Ithaca, N. Y.
Southern Architect. *m.* $2. Atlanta.
Stationary Engineer. *m.* $1. Chicago.
Steamship. *m.* Leith, Scotland.
Stevens' Indicator. *qr.* $1.50. Hoboken.
Stone. *m.* $2. Chicago.
Street Railway Journal. *m.* $4. New York.
Street Railway Review. *m.* $2. Chicago
Technology Quarterly. $3. Boston,
Tradesman. *s-m.* $2. Chattanooga, Tenn.
Trans. Am. Inst. Elect. Engineers. *m.* $5. New York.
Trans. Am. Inst. Mining Engineers. New York.
Trans. Am. Soc. Civil Engineers. *m.* $10. New York.
Trans. Am. Soc. Mechanical Engineers. New York.
Transport. *w.* £1, 5s. London.
Western Electrician. *w.* $3. Chicago.
Western Mining World. *m.* $4. Butte, Mon.
Wiedemann's Annalen.
Wisconsin Engineer. *qr.* $1.50. Madison.
Zeitschrift für Beleuchtungswesen.
Zeitschrift für Electrochemie. *s-m.* 16 marks. Halle.



By *J. A. L. Waddell and Mr. Hedrick.*

Mr. Waddell is widely known as an engineer and the university was very fortunate in securing this course of lectures from him. He is a native of Canada but obtained his professional education at the Renssaeler Polytechnic Institute, graduating in 1875. Besides the regular degree obtained there he has since received an honorary and a master's degree from McGill university. He has spent a large part of his life in bridge engineering chiefly in private practice, but was for several years the western representative of the Phoenix Bridge Company. Some of his most important structures are the Halsted street lift bridge in Chicago; the Red Rock cantilever bridge with a 660 foot span; and bridges over the Missouri River at Jefferson City, Omaha and Sioux City. He has also acted as consulting engineer for the Lake street and Northwestern Elevated Railroads in Chicago.

Mr. Ira Hedrick is chief draughtsman for Mr. Waddell. Six lectures were delivered by Mr. Waddell assisted by Mr. Hedrick.

First Lecture. — Mr. Hedrick read from a paper by Mr. Waddell written for Am. Soc. C. E. on Elevated Railroads describing bad features of ordinary work. He then discussed the general principles involved, necessity of studying local conditions and adapting structure to them. He illustrated by the work done on the Northwestern L and the Union loop of Chicago. He then showed the 6 or 7 designs showing different methods of solving problems, only one or two of these however giving minimum weight of material for equal stiffness.

Second Lecture.—By Mr. Waddell on First Principles of Bridge Design, consisted of several chapters of a proposed book which were written for the use of the men in the office. He emphasized strongly the importance of keeping close to theory and stated in some 25 axioms all the important fundamental points in bridge designing. The various styles of trusses were shown and commented upon as was also the new form of truss, called the "A" truss, designed by Mr. Waddell.

Third Lecture was on the Artistic Design of Bridges. The importance and frequent neglect of this feature was discussed. He showed that much could be done in the way of improving appearance with little or no extra cost. Views were

shown, showing a striking contrast between designs where this effect was considered and where it was neglected.

Fourth Lecture was a continuation of Lecture 2.

Fifth Lecture.—A large number of blue prints were shown and explained. These included some large structures such as a design for a bridge over the Danube at Buda Pesth of 1100 feet span. Many other structures were shown and commented upon. He then read a paper which he had delivered at University of Kansas and dealt with the work of the engineer.

Sixth Lecture.—By Mr. Hedrick describing the construction of the Jefferson City and Sioux City Bridges giving a complete history from the prospectus to the opening of the bridge illustrating all steps with lantern slides.

By *Mr. Isham Randolph.*

Mr. Randolph lectured on February 5th on the "Chicago Drainage Canal". He has been very prominently connected with construction work since 1880. Among the largest of these works may be mentioned the Chicago and Western Indiana Belt Railway, the Chicago, Madison and Northwestern Railway and the Chicago Drainage Canal. In the latter he is acting as Chief Engineer at present.

He outlined the growth of Chicago in population and commerce; gave a history of her water-supply and sanitary works and of the inception of present canal. He showed 130 slides illustrating the various methods employed by contractors for building the canal through the different classes of materials. His analyses of the causes leading to success or failure of particular machines contrived for special work was thoroughly enjoyed by all, as was his discriminating review of the records of work done by the various methods. The lecturer was particularly happy in introducing bits of humor to liven the time devoted to the lecture.

By *W. N. Merriam.*

Mr. Merriam gave a talk on February 6th on a recent trip to the South African Gold Mines. He is a graduate of U. W. with class of '81. He was for a number of years assistant geologist on the Lake Superior division of U. S. Geological Survey and has since engaged in mining work in Lake Superior region and elsewhere. His visit to the Gold Mines in Africa was made as agent of one of the largest American Companies manufacturing

mining machinery. After describing the trip in detail, the methods resorted to, to spend the time on the steamer, the tediousness of the journey by rail to the mining country, etc., he entered into the different processes of producing the metal. He illustrated his lecture by many views both as regard to the mining characteristics and also the characteristics of the natives. The lecture was very entertaining and was well received.

The following men will lecture before the end of the school year:

R. H. Pierce, Consulting Engineer, Chicago.

D. E. Baker, General Manager Metropolitan West Side Elevated Railway, Chicago.

M. H. Sperry, Signal Engineer, National Co.

E. C. Carter, Prin. Ass't., Engineer, C. & N. W. R. R.

J. N. Barr, Supt. Motive Power, C. M. & St. P. R. R.

R. H. Thurston, Director of Sibley College, Cornell University.

Boardman's Article.—An article on cement testing appears elsewhere in this number; the paper being quite long, on account of lack of space, and not wanting to cut any matter out, it was decided to present it in two numbers. This article is of special interest to engineers, as it presents the latest methods of the work. The amount of cement used in this work is simply enormous, being much greater than has ever been used on any engineering enterprise in the world. The testing done is very thorough and the methods used are the most up to date, several ingenious devices having been introduced. Among the latter may be mentioned the mixing machine, which is nothing more than the machine formerly used to prepare the drink known as "milk shake". This machine saves an immense amount of time and labor, both being reduced to about a tenth of what they were in the hand mixing method. Complete comparison of both methods are made and show interesting results. The comparison of briquette makers brings out a cause for the variation of results of cement tests by different men. Mr. Boardman has been nearly three years with the Sanitary Commission and is an authority on the subject. The article will be concluded in the March number.

Collegiate Tests.—The Journal of Electricity, August, 1896, has an editorial entitled, "The Value of Collegiate Tests," criticising adversely, the practice of publishing the results of comparative tests of commercial apparatus and withholding the names of the makers. The Journal says, "We generally consider that college instructors are incapable of being purchased outright, but is it not a fact that by gifts of apparatus and favors to the colleges and to the instructors the manufacturing companies are purchasing the silence of those men who should be our guides in determining the best apparatus to be used and the best engineering methods to be employed for accomplishing a definite purpose?" Coming as it does from a periodical whose editor is himself a college professor; whose laboratory must be kept up to date in its equipment; and who cannot be purchased, we feel that the critsism is earnest, and, as it hits the U. W. engineering department, we feel compelled to say a word in reply.

In the first place, we do not agree with the Journal that college instructors should be our guides in determining the best engineering practice. We will leave that duty to the practicing engineers of the country and ask of the instructor that he keep informed as to the best practice and teach it to the engineers of the coming generation. To do this, his laboratory must be equipped with modern appliances which he should consign to the historical corner as the mould begins to gather. How is he to get modern apparatus? Will the university buy them? Anyone who knows the tendency of a board of regents to limit the apportionment of funds to engineering department to that of the less expensive departments, will appreciate the difficulty of getting apparatus in this manner. The only other solutions of the problem are to enlist the sympathy of some beneficent millionaire, or else to establish such a reputation for the department, that every manufacturer that wants an unbiased test of his product selects that institution to do it. The latter course is precisely the one Wisconsin has pursued. Manufacturers are receiving daily applications from Universities and Colleges all over the country, for apparatus, and their waste baskets fairly groan under the weight of letters from learned professors and enthusiastic students. However, when a Wisconsin instructor or student wants to make a test, his application is placed on file

and carefully indexed, and the desired article shipped prepaid on the next express. A pleasant letter is sent to the applicant wishing him success in his undertaking and requesting that in case of publication, the identification of the result of the test on this particular piece of apparatus with the maker's name, be left entirely to the discretion of the latter. He knows about Wisconsin's tests on transformers, on alternating current motors, on steam injectors and a dozen other things; he knows that the transformer tests caused many reputable manufacturers to change their design; that the late tests on alternating current motors indicate a like result; that the injector tests point out the particular field for each type of injector, and that perhaps he likewise may be put on the right track; or, if already there, he wants a check on the work of his own men and a recommendation from an unbiased institution of reputation. We do not call this purchasing silence.

Now let us see about the benefit of these tests to the community. What engineer would advise his company to buy the apparatus of Jones & Jones just because that firm made a good showing in a comparative test of apparatus which THEY KNEW WOULD BE TESTED? Here their success is only a criterion of what they can do; not what they do do. The name of the maker might as well, then, be omitted in the publication of results, and the value of the publication is this: first, it gives the standard to be expected from first class apparatus, and second, the method of testing is given that a purchaser may himself make tests on his own goods before accepting them.

Induction Motors.—The method used by Mr. E. B. True in his tests on polyphase motors is analogous to that of Dr. Sumpner for transformer testing, but the separation of losses in the case of the polyphase motor is not so accurate. In the determination of iron losses the copper loss in the armature at no load, while small, is still a quantity that should be considered; and unless the machine under test is wound so that external connections can be made (as is possible with some machines) and this C^2R loss measured, a little too much waste energy will be charged to the iron. As to the copper loss in the field, or primary winding, a correction can easily be made.

We would suggest as a possible means of separating the hysteresis and foucault current losses in the iron, that the motor be run on two frequencies. This would enable the establishment of two equations involving the two unknown quantities.

Now as to the copper losses; when the rotor is blocked the slip is one hundred per cent. and consequently its core is subjected to a much more rapid variation of its magnetism than when running on a two per cent. slip. True enough, the magnetic density is greatly reduced but just how much this is compensated for by the increased slip is a question of some importance. We would suggest that the voltage be measured during this part of the test; then after allowing for the C R drop in the field, the number of lines of force be found and from the total volume of our iron and the already determined hysteresis and foucault current constants, this iron loss could be calculated; or, if the copper loss test be made on a very low frequency, this error would be nearly eliminated. A low frequency could be obtained by over exciting a generator all it could stand and then running it at the minimum speed that would supply the desired current. The speed is easily controlled at the engine.

The question might arise as to whether the armature current bears the same ratio to the field current when the rotor is blocked as when under ordinary running conditions. An examination of the general equations of Steinmetz, (Trans. A. I. E. E. 1895), shows that when the exciting current is neglected and the primary impedence assumed as equal to that of the secondary, when reduced to the secondary circuit, the ratio is independent of the slip but under no other conditions.

After the above considerations one would expect the efficiency obtained by Mr. True to be a little lower than that given by the brake method; and as that gentleman points out the discrepancy is about one per cent.

BOOK REVIEWS.

Steam Tables and *Engine Constants* by Thomas Pray, Jr., C. C. and M. E. This book contains several noticeable features which should commend it to all engineers interested in steam tests. A fatal fault with many works of this kind is a lack of accuracy, but Mr. Pray lays much stress on the correctness of

the tables, the computations being all made by himself and son, direct from the data of Regnault, Rankine and Dixon.

The following list of headings of the tables gives a good idea of the completeness of the work. Ratio of expansion, cut-off, etc.; Heat units in water from 32° to 212° F.; Factors of Evaporation; Heat of Steam; Steam Table for each F°; Hyperbolic Logarithm Table (to 5 places); Engine Constants; Pressure, Temperature, Volumne and Density of Steam; Regnault's Results at the Paris Observatory; Mean Pressure Multipliers for each one thousandth of the Stroke; Steam used Expansively; Temperature of each pound from 1 to 350.

A feature of the book is the table of Factors of Evaporation giving the multiplier by which the weight of feed water is to be multiplied to reduce to the equivalent evaporation of water "from and at 212° F,". This table is very complete, giving the factors for steam at from 15 to 200 ℔. absolute pressure, and feed water from 32° to 212° F. temperature. The advantages of this table will be readily appreciated by any one who has worked up boiler tests.

The book is about 7x10 inches and contains 100 pages. Published by the D. Van Nostrand Co., New York.

Problems and *Questions* in *Physics*, by Chas. P. Matthews, M. E., and John Shearer, B. S. The Macmillan Co., New York. Price $1.60.

This work is designed to supplement the elementary college courses in Physics, such as are given in our best American colleges and universities. One of the most important parts or the book is the introduction, as it contains a number of tables of physical quantities, such as are likely to be used in the solution of the problems. It also contains a discussion of measurement and units. Following the introduction are four chapters which are certainly appropriate in their order of arrangement. The first subject treated is Vectors; the next Graphic Methods, and the two remaining chapters are on Averages and Approximations. The treatment is clear and has the virtue of brevity. After this follows the long list of 1326 problems and questions. They are arranged under the following headings: Velocity; Acceleration and Force; Center of Inertia (or Mass,

or Gravity); Work and Energy; Friction; Pendulums and Moments of Inertia; Elasticity; Liquids and Gases; Specific Gravity and the principle of Archimedes; Heat; Static Electricity; Current Electricity; Magnetism; Vibrations; Sound; Strings; Strings General; Light; The Lens; Interference; Diffraction. After this follows a table of logarithims of numbers and another of the natural functions of angles. Here is a practice that we hope will die out. The student in science is compelled to buy as many tables of logarithims and of sines, etc., as textbooks. These tables are necessarily inadequate, no two are alike, and confusion is the inevitable result. As to the problems themselves it is needless to say much. The calculus notation is used to a slight extent. Illustrations are employed where clearness demands and of course the ground is covered thoroughly. A free use of mixed units makes the work valuable for the engineering student. Anwers to the problems are given in all cases.

Electric Lighting, a *Practical Exposition* of the *Art*, for the use of Engineers, Students, and others interested in the installation or operation of electrical plants.

Volume I. The Generating Plant, by Francis B. Crocker, E. M., Ph. D., Professor of electrical engineering in Columbia University, New York. Vice-President of the American Institute of Electrical Engineers. D. Van Nostrand Company, New York. Price $3.

"The plan adopted in this book is to follow the usual sequence in which the electric current is generated, transmitted, and utilized in electric lighting. That is to say, the introductory principles are first given; then the buildings, boilers, engines, dynamos, distributing conductors, etc., are considered in the natural order in which the electrical energy is obtained, and finally distributed." This book should prove valuable to all engineers and especially so to the student. It is so written that it does not require a knowledge of electricity in order to read it, and therefore can be easily understood by any person interested in the subject. The author has endeavored to give a brief and clear description of the various engines and dynamos and apparatus that are to be found in the average plant, together with simple instructions for their operation.

Discharge of River—See River.

DISCHARGING Electrified Conductors by Gases—Villari. L'Eclair Elec, Oct 31. W Nov 21.

DISINFECTING Boat of the New York State Board of Health, The (Ill)—Sci Am, Oct 3. 800 w. M Nov.

Disinfecting Methods, On Electrolytic—Elek Anz, Mar 29.

DISPATCHING by Telephone, Train—Ry Age, Oct 16. 1000 w.

DISPERSION—Oliver Heaviside. Electn, Lond, Aug 7. 2800 w. M Oct.

DISTRIBUTION and Transmission of Electrical Energy, Present Status of the—Louis Duncan. Elec Rev, Oct 7. Elec Eng, Oct 7. E Oct 21.

Distribution, Continuous Current High Tension—Thury. Engng, Lond, Aug 21. Elektrotechn Zeit, Aug 20. W Sept 12.

Distribution, Equalizer Systems of—Elec Rev, Lond, Aug 7. 1800 w. M Oct.

DISTURBANCES Due to Strong Currents—Wietlisbach. Engng, Lond, Aug 14. W Sept 5.

Disturbances in Submarine Cables, Electrical—W. H. Preece. Elec, Lond, Sept 25. Elec Eng, Oct 14.

Disturbances—See Electric Railways.

DOUGLASS Southern Railway—Lightning, Lond, Oct 2.

DRAFTING Room, System in the (Ill)—James C. Hemphill. Mach, Nov. 700 w.

DRAIN, The Trap on the House—Dom Engng, Oct. 600 w.

Drain Traps and Their Disadvantages, Main—F. W. Tower. Dom Engng, Oct. 1700 w.

Drains, Diameter and Inclines of—A. B. Plummer. Arch & Builder, Oct 10. 1800 w.

DRAINAGE of Buildings, The—Arch & Build, Oct 3. 1300 w. M Nov.

DRAWBRIDGE, Erection of a Long Four-Track (Ill)—Eng Rec, Sept 12. 1500 w. M Nov.

DREDGER, Electrically Driven Ladder—Elec Rev, Lond, Nov 13.

Dredger, An Electric—Sci Am Sup, Oct 3. E Oct 21.

Dredger, Electrically Driven Ladder (Ill)—Lond, Engineering, Oct 9. W Oct 31.

DRILL, Portable Universal (Ill)—Elec Rev, Lond, Oct 30. W Nov 21.

DRUMS for Light Ships, Veering (Ill)—Elec Rev, Lond, Oct 30. W Nov 21.

DRY-DOCK at Port Orchard, Government (Ill)—Sci Am, Oct 3. 1300 w. M Nov.

Dry Dock No. 2 N. Y. Navy Yard, Accident to (Ill)—Sci Am, Aug 22. 1800 w. M Oct.

DYNAMITE, Manufacture, Use and Abuse of—H. A. Lee. Can Eng, Sept. 1800 w. M Nov.

DYNAMO, A New "Three Wire"—Alexander Rothert. Elec Wld, Nov 7. 1200 w.

Dynamo, Combined Gas Engine and (Ill)—Lond Elec Rev, Oct 9. W Oct 31.

Dynamo Design—Elec Rev, Lond, Oct 30.

Dynamo, Designing a Bi-polar Drum (Ill)—Rankin Kennedy. Elec Rev, Lond, Oct 16. Serial Part 1. 700 w. M Dec.

Dynamo, How to Compound a—Pool-McKissick. Am Elec, Nov. W Nov 28.

Dynamo, How to Make a Simple (Ill)—S. M. Barriett. Power, Sept. 2800 w. M Oct.

Dynamo Telegraphing, Improvement in—Medina. Jour Elec, Aug. W Oct 17. Teleg Age, Nov 16. Jour of Elec, Aug. 2300 w. M Nov.

Dynamos (Ill)—Biostel. L'Eclair Elec, Oct 3.

Dynamos at the Berlin Exposition (Ill)—Mittelmann. Electrotechn Zeit, Oct 1. W Oct 17.

Dynamos, Cast Steel for—Elektrotechn Zeit, Oct 15. W Nov 7.

Dynamos, Energy Loss in—Corsepins. Elektrotechn Zeit, Sept 17.

Dynamos, Equalizers of Compound—Teyon. Am Elec, Sept. W Oct 3.

Dynamos, Faults in—Am Elec, Aug and Sept. W Oct 3.

Dynamos, Graphical Representation of the Flux in—Elec Rev, Lond, Aug 21.

Dynamos, The Design of Large Arc—George Albers. Elec Eng, Oct 7. 2200 w. M Nov.

EARTH a Great Magnet, The—Fleming. Elec Oct 14. W Oct 17.

Earth Resistance of High Tension Current by Means of the Line Voltage, Measurements of—Dr. Oscar May. Electrotechn Zeit, Oct 22.

ECCLESIOLOGICAL Notes from North Germany (Ill)—T. F. Bumpus. Arch, Lond, Sept 11. Serial Part 1. 3000 w. M Nov.

ECLIPSE of the Sun, The (Ill)—J. Norman Lockyer. Nature, Aug 27. Serial Part 1. 4400 w. M Oct.

EDINBURGH, Central Station at—Elec Rev, Lond, Oct 16.

EDUCATION in Germany and England, Scientific—Oswald. Elec Eng, Lond, Aug 28.

Education of Artisans, The Technical—Eng, Lond, Oct 9. 1800 w. M Dec.

Education, Technical—Electn, Lond, Oct 9.

Educational—Can Elec News, Aug.

EFFICIENCY, Negative—Halsey. Am Mach, Nov 12. W Nov 21.

Efficiency of a Dynamo, New Method of Determining the—Routin. L'Eclair Elec, Oct 24. W Nov 14.

ELECTRIC and Cable Railways, The Working Expenses of—Ry Wld, Sept. 1900 w. M Nov.

Electric Arc, Counter E. M. F. of the—W. S. Franklin. Science, Sept 11.

Electric Arc, Luminous Efficiency of the—Blondel. L'Eclair Elec, July 4. W Aug 1.

Electric Arc, Resistance of the—Frith and Rodgers. Phil Mag, Nov.

Electric Arc, Resistance of the—Gray. Electn, Lond, Nov 13. W Dec 5.

Electric Car Lighting—Ry Gaz, Oct 31. E Nov 18.

Electric Conductivity and Magnetic Homogeneity—Ebeling. Elektrotechn Zeit, Aug 20. W Sept 12.

Electric Cranes, Notes on—E. W. Anderson. Elec Eng, Lond, Sept 25. 5000 w. M Nov.

Electric Currents, The Course of Bullets Changed by—Elec Rev, July 1. 700 w. M Aug.

Electric Currents Through Air—Lord Kelvin, Bottomley & McLean. Elec, Lond, Sept 25. Electn, Lond, and Elec Eng, Lond, Oct 9.

Electric Development, The Possible and Impossible in—Baxter. Eng Mag, Oct.

Electric Discharge in a Magnetic Field—Salomons. Phil Mag, Sept. W Oct 3.

Electric Discharges in Rarified Metallic Vapors—Wiedemann and Schmidt. L'Eclair Elec, Aug 8.

Electric Energy, Method of Charging for—Pink. Lightning, Lond, Oct 1 & 8. W Oct 31.

Electric Fountain in Willow Grove Park, Philadelphia, The (Ill)—Elec Eng, Oct 7. 800 w. M Nov.

Electric Furnace—Moissan. Elec, Lond, Sept 25.

Electric Furnaces and the Conversion of Carbon into Graphite—Sci Am Sup, Aug 22. 2000 w. M Oct.

Electric Generators, Steam Engine for—Sperry. West Elec, Aug 1. W Aug 8.

Electric Illuminating and Power Company, The New Station of the Long Island City—Elec Wld, Oct 17. E Nov 4.

Electric Keyway Cutting Machines—Elec Rev, Sept 25. W Oct 3.

Electrical Light at the National Exposition at Geneva—R. B. Ritter. L'Ind Elec, Oct 10. E Nov 18.

Electric Light Mains, The Location of Faults in—F. C. Rapheal. Electn, Lond, Oct 16. W Nov 28.

Electric Light Plant Run by a Gas Engine, Test of an Isolated (Ill)—S. A. Beyland. Prog Age, Oct 15. E Nov 18.

Electric Lighting, Cost of—Elec Rev, Lond, Nov 13. W Dec 5.

Electric Lighting Exhibition at Geneva—Ritter. L'Ind Elec, Oct 10. W Nov 7.

Electric Lighting in London and Paris—Electn, Lond, Oct 30. W Nov 21.

Electric Lighting in Australia—Spencer. Electn, Lond, Aug 21.

The first few chapters give briefly the theory and history of electric lighting. These are followed by chapters describing the apparatus for generating the electric current, which embraces descriptions and illustrations of the various commercial machinery. There are chapters on Water power, Gas engines, Steam engines and dynamos in which the author gives the representative machines and their construction. The closing chapters are devoted to accumulators, their principles, use and action, and descriptions of the various instruments used in electric lighting.

The book is very well written and contains many illustrations, and diagrams.

The Journal of the *Western Society* of *Engineers* for October, 1896, gives a detailed and interesting account of the Bedford-Louisville Excursion, on which a number of our Senior Engineers and Professors were fortunate enough to go.

The article is the report of the Publication Committee, read before the Society, and is of interest especially to those who attended. It gives descriptions of the various places visited, and discussions on the products of the quarries at Bedford and Louisville. The article is interspersed with half-tones of the quarries visited, from photographs taken during the trip. In many of these familiar faces are to be seen.

The Journal also contains the minutes of the meeting that the student members of the party were invited to attend.

A Primer of the *Calculus* by E. Sherman Gould, M. Am. Soc., C. E.

This work is restricted to the rudiments of Calculus. "Within these narrow limits, however, the treatment is tolerably full, and suffices to show how far reaching a mathematical instrument the Calculus is, even in its elementary steps."

The author has aimed to give a working knowledge of the science — to teach a few elementary rules and then put them into immediate use, as far as they will go. This incites the student to more advanced steps. The author believes it best, in any art or science, to learn the practical process first and the theory or reason why afterwards, taking every thing for granted in the

mean time, more particularly when, as in calculus, the theory is somewhat perplexing. He says: "The theory is much better approached after the student's confidence in the practical outcome of the thing has been fully established by actual work. Indeed, in this way, he is liable to pick up a good deal of the doctrine as he goes along, and the knowledge of it that he thus acquires will guide him to what he still lacks. The recognized need will point to the best line of investigation.

The book is No. 112 of the Van Nostrand Science Series. It contains 91 pages of reading matter and 17 plates of figures. Published by the D. Van Nostrand Co., New York. Price 50 cents.

The *Buffalo Forge Co.* have issued a general catalogue that is not only very artistic but of great practical value to engineers, especially to those interested in air handling apparatus. The catalogue contains a description of the following machinery manufactured by the company: Horizontal and Upright Steam Engines; Mechanical Draft Fans and Apparatus; Steel Plate Steam and Pulley Fans; Fan System of Heating, Ventilating, and Drying; Disk Ventilating Fans; Blowers and Exhausters; Manual Training School Outfits; Hand and Power Blacksmith Drills; Punch, Shear and Bar Cutters; Tire Upsetters and Blacksmith Tools; Blacksmith Hand Blowers; Stationary, Portable and Heating Forges. But the catalogue gives much information besides the description of the machinery manufactured. There are a large number of tables which make the practical solution of problems in handling air a very simple matter- And more than this, since the facts and figures given are de. rived from actual test records, the result obtained may be relied on as being accurate. The tables and rules were established by the results obtained from the most extensive experiments, under varied conditions and involving the use of the most refined and accurate instruments. The book is freely illustrated with cuts that show clearly what they were intended to show. There are a large number of half-tones and the press-work is such that it makes it a pleasure to look through the book. It is library bound, cloth, 8x10 inches and conta ns 400 pages.

A *Book of Tools* is the name given by Chas. A. Strelinger & Co., Detroit, Mich., to their catalogue, and the name is certainly fitting. This book is a radical departure from the ordinary catalogue of tools and its advantages cannot fail to be appreciated by all who may have the good fortune to see it. One of the features is the manner in which the author gives his candid opinion of the tools described and the class of work to which they are best adapted. The book is remarkably complete, which makes it very desirable as a reference book for one may feel reasonably sure of finding in it the particular tool which is best adapted for the work he wishes to perform. The prices, too, can be relied on as being about right and do not, as is the case with some, keep one wondering whether he is to divide the printed figures by 2 or 3 to obtain the approximate true price. A very commendable feature is its compactness, for although it may be readily carried in the pocket (being 5x7 inches), it contains on its 550 pages one of the most complete and varied list of tools that has ever been compiled. The illustrations though necessarily small are clear and serve the purpose as well as if they were several times as large. The book should be found in the library of every engineer and machinist. Price, paper 25 cents, cloth 75 cents.

A DIFFERENCE.

A story is told by Mr. L.—— which shows that, no matter how much has been said and may be said to the contrary, people will still cling to the primitive idea that no difference exists between an engineer and an engine-man.

Mr. L.—— was at one time conspicously connected with the university as those who were with the classes of '92 or '93 will easily recall. After leaving the university, for reasons which need not here be stated (but which can however be easily ascertained by anyone interested by merely referring to any member of the classes mentioned) he drifted to M.—— in the neighboring state of M.——

After quite a deligent search he succeeded in finding a position with one of the large bridge companies. Having secured employment he again set out in true collegiate fashion to find a suitable boarding place. Luck was still with him and in a short time he had found a desirable room and an apparently desirable land-lady.

The room was very prettily furnished. Lace-curtains, carpets, rugs, everything seemed to be purposely selected to be suitable to the future occupant. This Mr. L.—— thought. After having recovered his breath, which had been lost for a time directly succeeding the naming of the price of the room, and, do not be mistaken, was due not to the expensiveness, but cheapness of the same, Mr. L.—— began to form an acquaintance with his new land-lady.

They talked of many things and finally the land-lady asked of Mr. L.—— what profession he was engaged in. "I am a civil-engineer," he replied.

The landlady looked astonished. Mr. L.—— became perplexed. "I am afraid," she finally said, "that I cannot let you have the room".

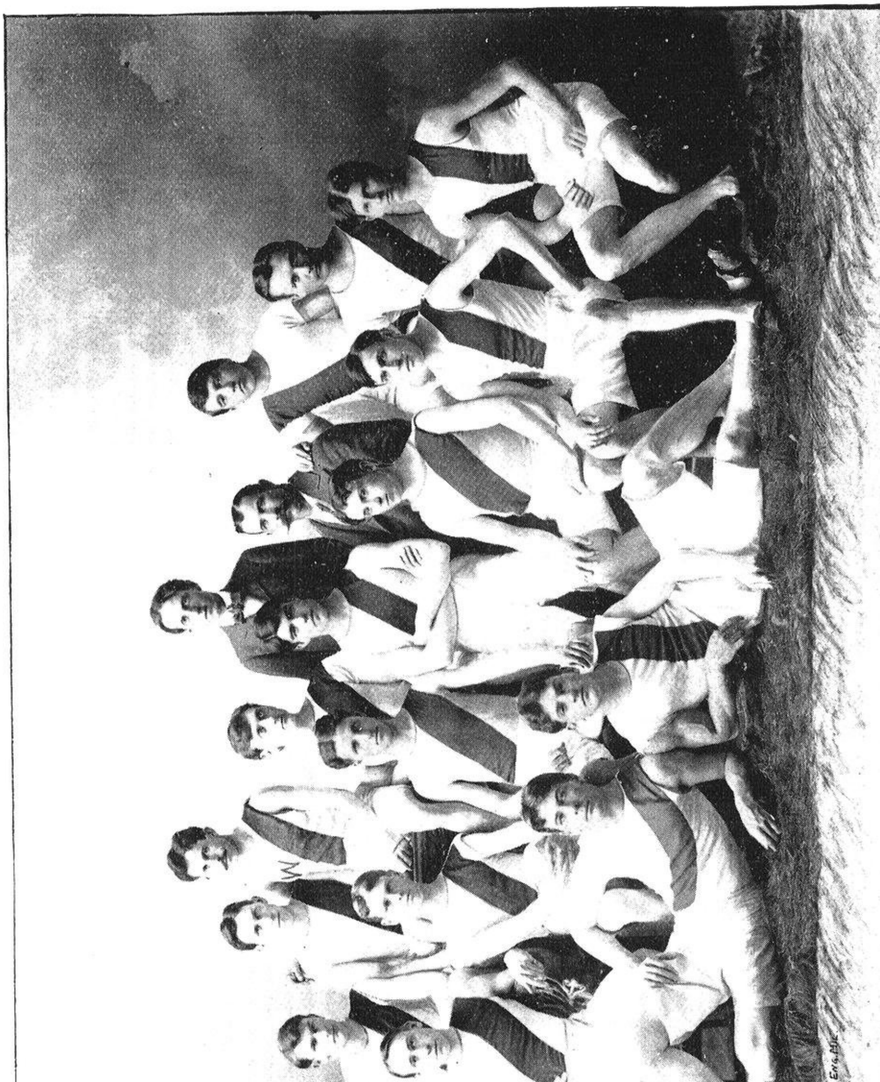
Mr. L.—— still astonished but having recovered to some extent, wished to know her reason for such action.

"All engineers are so dirty and I am afraid that you will ruin the furnishings of the room", replied the landlady.

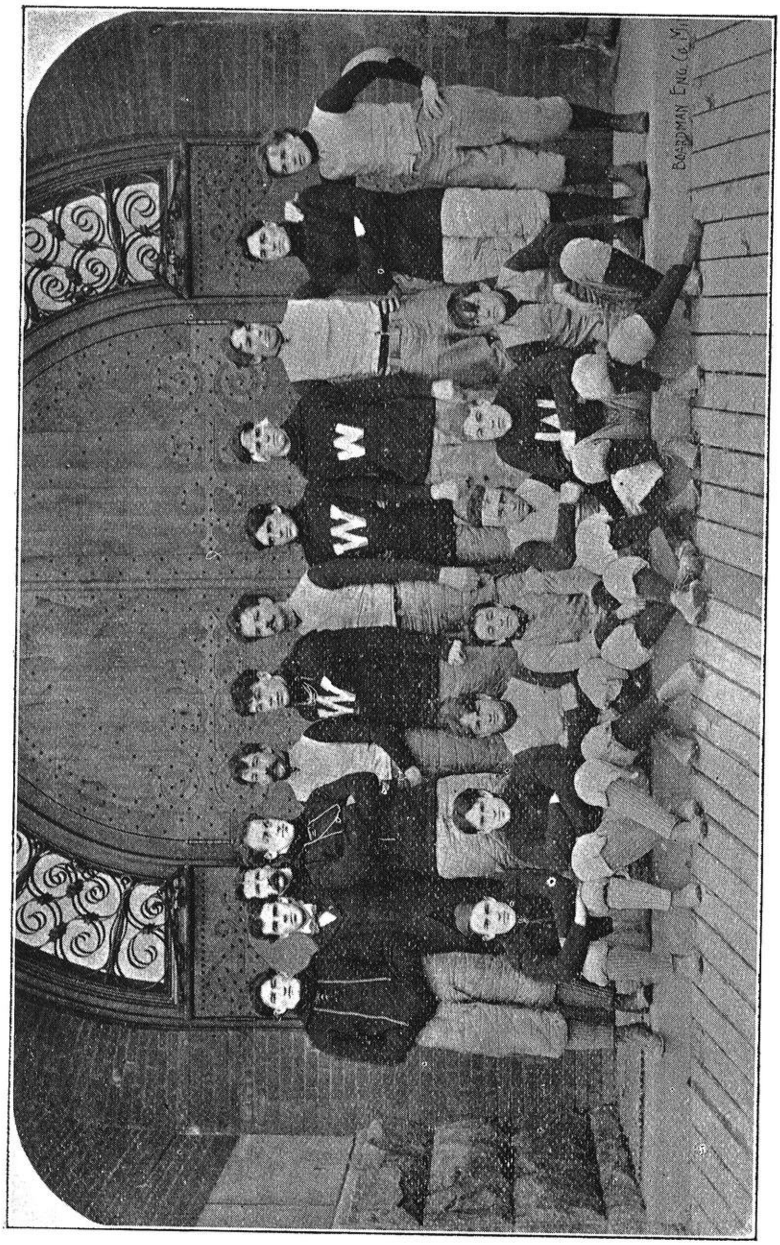
"But I am a civil-engineer," protested Mr. L.—— "You may be very civil," answered the lady of the house, "but you are to dirty."

Mr. L.—— was afterwards found looking for another room, lamenting his misfortune and not saying the best of things about "some —— people that don't know the difference between a pile-driver and a hand-saw".

University Views.



U. W. TRACK TEAM OF '96.



U. W. FOOTBALL TEAM OF '96.

Index of Advertisers.


CALIFORNIA in 3 Days
PORTLAND
SAN FRANCISCO
SACRAMENTO
LOS ANGELES
SAN DIEGO
OGDEN
SALT LAKE
CHEYENNE
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Chicago & North-Western Ry.
THROUGH SLEEPING AND DINING CARS TO SAN FRANCISCO AND LOS ANGELES
PRINCIPAL EASTERN AGENCIES:
New York: 423 Broadway 287 Broadway
Boston: 5 State St. 292 Washington St.
Chicago: 208 Clark St. 191 Clark St.

PINE CREEK District, Colorado—H. L. McCarn. Min & Sci Pr, Aug 29. 200 w. M Oct.

PINE, The Strength of Georgia—H. H. Miles. So Arch, Sept. 1300 w. M Nov.

PIPES From a Plumbers Point of View, Lead vs Iron for Supply and Vent—William Eccles. Arch & Build, Oct 24. 1100 w.

PISTONS, American Locomtive (Ill)—Am Mach, Oct 29. 1800 w.

PLANIMETER, Goodman's Hatchet (Ill)—Sci Am Sup, Sept 26. 200 w. M Nov.

Planimeter, The Prytz—Engng, Sept 11. 1200 w. M Nov.

PLANT, Belfast—McCowen. Elec Eng, Lond, July 31. W Aug 22.

Plant, Detroit Municipal—Eng News, Aug 13.

Plant, Incidental Points About a Central Station—West Elec, Aug 15.

Plant of the Chicago Board of Trade, The Reconstruction of the (Ill)—Bion J. Arnold. Trans A. I. E. E., Aug & Sept. 6000 w. M Dec.

Plant of the Duquesne Steel Works and Blast Furnaces, Electric—Elec Eng, Sept. 2.2200 w. M Oct.

Plant of the Syndicate Building, The Electrical (Ill)—Elec Wld, Aug 29. 2400 w. M Oct.

PLASTERING Methods and Materials—Thomas Jones. In Arch, Aug. 4200 w. M Oct.

PLATE Trials, American (Ill)—Eng, Lond, Aug 7. 1400 w. M Oct.

PLATINUM in New South Wales, The Occurrence—J. Jaquet. Eng & Min Jour, Aug 8. 900 w.

PLOW; Grand Trunk Railway, Snow (Ill)—Ry Mas Mech, Nov. 1000 w.

PLUMBERS' Craft and Education, The—Prof. Garnett. Dom Engng, Oct. 1400 w.

PLUMBING, A Sample of Criminal (Ill)—C. Desormeaux. Dom Eng, Sept. 400 w. M Nov.

Plumbing in a Reconstructed New York Residence (Ill)—Eng Rec, Oct 17. Serial Part 1. 1600 w.

Plumbing in Mr. E. C. Benedict's Country House (Ill)—Eng Rec, Sept 26. 1200 w. M Nov.

Plumbing, Most Common Defects (Ill)—Dom Engng, Oct. Serial Part 1. 500 w.

Plumbing Ordinance, Scranton, Pa—San Plumb, Aug 1. 3000 w.

Plumbing Regulations, New York—Met Work, Oct 24. 5500 w.

PNEUMATIC vs. Iron Tires for Vehicles (Ill)—Eng News, Oct 1. 500 w. M Nov.

POLAR Expedition, Nansen's—Sci Am, Aug 22. 1200 w. M Oct.

Polar Expedition, The Andree (Ill)—Sci Am Sup, Sept 12. 1000 w. M Oct.

POLARIZATION, A Theory of Galvanic—W. S. Franklin and L. B. Spinney. Science, Sept 11.

Polarization and Resistance of Batteries—Streintz, L'Eclair Elec, Sept 26. Wied Ann, 57.

Polarization Capacity, New Method of Measuring (Ill)—Gordon. Zeit f Elec, Oct 29. W Nov 21.

Polarization with Alternating Currents—Wein. Weid Ann, Vol 58, P 37. W Aug 15. Proc Lond Phys Soc, Aug.

Polarization of Thim Metallic Membranes—Luggin. L'Eclair Elec, Oct 17.

POLES in Washington, Rules for Suburban—Elec Eng, Nov 11.

POLYPHASE Circuits, Measuring Power in—Guilbert. L'Eclair Elec, Aug 1.

POOLING of Freight Cars—Ry Age, Sept 25. 900 w. M Nov.

Pooling, The Objection to—E. W. J. Bradstreet's, Aug 27. 1000 w. M Oct.

POSTAL Telegraph Service—Electn, Lond, Aug 28. W Sept 19.

POTASSIUM Per-Carbonate, Electrolytic Production—Electn, Lond, Oct 16.

POTENTIAL Difference Between Gases and Liquids—Kewrick. Elec Rev, Lond, Oct 9.

Potential in Moving Liquids, Electric—G. Goure de Villemontee. L'Eclair Elec, Sept 12 & 26.

POTTERY Kilns, New Stafferdshire (Ill)—Cons Repts, Sept. 1800 w. M Nov.

POWER Absorbed by Machine Tools—Pike. Am Mach, Sept 24. W Oct 3.

Power and Electric Transmission Plant of the Big Cottonwood Power Co., The Water (Ill)—W. P. Hardesty. Oct 1. 4800 w. M Nov.

Power Applied to Wood-Shops, Pneumatic (Ill)—John Davis Barnett. Trans Can Soc of Civ Engs, June. 5800 w.

Power Development, The Future of—Strong. Cassier's Mag, Aug. Ry Rev, Aug 22.

Power for Machine Tools—L. S. Summers. Elec Engng, Aug. 1300 w. W Aug 15.

Power House, Extension of the Niagara (Ill)—O. E. Dunlap. Elec Eng, Sept 16. 1100 w. M Nov.

Power House in Chicago, Railway (Ill)—West Elec, Nov 14.

Power House, The Modern—Richard McCulloch. Elec Eng, Oct 28. Serial Part 1. 3700 w.

Power House Transformed, A Railway—West Elec, Nov 14. E Dec 2.

Power in Small Units, The Use of Electric (Ill)—William Elmer, Jr. Eng, Mar Nov. 1400 w.

Power Plant at Austin (Ill)—Sci Amer, Aug 8.

Power Plant at Lake Bima-Kiota, Japan (Ill)—Tanage. Sci Am, Nov 7. W Nov 14.

Power Plant of the Standard Consolidated Mining Company, Addition to the—R. G. Brown. Trans Am Inst Min Engs, Sept. 4500 w. M Oct.

Power Plant, Where Shall We Locate the—C. Dennis. Sta Eng, Aug. 1400 w.

Power Ploughs, Prize for—Elektrotechn Zeit, Nov 12. W Dec 5.

Power Required for Metal Working Machinery—Dodge. Am Mach, Oct 8.

Power Required for Wood Working Machinery—Dodge. Elec Eng, Aug 12.

Power Stations, St Louis (Ill)—Elec Eng, Oct 21.

Power Station, The Hamburg Combined Electric—Eng Rec, Aug 15. 1500 w. M Oct.

Power, The Utilization of Water—Alph. Steiger. Prac Eng, Aug 21. Serial Part 1. 1600 w. M Oct.

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Power Transmission—F. H. Underwood. Eng Rec, Oct 3. 1000 w. M Nov.

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Power Transmission, Niagara—New York—Elec Eng, Nov 18. W Nov 28.

Power Transmission Plant, Big Cottonwood—Elec Eng, Sept 2. 1600 w. W Sept 12. M Oct.

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PROSPECT, A New—Arthur Lake. Col Eng, Sept. 1300 w. M Nov.

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RECTIFIERS for Arc Lighting, Use and Economies of—Hesketh. Electn, Lond, Aug 7. Elec Eng, Lond, May 22. 2880 w. W June 13. Electn Lond, Oct 30.

REFLECTION, Spectrum of—Birchmore. Elec Eng, Nov 11. W Nov 21.

REFUSE by Heat, Cost in Leeds of Destroying—Dr. Spottiswoode Cameron and Mr. George Darley. San Rec, Oct 9. 800 w.

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RENAISSANCE in France, The Early (Ill)—G. A. Middleton. Arch Rec, Oct. Dec. 2000 w.

REOSTENE: A New Resistance Metal—Harker and Davidson. Elec Rev, Lond, Oct 2. W Oct 24. Elec Eng, Lond, Oct 9. E Nov 18.

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Resistance Box, Self-Testing (Ill)—Engng, Lond, Nov 6.

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Resistances, Contact—Wirt. Elec Eng, Aug 5. W Aug 15.

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Resistances, Negative—G. F. Fitz-Gerald. Electn, Lond, Aug 7. W Aug 29.

RETORT Coking—John S. Kennedy. Tradesman, Aug 15. 2000 w. M Oct.

Retort House, A Modern (Ill)—William S. Miller. Pro Age, Nov 2. 5000 w.

Retorts at Cassel, Germany, Inclined—Emil Merz. Am Gas Lgt Jour, Sept 14. 1400 w. M Nov.

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RETURN Circuits for Electric Railways—Mommerque. L'Eclair Elec, Oct 10. W Nov 7.

RHEINFELDEN—Zeit f Elec, Sept 5. W Oct 3.

RHEOSTATS and Arc Regulators, Faults in—Am Elec, Oct.

RHEOSTENE—Dr. J. A. Harker and A Davidson. Elec, Lond, Sept 25.

RIFLE Balls—See Electromagnetic.

RIVER, An Underground—Bos Jour Com, Sept 26. 1500 w. M Nov.

River, The Discharge of the St. Lawrence (Ill)—C. H. McLeod. Trans Can S C E, June. 1800 w.

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Road in Budapest, The Electric Underground (Ill)—Joseph Herzog. Elec Wld, Oct 24. 1300 w.

Road of the Future, The—Gen. Stone. Clay Rec, Aug 12. 1300 w. M Oct.

Roads, The Management and Position of Rural—Builder, Oct 31. 1700 w.

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Roadmasters' Convention, The New England—Ry Age, Aug 28. 2200 w. M Oct.

ROASTING Iron Ore—Wedding. Engng, Lond, Oct 9.

ROBERSTON, The Works of R. H. (Ill)—Montgomery Schuyler. Arch Rec, Oct. Dec. 9000 w.

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ROLLING Stocks with Metal Frames, The Durability of—Amer Eng & R R Jour, Aug. 5000 w.

ROOFING and Other Purposes, The Application of Sheet Zinc for—W. H. Seaman. Eng & Min Jour, Oct 24. 1700 w.

ROOFS, Loads and Strength of—Can Arch, Oct. 2000 w.

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Rope Tests—Tech Quar, June-Sept. 250 w. M Nov.

Rope Transmission—J. F. De Voll. Age of St, Oct 24. 2000 w.

Ropes, Round vs. Flat Ropes—G. W. Westgarth. Eng, Lond, Sept 18. 800 w. M Nov.

Ropes, Wire—Can Min Rev, Aug. 3000 w. M Oct.

ROTARY Field Motors for Lecture Purposes (Ill)—Ganz. Elec Eng, Aug 12.

ROUEN Central Station (Ill)—L'Ener Elec, Oct 1.

ROENTGEN, An Old Experiment Analogous to That of—Holtz. L'Eclair Elec, Oct 10.

Roentgen Photograph of a Bullet in the Brain—Brissand and Londe. La Nature, Sept 5. W Oct 10.

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Roentgen Radiation—Threefall and Pollock. Lond, Electn, Elec Rev, and Elec Eng, Nov 20. W Dec 12.

Roentgen Ray Apparatus Operated from Alternating Current Circuits, On (Ill)—Edwin J. Houston and A. E. Kennelly. Am Electn, Aug. M Oct. W Aug 29.

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Roentgen Ray Discharge of—Perrin. Elec Jour, Sept 15. W Oct 3.

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Roentgen-Ray Researches—Roiti. L'Eclair Elec, Oct 17. W Nov 7.

Roentgen Ray Tube—L'Eclair Elec, Oct 31. W Nov 21.

Roentgen Ray Tubes (Ill)—La Nature, Nov 21.

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Roentgen Rays, Action of Metals and Salts on—Gladstone and Hibbert. Elec Eng, Lond, Oct 17. W Nov 7.

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Self-Induction Standards—Wien. Proc Lond Phys Soc, Sept.
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Shaft Fire and Its Lesson, Note on a—R. G. Brown. Trans Am Inst Min Engs, Sept. 1300 w. M Nov.
Shafts, A New Mode of Sinking—Aust Min Stand, Sept 17. 2300 w.
Shafts, Plumbing—George B. Hadesty. Col Eng, Aug. 3300 w. M Oct.
SHIP Building Industry, The North of England—Henry F. Swan. Col Guard, Oct 23. 3500 w. M Dec.
Ship Building of the World, The Mercantile—Eng Gaz, Sept. 1600 w. M Nov.
Ship Owning of the World, The Mercantile—Eng Gaz, Oct. 1600 w. M Nov.
Ship, The Bazin Roller (Ill)—Sci Am, Sept 12. 800 w. M Oct.
Shipping, Our Neglected—A. R. Smith. N Am Rev, Oct. 3300 w. M Nov.
Ships, Types of United States War—Ir Age, Aug 27. 1300 w. M Oct.
Ships, Safety in—Eng, Lond, Sept 25. 4700 w. M Nov.
SHOCK Prevention in Machinery—W. H. Atherton. Mech Wld, Oct 23. 2200 w.
SHOPS at Concord, N. H., New—Ry Rev, Sept 26. 800 w. M Nov.
Shop Experience in Entrance Examinations, Credit for—Am Mach, Sept 17. 1800 w. M Nov.
Shop Management, Six Examples of Successful (Ill)—Henry Roland. Eng Mag, Oct. Serial Part 1. 4200 w. M Nov.
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SIEGEL-COOPER Department Store, The Mechanical Features of the—Eng Rec, Oct 3. Serial Part 1. 2000 w. M Nov.
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Signals in Vienna, Fire-Alarm—Chitil. Zeit f Elec. Oct 1.
SIGNALLING and Interlocking in Chicago—Ry Age, Sept 11. 600 w. M Nov.
Signalling and Interlocking on the Union Elevated or Down-Town Loop, Chicago—R R Gaz, Aug 21. 800 w. M Oct.
Signalling, First Principles in Railroad (Ill)—H Paine. Eng Mag, Aug. 52000 w.
Signalling on the Park Avenue Viaduct; N. Y.
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Central R. R., A Double Blade Semaphore for Block—Eng News, Oct 22. 1200 w.
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Silver-Lead Smelting Plant, A Modern—L. S. Austin. Trans Am Inst Min Engs, Sept. 5400 w. M Nov.
Silver Losses in Cupellation—L. D. Godshall. Trans Am Inst Min Engs, Sept. 1400 w. M Nov.
Silver Mining in British Guiana—E. D. Ingall. Min Jour, Aug 29. 2500 w. M Oct.
Silver Mining in Kaotenay, B. C.—Can Min Rev, Sept. 4800 w. M Nov.
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SLEEPERS in Austria, Longitudinal (Ill)—Ry Rev, Oct 31. 1000 w.
Sleepers in Queensland, Steel—John A. Griffiths. Ind & East Eng, Sept 19. Serial Part 1. 2300 w.
SMELTING by Electricity, Iron—Dr. de Laval and Robson. Elec, Lond, Sept 25. Elec Eng, Oct 14.
Smelting, Electric Iron—Laval process. Elec Eng, Oct 14. W Oct 31.
Smelting Furnace, Electric (Ill)—Ir Age, Oct 8.
SMOKE Prevention from a Mechanical Standpoint—C. H. Benjamin. Can Eng, Sept. 1500 w. M Nov.
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SPAN—See Railway.
SPARK Discharge, The Action of Light on—E. Warburg. Annal de Phys & Chem, No. 9. E Nov 25. Electn, Lond, Oct2. W Oct 24.
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SPECIFICATIONS? Who Should Prepare—Eng News, Aug 20. 1300 w. M Oct.
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SPECULATIVE Enterprises, Engineers and—Eng News, Oct 22. 1400 w.
SPEED Regulation of Induction Motors—P. M. Heldt. Am Electn, Sept. 1500 w. M Nov.
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STABLES—C. H. Blackall. Am Arch, Oct 10. Serial Part 1. 2500 w.
Stables, Ventilating and Warming—Can Arch, Oct. 2000 w. M Dec.
STACK, The Erection of a Large Steel (Ill)—Fred A. Dillon. Power, Nov. 1400 w.
STADIA Surveying, Methods and Results of—F. B. Maltby. Jour Assn of Eng Soc, Sept. 10000 w.
STAGE at the Munich Royal Residence and Court Theatre (Ill)—Am Arch, Sept 12. 1200 w. M Nov.
STAIR Construction, A German System of Metal (Ill)—Eng News, Aug 27. 400 w. M Oct.
STANDARD Cell, One-Volt—Elec, Lond, Sept 25.
Standards for Rating Apparatus—W. J. Clark. St Ry Rev, Sept 15. 1200 w. M Nov.
ST. PAUL—See Transportation.
STARTING Box with Under-Load and Over-Load Circuit Breaker (Ill)—Am Mach, Aug 27. 800 w. M Oct.
STATION at Jever, Municipal (Ill)—Elektrotechn Zeit, Oct 8. W Oct 31.
Station at Providence, New Passenger (Ill)—Ry Rev, Aug 29. 2300 w. M Oct.
Stations in Vienna, Operating Cost of the—Goldenzweig. Zeit f Elek. W Oct 3.
Station Statistics, Central—Ross. Elektrotechn Zeit, Sept 10. W Oct 3.
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Station, Incidental Points about a Central—West Elec, Aug 15. 1200 w. M Oct.
Station of the Long Island City Electric Illuminating and Power Company, The New (Ill)—Elec Wld, Oct 17. 600 w.
STATISTICS of the Association of the Elektricitaets-werken for the Fiscal Year 1894-95—Elec, Aug 26. M Oct.
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Statistics, Some Continental Electric Lighting—F. Ross. Electrotechn Zeit, Sept 10. Elec, Lond, Sept 25.
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Steam Engine, The Raworth "Universal" (Ill)—Electn, Lond, Sept 11. 700 w. M Nov.
Steam Engines for Electric Generators—Sperry. West Elec, Aug 1. W Aug 8.
Steam Locomotion on Common Roads (Ill)—W. Fletcher. Eng, Lond, Sept 4. 700 w. M Nov.

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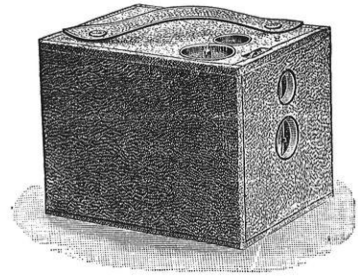

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